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50th Anniversary Special Issue

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SPECIAL ISSUE 50th ANNIVERSARY

Editorial

This special issue marks the 50th anniversary of the journal *Économie et Statistique*, now *Economie et Statistique / Economics and Statistics*. Adopting, of course, a long-term perspective, this issue brings together a series of papers on some of the major trends in the French economy over the past half-century or in more recent decades, in areas such as the distribution of value added, growth and income distribution, changes in the labour market and social structure, and inequalities. It also addresses the new challenges facing our economies, with the question of artificial intelligence on the one hand and the emergence of environmental concerns on the other. Finally, two papers also examine developments in some of the techniques used by studies published in the journal, namely econometric policy evaluation methods and microsimulation models. This collection of papers does not claim to be exhaustive since it would have been impossible to cover all the topics examined by the journal in its 500 or so issues published over the past five decades. However, it is indicative of the progress made and of the position now held by the journal – specifically, an academic-level journal devoted to providing quantitative insights into the economy and society and publishing articles that draw on a large amount of data produced by the official statistical system, whether or not their authors work within that system.

The journal's current position is the result of a process of gradual change. When the journal was founded, Jean Ripert, then Director General of Insee, presented it in the editorial of the first issue as "Insee's flagship journal, intended for specialists but also for a non-specialist audience" (Jean Ripert, 1969. La réforme des publications à l'Insee, *Économie et Statistique* n°1, pp. 3-5). The aim was to present "the work of the Institute", to "guide the reader through statistical production" and to "describe and disseminate the available data". Jean Ripert also noted that Insee could not claim to reach all audiences effectively, but that its responsibility was to "act as the first link in the chain" and to "facilitate the work of those who come after us – the press, but also intermediary bodies, associations, teachers, companies, etc."

It was in this line that the articles were initially published, then the journal evolved more clearly towards the side of research: today, the journal is no longer focused on disseminating the work of Insee statisticians – the Institute's editorial offer has expanded, thereby fulfilling this objective – but stands rather as an academic journal published by a statistical institute, a very special situation which has hardly any equivalent. The journal has evolved, but its goals remain fundamentally the same: to inform the social and economic debate with facts and observations and to allow all parties involved to use the publication to ensure it reaches the widest possible audience. Two essential requirements must always be reconciled and cannot be contradictory: first, the quality of analyses and, second, clarity of expression.

Today, the journal is no longer the sole preserve of Insee's economists and statisticians, having gradually begun in the 1990s to welcome external contributors, who now account for the vast bulk of the journal's authors. Should we regret these changes? Absolutely not. After all, they reflect another very positive development, which is that all researchers, whether or not they belong to Insee, can now access all the information collected by the official statistics system, including, of course, aggregate level statistics, but also detailed data on individuals, households and firms, which provide the material for so many studies. Long gone are the days when only an Insee researcher could gain access to certain survey data or administrative files.

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Alongside this, quality standards have improved. Originally, publication was only subject to internal approval from above. Today, the manuscripts submitted are systematically assessed by anonymous reviewers as part of a standard peer review system. And the journal, like any academic journal, now has a formal governance structure with a Scientific Committee since 2003 and an Editorial Advisory Board since 2014.

As a natural corollary of these changes, the papers published in the journal do not necessarily reflect the views of Insee. Indeed, the readers are systematically reminded that "the views and opinions expressed by the authors are their own and do not necessarily reflect those of the institutions to which they belong or of Insee itself." This precaution is not always sufficient, and when there is a debate over a paper, it is often presented as "an Insee study". From my point of view as a publishing director, I find the confusion regrettable, although it does not, and indeed should not, cause us to avoid a subject or reject a paper on the grounds that it might generate controversy. In practice, informing debates cannot always be done by staying out of the debate.

The editors have always been, and remain, committed to facilitating access to articles, in particular with the use of "boxes". While these were initially intended to accommodate the most technical developments so that they do not interfere with the ease of reading, they now contribute to a rigorous presentation of the sources used and their possible treatment. I am aware that this is not standard practice in academic journals, but I will nonetheless continue to defend the original model – an extremely useful model in my view – of a journal that sets high standards while at the same time striving to remain accessible to readers who may not necessarily be experts in the topics discussed.

In very recent years, the journal has continued to evolve with the aim of achieving greater international openness. This is precisely why *Économie et Statistique* has become "*Economie et Statistique/Economics and Statistics*", published simultaneously in French and English, and both available on the Insee website. However, the journal has remained faithful to the same key principles, including openness to different topics and disciplines and a dual commitment to official statistics and research, which give it a distinctive place both at Insee and within the field of French journals.

While I very much hope that this anniversary will be followed by many more, I would also like to thank the editors-in-chief we have had since 1969, the academics who have agreed to sit on the Scientific Committee over the past fifteen years, and all the reviewers working anonymously behind the scenes.

Jean-Luc Tavernier
Director General of Insee, Publishing Director

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Michel-Louis Lévy (1969-1972); Alain Desrosières (1973-1974); Bruno Durieux (1975); Catherine Blum-Girardeau (1975-1980); Claude Thélot (1981-1982); Daniel Temam (1983-1985); Alain Charraud (1986-1989); Philippe Domergue (1989-1993); Pierre Morin (1993-2011); Didier Blanchet (2011-2015); Laurence Bloch (2016-2018).

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Fifty Years of Abstracts in the Journal Economie et Statistique

Julie Djiriguian* and François Sémécurbe*

Natural language processing, is nowadays a toolbox routinely used to explore the content of various texts. On the occasion of the 50th anniversary of the journal *Économie et Statistique* (then *Economie et Statistique / Economics and Statistics*), we propose in this short article an application to the abstracts of the 2,184 "academic" articles published in this journal since 1969 (see Box). Which words are most frequently used? What underlying topics do they suggest and have these topics changed over the years?

After preliminary treatments (Box), we obtain a set of 181,572 words for the 50 years. A representation in the form of a word cloud highlights the most frequent words (Figure I).

Figure I
Word cloud on the corpus of abstracts from 1969 to 2019

Note: Our apologies to those who do not read French, but the journal has published in French for most of its life, and it would not have made sense to translate the stock of words. Some translations will be provided below and in the rest of the article.
Reading Note: 'emploi' (employment) is the most frequent word in the entire corpus of Economic and Statistical abstracts (with 2,176 occurrences out of 181,572 words). The next most frequent words are 'entreprise' (companies), 'travail' (work), 'ménage' (household).
Sources: Abstracts of academic articles, *Économie et Statistique* (1969-2016) and *Economie et Statistique / Economics and Statistics* (2017-2019).

JEL Classification: C38, C63
Keywords: text analysis, natural language processing, topic modeling, Latent Dirichlet Allocation

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As a whole, this representation of the vocabulary of the abstracts illustrates first of all the generalist nature of the journal. The word with the highest relative frequency is 'employment' (emploi), then, by decreasing relative frequency, the words 'company' (entreprise) and 'household' (ménage).

The most frequent words over fifty years are, of course, also most frequent by decade, and the trilogy 'employment', 'company', 'household' is confirmed, even if in a variable order until the decade 2000 and with some eclipses: 'household' in the decade 2000, 'company' in the last decade (Figure II). Variability is much greater for words with a lower relative frequency.

Figure II
Word clouds by decade

Sources: Abstracts of academic articles, *Économie et Statistique* (1969-2016) and *Economie et Statistique / Economics and Statistics* (2017-2019).

The most constant is the word 'employment'. However, it would be adventurous to interpret this dominance as a sign of a "specialization" of the articles published in the journal. Rather, it can be seen as a "hub", around which many angles of economic analysis can be articulated, analysis of the activity at the macro level or, at the micro level, of the behaviour and situation of its actors, companies and households. If we pull a little on the thread, we can also see it as reflecting an almost permanent concern for employment since the late 1970s, which would make it either the subject of interest or the entry point for

many articles; and if we draw a little further, we can recall that the *enquête Emploi* (the French LFS) is one of the oldest of Insee's surveys covering the working age population, and used in a large number of articles published in the journal.

Quantifying the most frequent words – even more since they are only "words" and not "keywords", and they are considered independently of each other – is obviously not enough to describe the contents of a set of texts. Topic modelling methods allow associations to be identified by simultaneously analysing all the words that are part of a text. To explore a little further, we use here Dirichlet's latent allocation (LDA, see Box), which is based on probabilistic modelling. This method is frequently used to interpret underlying topics based on the group of words that characterize them. It should be noted, however, that, like any textual analysis, this method is based on strong hypotheses and choices (in particular at the pre-processing step) that condition the result, and that the identification – or interpretation – of topics based solely on the words associated with them can be tricky.

This method requiring to fix a priori the number of topics, we have fixed it at three. After the various estimations made for all the abstracts, we obtain the following associations of words that we will, for convenience, call by their first most frequent word - which refers (necessarily, since at the base is the same "stock" of words) to one or the other of the three words that appeared most frequently in Figure I:

- a topic called "companies", which evokes the vocabulary of economic activity in the most standard, rather macroeconomic sense – including the words:

ecompany / growth / sector / france / industrial / market / country / production / industry / activity / employment / economic / price / investment / economy / labour / development / rate / productivity / product / price / demand / decline / structure / trade / trade / politics / foreign / small / foreign / term / account / capital / region / region / service / productive / explain / domestic / cost / equipment / high…

- a topic called "households" which is more about combining words from the vocabulary of income and living conditions:

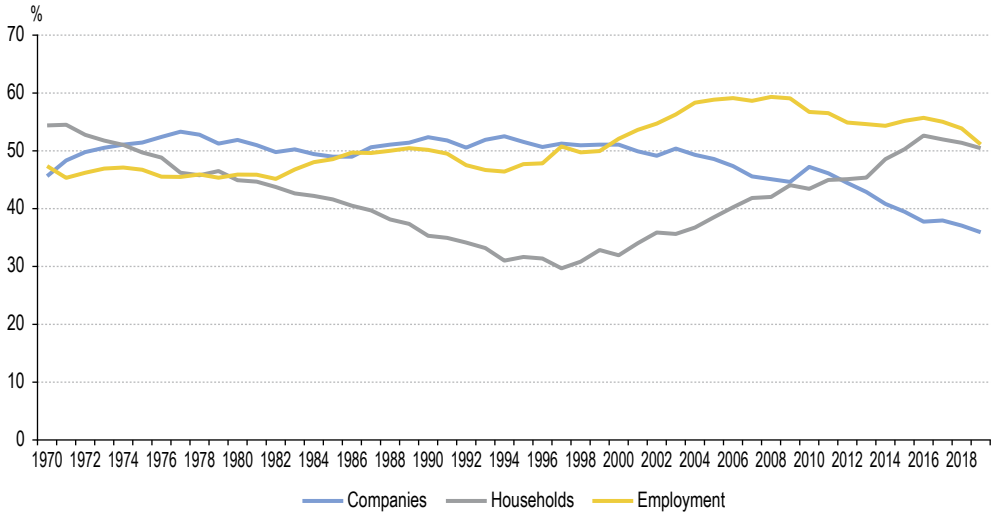
household / survey / income / account / economic / statistical / social / model / france / term / method / financial / housing / question / estimation / policy / work / information / consumption / rate / main / system / life / price / insee / help / national / public / approach / driving / cost / take / behaviour / base / individual / study / expenditure / population / evaluation / economy…

- a topic called "employment", where we find the categories of microeconomic analyses of the labour market:

employment / work / youth / woman / age / active / employee / unemployment / professional / activity / category / social / man / time / worker / life / child / wage / duration / manager / population / survey / family / higher / market / occupy / training / familial / old / sector / profession / increase / courses / gap / generation / work / diploma / unemployed / contrast / decrease…

To finish, we can represent the topics over the years in terms of their "weight", i.e. the proportion of abstracts containing at least three of the main words of each topic (Figure III). The presence in the abstracts of words associated with the topic "employment" tends to rise from the 1980s, then more markedly from the mid-1990s to the end of the 2000s. On the contrary, the number of words in the topic "companies" decreased from the 2000s onwards. Finally, the presence of the words of the topic "households" presents a more singular aspect, with a decline until the second half of the 1990s, then an increase of equivalent magnitude thereafter.

Figure III
Proportion of abstracts containing at least one of the three main words of each topic



Note: Adding the weights results in a total over 100%%, since a given word can appear in more than one topic.
Sources: Abstracts of academic articles, *Économie et Statistique* (1969-2016) and *Economie et Statistique / Economics and Statistics* (2017-2019).

* *
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We are here at the limits of the exercise proposed in this short article, which had no other purpose than illustrative. To draw an interpretation would require a much larger investigation... which will have to wait, because if 2,184 articles and 181,572 words seem "a lot", it is a small corpus for the implementation of the techniques used here. □

Box – **Methodology**

Textual analysis gathers all the methods used to extract and analyse the information contained in texts. It can be used on data from a wide variety of sources (administrative texts, legal decisions, discussions on social networks, etc.) to reveal underlying topics, analyse feelings, or predict a variable (see Anzovino *et al.*, 2018; Wu *et al.*, 2018; Xing *et al.*, 2018). Text data is by nature unstructured, so any textual analysis process begins with a step of preparing the text to clean it up and transform it into usable digital data. These digital data are then used for the statistical analysis itself.

The statistical observations of a textual analysis are texts, called 'documents' (here the abstracts). Each document is divided into elements (tokens), words, punctuation, association of several words (n-grams) if necessary. Pre-processing consists first of all in removing non-informative elements - punctuation, numbers, and 'stopwords'. Stopwords are insignificant words that appear in the entire corpus studied; some are "obvious" (for example, conjunctions) but others require arbitration, necessarily subjective. All the terms remaining after this step will constitute the 'variables' of the analysis. These pre-treatment steps are often tedious and can involve arbitrary or ad hoc choices. The subsequent textual analysis is therefore very sensitive to these choices.

The informative words are then standardized to make them comparable: case harmonization, spelling correction, 'lemmatization'. Lemmatization consists in finding the neutral form of a word: for example, a conjugated verb is found, after this operation, at the infinitive. This operation is complex, because it requires in particular to clarify cases of homonymy. Documents and 'variables' can then be represented by a numerical matrix where each line measures for a given document the number of occurrences (or another measure: binary coding - presence/absence - is classic) of each word/variable of the whole vocabulary retained within each document. The resulting matrix is often large (there are more words/columns than documents/lines) and sparse (many 0). It can be analyzed using various statistical methods. →

Box (contd.)

The interpretation of a text results from the association of words (Hapke *et al.*, 2019). To examine these associations, we have implemented here an analysis related to topic modelling called Latent Dirichlet Allocation (LDA, cf. Blei *et al.*, 2003). It is a generative probabilistic model, which estimates by Bayesian inference methods (variational Bayesian, Gibbs sampling, etc.) from the words observed in the documents, the weight of the topics in each document and the distributions of the characteristic words of each theme. This method requires that the number of topics be determined *a priori*.

LDA is based on strong assumptions that need to be underlined. First, the estimation of the parameters of the word distributions for each topic and those of the topic within a document begins with a random initialization: two different initializations can generate two different thematic structures. Second, LDA, like a large part of textual analysis methods, is based on the assumption that the order of words has no impact (it is referred to as a 'bag-of-words' approach). Under this assumption, the documents are divided into unordered lists of words. As words are also decisive for the interpretation of themes, pre-treatment is also crucial here.

The analysis presented here covers the abstracts of all the academic articles published in the journal between 1969 and 2019. Prior to the pre-processing of the texts, we excluded 764 "non-academic" articles: until the 1970s, the journal published the presentation of survey results, territorial panoramas, or other short articles of information that then disappeared (or gave rise to publications in other Insee collections). General introductions to special issues were also not included. There remain 2,184 abstracts containing 432,000 words.

Pre-treatments have mainly consisted in removing the figures and stopwords contained in the abstracts and "lemmatizing" the words. To this end, we used the spaCy library with Python, which detects the grammatical function of words in a text, which is more effective than using a simple dictionary. In addition to the stopwords proposed by spaCy, we have excluded *ad hoc* words, on the basis of based on the results obtained in statistical analyses (for example, the word 'year', which produces insignificant links between summaries). At the end of these pre-processing operations, the database contains 2,184 abstracts and 181,572 words.

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Preface – Times have changed

Daniel Cohen*

So much water has flowed under the bridge since the first issue of *Économie et Statistique.* Fifty years ago, France was just emerging from the political and social big chaos of May 1968. The country was driven by a powerful growth spurt, known as the *Trente Glorieuses* (or the Thirty Glorious Years), according to the famous term coined by Jean Fourastié. As the article by **Didier Blanchet and Fabrice Lenseigne**, in this issue which covers some of the major issues that have impacted this changing period, points out, the income of the French has increased by a factor of 4.5 since 1960. Whoever earns, say, 2,000 euros per month today, would have earned 450 at the time! The figures are indeed partly abstract; nevertheless, they provide an illustration of the tremendous transformation that the French have undergone during this period. Blanchet and Lenseigne also point out why frustration is now common: we have consistently seen a slowdown in growth. Labour productivity, which summarises the progress of our technological system, has fallen from an annual growth rate of 4.5% from 1960 to 1975, to 2.1% from 1974 to 1992, then 1.1% from 1993 to 2008, and then almost non-existent to the present days with an annual rate of +0.6%. The translation in terms of disposable income is mechanical: it is growing increasingly slowly. Taking demographics into account by adjusting household income by size (using consumption units method, which gives a lower weighting to children), income has been stagnant for ten years, whereas it was doubling every fifteen years at the beginning of the period!

There are many causes for this slowdown: the end of the phase during which France was catching up (economically) with the United States and, more generally, the decline in technological progress, in the United States itself, which reflects the slowdown in the dynamics driven by industrial growth. Much earlier in 1948, Jean Fourastié (again) in his book entitled *Le grand espoir du XX^e siècle* (The Great Hope of the XX^th Century) foretold of the imminent arrival of a service society. The "great hope" was that it would give a prominent place to jobs in which humans would take care of humans (as doctors, teachers, psychoanalysts, etc.), rather than spend their time working the land or with materials. However, his optimism was counterbalanced by another issue, one which was not too troubling in his eyes, namely that this transition would also result in a slowdown or even an end to economic growth. If the production of a provider is measured by the time spent with clients, such as a caregiver with an elderly person or an actor in a theatre, then it is inevitable that growth slows down. This syndrome is also known to economists as Baumol's "cost disease". The whole issue of new technologies, as analysed by **Philippe Aghion, Céline Antonin and Simon Bunel** in this issue, can be seen as a difficult way to ward off this "cost disease".

The paradox that can sometimes be difficult to perceive is that the growth rate during the *Trente Glorieuses*, which seems miraculous today, was subject to formidable challenge in its time. May '68 marked the outbreak of a rejection of this model by the youth, both students and workers, who no longer accepted the hierarchical and patriarchal order of

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the industrial society of the time. In some respects, the ensuing transformation tried to respond to the aspirations born in the sixties.

As analysed in three articles, a huge transformation of the labour market will be undertaken during the last fifty years. The feminisation of the labour market is its first distinctive feature. One after another, the professions considered male (lawyers, doctors, etc.) have become predominantly female. As **Dominique Meurs and Pierre Pora** point out, women have fully caught up with men in terms of human capital (education and experience), or even surpassed them in this area. However, the gender pay gap remains very high: women earn 20% less than men, on average, in particular because of the delays in promotion that maternity still causes. This is the major unfinished task of the feminisation of labour: to ensure that fatherhood is as (little?) demanding as motherhood with regard to both parents' careers.

The increase in education and jobs qualifications is the other major change over the period covered. People have been entering the labour market increasingly later, as the enrolment rate of new cohorts has risen. One of the great hopes of what was called, for a time, the post-industrial society, was to become a society of information and knowledge. However, as shown by **Dominique Goux and Éric Maurin**, this is also the cause of a new frustration. Many young people with higher education qualifications have had to resort to taking jobs that are less skilled than expected, *de facto* competing with less educated young people who thus suffered unexpected competition, pushing their wages down, creating a double penalty of de-skilling for graduates and increased competition for those with lower educational attainment. The increased competitive pressure on the labour market has also led to increased job insecurity. As **Olivier Marchand and Claude Minni** point out, job insecurity has emerged in a great number of situations, for young people entering the labour market who have to work a very large number of short fixed-term contracts before finding stable employment, for all those who are now included in the "unemployment halo", neither entirely in employment nor entirely without it...

A large number of OECD countries have seen a decline in the labour share. The analysis of **Mathilde Pak, Pierre-Alain Pionnier and Cyrille Scwhellnus** shows that this decline is partly linked to the emergence of "superstar" firms, at the technological frontier, with low labour intensity. The globalisation of the value chain, by putting competitive pressure on labour, is also one of the factors contributing to it. However, not all countries have experienced this decline, either because of the absence of superstar firms or because the labour market has proved more protective. As **Gilbert Cette, Lorraine Koehl and Thomas Philippon** demonstrate, this is the case in France, where the measurement of an overall decline in the labor share depends very much on the point of comparison selected, and on a number of hypotheses on the statistical treatment of income, particularly from property.

In the field of income and wealth distribution, **Bertrand Garbinti and Jonathan Goupille-Lebret** also provide a comparison with the American situation. In the United States, the proportion of national income going to the bottom half of the population has halved, falling from over 20% in 1983 to 10% today! The developments shown by the French data are less striking, yet remain marked. High incomes have grown twice as fast as for the rest of the population since 1983: the income of the richest 1% has increased by 2.2% per year, compared with less than 1% for the remaining 99% of the population. Ultimately, the share of total income held by the top 1% has risen from 7% in 1983 to 11% in 2014, an increase of 50%.

Understanding inequalities often means leaving the reassuring realm of macroeconomics, used to reasoning from a representative agent, to understand the micro-reality of the social world. The article by **François Legendre** paints an invigorating picture of the progress that has been made in this area by microsimulation models. **Denis Fougère and Nicolas Jacquemet** also provide an exciting survey of the methods of impact evaluation

of economic and social policies, while being mindful of the biases that arise from the selection effects or self-selection of the targeted populations.

Looking back at the past years, it would have been very difficult to predict, in 1960, that the difficulty of making ends meet and getting to the end of the month would remain so significant for entire groups of the population, despite a 4.5-fold increase in household disposable income. A sense of fear of the future, which seems very high today, largely explains the unease of the working classes all over the world. Yet growth, the slowdown of which appears to be the cause of all the problems, raises many questions itself. Measuring the impact of growth on climate change, a topic which could not have been raised in the first issue of *Économie et Statistique*, has become a key point. Indeed, the 1973 oil crisis had certainly demonstrated limits due to the depletion of scarce resources, analysed in the famous Meadows report "Limits to Growth". Very early on, however, in a prophetic article published in 1972, Nordhaus and Tobin countered that limits on growth were not due to the stated scarcity of oil, but rather to the scarcity of common goods, available free of charge and therefore subject to excessive exploitation. Their analysis already pointed to the need to focus on conserving free natural resources ("fresh air"), rather than conserving "chargeable" natural resources: "*At present, there is no reason to arrest economic growth to conserve natural resources, although there is good reason to provide proper economic incentives to conserve resources which currently cost their users less than true social cost.*" (Norhaus & Tobin, 1972, p. 24). This is a prophetic analysis, which underlines how the stated scarcity of oil was not the problem but, on the contrary and in the exact opposite manner, that the problem was that the rise in prices triggered new discoveries that threatened the planet's climate balance. The article by **Alain Quinet** shows the full extent of the efforts that still need to be made to meet the challenge posed by our growth model. We will know in 50 years, for the centenary of *Economie et Statistique / Economics and Statistics*, if this challenge has been met by the new generations. □

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Labour Share Developments in OECD Countries Over the Past Two Decades

Mathilde Pak*, Pierre-Alain Pionnier and Cyrille Schwellnus***

Abstract – Over the past two decades, real wage growth in many OECD countries has decoupled from labour productivity growth, as labour income shares have declined. This paper analyses the drivers of labour share developments using a combination of industry- and firm-level data. Technological change in the investment goods-producing sector and greater global value chain participation have compressed labour shares, but the effect of technological change has been significantly less pronounced for high-skilled workers. Countries with falling labour shares have witnessed both a decline at the technological frontier and a reallocation of market shares toward "superstar" firms with low labour shares. The decline at the technological frontier mainly reflects the entry of firms with low labour shares into the frontier rather than a decline of labour shares in incumbent frontier firms, suggesting that thus far this process is mainly explained by technological dynamism rather than anti-competitive forces.

JEL Classification: D33, F66, J24, J38, J58, L11, O33
Keywords: labour share, superstar firms, global value chains, skills, public policies

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Real wage gains are normally the most direct mechanism through which productivity gains are transmitted to workers. However, over the past two decades, real wage growth in many OECD countries has decoupled from labour productivity growth as the share of labour income in total income has declined. Since wages are typically the main source of market income (total pre-tax income excluding income from government sources) for low- and middle-income households, this decoupling also tends to raise broader measures of income inequality.

This paper analyses labour share developments in OECD countries using a combination of aggregated and disaggregated data. Aggregated data are used to provide descriptive evidence on recent labour share developments, with disaggregated data at the industry- and firm levels providing evidence on the role of technology, global value chain expansion and public policies. The analysis based on disaggregated data further provides insights into the mechanisms underlying aggregate labour share developments, including the roles of substitution of capital for labour (henceforth capital-labour substitution) and firm dynamics.

The contribution of this paper to the existing body of research is threefold. First, the empirical analysis is based on industry-level data, which allows a more credible identification of the policy drivers of labour share developments than existing studies based on country-level data (IMF, 2017; Stockhammer, 2017). Second, the paper analyses the role of skills and routine-task intensity in shaping the response of labour shares to technological change and global value chain expansion and analyses a broad range of potential policy determinants in a unified empirical framework. Third, the paper sheds light on a number of micro mechanisms underlying aggregate labour share developments. In particular, it analyses the extent to which aggregate labour share developments are related to high-productivity firms pulling away from other firms and capturing a larger share of the market ("winner-takes-most" dynamics).

The main findings are as follows:

- For the OECD as a whole, the labour share has declined over the past two decades, but there have been large differences across countries. About half of the covered countries experienced significant declines whereas the others experienced constant or increasing labour shares;

- Technological change and globalisation can explain most of the average contraction of the labour share. Technology-driven declines in relative investment prices and, to a lesser extent, the expansion of global value chains (in which different stages of production are spread across countries or regions) account for about two-thirds of the aggregate labour share decline in the OECD;

- The substitution of capital for labour in response to declines in relative investment prices is particularly pronounced in industries with a predominance of high routine tasks. High shares of high-skilled workers reduce the substitution of capital for labour even in highly routine task-intensive industries;

- Pro-competition product market reforms raise the labour share by reducing producer rents that tend to accrue to capital owners. A number of labour market policies and institutions that strengthen workers' bargaining power, such as higher minimum wages, can reduce the labour share by raising labour costs and triggering the substitution of capital for labour. Higher spending on active labour market policies raises the labour share by preserving labour market attachment and skills of workers who lose their jobs;

- Countries with falling labour shares have witnessed both a decline at the technological frontier and a rise in market shares of capital-intensive "superstar" firms with low labour shares ("winner-takes-most" dynamics). The labour share decline at the technological frontier mainly reflects the entry of capital-intensive firms with low labour shares into the frontier rather than a decline in incumbent frontier firms, suggesting that thus far "winner-takes-most" dynamics are mainly explained by technological dynamism.

The remainder of the paper is structured as follows. The second section describes recent labour share developments across OECD countries, with a particular focus on the use of firm-level data to analyse and discuss the role of "winner-takes-most" dynamics. The third section describes the empirical setup and the empirical results. The fourth section concludes with a number of policy implications.

Recent Labour Share Developments across OECD Countries

Aggregate Labour Share Developments

The labour shares in this section cover the period 1995-2017 and are defined as labour

compensation of salaried and self-employed workers as a share of value added at factor costs in the total economy excluding the primary, housing and non-market industries. They are constructed from industry-level data in the OECD Annual National Accounts Database, complemented with additional data from the archives of the OECD STAN database, OECD Annual Labour Force Statistics and the EU-KLEMS database. Labour compensation is the sum of compensation of salaried workers and the imputed compensation of self-employed workers, with the imputation based on the average compensation of salaried workers in the corresponding industry.[1] Value added at factor costs is defined as value added at basic prices minus taxes net of subsidies on production. Using value added at factor costs in the denominator ensures that labour and capital shares of value added sum to one.[2]

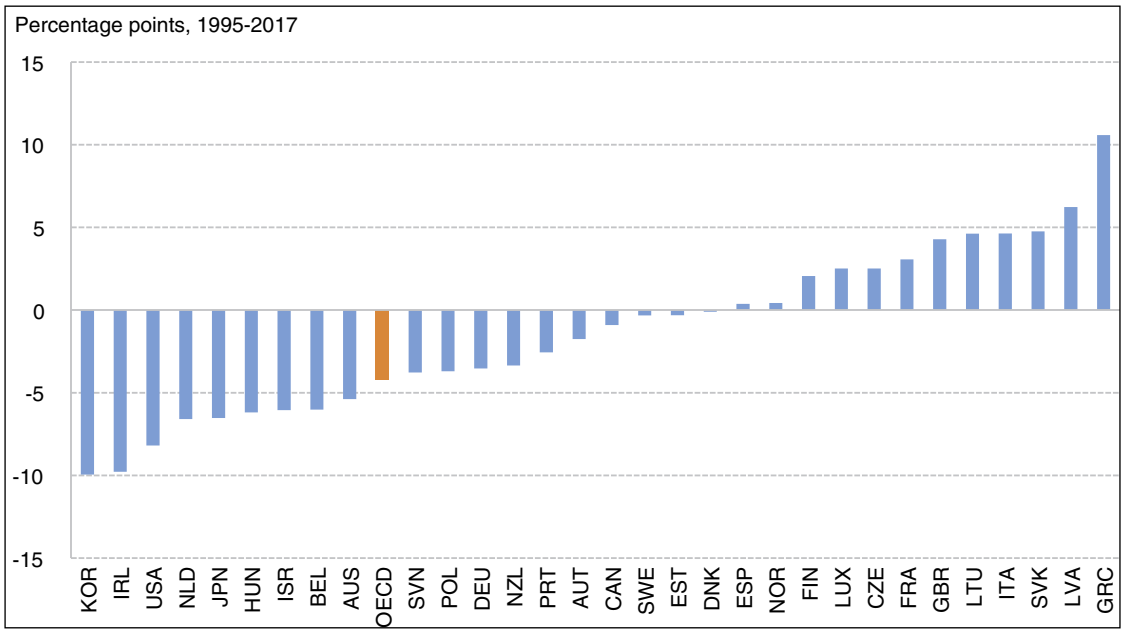
The aggregate OECD labour share has declined significantly over the past two decades, but there have been large differences in labour developments across countries (Figure I). While labour shares declined significantly between 1995 and 2017 for about half of the covered countries (including Germany, Japan and the United States), they remained about constant or increased for the other half (including France, Italy and the United Kingdom).[3]

Declines in labour shares excluding primary, housing and non-market sectors are typically less pronounced than in the total economy (see Table 1). Total-economy labour shares may partly be driven by developments in specific industries for which there are significant conceptual and measurement issues. For instance, total-economy labour shares are partly explained by developments in housing rents, which may in turn be driven by factors other than those driving capital income in the business sector and may have different distributional consequences.

A further issue with total-economy labour shares is that they are partly driven by commodity price developments and by imputation choices in the non-market sector. For countries with large

1. Depending on data availability, the imputation is based on hourly labour compensation or on per-capita labour compensation of salaried workers.
2. For Canada and Israel, value added is at basic prices, since data on taxes net of subsidies on production are unavailable. Ireland's labour share is computed over the period 1995-2014 since value added in 2015-2016 is distorted by the relocation of intellectual property assets by multi-national enterprises in 2015 (OECD, 2018).
3. The larger cross-country heterogeneity in terms of changes in labour shares with respect to Karabarbounis & Neiman (2014) likely reflects differences in sampling periods (mid-1990s to 2016 in this paper versus mid-1970s to 2012 in Karabarbounis & Neiman, 2014) and treatment of self-employed workers (imputation of self-employed workers' wages using industry-level wages in this paper versus absence of imputation in Karabarbounis & Neiman, 2014).

Figure I
Changes in the labour share without the primary, housing and non-market industries



Notes: The OECD average is the GDP-weighted average of changes in labour shares over the 31 countries covered by the analysis. Start year is two-year average or 1994-1995 for Australia, Denmark, Finland, France, Japan, Korea, New Zealand, Norway, Sweden and United States; 1995-1996 for Austria, Belgium, Czech Republic, Estonia, Germany, Greece, Hungary, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Portugal, Slovak Republic, Slovenia, Spain and United Kingdom; 1997-1998 for Canada; 2000-2001 for Poland. End year is average of 2016-2017 for all countries except for France, Norway, Slovak Republic, Slovenia, Sweden, United Kingdom and United States (2015-2016); Canada, Israel, Japan, Korea and New Zealand (2014-2015); Ireland (2013-2014).
Sources: OECD National Accounts Database, OECD STAN Database, OECD Annual Labour Force Statistics Database and EU KLEMS Database.

agricultural or mining (i.e. primary) sectors, developments in total-economy labour shares are largely driven by developments in commodity prices; when commodity prices increase, aggregate profits rise without commensurate increases in aggregate wages.[4] In Australia, for instance, where the mining sector is large, the non-housing labour share declined by around 7 percentage points over the period 1995-2016, but it declined by only around 3 percentage points when the agriculture, mining and non-market sectors are excluded (Table 1). Moreover, national accounting conventions in the non-market sector may bias developments in labour shares. Value added in the non-market sector is equal to the sum of wage compensation and capital consumption,

4. The decline in the aggregate labour share partly reflects a change in industry composition: as commodity prices increase, the share of the mining sector – for which the labour share is low – in total value added increases.

Table 1
Contributions to changes in total economy labour shares
Percentage points, 1995-2017

	Changes in labour share	Contributions of			
	Total economy	Non-primary business sector	Housing sector	Primary industries	Non-market sector
Australia	-7.1	-3.6	-0.6	-3.5	0.6
Austria	-4.2	-1.2	-1.4	-1.8	0.2
Belgium	-2.2	-4.1	0.9	0.2	0.8
Canada	-2.4	-0.8	0.5	-1.8	-0.3
Czech Republic	1.8	1.8	-0.8	-0.3	1.1
Denmark	0.7	0.0	0.0	0.0	0.7
Estonia	-0.4	-0.1	-1.3	-1.2	2.2
Finland	-2.3	1.3	-2.1	-1.0	-0.5
France	0.2	1.9	-1.1	-1.0	0.5
Germany	-2.6	-2.5	0.2	-0.6	0.2
Greece	6.6	6.0	-1.9	0.5	2.0
Hungary	-5.9	-4.1	-1.0	-1.9	1.1
Ireland	-9.1	-7.2	-0.7	-0.7	-0.5
Israel	-7.2	-3.8	-1.8	-0.2	-1.4
Italy	0.4	3.0	-2.1	-0.3	-0.2
Japan	-5.8	-4.9	-1.1	-0.5	0.7
Korea	-11.5	-7.3	0.0	-3.9	-0.3
Latvia	2.6	4.2	-2.6	-2.4	3.4
Lithuania	3.3	3.0	0.9	-1.0	0.5
Luxembourg	3.6	1.9	1.2	-0.2	0.8
Netherlands	-2.2	-4.5	0.7	0.9	0.6
New Zealand	-1.1	-2.2	-0.3	-0.5	1.9
Norway	-0.9	-0.1	0.5	-1.9	0.6
Poland	-9.6	-2.9	0.7	-7.0	-0.5
Portugal	-5.3	-1.7	-2.3	-0.4	-0.9
Slovak Republic	2.9	3.5	0.4	-1.2	0.2
Slovenia	-11.1	-2.8	0.5	-8.6	-0.1
Spain	-2.9	0.1	-2.7	-0.3	-0.1
Sweden	2.7	-0.2	2.5	-0.2	0.7
United Kingdom	5.9	2.9	0.6	1.1	1.3
United States	-4.7	-5.3	-0.5	-0.1	1.3
OECD (GDP weighted average)	-3.3	-3.0	-0.6	-0.5	0.7
OECD (unweighted average)	-2.2	-1.0	-0.5	-1.3	0.5
G7 (unweighted average)	-1.3	-0.8	-0.5	-0.5	0.5

Notes: See Figure I for sample period and Online complement C2 for analytical details on the statistical decomposition.
Sources: See Figure I.

which artificially implies limited variation over time.[5]

Most of the decline in the business labour share excluding the housing and primary sectors took place before the global crisis of 2008-09 (Figure II). However, labour share developments have been very heterogeneous across countries, with no pre-crisis decline for the country at the third quartile of the distribution of cumulated labour share changes and a large decline for the country at the bottom quartile. Given that this narrowly defined labour share is not affected by house and commodity price developments, the timing of the decline and rebound suggests that the structural factors that drove down the labour share before 2005 weakened thereafter.

The timing of the decline and the rebound of the labour share is consistent with evidence suggesting that the pace of expansion of global value chains associated with China's integration into the world trading system slowed in the wake of the global crisis of 2008-2009 (Ferrantino & Taglioni, 2014). Alternative explanations could be the slowing pace of IT-related technological change or the reduced scope for regulatory reforms, especially in network industries, which appear to be two major drivers of labour share declines (Karabarbounis & Naimen, 2014; Azamat *et al*., 2012). The post-2005 rebound in the labour share may partly also reflect business cycle conditions, with limited downward adjustment of wages and employment during and in the wake of the global economic crisis.

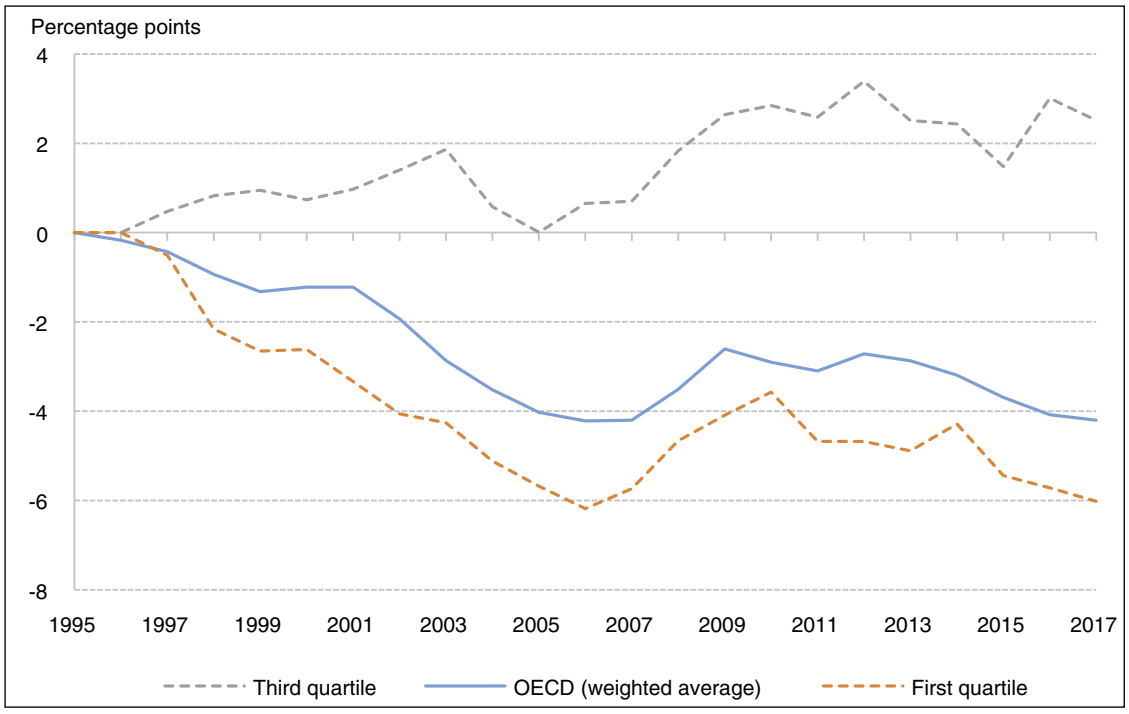
Descriptive Evidence on the Micro Mechanisms Underlying Aggregate Labour Share Developments

Firm-level data based on the ORBIS dataset allow analysing whether labour share developments over the period 2001-2015 are consistent with "winner-takes-most" dynamics.[6] In order to

5. The finance sector is included in the analysis. Excluding the finance sector would only have a marginal effect on labour share developments for most countries, the exception being Australia and Luxembourg for which the exclusion of the finance sector would make the change in the labour share 2-3 percentage points more positive over the period and Hungary for which it would make it 2 percentage points more negative.

6. The ORBIS firm-level dataset is available for a broad range of OECD countries and contains information from firms' income statements and balance sheets, including information on revenues, value added, employment and compensation. Coverage of firms is uneven across countries, with data for some countries covering a large fraction of firms, such as for Finland, Italy, Portugal, Sweden and Spain, but only a small fraction in others, such as the United States (only listed firms) and the first half of the 2000s for Germany. The main characteristics of leading and other firms are described in Online complements Table C1-II. Link to the Online complements at the end of the article.

Figure II
Cumulated change in OECD labour share



Notes: See Figure I. Excluding primary, housing and non-market industries.
Sources: See Figure I.

limit the influence of erratic or implausible firm behaviour, the dataset is cleaned by removing extreme outliers using the procedure described in Andrews *et al*. (2016). For the purpose of the labour share analysis in this paper, the dataset is additionally cleaned by removing observations with extreme values for labour shares. The resulting database covers firms in the non-primary and non-financial business sector of 15 OECD countries and closely tracks developments in labour share dynamics in the national accounts.[7]

In countries that experienced declines in labour shares over the period 2001-2015, wages in technologically leading firms decoupled from productivity but closely tracked productivity in the remaining firms (Figure III). This implies that in these countries labour shares within the group of leading firms declined while they remained constant in the remaining firms, which is consistent with "winner-takes-most" dynamics.[8] The best firms in these countries diverged from the remaining firms in terms of both productivity and wages, but wage divergence was much less pronounced than productivity divergence.[9] Given that technologically leading firms account for approximately 25% of aggregate value added of the firms in these countries, developments in leading firms contributed significantly to the decline in the labour share.

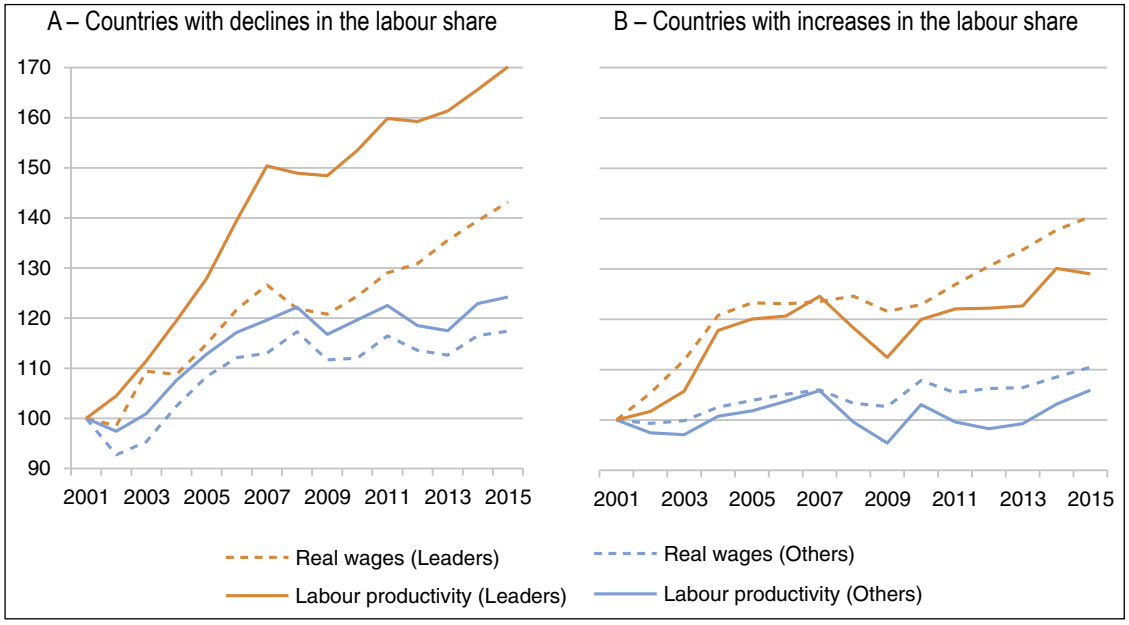
In countries that did not experience declines in labour shares, real wage growth outpaced labour productivity growth in both leading firms and the remaining firms. Productivity and wages in leading firms diverged from those of the remaining firms, but labour shares were broadly constant before the crisis of 2008-09 and increased in both groups thereafter. This suggests that in countries with increases in labour shares over the period 2001-2015 "winner-takes-most" dynamics were less pronounced. One possible explanation could be that there was less technological dynamism in countries with increases in labour shares, which is consistent with the fact that productivity growth of the leading firms in these countries was similar to that of the non-leading firms in countries that experienced labour share declines.

7. The covered countries are Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Korea, Netherlands, Spain, Sweden, United Kingdom and United States.

8. Leaders are defined as the top 5% of firms in terms of labour productivity within each country group in each industry and year, implying that the composition of firms at the technological frontier is allowed to vary over time.

9. The decoupling of wages from productivity in leading firms does not appear to reflect an increase in stock option compensation. Stock option compensation is typically found to be particularly prevalent in finance and ICT services (Elsby et al.*, 2013). The role of increasing stock option compensation can be assessed by removing the finance and ICT industries from the analysis in Figure III. Since the figure remains qualitatively and quantitatively unchanged, increasing non-cash compensation is unlikely to be the main driver of decoupling of wages from productivity in leading firms in countries with declining labour shares (Schwellnus* et al.*, 2018).*

Figure III
Average wages and productivity in the best firms and the rest, 2001=100



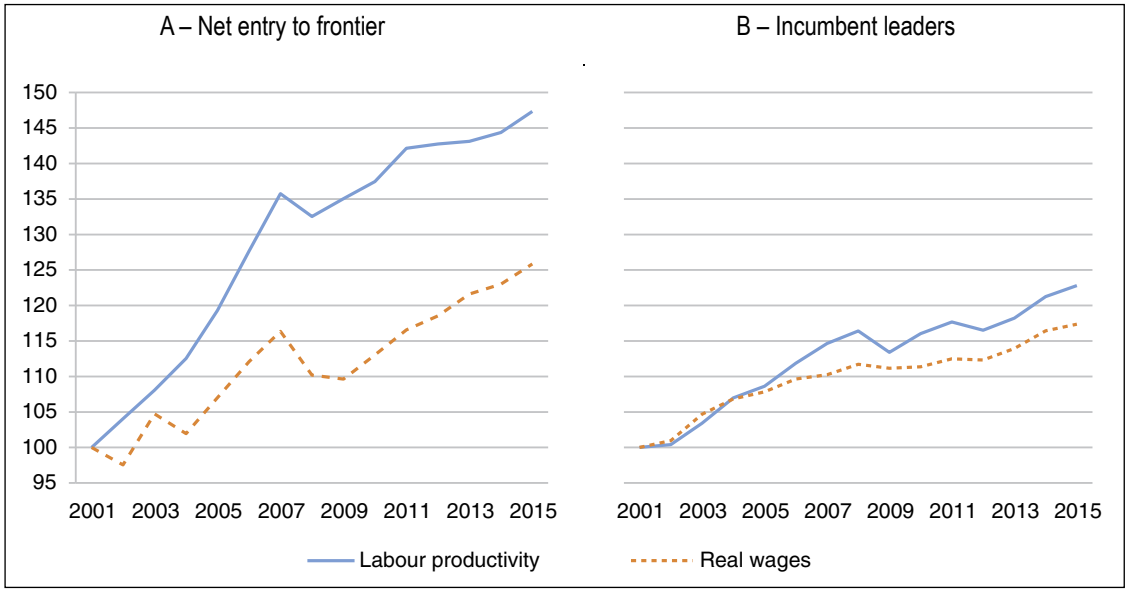
Notes: Labour productivity and real wages are computed as the unweighted mean across firms of real value added per worker and real labour compensation per worker. Leaders are defined as the top 5% of firms in terms of labour productivity within each country group in each industry and year. The countries with a decline in the labour share excluding the primary, housing, financial and non-market industries over the period 2001-2015 are: Belgium, Denmark, Germany, Ireland, Korea, Netherlands, Sweden, United Kingdom and United States (see Online complements, Table C1-I). The countries with an increase are: Austria, Estonia, Finland, France, Italy and Spain.
Sources: OECD calculations based on OECD-ORBIS.

The decoupling of wages from productivity in technologically leading firms is overwhelmingly explained by the entry of low-labour share firms and the exit of high-labour share firms from the technological frontier (Figure IV). The decoupling of wages from productivity in leading firms can be decomposed into contributions from firms staying at the technological frontier ("incumbents") and firms entering and exiting it ("net entry"). While productivity and wages remained closely linked in incumbent technological leaders, net entry into the frontier drove a large wedge between wage and productivity growth. This implies that labour shares were significantly lower for firms entering the technological frontier than for those exiting it. This result suggests that the decline of labour shares at the technological frontier was not driven by increasing markups or capital intensity in firms remaining at the technological frontier but rather by the entry of new firms with higher markups or higher capital intensity into the technological frontier.[10]

Overall, even though superstar firm dynamics do not appear to be a global phenomenon, the firm-level analysis suggests that in a number of countries such dynamics have contributed to labour share declines. In the group of countries, experiencing declines in labour shares, not only has there been a decline in labour shares within the group of technologically leading firms but the evidence also suggests that there has been a reallocation of market shares toward these firms (Schwellnus *et al.*, 2018). The fact that firms entering the frontier are generally smaller (in terms of employment) and younger than those remaining at the frontier and exiting it suggests that the decline in frontier firms' labour share cannot be explained by large monopolistic firms limiting entry into the market.[11] Moreover, the decline in frontier firms' labour share reflects net entry of firms with low shares into this group rather than the decline of labour shares of incumbent frontier firms, which is another indication that the decline in the labour share may thus far mainly reflect technological change rather than barriers to entry.

10. Capital intensity in firms entering the technological frontier was about twice that of exiting firms (see Online complements Table C1-III).
11. The share of firms employing less than 100 workers and have been in existence no more than 5 years is 14% for entrants into the technological frontier, whereas it is 7-8% for firms staying at the frontier or exiting it (see Online complements Table C1-IV).

Figure IV
Net entry fully explains the decoupling of wages from productivity in leading firms



Notes: Contributions to labour productivity and real wage growth at the frontier, countries with declines in labour shares. Contributions to real wage growth and labour productivity growth are based on the decomposition $\Delta X = \left[s_2^{stay} X_2^{stay} - s_1^{stay} X_1^{stay} \right] + \left[s_2^{entry} X_2^{entry} - s_1^{exit} X_1^{exit} \right] = \left[s_1^{stay} \Delta X^{stay} \right] + \left[s_1^{exit} \left(X_2^{entry} - X_1^{exit} \right) \right] + \varepsilon$, where X denotes the logarithm of labour productivity or real wages; s denotes the share of each group of firms in the total number of leading firms; superscripts denote groups of firms; and subscripts denote the period (Baily *et al.*, 1992). The way in which the frontier is constructed implies $\varepsilon = 0$ (Online complement C1) so that the first term in squared brackets in the second equality can be interpreted as the contribution of incumbents to growth of labour productivity and wages at the frontier (Panel B) and the second term the contribution of net entry (Panel A). The countries with a decline in the labour share excluding the primary, housing, financial and non-market industries over the period 2001-2015 are: Belgium, Denmark, Germany, Ireland, Korea, Netherlands, Sweden, United Kingdom and United States (Online complement, Table C1-I).
Sources: OECD calculations based on OECD-ORBIS.

Empirical Analysis

Capital-augmenting technological change or technology-driven declines in equipment prices may reduce the labour share by raising capital intensity. If factor prices are determined competitively, the labour share declines with capital intensity so long as the elasticity of substitution between capital and labour is above unity. Most estimates of the elasticity of substitution are based on within-country time series variation of factor shares and factor prices. These estimates generally imply an elasticity of substitution below one (Chirinko, 2008). By contrast, Karabarbounis & Neiman (2014) use cross-country and cross-industry variation in labour shares and relative investment prices to obtain an elasticity of substitution in the range of 1.2-1.5. According to their estimations, large declines in equipment prices across a broad range of high-income and emerging economies explain around 50% of the global decline of the labour share.

Globalisation in the form of increased trade integration may have similar effects on the labour share as increases in capital intensity (Acemoglu & Autor, 2010). For instance, offshoring of the most labour-intensive stages of production or increased import competition may lead to worker displacement and an increase in capital intensity. If the aggregate elasticity of substitution between capital and labour is above unity, this would reduce the labour share. The cross-country evidence in Harrison (2005) and the cross-industry evidence for the United States in Elsby *et al*. (2013) are consistent with this hypothesis. In a cross-country, cross-industry study IMF (2017) find that increased participation in global value chains has reduced the labour share in low-income countries but that there is no effect in high-income countries.

Setup

The empirical analysis focuses on capital-augmenting technological change as measured by changes in relative investment prices and offshoring as measured by global value chain expansion. It is conducted at the industry-level over the period 1995-2011 on twenty OECD countries for which the dependent and all explanatory variables can be constructed.[12] Adopting an industry-level approach to the modelling of labour shares is both conceptually and econometrically appealing. From a conceptual standpoint, the fact that changes in aggregate labour shares overwhelmingly reflect developments within industries rather than cross-industry reallocation justifies modelling industry-level labour shares to explain aggregate developments.[13] From an econometric standpoint, the industry-level approach has the advantage that country- and industry-specific trends can be controlled for through an appropriate fixed effects structure.

The econometric models focus on medium-term changes in labour shares. For this purpose, the data is split into three periods of approximately five years (1995-2000, 2000-2005 and 2005-2011). The analysis of medium-term changes rather than long-term changes over the entire period permits a more precise estimation of the effects of structural and policy drivers of labour shares while allowing labour shares sufficient time to adjust given that the elasticity of substitution between labour and capital is likely to be higher in the medium term than in the short term. Depending on the specification, business-cycle effects are controlled for by including country-period fixed effects or changes in output gap as explanatory variables.

The first hypothesis tested by the empirical model is that a decline in the relative investment price reduces the labour share, with the reduction being larger in industries using a larger share of routine labour. Declines in relative prices of capital goods lead to the substitution of capital for routine labour, which reduces the overall labour share under the assumption of an elasticity of substitution between capital and routine labour above unity (Karabarbounis & Neiman, 2014). The model also tests whether the negative effect of a given relative investment price decline on the labour share is larger in industries with large shares of routine labour, which would be the case under the assumption that the elasticity of substitution with capital is higher for routine than for non-routine (IMF, 2017; Schwellnus *et al*., 2018).

The second hypothesis tested by the empirical model is that offshoring reduces the labour share. On the one hand, the decline in the cost of offshoring leads to the substitution of imported intermediate goods for domestic routine labour

12. The countries included in the econometric analysis are Australia, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Slovak Republic, Spain, Sweden, the United Kingdom and the United States.

13. At the level of industry disaggregation used in this paper, labour share developments within industries explain around 80% of aggregate labour share developments (Schwellnus et al.*, 2018), which is broadly in line with previous studies (Bassanini & Manfredi, 2012; Karabarbounis & Neiman, 2014; IMF, 2017). Given that reallocation across industries explains only a small fraction of aggregate labour share developments, weighting industries with shares in aggregate value added in the regression analysis allows making direct statements on aggregate effects.*

and thereby to a reduction in the domestic wage bill as a share of gross output. On the other hand, offshoring of previously domestically produced output leads to a reduction in domestic value added as a share of gross output. In addition to these within-firm effects, offshoring may also reallocate production across firms with different labour shares. The theoretical ambiguity of the effect of offshoring is consistent with conflicting results on the impact of offshoring on the labour share in the empirical literature. While a number of studies find a negative impact (Elsby *et al.*, 2013; IMF, 2017), other studies find that the negative impact on the wage bill is smaller in magnitude than the impact on value added so that the labour share increases in response to offshoring (Autor *et al.*, 2019).[14]

The estimated baseline empirical specification is as follows:

$$\Delta LS_{ijt} = \beta_1 \Delta P_{ijt}^{Inv} + \beta_2 \Delta T_{ijt} + \beta_3 \left(RTI_{ij}^{0} \times \Delta P_{ijt}^{Inv} \right) + \beta_4 \left(RTI_{ij}^{0} \times \Delta T_{ijt} \right) + \beta_4 X_{ijt} + \alpha_{it} + \alpha_{jt} + \varepsilon_{ijt} \quad (1)$$

where subscripts i, j and t denote, respectively, countries, industries and periods; ΔLS_{ijt} denotes the medium-term (5- or 6-year) change in the labour share; RTI_{ij}^{0} denotes initial routine task intensity; ΔP_{ijt}^{Inv} denotes the medium-term change in the relative investment price; ΔT_{ijt} denotes the medium-term change in participation in global value chains; X_{ijt} denotes control variables that vary at the country-industry-period level, including the initial routine task intensity RTI_{ij}^{0}; α_{it} and α_{jt} denote country-by-period and industry-by-period fixed effects. Given that the model is estimated in differences, the fixed effects pick up country-period and industry-period specific trends.[15] A drawback of the fixed effects structure in equation (1) is that it does not permit the explicit identification of business cycle effects since changes in the output gap are perfectly collinear with the country-period fixed effects. Some of the results reported below therefore replace the country-period fixed effects by country fixed effects while including medium-term differences in the output gap.

The baseline empirical specification can be augmented by a difference-in-differences setup in the spirit of Rajan & Zingales (1998) to analyse the role of public policies. This approach uses within-country labour share differences across industries to econometrically identify the effects of public policy reforms. More specifically, it assumes that the response of labour shares to a given policy reform is greater in industries that are more exposed to this policy reform. This introduces an exogenous source of cross-industry variation in the policy shock which helps identifying the policy effect on labour shares. The advantage of using cross-industry data to identify the effect of public policies is that it allows to control for unobserved country-specific trends, which could bias the results in a simple cross-country setup. The disadvantage is that it does not allow to explain cross-country heterogeneity in labour share developments, as cross-country differences in public policy and institutional developments are captured by the country-period fixed effects.

The empirical specification takes the following generic form:

$$\Delta LS_{ijt} = \beta_1 \left(Exp_j^k \times \Delta Pol_{it}^k \right) + \beta_2 \Delta P_{ijt}^{Inv} + \beta_3 \Delta T_{ijt} + \beta_4 X_{ijt} + \alpha_{it} + \alpha_{jt} + \varepsilon_{ijt} \quad (2)$$

where Exp_j^k denotes the industry exposure variable relevant for public policy k; ΔPol_{it}^k denotes the medium-term change in policy k; and the remaining notation is as in equation (1) above. The choice of exposure variables for each policy variable is reported in the Online complements, Table C2-I.

Data

The industry-level labour share data are based on the same data sources, imputation methods and industry coverage as in the second section. Industry-level relative investment price indices are constructed as the ratio of price deflators for gross fixed capital formation to value added price deflators by industry in the OECD Annual National Accounts database with additional data from the EU-KLEMS database and the archives of the OECD STAN database.[16]

In line with previous studies, industry-level participation in global value chains is constructed as the sum of backward and forward linkages in vertical specialisation of production. Backward linkages measure the offshoring of intermediate inputs used in exports and are defined as foreign value added embodied in exports. Forward linkages measure trading partners' offshoring of

14. Offshoring is measured by participation in global value chains, which is defined as the sum of the share of foreign value added in gross exports (backward participation) and the share of exports consisting of intermediate inputs used by trading partners for the production of their exports to third countries (forward participation).

15. Identification in this specification is obtained through the acceleration or deceleration of labour shares and the explanatory variables over and above country- and industry-specific trends.

16. The same reference year (2000) is used for all indices.

intermediate inputs and are defined as domestic value added used as intermediate inputs in trading partners' exports.[17] For the sample of high-income countries included in this paper, increases in backward and forward linkages are likely to have similar effects on labour shares: offshoring raises specialisation on the most capital-intensive stages of production while trading partners' offshoring raises demand for capital-intensive intermediate goods. The data are sourced from the OECD TiVA database, the OECD Annual Accounts database and EU-KLEMS database.

The industry-level routine intensity index is based on the occupation-level routine intensity index of Marcolin *et al*. (2016) and the industry-level skill indicators are constructed from the OECD Survey of Adult skills (PIAAC). The occupation-level routine intensity index provides a measure of the routine content of occupations, based on data from PIAAC. The routine intensity index measures the degree of independence and freedom in planning and organising the tasks to be performed on the job. The occupation-level index is translated into an industry-level index by constructing the weighted average of the occupation-based index by industry, with the occupational weights by industry obtained from the European Labour Force Survey (1995-2015).[18] PIAAC also allows constructing industry-level skill indicators in three areas: literacy, numeracy and problem-solving in technology-rich environments.[19]

Results

The Role of Technological Change, Globalisation and Skills

According to the baseline specification in Equation (1), declines in relative investment prices and increases in GVC participation reduce the labour share.[20] Both in a modified baseline specification that allows estimating the effect of the business cycle on labour shares (Table 2, Columns 1) and in the baseline specification (Column 2), the estimated semi-elasticity of the labour share to the relative investment price is 0.19, which suggests that on average across industries a decline in relative investment prices of 10 percent reduces the labour share by approximately 1.9 percentage point. The estimated semi-elasticity of the labour share to GVC participation is around -0.1, which suggests that an increase of backward and forward linkages of 10 percentage points of value added reduces the labour share by 1 percentage point.

The baseline results are consistent with macro-level evidence that the labour share is counter-cyclical. The coefficient on changes in the output gap – i.e. the difference in business cycle conditions in the initial year and the final year of each 5-year period – is negative and statistically significant at the 1% level, with the estimated semi-elasticity suggesting that a 1 percentage point increase in the output gap (observed GDP growth exceeding potential GDP growth by 1 percentage point) reduces the labour share by 0.5 percentage point. Replacing country-period fixed effects by changes in the output gap neither qualitatively nor quantitatively changes the results on relative investment prices, global value chain participation and the interactions with routine-task intensity (Schwellnus *et al*., 2018).

The baseline specification further suggests that a decline in relative investment prices reduces the labour share by more in industries with high initial routine intensity (Table 2, Column 3). To test for heterogeneous effects of changes in the relative investment price across high- and low-routine industries, the change in the relative investment price is interacted with an indicator variable that takes a value of 1 if initial routine intensity is higher than in the median industry. The estimated semi-elasticity is 0.11 for low-routine industries whereas it is around 0.22 for high-routine industries, with the difference being statistically significant.[21] By contrast, there is no such heterogeneity across low- and

17. Backward and forward linkages are normalised by industry-level value added to account for the overall trade openness of the industry. To avoid spurious correlations with the denominator of the labour share 5-year changes in global value chain participation are defined as follows: $\Delta GVCP_{ijt} = \Delta ln\left(\frac{FWP_{ijt} + BWP_{ijt}}{EXGR_{ijt}}\right) \times \frac{EXGR_{ijt_0}}{VA_{ijt_0}}$, *where* FWP_{ijt} *and* BWP_{ijt} *are forward and backward linkages in in country* i, *industry* j *and year* t*;* $EXGR_{ijt_0}$ *and* VA_{ijt_0} *are respectively gross exports and value added; and* t_0 *is the initial year of each five-period in the empirical analysis.*

18. For Australia, Japan, Korea and the United States, the simple average of the occupational weights across all European countries is used.

19. The share of high-skilled workers at the industry level is defined as the share of adults in each skill area achieving the two highest PIAAC competency levels for numeracy and literacy, and the highest competency level for problem solving. Data for problem solving exclude France, Italy and Spain since they did not participate in the assessment of problem solving in technology-rich environments. For these countries, the simple average across all countries is used.

20. All results reported below are robust to including industries' initial labour shares to control for unobserved industry characteristics (Schwellnus et al.*, 2018).*

21. The coefficient on the change in the relative investment price in Column 3 (0.11) denotes the semi-elasticity for low-routine industries. The sum of this coefficient and the estimated coefficient on the relative investment price interacted with the indicator of high routine intensity (0.22) denotes the semi-elasticity for high-routine industries.

Table 2
Baseline specification

	(1)	(2)	(3)	(4)
Dependent variable	Change in business labour share excluding primary, coke and housing industries			
Change in relative investment price	0.19*** (0.03)	0.18*** (0.03)	0.11*** (0.04)	0.18*** (0.03)
Change in GVC participation	-0.10** (0.04)	-0.11** (0.04)	-0.11** (0.04)	-0.09* (0.04)
High routine intensity×Change in relative investment price			0.11** (0.05)	
High routine intensity×Change in GVC participation				-0.04 (0.05)
Change in output gap	-0.47*** (0.11)			
High routine intensity	Yes	Yes	Yes	Yes
Industry×Period fixed effects	Yes	Yes	Yes	Yes
Country×Period fixed effects	No	Yes	Yes	Yes
Country fixed effects	Yes	No	No	No
Observations	959	968	968	968
Number of countries	20	20	20	20
Number of industries	19	19	19	19
Adjusted R^2	0.26	0.28	0.30	0.28

Notes: Selected OECD countries, 1995-2011. The dummy for high-routine intensity is set to 1 when the share of high routine employment in an industry is above the median across countries and industries. Changes denote 5-year differences. Weighted OLS, with the share of industry-level value added in total value as weights. Standard errors are clustered at the country level. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.
Sources: OECD National Accounts Database, OECD TiVA Database, Marcolin *et al.* (2016), European Labour Force Survey, OECD Economic Outlook Database N° 99.

high-routine intensive industries for the estimated semi-elasticity of the labour share to increased GVC participation (Table 2, Column 4).[22]

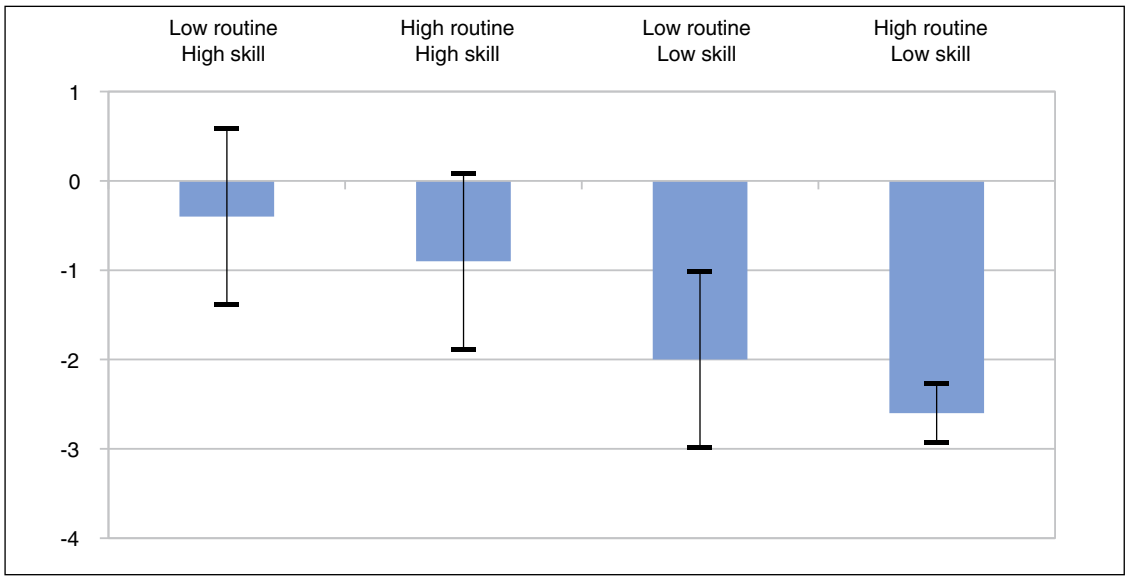
Even at a given level of routine task intensity, labour share declines in response to relative investment price declines are lower in countries and industries with a high share of high-skilled workers (Figure V). One explanation could be that high-skilled labour is more complementary to capital than low-skilled labour, implying lower capital-labour substitution in response to declines in relative investment prices (Krusell *et al.*, 2000).

Taking the estimated elasticities of the baseline model at face value, the observable variables included in the model can account for a significant part of the aggregate labour share decline in the covered OECD countries over the sample period (see Online complements, Figure C2-I). The observed average decline in the relative investment price across countries and industries over the sample period was around 19% and the average increase in GVC participation around 6 percentage points. Assuming that the elasticities estimated at the industry level are similar to those at the aggregate level, over the period 1995-2016 the baseline results suggest that investment price declines reduced the labour share by around 3.5 percentage points and increased GVC participation by around 0.6 percentage point.[23] Over the same period, business cycle effects reduced the labour share by around 0.2 percentage point as the average output gap increased by 0.4 percentage point. The contribution of changes in the relative investment price, global value chain participation and business cycle conditions to the observed change in the labour share was around 4 percentage points, about 90% of the observed decline in the labourshare.

Firm-level analysis can shed light on the micro-level mechanisms underlying the estimated industry-level effects. In particular, firm-level analysis can help understand the extent to which relative investment prices and global value chain participation affect industry-level labour shares primarily through changes in labour shares within firms or through changing firm composition. Since firms in the same industry face similar changes in relative investment prices,

22. This result is robust to restricting the sample to high-income countries.
23. Industry-level elasticities can plausibly be assumed to be similar to aggregate elasticities because within-industry labour share developments explain aggregate developments (Schwellnus et al.*, 2018) and the regression analysis weighs industries by shares in value added.*

Figure V
Change in the labour share in response to a 10% decrease in the relative investment price, percentage points



Notes: 90% confidence interval. Based on the industry-level results for numeracy skills reported in Schwellnus *et al.* (2018).
Sources: Schwellnus *et al.* (2018)

the industry-level response of labour shares should at least partly be driven by within-firm developments rather than reallocation effects. The results suggest that the effect of changes in relative investment prices partly operates through within-firm changes, with larger effects in highly productive firms and smaller effects in firms that are more dependent on external finance (Appendix). Highly productive firms may be better able to adopt new technologies embodied in capital goods if adoption requires complementary know how and firms with better access to external finance may be better able to raise investment in response to a decline in relative investment prices. By contrast, the firm-level analysis finds no evidence that global value chain expansion affects labour shares within firms, suggesting that the industry-level effect mainly reflects a shift in firm composition to firms with lower labour shares.

The Role of Public Policies and Institutions

The estimated effects of public policies and institutions are presented in Table 3. The main results can be summarised as follows[24]:

- Pro-competition product market reforms raise the labour share (Column 1, Row 1).[25] The impact of pro-competition product market reforms on the labour share is a priori ambiguous: while reductions in product market rents tend to raise the labour share, reductions in regulatory barriers to investment tend to induce capital-labour substitution. The empirical results suggest that the upward effect on the labour share of pro-competition product market reforms through a reduction in markups appears to outweigh the downward effect through capital-labour substitution. Assuming that the effect of pro-competition product market reforms is negligible in the least exposed industry, the average country-level effect can be approximated as the value-added weighted average in the remaining industries.[26] According to this approximation, lowering the indicator of product market regulation by one standard deviation of the cross-country distribution in 2013 (which corresponds to lowering it from the level in Germany to the level in the United Kingdom) would increase the labour share by around 0.8 percentage point;

24. Results are robust to the exclusion of the benchmark country from the sample, i.e. United Kingdom for regressions including the share of low-wage workers as the industry exposure variable and United States for the other regressions.

25. Since the indicator of product market regulation is available only for the years 1998, 2003, 2008, 2013, the specifications including this indicator are estimated over the following five-year periods: 1998-2003, 2003-2008 and 2008-2013.

26. The average country-level effects in this section are computed as follows: $\beta_1 \sum_j \omega_j \left(Exp_j^k - Exp_{min}^k \right) \Delta Pol_t^k$, *where subscripts* j *and* k *denote, respectively, industries and policies;* β_1 *is the estimated coefficient on* $\left(Exp_j^k \times \Delta Pol_{it}^k \right)$ *in equation (2);* ω_j *denotes the cross-country average value added share of industry* j *over the period 1995-2011;* Exp_{min}^k *denotes the exposure value of the least exposed industry;* ΔPol_t^k *denotes the change in policy* k.

- Reducing employment protection for regular workers raises the labour share (Column 2, Row 2). Employment protection legislation can affect the labour share by influencing the cost of labour relative to capital and by changing workers' bargaining position. Empirically, reducing employment protection appears to affect the labour share primarily through the reduction in the relative price of labour and the consequent substitution of labour for capital rather than the weakening of workers' bargaining position. This is consistent with results in Cette *et al*. (2016) suggesting that in OECD economies the strengthening of employment protection results in capital-labour substitution.[27] Using the previous approximation suggests that lowering the indicator of employment protection by one standard deviation of the cross-country distribution in 2011 (which corresponds to lowering it from the level in Austria to the level in Australia) would increase the labour share by around 4 percentage points;

- An increase in active labour market spending raises the labour share (Column 3, Row 3).[28] The results suggest that these policies can be effective in offsetting technology- or globalisation-related capital-labour substitution by preserving workers' labour market attachment and skills. Using the same approximation as above suggests that increasing active labour market spending by one standard deviation of the cross-country distribution in 2011 (which corresponds to raising it from the level in the United States to the level in Norway) would increase the labour share by around 4 percentage points;

- On average, across countries, increases in minimum wages reduce the labour share (Columns 4, Row 4). Increases in minimum wages may strengthen workers' bargaining position, but over the 5-6 year horizon considered in this paper the upward effect on the labour share through higher wages appears to be more than offset by capital-labour substitution. Using the aforementioned approximation suggests that increasing the minimum wage (relative to the median wage) by one standard deviation of the cross-country distribution in 2011 (which corresponds raising it from the level in Australia to the level in France) would lower the labour share by around 1 percentage point.

- By contrast, the coverage and centralisation of collective bargaining, the tax wedge (the share of income taxes and social security contributions in total labour costs) and corporate taxes do not appear to affect the labour share (see Online complements, Table C2-II). The insignificance of collective bargaining suggests that capital-labour substitution and changes in rent sharing in response to collective bargaining reforms broadly offset each other. The insignificance of the tax wedge may reflect the fact that in the medium run social security contributions are partly shifted to workers (Bozio *et al*., 2017), which would imply that reducing the tax wedge raises wages net of social security taxes with only little effect on the overall cost of labour.

The main concern with the difference-in-differences approach adopted above is that the effects of different policies are analysed one by one. For instance, reforms of employment protection and product market regulation are correlated and may both have larger effects in industries with large firm turnover, which makes it difficult to attribute the estimated effects to one policy or the other. To address this issue, the baseline specification is augmented with the interaction between the preferred exposure variable and another policy.[29] The results on the effects of product market regulation, employment protection, minimum wages and active labour market policies are broadly robust to augmenting the baseline model with the interaction between the preferred exposure variable and another policy (Table 3). For instance, the coefficient on the interaction of firm turnover with changes in product market regulation remains statistically significant and around 0.3 when interactions of firm turnover with changes in other policies are included in the regression model (Column 1). In the case of employment protection and active labour market spending, the estimated coefficient from the baseline model remains fairly stable but loses statistical significance in some specifications.

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27. Ciminelli et al.*(2018) find that loosening employment protection for regular workers reduces the labour share, but their results are not directly comparable with the ones in this paper. First, their indicator of employment protection is based on a "narrative approach" which classifies over 100 legislative and regulatory actions related to employment protection into one of the three following categories: non-reform years, liberalisation reform years and tightening reform years. Second, their estimations do not systematically control for changes in investment prices or trade openness. Third, their empirical analysis is conducted on a slightly broader country and period sample.*

28. The measure of active labour market spending in this paper includes spending on training and employment subsidies. Public spending on public employment services is found to have a statistically insignificant effect on the labour share.

29. Simultaneously including all interaction terms raises issues of multicollinearity.

Table 3
The effect of public policies on the labour share

	(1)	(2)	(3)	(4)
Controlling for:	Change in PMR×EXPO: Firm turnover	Change in EPL×EXPO: Worker reallocation	Change in ALMP×EXPO: Low-skilled workers	Change in minimum wage×EXPO: Low-wage workers
(1) Change in PMR×EXPO	**-0.31**** **(0.13)**	-0.25* (0.12)	1.01*	-0.08** (0.03)
(2) Change in EPL×EXPO	-0.20* (0.11)	**-0.24*** **(0.13)**	1.09* (0.61)	-0.08** (0.04)
(3) Change in ALMP×EXPO	-0.25* (0.12)	-0.22 (0.13)	**1.10*** **(0.61)**	-0.08** (0.03)
(4) Change in minimum wage×EXPO	-0.21 (0.15)	-0.18 (0.11)	1.03* (0.51)	**-0.08**** **(0.03)**
(5) Change in CB coverage×EXPO	-0.31** (0.13)	-0.24 (0.14)	0.71 (0.51)	-0.09*** (0.03)
(6) Change in CB decentralisation×EXPO	-0.30** (0.13)	-0.26 (0.15)	1.12 (0.65)	-0.08* (0.04)
(7) Change in tax wedge×EXPO	-0.31** (0.12)	-0.23* (0.12)	0.80 (0.49)	-0.08** (0.03)
(8) Change in corporate tax×EXPO	-0.32** (0.12)	-0.28* (0.15)	1.10* (0.53)	-0.06 (0.04)

Notes: Selected OECD countries, 1995-2011. PMR stands for product market regulation; EPL for employment protection legislation; ALMP for active labour market policies; CB for collective bargaining; and EXPO for exposure variable. The table reports the estimated coefficients on the interaction term in the column heading, with each row reporting the estimate when controlling for the interaction term in the row heading. Coefficients in bold font show the baseline estimates in Pak & Schwellnus (2019). Public policies and institutions denote 5-year differences. Standard errors are clustered at the country level. Weighted OLS, with the share of industry-level value added in total value as weights. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.
Source: Pak & Schwellnus (2019).

* *
*

This paper suggests that technological change and greater global value chain participation have reduced labour shares, including by inducing the substitution of capital for labour and strengthening "winner-takes-most" dynamics. Raising skills is key to reconnect real median wages to productivity by limiting technology-induced capital-labour substitution while competition-friendly product market policies support the transmission of productivity gains to average wages by limiting the share of rents appropriated by capital owners. Although labour market policies that strengthen workers' bargaining position may raise wages in the short term, especially for lower-wage workers, they can have unintended side effects on the sharing of productivity gains in the medium term by inducing the substitution of capital for labour.

Looking forward, continued technological change is likely to put further downward pressure on labour shares and create new challenges for the broad sharing of productivity gains. Further efficiency gains in the production of investment goods may further reduce their relative prices and raise capital-labour substitution. Technological progress may also fundamentally change the substitutability of capital and labour. For instance, technological advances in artificial intelligence and robotics could make more human tasks – including cognitive tasks – replaceable by capital in the future (Baldwin, 2019).

These technological advances may further strengthen "winner-takes-most" dynamics, with wages decoupling further from productivity at the technological frontier and market shares being reallocated to a small number of "superstar" firms with low labour shares. This paper finds no evidence that the emergence of "superstar" firms indicates the rise of anti-competitive forces rather than technological dynamism. Nonetheless, competition policy will need to find the right balance between preventing anti-competitive practices by incumbent technological leaders and encouraging innovation by allowing entrants into the technological frontier to reap the rewards for their innovations. Irrespective of the source of emerging "winner-takes-most" dynamics, policies that raise human capital through education and training will play a crucial role to broaden the sharing of productivity gains by ensuring that workers can make the most of ongoing technological advances. □

Link to Online complements: https://www.insee.fr/fr/statistiques/fichier/4253015/510-511-512_Pak_Pionnier_Schwellnus_complements_FR.pdf

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APPENDIX

THE RESPONSE OF FIRM-LEVEL LABOUR SHARES TO RELATIVE INVESTMENT PRICE DECLINES

This box analyses the extent to which firm-level labour shares respond to changes in industry-level relative investment prices and whether the response differs across firms. Two potential sources of firm heterogeneity are investigated: initial productivity to proxy for know-how required for technology adoption and initial financial leverage to proxy for external finance dependence.

In order to assess whether within-firm labour shares respond to changes in industry-level relative investment prices, the following baseline equation is estimated:

$$\Delta LS_{cjit} = \beta_1 \Delta P_{cjt}^{Inv} + \beta_2 \Delta T_{cjt} + \gamma' X_{cji0} + \alpha_{cj} + \alpha_t + \varepsilon_{cji}$$

where subscripts *c, j, i, t* denote, respectively, countries, industries, firms and time; ΔLS_{cji} denotes the annualised long difference in the firm-level labour share, with long differences computed over the longest period a firm is observed and the sample is constrained to firms that are observed for at least eight years over the period 2001-2013; ΔP_{cjt}^{Inv} denotes the annualised long difference of the log relative investment price; ΔT_{cjt} is the annualised change in global value chain participation; X_{cji} is a set of firm-level controls that include: initial values of the firm's age, size (as measured by employment) and the initial labour share[(a)]; α_{cj} denotes country-industry fixed effects and α_t are period-fixed effects that cover all permutations of possible start and end years over the period 2001-2013.

In order to address the question of whether the response of firm-level labour shares to changes in industry-level relative investment prices depends on firms' initial productivity and initial financial leverage, the baseline equation is augmented as follows:

$$\Delta LS_{cjit} = \beta_1 \Delta P_{cjt}^{Inv} + \beta_2 \Delta T_{cjt} + \beta_3 \left(C_{cji0} \times \Delta P_{cjt}^{Inv} \right) + \gamma' X_{cji0} + \alpha_{cj} + \alpha_t + \varepsilon_{cji}$$

where all definitions are as in the baseline and C_{cji0} denotes initial productivity and/or initial financial leverage, and X_{cji0} includes C_{cji0}. Including separate country-industry and year-fixed effects instead of including combined country-industry-year fixed effects has the advantage that both the effect of industry-level relative investment prices for a low-productivity/low-leverage firm and the interaction with these firm characteristics can be identified. To check the robustness of the estimated coefficient on the interaction terms, the separate industry and year-fixed effects can be replaced by combined country-industry-year fixed effects.

The model is estimated using firm-level data from OECD-ORBIS and industry-level relative investment price indices for nine countries for which long differences in labour shares can be computed for a sufficient number of firms.[(b)] High-productivity firms are defined as the top 5% of leading firms within an industry with the highest labour productivity across the countries covered by the analysis. Access to external finance is proxied by a measure of leverage, the rationale being that highly leveraged firms may both be more dependent on external finance and find it more difficult and costly to raise external funds.[(c)] The results reported below are based on the ratio of current liabilities and long term debt to total assets.[(d)]

A decline in the relative investment price is estimated to reduce firm-level labour shares (Table A, Column 1). The average estimated firm-level semi-elasticity is around 0.15, remarkably similar to the estimated industry-level semi-elasticity of around 0.2. However, the firm- and industry-level results are not directly comparable as high-productivity firms – for which the estimated semi-elasticity of labour shares to relative investment prices is higher (Column 2) – are over-represented in OECD-ORBIS. Moreover, the firm-level analysis is based on 8-year or longer differences as compared to 5- or 6-year differences in the industry-level analysis and is based on a more limited country and year sample. Consequently, the positive and statistically significant semi-elasticity in the firm-level analysis implies that declines in the relative investment price affect aggregate labour shares at least partly through within-firm effects, but the similarity in estimated semi-elasticities across the firm- and industry-level analyses cannot be interpreted as ruling out composition effects. By contrast, the insignificance of the estimated coefficient on global value chain participation suggests that the effects of increased global value chain participation mainly operate through the reallocation of production from high-labour share to low-labour share firms, which is consistent with the reasoning in third section and the theoretical model described in Schwellnus *et al*. (2018).

High leverage (i.e. high external finance dependence) dampens the transmission of declines in the relative investment price on the labour share (Table A, Columns 3-5). In firms that are more financially leveraged a decline in the relative investment price reduces the labour share significantly less than in less leveraged firms. The semi-elasticity of labour shares to the relative investment price for a firm with a leverage ratio of 100% is about one third lower than for a firm with zero leverage. This result is robust to including the dummy for high-productivity firm and leverage simultaneously, suggesting that it does not simply capture the fact that high-productivity firms may be less financially leveraged.

(a) Given that the above specification of the firm-level regressions considers only one long difference per firm, firm fixed effects cannot be included. Including the initial values of the dependent variable allows controlling for unobserved firm characteristics in the absence of firm fixed effects (Angrist & Pischke, 2009).

(b)The analysis is constrained to the same industries as the industry-level analysis. The included countries are Belgium, Finland, France, Germany, Italy, Korea, Spain, Sweden and United Kingdom. In order to ensure that results are not driven by firms with extreme values in long differences in labour shares, firms with long differences outside the [-40,+40] percentage point interval are removed from the analysis. The analysis is further constrained to country-industry cells with more than 30 firms in order to ensure that the industry-level variables are identified by a sufficient number of firms. The results are robust to alternative sample restrictions.

(c) Ferrando & Mulier (2015) find that firms with lower leverage ratios are less likely to be financially constrained. Giroud & Mueller (2017) provide evidence for U.S. firms on a positive relationship between pre-crisis leverage ratio and financial constraints during the Great Recession. Love et al. *(2007) show that during the Asian Financial Crisis, a firm's vulnerability to financial market imperfections increased the higher its short-term debt to asset ratio. Current liabilities include loans, liabilities to credit Institutions, trade payables and any other liabilities due within one year, as well as accruals and deferred income.*

(d) The results are robust to using a dummy for low vs high financial leverage.

Table A
Financial constraints reduce the elasticity of the labour share to the relative investment price

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	Change in firm-level labour share				
Change in relative investment price	0.14*** (0.05)	0.13** (0.06)	0.18*** (0.05)	0.17*** (0.06)	
Change in GVC participation	-0.02 (0.05)	-0.01 (0.05)	-0.02 (0.05)	-0.01 (0.05)	
Leader×Change in relative investment price		0.19*** (0.07)		0.19*** (0.07)	0.18** (0.07)
Leverage×Change in relative investment price			-0.06** (0.02)	-0.05** (0.03)	-0.06** (0.02)
Initial leverage and/or initial leader	No	Yes	Yes	Yes	Yes
Firm-level controls	Yes	Yes	Yes	Yes	Yes
Country×Industry fixed effects	Yes	Yes	Yes	Yes	No
Year fixed effects	Yes	Yes	Yes	Yes	No
Country×Industry×Year fixed effects	No	No	No	No	Yes
Observations	416,888	416,888	416,888	416,888	416,888
Adjusted R2	0.21	0.22	0.21	0.22	0.22

Note: Selected OECD countries, 2001-13. Firm-level controls include the initial firm-level labour share, age and employment. The included countries are Belgium, Germany, Spain, Finland, France, Italy, Korea, Sweden and United Kingdom. A leader is defined as belonging to the top 5% firms within an industry with the highest labour productivity across the countries covered by the analysis. Firm-level financial leverage is proxied by the ratio of current liabilities and long term debt to total assets. Standard errors are clustered at the country-industry level. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.
Sources: OECD calculations based on OECD-ORBIS.

Overall, the firm-level results suggest that industry-level investment prices affect the labour share partly through changes within firms rather than composition effects, with high-productivity firms and firms with low financial leverage typically responding more strongly. By contrast, there is no evidence that changes in global value chain participation affect firm-level labour shares, suggesting that they operate mainly through composition effects.

The Labor Share in the Long Term: A Decline?

Gilbert Cette*, Lorraine Koehl and Thomas Philippon*****

Abstract – We challenge the accepted wisdom of a global secular decline in the labor share. A simple theoretical model is proposed to highlight the main factors of change in the labor share. We document three issues in the existing literature: (i) starting periods for the empirical analysis; (ii) accounting for self-employment; and (iii) accounting for residential real estate income. An empirical analysis is carried out since the post-war period for France and the United States, and since the 1990s for ten developed countries and on a six-country "euro area". How the three questions above are addressed is crucial to the diagnosis. When the biases that may arise with the three issues mentioned above are eliminated, the labor share in the market sector does not show a general downward or upward trend. The choice of period has a huge impact, as does the treatment of real estate services, whose inclusion or not in the value added can result in significantly different trends.

JEL Classification: D33, D24, J33
Keywords: labor share, labor cost, value added sharing

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The evolution of the labor share plays a central role in economics. Following Kaldor (1957), economists have viewed the relative long-term stability of the labor share as an important stylized fact. In recent years, however, the stability of the labor share has been challenged. The common wisdom is that there has been a global and gradual decline in the labor share over the past 30 or 40 years. For instance, Grossman *et al.* (2017) motivate their recent paper by writing that "*unlike several of the other explanations for the decline in the labor share, ours does not rely on considerations that are specific to the United States. The shift in aggregate factor shares has been seen in the data for many countries, especially among the advanced countries*". The IMF (2017) and OECD (2018) also mention that the labor share has been on a downward trend in a large majority of developed countries since the early 1990s.

Why would the labor share decline? Karabarbounis & Neiman (2014) contend that the decline in the labor share is global and mainly driven by a decline in the relative price of investment goods. This explanation hinges on an elasticity of substitution between labor and capital above 1. The empirical consensus, however, is a value below 1 for the elasticity of substitution, as we review below. Another issue is that the drop in the price of investment goods occurred mainly in the early 1980s and the 1990s, while the labor share, especially in the United States (US), only dropped in the 2000s, at the time where the relative price of investment was more stable. For Acemoglu & Restrepo (2018) also, technological factors could contribute to a decrease of the labor share, as "*automation increases output per worker more than wages and reduce the share of labor in national income*".

Elsby *et al.* (2013) emphasize offshoring of the labor-intensive component of the US supply chain as a leading potential explanation of the decline in the US labor share over the past 25 years. The threat of offshoring would also have contributed to a decline in union density and to labor's bargaining power.

Autor *et al.* (2017) argue that the labor share decline could be the consequence of the growth of firms with low labor share technologies, especially in the digital economy. These firms might have low marginal costs and might gain market shares if consumer demand becomes more elastic. For Aghion *et al.* (2019) the growth of large firms with a high productivity and a low labor share is related to a decrease in the cost of running a higher number of product lines. This decrease in costs comes from the use of information and communication technologies (ICT).

Our main point is to challenge the accepted wisdom of a general decline in the labor share. We show that there has been no systematic trend in the labor shares in most countries and we emphasize three important biases that have plagued the existing empirical literature: (i) the starting period chosen for the analysis; (ii) accounting for self-employment; and (iii) accounting for residential real estate income.

Let us start with the first bias: the starting points for the time series. Before the literature on the surprising decline in the labor share, there was a literature on the surprising increase in the labor share. The labor share increased during the stagflation of the 1970s, especially in Europe. As Blanchard (1998) notes, there was an increase in both unemployment and the labor share in the 1970s. This situation is commonly interpreted as a "wage push", as wages failed to adjust to the slowdown in underlying productivity growth. Following the oil shocks of the 1970s, countries that were net importers of oil and gas experienced an adverse change in their terms of trade. Several factors explained the size and the duration of the "wage push": the reliance on oil and gas importations, the dual indexation of wages on consumption price and of prices on labor costs, and the impact of unemployment on wage dynamics (the Phillips curve). Unemployment continued to increase during the 1980s, pushing wages down and leading to a sharp decline in the labor share. The labor share mostly reverted to its long run value, but the transition involved some overshooting as firms adopted labor saving technologies. The labor share in many European countries was above its steady state value in the late 1970s, and it was bound to revert to its long run average. Any empirical analysis that takes the period 1973-1983 as a starting point is likely to find a spurious decrease in the labor share. Another aspect linked to this first bias is that labor share analyses have to take into account that the position in the business cycle at the beginning and at the end of the sample might be different, which could also affect the change in the labor share.

The two other biases have already been studied in the literature. For instance, Elsby *et al.* (2013) show that the imputation of the labor income

for the self-employed explains about 1/3 of the measured decline in the labor share in the United States. Rognlie (2015) or Gutiérrez (2017) explain the impact of the real estate sector in detail.

Our analysis starts with France and the United States, for which we are able to construct measures of the labor share for the entire post-war period. When the three biases mentioned above are corrected, we do not observe any structural decrease of the labor share in France; if anything, we find a slight increase over the last two decades. In the United States, we observe a decrease in the labor share, but it is not a secular decline: the labor share shows no trend until 2000 but declines sharply between 2000 and 2015.

We then extend our analysis to a six-countries "Euro Area" (including France, Belgium, Germany, Italy, the Netherlands, Spain) and ten developed countries: France, United States, Belgium, Denmark, Germany, Italy, the Netherlands, Spain, Sweden, and the United Kingdom. Here, the analysis can only start in the 1990s. We find a decline in the labor share in four countries, an increase in five countries and a quasi-stability in the "Euro Area" and one country – so no global decline in the labor share. These results are consistent with those of Rognlie (2015) on the G7 economies and of Gutiérrez (2017). They are also broadly consistent with OECD (2018) for the same set of countries and total economy, but not directly comparable beyond that, because their approach to the business sector is narrower.[1]

The rest of our paper is organized as follows. Firstly, we describe a simple theoretical model to frame the discussion of the three biases. The next section provides the empirical analysis, first over a long period of seven decades for France and the United States, and after for the ten countries over a shorter period of two decades. The last section concludes.

A Simple Theoretical Framework

Labor Share in Production

Consider a standard CES production function with capital K and labor N:

$$Y = \left[(1-\alpha)^{\frac{1}{\eta}} N^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} K^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

where Y is the production, η is the substitution elasticity between capital and labor, and α is a parameter of distribution.

We assume that firms are price takers in the factor market, i.e., they take the wage W and the rental rate R as given when choosing how much capital and labor to hire. On the other hand, we assume that firms have market power when they sell their output, so that they charge a markup μ of price over marginal cost. The marginal cost of production χ is:

$$\chi = \left[(1-\alpha) W^{1-\eta} + \alpha R^{1-\eta} \right]^{\frac{1}{1-\eta}}$$

Firms set their markup so that:

$$P = \mu\chi$$

This is a standard assumption in macroeconomic models, but we note that there is increasing evidence of monopsony power in the U.S. labor markets (Azar *et al*., 2017; Benmelech *et al*., 2018). Two-sided platforms (e.g. Amazon) can also have monopsony power over merchants.

Cost minimization implies that the capital labor ratio satisfies:

$$\frac{K}{N} = \frac{\alpha}{1-\alpha} \left(\frac{W}{R} \right)^{\eta}$$

and profit maximization implies:

$$\mu \frac{W}{P} = \left[(1-\alpha) \frac{Y}{N} \right]^{\frac{1}{\eta}} \text{ and similarly } \mu \frac{R}{P} = \left(\alpha \frac{Y}{K} \right)^{\frac{1}{\eta}}$$

The labor share is defined as:

$$\Lambda = \frac{WN}{PY} = \frac{(1-\alpha)^{\frac{1}{\eta}}}{\mu} \left(\frac{Y}{N} \right)^{\frac{1-\eta}{\eta}}$$

This shows how the labor share depends on the output/labor ratio. Using the production function, we can express this ratio as a function of the capital/labor ratio:

$$\frac{Y}{N} = \left[(1-\alpha)^{\frac{1}{\eta}} + \alpha^{\frac{1}{\eta}} \left(\frac{K}{N} \right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

Finally, we can use the cost minimization condition to obtain:

1. *Specifically, they exclude real estate income and also other activities as agriculture, mining and quarrying, education, health and social services. The share in the business sector of these excluded activities changes over time and differs between countries.*

$$\left(\frac{Y}{N}\right)^{\frac{1-\eta}{\eta}} = \frac{1}{(1-\alpha)^{\frac{1}{\eta}} + \alpha^{\frac{1}{\eta}}\left(\frac{K}{N}\right)^{\frac{\eta-1}{\eta}}}$$

$$= \frac{1}{(1-\alpha)^{\frac{1}{\eta}}} \frac{1}{1+\frac{\alpha}{1-\alpha}\left(\frac{W}{R}\right)^{\eta-1}}$$

We therefore have the following expression for the labor share:

$$\Lambda = \frac{1}{\mu} \frac{1}{1+\frac{\alpha}{1-\alpha}\left(\frac{W}{R}\right)^{\eta-1}} \quad (1)$$

Equation (1) allows us to summarize many theories about the labor share. The Cobb Douglass assumes that $\eta = 1$. In that specific case:

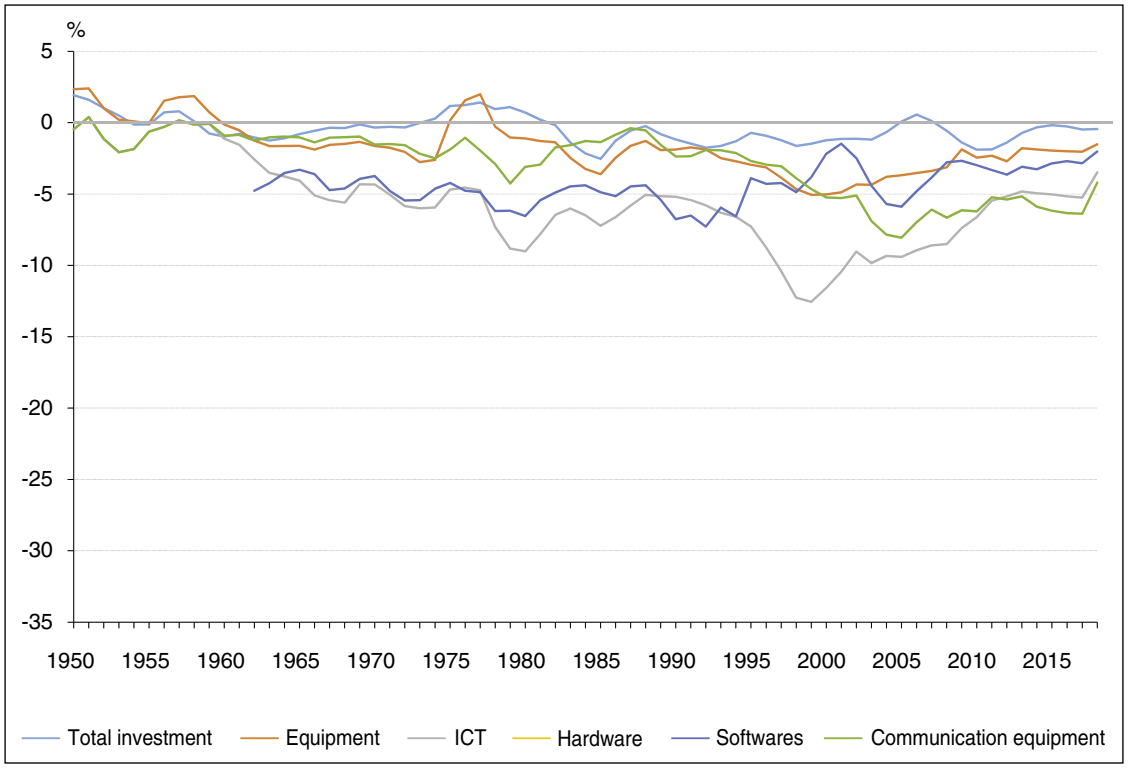
$$\Lambda = \frac{1-\alpha}{\mu}$$

The labor share can decline because of higher markups (μ increases) or because of capital bias technology (α increases). When the substitution elasticity differs from 1, changes in factor prices change the labor share (see relation 1).

Karabarbounis & Neiman (2014) assume that the substitution elasticity is greater than 1 ($\eta > 1$) and argue that R has decreased. In that case the increase in the cost ratio of labor to capital W/R implies a large demand for capital relative to labor and a drop in the labor share. There are three issues with this explanation. One issue is that empirical estimates of the substitution elasticity usually find values in the range of 0.4-0.8 (see for instance the literature survey and original estimates on plant level US data from Oberfield & Raval (2014), or Raval (2019), or the recent meta-analysis from Knoblach *et al.* (2019), using estimates from 77 studies on the US economy). The assumption of a substitution elasticity greater than 1 does not get much support in the literature.

The second issue is that the timing of the decrease in the relative price of investment does not match the timing of the decreased in the labor share. Figure I presents the growth rate of the investment price relative to the GDP price in the US. We focus on the US here because the Bureau of Economic Analysis (BEA) has done substantial work to measure the prices of

Figure I
Growth rate of the investment price relative to the GDP price in the US, 1950-2017



Notes: The growth rates are smoothed using a three-year moving average. Total investment price includes construction price, which is not represented.
Sources: Bureau of Economic Analysis. Authors' calculations.

various investment goods. We see that the relative price investment has been decreasing for several decades, but this decrease was stronger in the 1980s and 1990s, while, as we show later, the labor share only declines in the 2000s.

The third issue is related to the evolution of the capital coefficient over the period shown in Figure II. We observe that the capital coefficient in value is quite-stable over the long 1949-2017 period, despite the decline of the equipment relative price, which suggests a substitution elasticity equal to 1. We could even consider a light decline of this capital coefficient in value, when the relative price of investment goods is declining substantially, which would suggest a substitution elasticity below one.

Another strand of literature argues that η is small at least in the short to medium run. A wage push could then increase the labor share at this time horizon. Formally, W/R goes up, firms cannot substitute much capital, and so the labor share increases. This can help explain the dynamics of the labor share in Europe in the 1970s (Blanchard, 1998).

In the long run, technology can also change. A prime example is automation. For Acemoglu & Restrepo (2018), automation increases productivity more than wages, which reduces the labor share. Martinez (2018) builds a model where capital and labor are complementary ($\eta < 1$) and the aggregate production function resembles a constant elasticity of substitution (CES) production function, but with endogenous weights influenced by automation. Opening trade to low wage countries can also lower the equilibrium wage (at least for low skilled workers) and, assuming $\eta < 1$, can lead to a lower labor share.

Three Biases

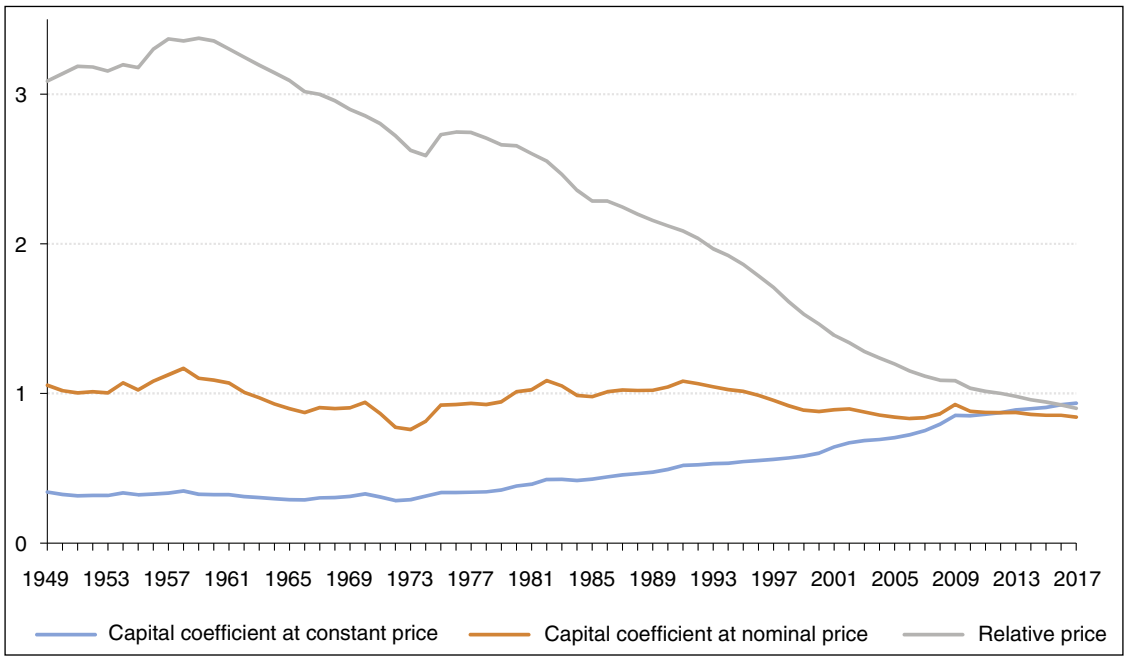
We now emphasize three issues in empirical estimates of trends in labor shares.

Initial Period

Most international studies of labor share focus on trends, not on levels. Comparison of levels across countries is complicated because of differences in industrial composition and in the statistical methodologies. In fact, we discuss two such issues below. As a result, most studies shy away from level comparisons and focus on trends.

The problem with trends is that they depend on the choice of the initial period. If shocks are

Figure II
Capital coefficient (ratio capital / GDP) – Equipment



Sources: GDP in constant price, investment and GDP price: National accounts – BEA; Equipment capital in constant price: Bergeaud *et al.* (2016) calculations from National Accounts – BEA investment data. See www.longtermproductivity.com

small, this is not an issue. But when shocks are large, this can create severe biases.

Equation (1) assumes away adjustment costs and transition dynamics. To be more precise, consider a model with nominal rigidities. Following Blanchard (1998), let us define a "wage push" as wage inflation in excess of underlying labor productivity growth. When prices are rigid in the short term, a wage push leads to a lower markup μ. This increases the labor share. In addition, if the substitution elasticity is less than one – the empirically relevant case as we have discussed – an increase in the ratio *W/R* also increases the labor share.

These effects can be large, but they are temporary. If one takes the period after the wage push as the starting point, then simple mean reversion can create the illusion of a decline in the labor share, while in fact the labor share is simply returning progressively to its initial steady state.

Self-Employment

The second issue is self-employment. The labor share of employees is easier to estimate than that of self-employed individuals (Elsby *et al.*, 2013). Workers who are on the payroll of employers earn wages as well as employer contributions to pensions and insurance funds. Their compensation is usually well measured.

For self-employed workers, on the other hand, it is usually difficult to distinguish labor and capital income. The usual way to deal with the issue is to assume that self-employed workers earn the same wage as employees in their industry (see Box). We follow the literature, but we note that the adjustment can be biased since it assumes that self-employed workers are identical to employees. This issue matters especially when the share of self-employment varies over time or across countries.

Real Estate

The last issue is capital income from real estate. In the model above, *K* represents capital used by firms to produce goods and services. It does not include residential real estate. In National Accounts, however, income from residential real estate is counted as capital income.

The proper way to account for real estate income depends on the question we want to answer. Real estate capital income is indeed a form of capital income, and it has important redistributive effects within and across generations. If we are interested in the dynamics of wealth inequality, we must clearly include real estate capital.

On the other hand, if we seek to understand the impact of technology, trade, or market power, we should carefully remove residential capital income from our measures. The theories discussed above emphasize the evolution of productive capital and predict how value added is shared between labor compensation and profits. To assess the impact of automation, AI, trade, unionization, oligopoly rents, or monopsony power, we must use a measure of capital income that does not include real estate income.

There are in fact two levels of bias. First, at the country level, residential rentals are part of value added, with rentals imputed for owner occupied dwellings. This can clearly create a bias when the value added of real estate over GDP changes. A solution is to compute the labor share excluding the real estate sector. We make this correction but however, we have to keep in mind that another one which is not done could be considered. In many countries, business firms own real estate and earn rental income. This rental income is not part of payment to productive capital and creates a bias in the measurement of the labor share even at the level of the manufacturing sector.

Labor Share Developments in Ten Developed OECD Countries

In this section, we look at the labor share trends in ten developed OECD countries for which available data allow us to analyze the biases mentioned in the previous section (see also Box). These ten countries are Belgium, Denmark, France, Germany, Italy, The Netherlands, Spain, Sweden, the United Kingdom and the United States. We also look at the labor share trends in a reconstituted "Euro Area" comprising Germany, France, Italy, Spain, the Netherlands and Belgium.[2] For France and the United States, data used to build labor share

2. In 2017, these six countries represented 86% of the GDP of the whole Euro Area.

Box – Data and Definitions

Data Sources

We chose the data sources that yield the longest time series. For France and the United States, we use data from the National Statistical Institutes – Insee and the BEA respectively – and we can go back as far 1949. For the 8 other countries, we use the OECD STAN database, which provides data from different dates but, at least from 1995, for all countries. The data come primarily from annual National Accounts and are available via Eurostat for European countries. The OECD fills in some missing information, especially in early years and for detailed levels, so it may not reflect exactly National Accounts publications.

Labor Share Calculation Methodology

We first compute the labor share (unadjusted) as the ratio of employees' compensation (D1)[(a)] to value added at factor costs, which is gross added value (B1G) minus taxes (D29) and subvention (D39) to production. In the case of France, however, the National Accounts allow us to separate taxes on wages and workforce from other taxes on production, and then we consider taxes on wages as part of labor costs.

Self-Employment Adjustment

As the self-employed worker income include income from labor and capital income (mixed income), measuring the self-employed's compensation is a common problem in calculating the labor share. National accounts provide a breakdown of value added at factor costs into employees' compensation, gross operating surplus, and mixed income at various levels of aggregation (industries, sectors, and the entire economy). Mixed income is the income of self-employed workers, but to separate in it compensation for labor services from payment to capital needs some conventional choices.

One usual way to separate the labor and capital shares in self-employed mixed income is to assume that self-employed workers earn the same gross hourly wages as employees in the same industry. These adjustment matter especially when the structure of employment between paid and independent workers changes. For instance, in France, the number of self-employed workers has decreased since the Second World War (their share increased from 39% of total employment in 1949 to 13% in 2017), in particular because of the decline in the agricultural employment.

Here, we compute the average hourly gross wage for employee at the detailed industry level, and we apply it to self-employed workers. We use seventeen various industries for France, seventeen for the US in the later years and twelve for the earlier ones, and thirty-four for all the other countries. In the US, the classification has changed over the considered period, going from the 1972 Standard Industrial Classification (SIC) systems to the 1987 one in 1987, and then to North American Industry Classification System (NAICS) in 1997. In consequence, the labor share curve is discontinuous in 1997 and 1987, without restatement. For these two years, we computed the labor share using two sets of data, and then we fitted the trend from the earlier year to the value given by the earlier set of data. These adjustments go from -2.7% to +3.9%.

Scope

The labor share has been calculated on different fields: first, on the total economy (all the branches of activities), second on the business sector[(b)], then on business sector minus real estate services. These indicators are corrected as described above for self-employed workers. For France and the US, we have also calculated to other labor share indicators: the first on the business sector without any self-employment worker correction, to show the impact of such correction, and also on non-financial companies (NFC). The NFC scope does not include self-employed workers in France and the United States, which is not always the case for other countries (see Pionnier and Guidetti, 2015).

Are considered as non-business branches the following ones: Public administration and defense services, Compulsory social security services (Section O)[(c)], Education services (Section P); health and social work services (Section Q), Arts, entertainment and recreation services (Section R); Other services (Section S) and Private households as employers (Section T). This definition has been applied to all countries rather than considering non-business sector on a case-by-case basis, even though there are differences. For example, health services are considered[(d)] as a non-business branch in France but as a business branch in the USA. Applying the same definition for non-business sector provides a coherent field for all sectors.

Definition of Imputed Rents

In National Accounts, renting a dwelling to a person is equivalent to producing a housing service, for which rent is the remuneration. By convention, it is considered that owner-occupiers provide this housing service to themselves; the notion of imputed rent refers to the rent they would pay for that dwelling. A significant part of the production of real estate service corresponds to these imputed rents: in France, in 2015, rents make up for 97% of the total added value of real estate services, with 61% consisting in imputed rents alone.

Without this correction, it would not be relevant to compare GDP between countries with different rates of home ownership. On the other hand, the correction creates measurement issues.

(a) Classification from the ESA 2010.
(b) We consider here and in the whole paper "business sector" as equivalent to "market sector".
(c) Classification NACE Rev.2.
(d) Market and non-business branch is a distinction based on the evaluation method in national account. A service or product is considered as non-market if it is free or sold at a non-economic significant price (less than 50% of the cost). In this case, the value of the production is estimated as the sum of production costs.

indicators are directly available from Insee (the French National Statistical Institute) and the BEA over a very long period, dating back at least from the late 1940s. For this reason, we look first at the labor share evolution over a long period in these two countries, then over a shorter period (since the mid-1990s) at the evolution of the labor share in the eight other developed OECD countries.

Long Term Focus on France and the United States

Five labor share indexes are built and compared for the two countries over the whole period 1949-2017. The first indicator is built on the whole economy. Its main advantage is to be exhaustive. But its disadvantage is to include the non-market activities, which mainly correspond to the public administration representing about a quarter of the total in the current period in the two countries, and whose calculation, dictated by strict international accounting conventions, is very specific and relies mainly on a cost approach. The second indicator is built on the business sector and avoids this difficulty. The third indicator is also built on the business sector, but without any correction concerning self-employed workers in contrast to the two previous indicators and the next one, with the aim of illustrating how large this correction is. The fourth indicator is built on the business sector excluding real estate activities (which represent 16% of the business sector value added at the end of the period in the two countries) for the reasons indicated in the previous section. Finally, the last indicator is built on the scope of non-financial corporations (NFC) excluding self-employment[3] and financial corporations, for which the value added evaluation is fragile and strongly influenced by international accounting conventions. This NFC scope has the greatest precision and is the least influenced by accounting conventions, but only covers about half of the GDP at the end of the period in the two countries.

The Labor Share in France

Figure IV-A presents the five labor share indicators for France. The case of France illustrates perfectly the three biases mentioned in the previous section.[4]

Concerning the first bias, we see that the diagnosis of the labor share trend depends largely on the initial period. Over the last decades, the labor share in the total economy or in the business sector exhibits no clear trend from the end of the 1980s, and on the contrary exhibits a clear decrease from the end of the 1970s or the early 1980s. The two oil shocks of the 1970s provoked a wage push and, as a consequence of price inertia, a dramatic increase of the labor share. From the mid-1980s, the strategy of "competitive disinflation" (*désinflation compétitive*) implemented by the French Government managed to slow down the wages and to help a decrease in the labor share. This strategy was successful and, from the end of the 1980s, the labor share seemed to have reached a new equilibrium which lasted two decades, until the financial crisis emerged in 2008. The French story suggests that to evaluate the trend of the labor share, the initial period must be chosen before or after (but not during) a labor share temporarily changed by specific large shocks, as for instance the two oil shocks of the 1970s and the following ten year adjustment.

Concerning the second bias, it appears that the correction for self-employment largely impacts the level and the trend of the labor share in France. The non-corrected labor share indicator is lower and grows more rapidly than the corrected one. The growth gap comes from the continuous decrease of the share of self-employed in total employment, which went from about 39% to about 10% between the end of the 1940s and the early 2000s (see Figure V). Then it remained quite stable until the end of the 2000s and then it increased slightly by about 1 percentage point, as a result of the creation of a specific status of "self-entrepreneur" (*auto-entrepreneur*) in 2008. From these changes in the share of self-employed in total employment, the gap between the corrected and the non-corrected labor share indicators decreased from about 25 percentage points at the end of the 1940s to about 5 percentage points in the early 2000s then remained relatively stable eafter. It therefore seems necessary to consider corrected indicators to analyze the trends of the labor share.

Concerning the third bias, it appears that removing real estate services totally changes the diagnosis of the trend of the labor share. Except for the long decade affected by the oil shocks from the mid-1970s to the mid-1980s,

3. The fact that the NFC scope does not include self-employed workers is specific to a few countries, such as France and the United States (see Pionnier & Guidetti, 2015). For this reason, we do not calculate and analyse its evolution for other developed countries in the next section.
4. Of these three possible biases, the two first were recently analyzed by Cette & Ouvrard (2018).

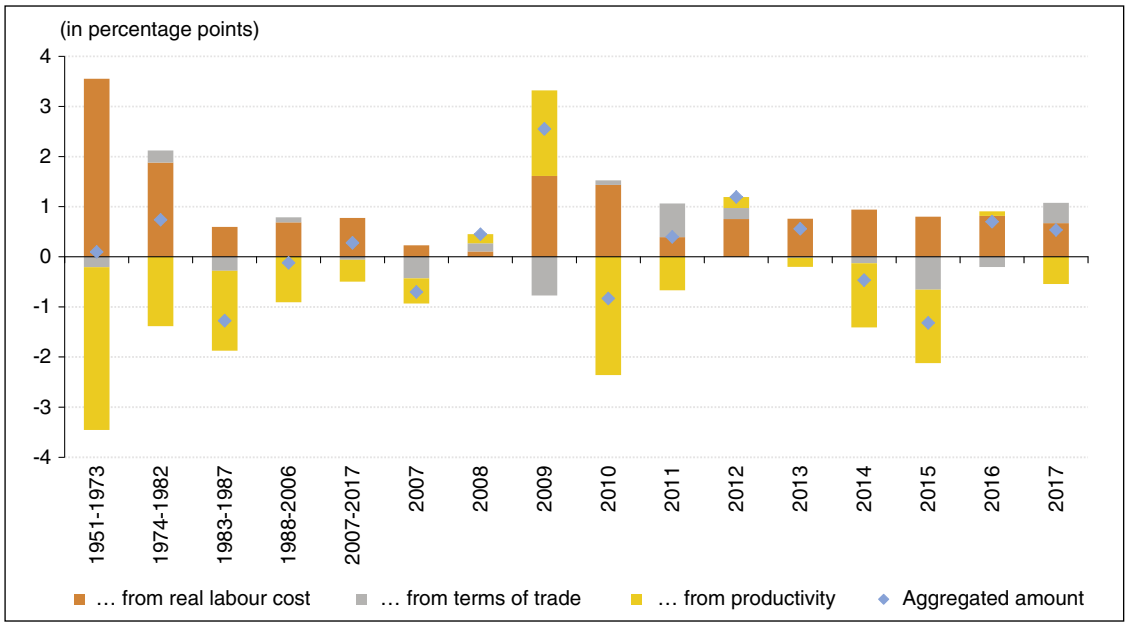
the labor share in the business sector (including real estate services) exhibited a decreasing trend until the financial crisis in 2008, followed by an increase afterwards. From the end of the 1940s to the financial crisis, the decrease was about 12 percentage points and the following increase until the current period has been about three 3 percentage points. Excluding real estate services, the business sector labor share indicator shows a totally different evolution, with very large fluctuations around a quite stable level of about 70%. From the end of the 1940s to the first oil shock, it fluctuated around this stable level, then it was above during the long decade from the mid-1970s to the mid-1980s, then it was below for two decades until the financial crisis of 2008; since then it has fluctuated again around this stable level. The gap between the two labor share indicators comes from the increasing share of real estate services in the total value added, from about 3.5% at the end of the 1940s to about 16% in 2008, this share remaining quite stable afterwards (see Figure VI). For NFCs, the diagnosis is very similar to that in the business sector excluding real estate services.

The trends of the labor share in France thus appears very sensitive to the three biases, and their correction seems necessary to establish a diagnosis. From the preceding, it appears that in France the diagnosis after correction is that the labor share has experienced large fluctuations around a quite stable level over a very long period of seven decades from the end of the 1940s. But a false diagnosis of an increase in the labor share could be made without the correction of self-employment and, in contrast, an opposite false diagnosis of a decrease could be made without excluding real estate services or choosing the initial period in the decade from the mid-1970s to the mid-1980s.

To better understand the evolution of the labor share, we use an accounting analysis to break it down between the contributions of apparent labor productivity, terms of trade and real labor cost.[5] Figure III presents these three contributions to the evolution of the labor share in the business sector excluding real estate services in France from early 1950s to 2017. During this period, real labor costs contribute positively to the evolution of the labor share, while productivity tends to contribute negatively, in the same order of magnitude. While terms of trade contribute positively or negatively, depending on the conjuncture, and from times to times significantly, it does not explain a large part of the evolution of the labor share. The increase in the labor share from 1973 to 1982 reflects

5. *That is, with the notation adopted above, (WN)/(PY) = (W/Pc) (Pc/P) (Y/N)$^{-1}$ where Pc is the household final consumption price. The apparent labor productivity is defined as (Y/N), terms of trade as (Pc/P) and real labor cost as (W/Pc).*

Figure III
Contributions to labor share variations in the business sector excluding real estate services



Sources: Insee, National Accounts. Authors' calculations.

real labor costs increasing at a higher rate than apparent labor productivity. This situation was reversed in the 1980s, resulting in a sharp drop of the labor share. From 1988 to 2016, the labor share is relatively stable. The sharp increase in 2009 is explained by the positive contribution of real costs and productivity and the decrease and increase observed since are caused by the discrepancies between the contributions of real labor costs and apparent labor productivity. From this accounting analysis, we can conclude that in the short term the evolution of the labor share reflects from times to times the condition of terms of trade, for example in 2007 or 2015, but mainly the difference in the contributions of apparent labor productivity and real labor costs. The increase in the labor share over the period 2007-2017 comes from a higher growth of labor costs than of productivity growth.

The Labor Share in the United States

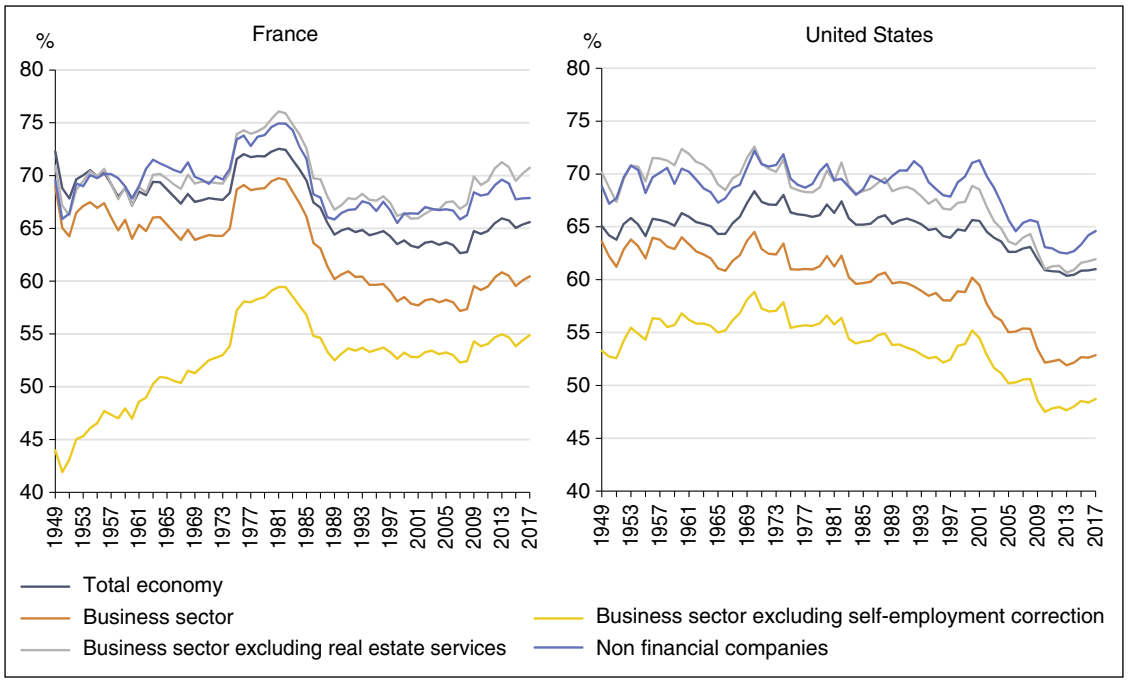
Figure IV-B presents the five labor share indicators for the US. These five indicators exhibit similar trends over the whole period: stability from the end of the 1940s to the early 1970s, then a decrease until the financial crisis, in 2009, and then quasi-stability. The three biases appear to be a lot smaller in the US than in France, for particular reasons.

Concerning the first bias, the oil shocks of the 1970s did not have a significant impact on the labor share indicators, contrary to France. The reason is that the US was at this period a major producer of petrol and gas, so that the oil shocks have mainly involved a transfer from energy user sectors to the petrol and gas producer sector, not as in France where the transfer went from all sectors to petrol and gas foreign country producers.[6] The share of petrol and gas extraction in the total value added increased in the US from about 1% in the early 1970s to a maximum of 4% in the early 1980s, to fall back to 1% in the early 1990s.

Concerning the second bias, we observe that the self-employment correction has an effective impact on the labor share indicators mainly before the early 1970s, and not really afterwards: during this sub-period 1949-1970, the business sector uncorrected labor share indicator increased by 5 percentage points when the corrected indicator remained quite stable. The reason is that the share of self-employed workers in total employment decreased from about 17% to about 9% during this sub-period, to remain stable thereafter until the early 1990s and then to decrease again very slightly, to

6. *This explanation was already given by Baghli* et al. *(2003).*

Figure IV
Labor share as a percentage of the value added

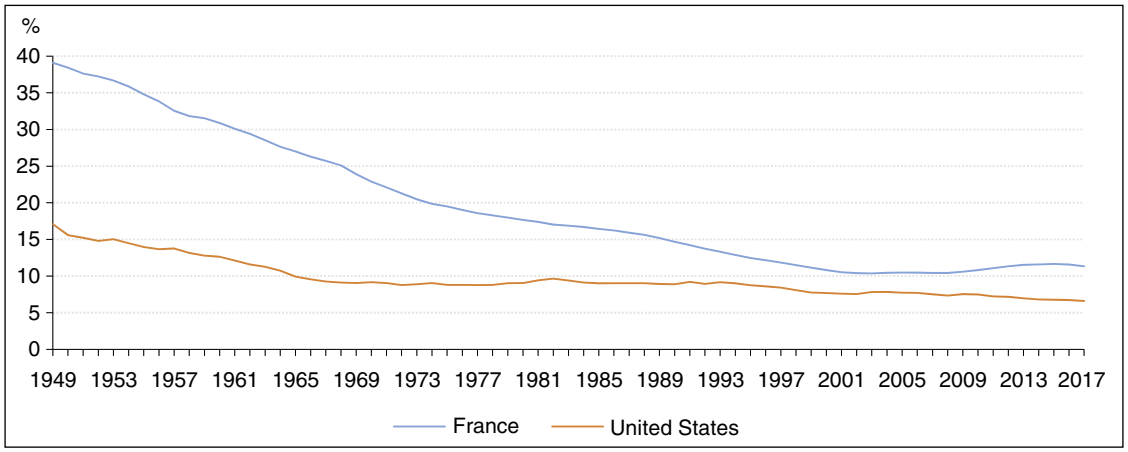


Sources: Insee and BEA, National Accounts. Authors' calculations.

about 7% until the current period (Figure V). The large decrease of the self-employed worker share in total employment observed in France until the early 2000s happened mainly before the Second World War in the US.

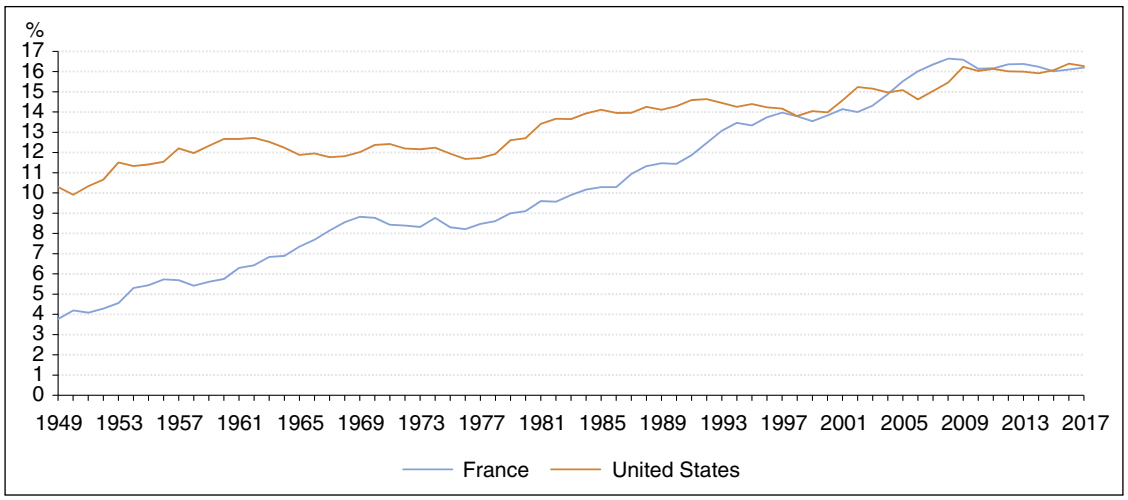
Concerning the third bias, it appears that the impact of real estate services on the labor share trend is a lot smaller in the US than in France. The reason is that, over the whole 1949-2017 period, the share of real estate services in the total value added increased by about 6 percentage points (from about 10% to about 16%) when the increase was about twice as high in France (Figure VI). This is why, contrary to France, excluding real estate services reduces the decrease of the business sector labor share but does not reverse or even cancel it. From its maximum in 1970 to its current level in 2017, the business sector labor share indicator decreased by about 12 percentage points (from 64.5% to 52.5%) for the uncorrected indicator and by about 10 percentage points (from 72% to 62%) for the corrected one. Nevertheless, for the non-financial companies, the labor share has fluctuated around a stable level of about 70% from the end of the 1940s to the early 2000s, to decrease thereafter by about 5 percentage points until the current period, this decrease being observed only before 2010. So, the labor share decrease seems confirmed in the US, but mainly during the first decade of the century, this orientation being less obvious before and after.

Figure V
Share of self-employed workers in the total employment



Sources: Insee and BEA, National Accounts. Authors' calculations.

Figure VI
Share of real estate services in the total value added



Sources: Insee and BEA, National Accounts. Authors' calculations.

Thus, the diagnosis on the labor share trend differs for France and the US. When we take into account the three biases, it appears that, in France, we do not observe any structural decrease and we could even consider that the labor share would have increased over the last two decades.

In the US, we observe a decrease after 2000. This decrease in the US labor share coincides with three other evolutions in the US economy: an increase in industry concentration, an increase in profits, and a fall in investment relative to output. Covarrubias *et al*. (2019) discuss the relative importance of competition, barriers to entry, technology, and trade. Trade plays an important role in manufacturing. Overall, however, the evidence suggests that an increase in market power in most industries in the 2000s explains the dynamics of concentration, profits, investment, and the labor share. Market power comes from rising barriers to entry, weak antitrust enforcement, and lobbying by incumbents.

The Labor Share Developments in the "Euro Area" and in Eight Other Developed Countries

We look now at the labor share orientation for eight other developed countries for which data from the STAN OECD database is available with enough details to build our indicators: Belgium, Denmark, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom. We compare the labor share evolution from the earliest possible year, and at least from 1995, to the current period for the business sector and the business sector excluding real estate services. As value added sharing between labor and capital does not really make sense in the public sector (see above), we don't comment here upon the labor share orientation in the total economy.[7] Since the orientation of the labor share does not change when financial activities are excluded from the value added, we don't comment here upon the corresponding indicator. The indicators presented below are adjusted for self-employment. Depending on the country, the last observation corresponds to 2015, 2016 or 2017. We look also at the labor share at the level of a six-countries "Euro Area" comprising Germany, France, Italy, Spain, the Netherlands and Belgium.

Figures VIII and IX present the evolution of the labor share indicators respectively in the "Euro Area" and in the eight countries. The table below presents the main results from the comparison. We have included France and the United States in this Table, to enlarge the comparison. As much as the comparison is possible (and on comparable period), the orientation of the labor share over the period in the different countries seems consistent in the total economy as well as in the business sector with the one described in recent international analyses, as for instance IMF (2017) or OECD (2018).

It appears that over the period, the labor share increased more or decreased less when real estate services are removed from the value added than when they are kept, in the "Euro Area" and in seven of the ten considered countries. The three exceptions are Belgium, the Netherlands

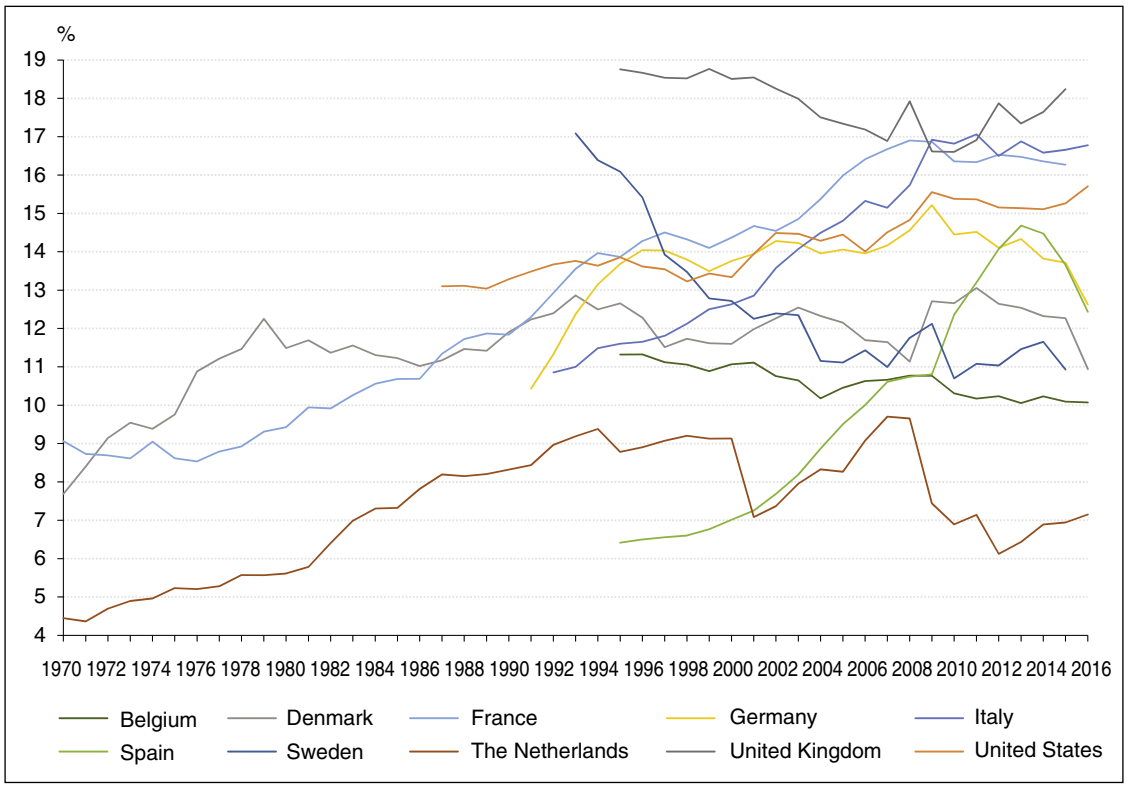
7. The labor share is always higher in the total economy than in the business sector, but the trends of the two indicators are similar in the eight countries (see Figure IX).

Table
Labor share orientation in the business sector, from the earliest year to the current period

		With real estate services		
		Decrease	Stability	Increase
Without real estate services	Decrease	Belgium Denmark Germany Netherlands United States		
	Stability	"Euro Area" France		Sweden
	Increase	Spain	Italy	United Kingdom

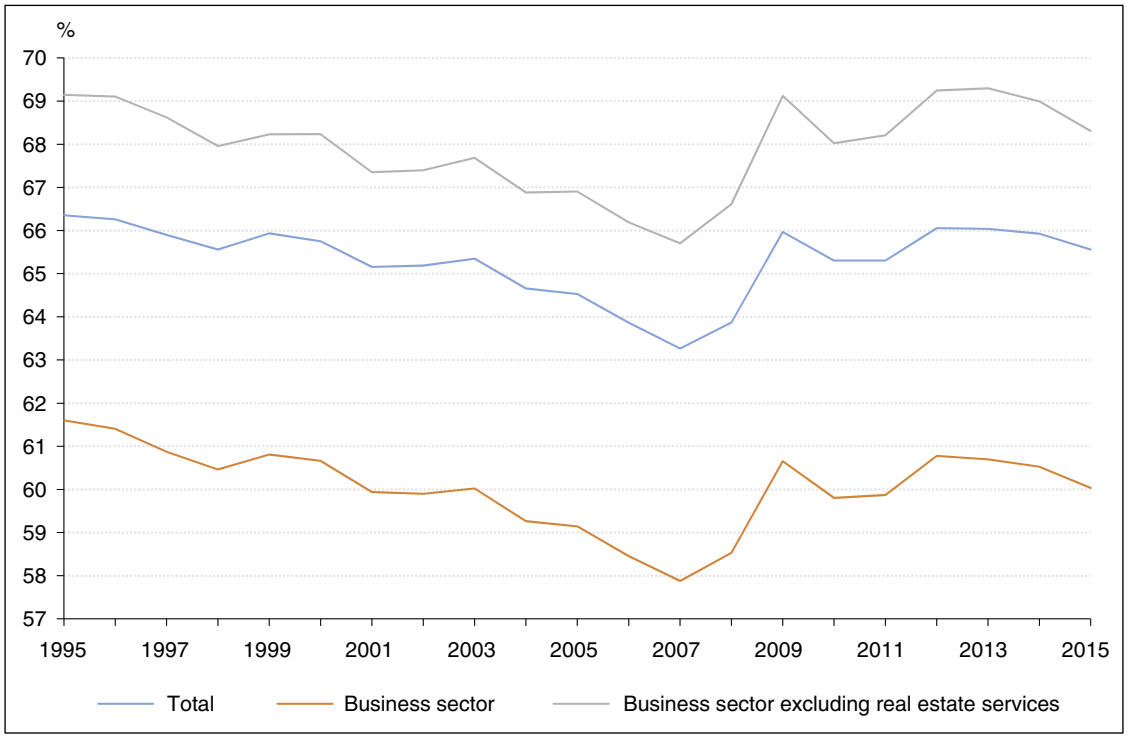
Notes: We consider that the labor share increases (decreases) if the slope of the linear trend over the available period is above (below) 0.025 (-0.025) percentage point per year. The periods considered in this table correspond to those of Figures IV and IX: 1949 to 2017 for France and the United States; 1970 to 2016 for Denmark and the Netherlands; 1992-2016 for Italy; 1993 to 2015 for Sweden; 1991-2015 for Germany; 1995-2015 for Spain and the United Kingdom and 1995-2016 for Belgium.

Figure VII
Share of real estate services in the business sector value added 1970-2016



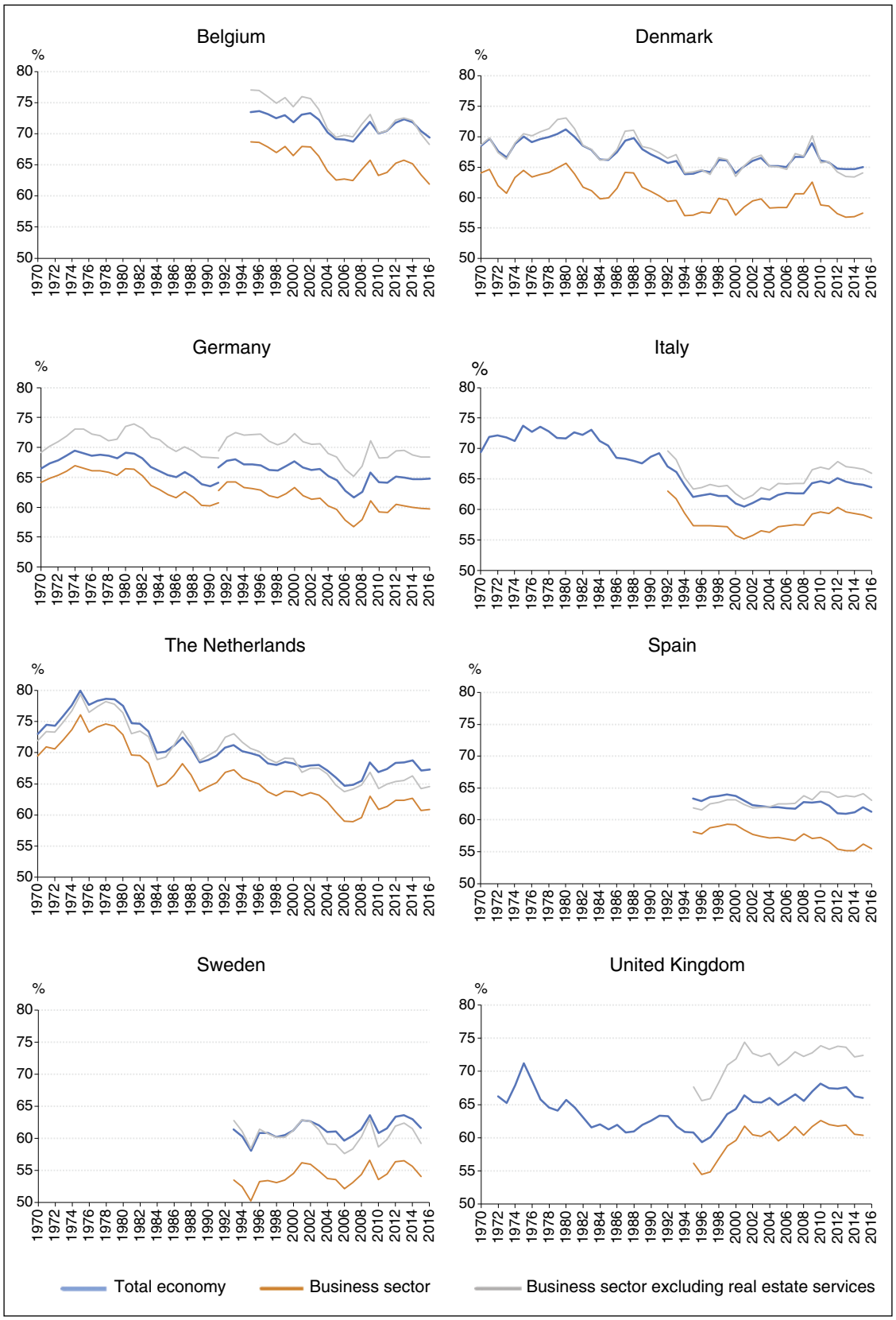
Source : OECD, STAN database. Authors' calculations.

Figure VIII
Labor share in the "Euro Area" as a percentage of the value added



Notes: The Euro Area in this figure includes Germany, France, Italy, Spain, The Netherlands and Belgium. In 2017, these six countries represented 86% of the whole Euro Area's GDP.
Sources: OECD, STAN database. Authors' calculations.

Figure IX
Labor share as a percentage of the value added



Notes: In Germany, the break corresponds to the reunification event.
Sources: OECD, STAN database. Authors' calculations.

and Sweden. This stems from the fact that in these three countries, the share of real estate services in the business sector value added decreased slightly whereas it increased in the seven other countries (cf. Figure VII). In Spain, the increase was large enough to change the sign of the labor share evolution, this evolution being, from 1995 to 2016, about -2 percentage points with real estate services kept in the value added and +2 percentage points when they are excluded. The share of real estate services in the business sector value added increased from 6.4% to 12.4% over this period in this country, which was the biggest increase observed over the ten countries in our analysis. In France, the labor share evolution changed from a decrease with real estate services kept in value added to a stability without.

For the "Euro Area" and the ten developed countries analyzed here, the orientation of the labor share in the business sector is not a general downward or upward one. With real estate services included in the value added, it is a clear downward trend in the "Euro Area" and in seven countries, a clear upward one in two countries and a quasi-stability in the last country. When real estate services are excluded from the value added, it becomes a clear downward trend in five countries, a clear upward one in three countries and a quasi-stability in the "Euro Area" and in two countries. Then, the usual diagnosis of a general downward orientation of the labor share in developed countries over the last decades is not confirmed for our dataset of ten developed countries and the "Euro Area". As commented before, even the downward trend is not so clear concerning the US. The relevant correction for real estate services decreases the number of countries for which the labor share orientation is clearly on the decrease.

* *
*

This analysis has challenged the accepted wisdom of a general labor share decline. A simple theoretical model was proposed to raise the main factors of labor share changes. The empirical analysis was carried out on a subset of the "Euro Area" and ten developed countries: Belgium, Denmark, France, Germany, Italy, The Netherlands, Spain, Sweden, the United Kingdom and the United States. For France and the United States we were able to construct measures of the labor share for the entire post-war period. For the "Euro Area" and the ten other countries, the analysis started in the 1990s.

Three important biases appear to have plagued much of the existing empirical literature: (i) the starting periods for the analysis; (ii) accounting for self-employment; and (iii) accounting for residential real estate income. When these three potential biases are set aside, the orientation of the labor share in the business sector does not appear to be a general downward or upward one. With real estate services included in the value added, it is a clear downward one in the "Euro Area" and in seven of the ten countries, a clear upward one in two countries and a quasi-stability in the last country. When real estate services are excluded from the value added, it becomes a clear downward one in five countries, a clear upward one in three countries and a quasi-stability in the "Euro Area" and in two countries.

The evolution of the labor share appears greatly influenced by the starting point chosen. This is particularly striking in Europe, where there was an increase in the labor share following the oil shocks in the 1970s. This increase may lead to interpret a return to the long-term trend being as a decline in the labor share. The second bias concerning the self-employed workers is a recurring question in the calculation of the labor share in value added. The correction we apply is classic, but it is important to keep in mind the extent of the effect this correction may have when the shares of paid and self-employed work vary, either between countries or over time.

Lastly, real estate income is a type of capital income that has important redistributive effects and must be included when analyzing income inequality. But it seems to us appropriate to exclude it to analyze the sharing of value added between labor compensation and profits. Usual explanations of labor share trends (technology, trade, market power, unionization, etc.) have nothing to do with real estate income. And as shown in this paper, excluding real estate income substantially changes the diagnosis on the labor share trends. □

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Economic Growth and Household Purchasing Power in France: Key Changes Since 1960

Didier Blanchet and Fabrice Lenseigne*

Abstract – In France, recent economic trends have rekindled the feeling of divergence between global economic growth and changes in purchasing power. Long series of national accounts help put this gap in perspective. More so than GDP, the most appropriate indicator for capturing changes in the living conditions of households is gross disposable income (GDI) per consumption unit. Several factors have combined to limit its rise since the 1960s and, despite its recent recovery, it has tended to stagnate over the last decade, as between the late 1970s and the 1980s. Overall, the picture over the past few decades is not one of a steadily rising standard of living. But national accounts do not support the hypothesis of a decline in purchasing power. Two factors may account for its perceived decline: may appear somewhat inconsistent with. However, vertical inequalities have remained relatively stable and parity in living standards between workers and pensioners has been maintained as well. It will be more difficult to achieve such a parity in the future.

JEL Classification: E01, E23, E25
Keywords: gross domestic product, household disposable income, purchasing power, inequality, ageing, pensions

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Economic growth and changes in purchasing power are central and recurring themes in social debates. The recent period has been particularly rich in discussions and controversies around trends on both fronts in a context affected by a large number of measures impacting purchasing power with varying effects depending on the population considered. One of these measures has been the shift from unemployment and health insurance contributions towards the CSG (Generalised Social Contribution), with different impacts on workers and pensioners, but also within both categories of population. Changes in indirect taxes on fuel have been another point of concern. Combined with oil price variations, they have weighed heavily on those households most dependent on cars. These changes have contributed to a perceived decline in purchasing power affecting many households.

On top of it, the abolition of the wealth tax on financial assets (in French, *impôt sur la fortune*, or ISF) and the shift from general income taxation and social security contributions to a single flat-rate tax (*prélèvement forfaitaire unique*, or PFU) of 30% on capital gains from the sale of securities have exacerbated further the sensitivity of many French people to the issue of inequality.

Both points – i.e. purchasing power and inequalities – can be confronted to GDP growth. It has remained positive, with a total of 9.5% since 2008 (1.7% for year 2018), a growth from which a majority of households do not feel they have benefited, hence a widespread perception that growth tends to be poorly measured and/or that it benefits some segments of the population more than others.

The aim of this paper is to put these current questionings into perspective by revisiting the links between household income growth and overall economic growth – in the sense of GDP – since the early 1960s. Macroeconomic series reveal findings that ultimately appear largely consistent with household perceptions, contrary to a common view that national accounts tend to be disconnected from changes in the real living conditions of the population.

GDP and Disposable Income: A Re-Examination of the Two Concepts

Some preliminary remarks are necessary to clarify the main concepts addressed in this paper, namely the nature and scope of gross domestic product and the various possible definitions of the concept of household disposable income.

GDP is an accounting construction that can be defined in several ways, the most relevant for our purposes being to view it as a measure of the net income flows generated by the productive activities carried out on the national territory, whether market or non-market activities. In accounting terms, GDP corresponds to the product of the volume of work and the apparent productivity of that work. These income flows are known as primary income, and represent the remuneration of the factors of production, capital and labour (whether employed or self-employed) used to produce.

Gross disposable income (GDI) measures what agents are left with to consume or invest after all the taxes for which they are liable (income tax, other taxes and social security contributions) and all the cash transfers they receive have been taken into account. GDI is referred to as "gross" because, like GDP, it does not take into account the depreciation of capital, but it is net of all cash transfer flows. At the level of agents taken in isolation, GDI may differ significantly from primary income. At the level of the economy as a whole, however, the concept is very close to GDP, with the gap corresponding to the flow of production income between France and the rest of the world, including the wages of cross-border workers and incoming and outgoing flows of dividends corresponding to the returns on inward and outward foreign investments.

The national accounts introduce a second definition of household GDI: "adjusted gross disposable income" (AGDI), which includes all in-kind social transfers. In-kind social transfers correspond to individual goods and services provided to households, whether these goods and services are produced by general government agencies (such as public education), purchased on the market and partially reimbursed by general government agencies (such as health care reimbursements in the private sector), or services provided by non-profit institutions serving households (NPISH). For national accountants, the aim of introducing this second definition is to make national consumption levels more comparable between countries by offsetting the impact of the same goods and services being consumed in market or non-market forms in different countries.

Changes in household GDP and primary income, as well as changes in the purchasing power of their GDI or AGDI, are the result of a set of mechanisms that are macroeconomic (working

population, general productivity gains, ratio of non-working population to total population, inflation), microeconomic (taxes and social security contributions, rules for the formation of social rights) or institutional (share of the production of non-market services provided by general government agencies). It is the interaction of all these mechanisms that drives the formation and redistribution of income.

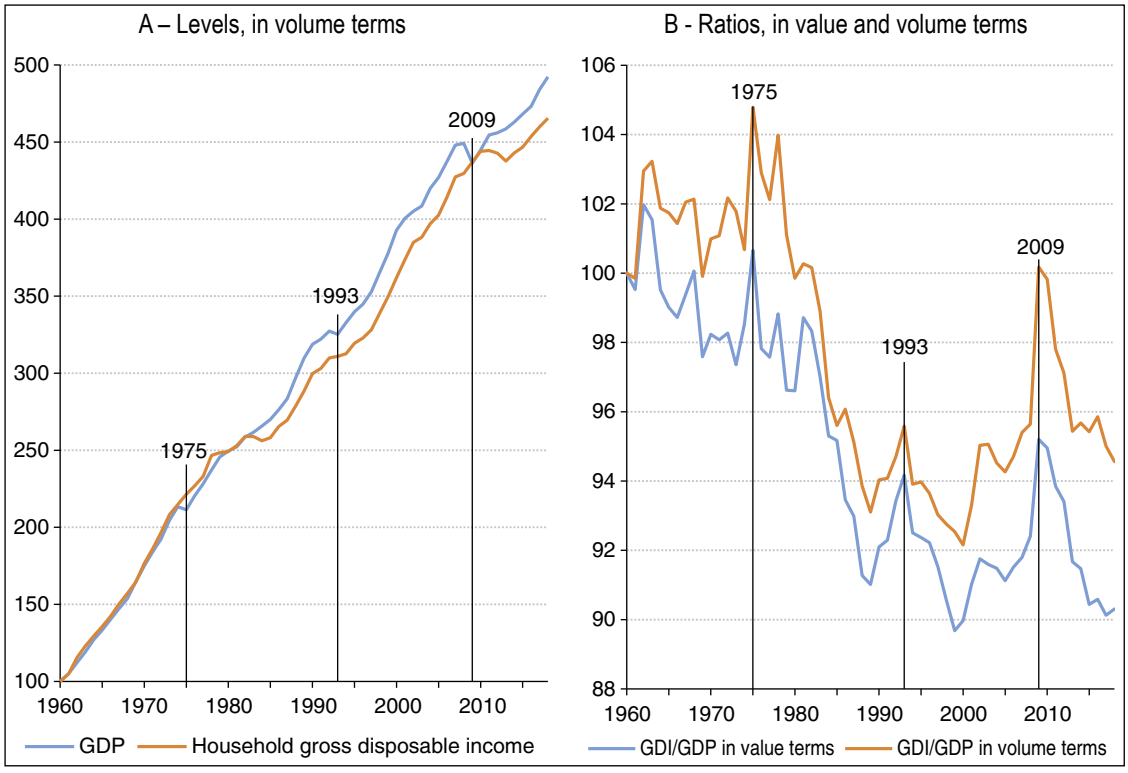
GDP and Household Gross Disposable Income in the Long Run

Since 1960, real GDP and the purchasing power of total household GDI have increased more than 4.5-fold (Figure I-A), but with a slightly smaller increase for GDI, with a cumulated gap of around 5% over the entire period, this gap being even more pronounced in nominal terms, of the order of 10% (Figure I-B). The difference between these two gaps reflects the slightly divergent trends between the deflator of GDP and household consumption prices, with a consumer price index affected by the lower growth rate of imported goods prices.

The period was also marked by three recessions, in 1975, 1993 and 2009, conventionally used to distinguish four sub-periods to which we will refer throughout the article. The first sub-period runs from 1960 to 1974 and corresponds to the second half of the post-war boom known as the "Glorious Thirty Years" – a period during which real GDP and the purchasing power of GDI showed identical trends. The first oil shock put an end to this period and triggered the beginning of a second sub-period initially marked by a more positive trend in GDI compared to GDP, which can be explained by a set of policies designed to support demand initially implemented to accomodate the shock, before the "austerity turn" (in French, the *tournant de la rigueur*) reversed these trends. The purchasing power of GDI fell most sharply during this period, before eventually returning to a trend similar to that of GDP.

The second recession episode marking the beginning of the third sub-period was the one of 1993, with a delayed response of GDI leading to a temporary recovery in the GDI/GDP ratio, albeit on a much smaller scale than in 1975. The gap between GDP and GDI trends was again very pronounced in the wake of the subprime crisis from 2008 onwards. 2008 saw a marked decline in GDP, while GDI continued on the same momentum before slowing down, only experiencing a downward trend in 2012 and 2013, then returned to a trend similar to GDP (Mahieu, 2018).

Figure I
GDP and total household GDI, base 100 in 1960



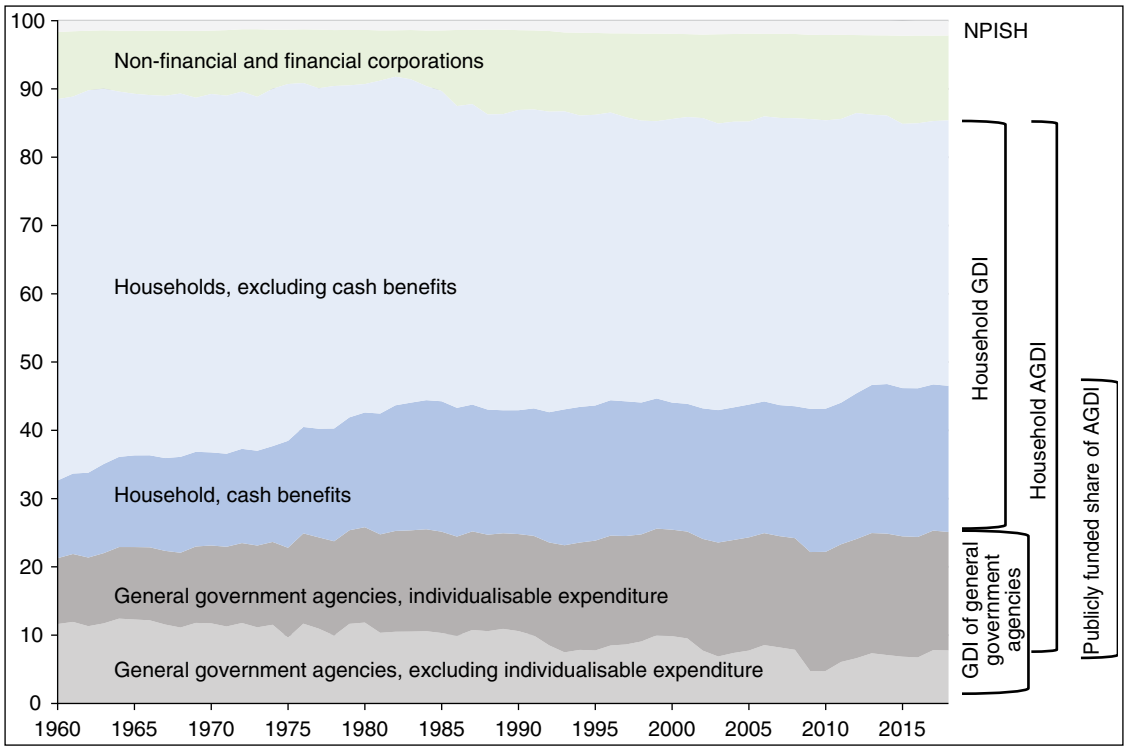
Sources: Insee, National Accounts.

The breakdown of total GDI in nominal terms by category of agent provides a basis for specifying the factors behind the relative decline in household GDI (Figure II). Excluding households, a distinction can be drawn between three groups of agents: companies (non-financial corporations and financial corporations but excluding sole proprietorships whose income is fully incorporated into household income), general government agencies and NPISHs. The share of the latter is marginal and will not be examined further. As far as companies are concerned, GDI represents the amount left over from disposable income to self-finance investment after payment of all expenses, including interest expense and shareholder remuneration. The changes observed in the share of corporate GDI in total GDI parallel those of the margin rate, as measured by the ratio of gross operating surplus to value added. This share remained stable until the first oil shock, before declining after the shock and subsequently rising again to slightly above its pre-1975 level as a result of the austerity measures introduced in the 1980s, after which it remained remarkably stable.

The post-1975 episode, although isolated, is one of the factors contributing to the structural decline in the share of GDI going to households. The decline is also explained by a broader trend related to the apparent distribution of income and consumption between households and general government agencies. It reflects the increase in public funding allocated to household final consumption, which can be brought to light by isolating two sub-components of the GDI of both households and general government agencies. Within household GDI, a distinction is made between what remains of primary income after taxes and social contributions and what goes to households in the form of cash benefits. The GDI of general government agencies corresponds to the income available to them after payment of these cash benefits. Within their GDI, a distinction can be drawn between what they use to finance the services provided to individuals, that feed into household AGDI, which therefore accrues directly to households, and what is used to finance other public expenditures (corresponding, broadly, to regalian expenses) that ultimately also benefits other agents but would only be allocable among these agents at the cost of very conventional distribution assumptions.

The increase in public funding devoted to household final consumption is observed on both sides of the "border" of their GDI (Figure II). Within this border, the share of GDI composed of cash benefits increased from 11.4% to 21.5%

Figure II
Distribution of total disposable income among the main categories of agents



Sources: Insee, National Accounts.

of the national GDI between 1960 and 2017. While neutral in terms of the level of overall GDI, when it comes to its nature, the change is relatively significant: in 2017, the distribution of GDI between net primary income and cash benefits was two-thirds to one third, vs. 83% to 17% in 1960. An identical trend is observed on the other side of the household GDI border, with the individualizable expenditures (education and health care mostly) of general government agencies rising from 9.6% to 17.4% of the economy's overall GDI. As a consequence, contrary to GDI, AGDI saw its share in the disposable income of the total economy remaining stable and even slightly increasing over the period, rising from 76.9% to 77.7% of overall GDI between 1960 and 2017. The transition to AGDI also erases the long-term impact of the increase in corporate GDI seen during the 1980s. On the other hand, there has been a decline in the income left to general government agencies to finance expenditure other than cash benefits and AGDI, one consequence of which being an increase in the use of public debt.

From Overall GDI to Average Individual GDI

These changes in the distribution of overall GDI represent very significant phenomena. However, overall, the purchasing power of household GDI increased considerably over the entire period, in a proportion very similar to that of GDP. Yet an obvious limitation of GDI thus conceived is that it operates on a macroeconomic level. Measuring global GDI is useful for macroeconomists since its changes are one of the drivers of aggregate demand, itself a determinant of employment trends, and it is precisely because of this that short-term analysts seek to monitor it. However, such changes would provide information on individual purchasing power only if the population remained constant in level and structure over time, which is not the case.

What steps can we take to develop something akin to a concept of individual purchasing power? A first option is GDI per capita. However, while it may be the easiest option to implement, it ignores the fact that living standards also depend on the distribution of the population among households. A second but irrelevant option is to calculate average GDI as a proportion of the number of households. While it may be interesting to know how much each household has at its disposal to live, if households are becoming smaller over time, it is only natural that the GDI of each household should be increasingly lower, without necessarily leading to a lower standard of living. The way living standards are affected by the gathering of individuals into households of varying sizes only goes through the economies of scale that result from living in the same dwelling. This is what is captured by the notion of consumption unit (CU), which weights individuals according to their position in the household. The scale currently used is the so-called "OECD" scale, which assigns one consumption unit to the first adult, 0.5 units to each member aged 14 and over and 0.3 units to any child aged under 14. We may therefore choose to calculate the ratio of GDI to the number of CUs.

The three types of adjustment have a significant downward impact on changes in the purchasing power of GDI (Figure III), from a multiplication of total GDI by 4.5 from 1960, we move to multiplications by 3.2 for the GDI per head, 2.8 with the GDI per CU and 2.2 per household. The intermediate adjustment using the GDI per CU will be preferred. The remaining growth continues to be significant, but shows three periods of stagnation or temporary slowdown, falling in between or following the three negative shocks to GDP seen in 1975, 1993 and 2008: a period of stagnation lasting from 1978 to 1987, a less pronounced slowdown around the 1993 shock and the current period beginning with the subprime crisis, with a level of purchasing power per consumption unit only returning to its 2007 level in 2017, despite a significant recovery at the end of the period.

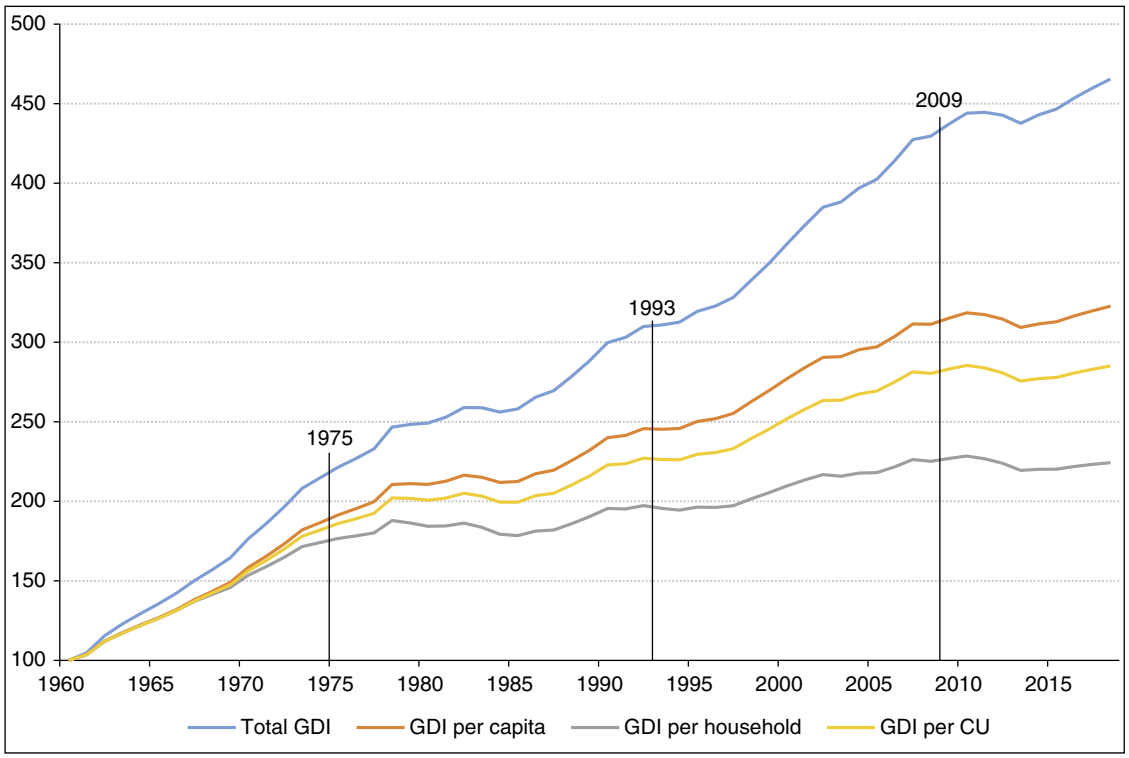
The transition from GDP to purchasing power per consumption unit can be broken down into several steps to highlight the factors that have driven this purchasing power, upwards or downwards. Several breakdowns of GDI/CU are possible. The breakdown chosen here starts with the contribution of employed people's productivity (i.e. GDP/employment), which almost invariably leads to an increase, the only exceptions being the three years of recession. Then, in order:

- The effect of the employment rate of the labour force (employment/labour force);

- The effect of the overall labour force participation rate, defined as the ratio of that labour force to the age group which, on average over the period, was the most representative of the cohorts participating in the labour market, i.e. the 20-59 age group (labour force/population aged 20-59);

- The demographic effect of the ratio of this age group to the total population (20-59 age group/total population);

Figure III
Overall GDI and alternative measures of GDI at the individual level



Sources: Insee, National Accounts.

- The effect of household composition corresponding to the ratio of the total population to the total number of consumption units (total population/total number of CUs);

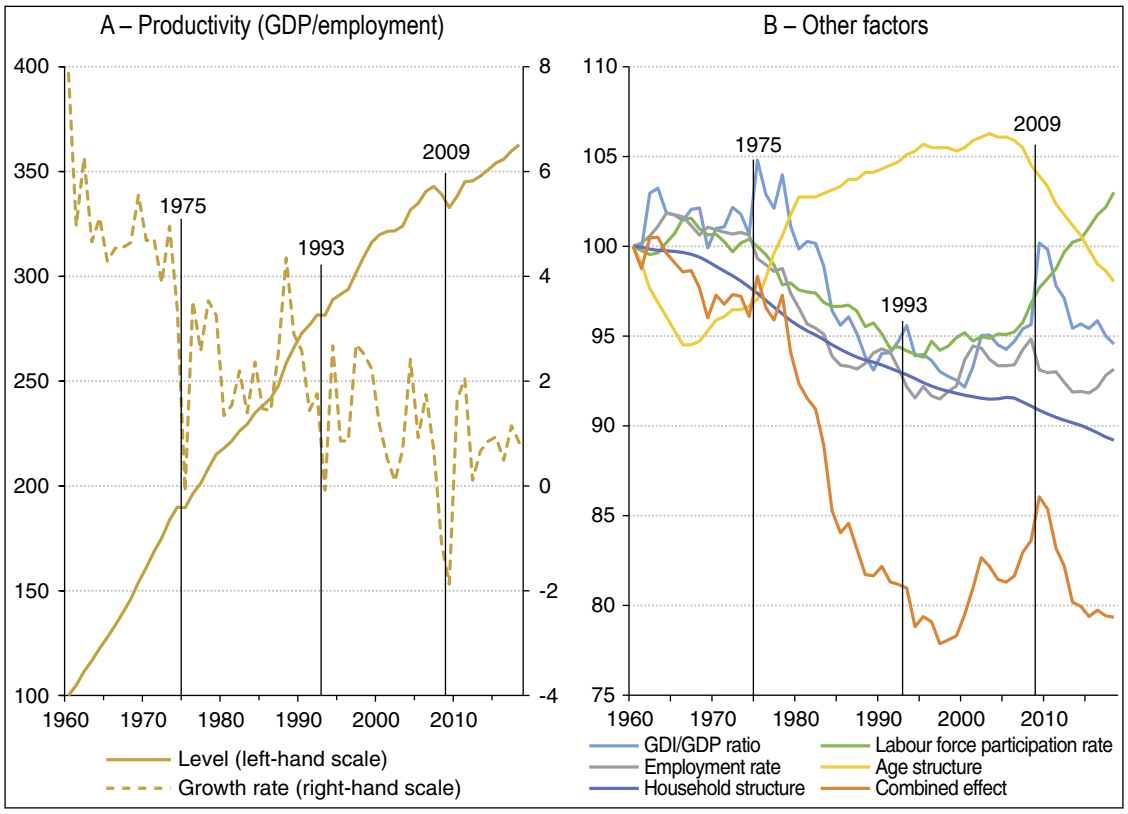
- And finally the effect of the distribution of GDP between the GDI of households and other agents, already discussed at the macroeconomic level (GDI/GDP).

The product of all these effects expressed in base 100 of 1960 gives the change in the GDI/CU ratio. Because of its magnitude, the effect of productivity is displayed separately (Figure IV-A). This is what determines the overall trend towards an increase in living standards. The ratio of GDP to the number of people in employment has increased by a factor of 3.6 since 1960, representing an average annual growth rate of 2.2%, although a gradual slowdown can be seen from one sub-period to the next: 4.5% per year between 1960 and 1974, 2.1% per year between 1974 and 1992, 1.1% between 1993 and 2018 and finally just 0.6% per year since 2008. While the downward trend in productivity is debatable, a number of factors may nonetheless be put forward, including (but not limited to): the end of the post-war adjustment period (the so-called "catch up effect" during the "Glorious Thirties"), reallocations of the economy towards sectors structurally less inclined to generate productivity gains (typically the transition from a manufacturing economy to a service economy), the hysteresis effect caused by the destruction of capital during recessionary periods (1974, 1993, 2008) and the deterioration in the allocative efficiency of production factors (reduced mobility of production factors, particularly labour, deterioration in the quality of economic policy).

Other factors played a much smaller role, within a range of between -20% and +10% cumulatively over the entire period.

The effect of household composition has tended to be downward, cutting the standard of living by around 10 points over the whole period. The effect of the dependency ratio shows a more contrasting trend. At the beginning of the period, it had a negative impact on living standards because of the high annual birth rate, the effect of which was to increase the number of young dependents. The birth rate then fell from 1975 onwards, reflecting the end of the "baby boom" era. In addition, between 1975 and 1980, the transition to retirement of the baby-bust generations born during World War I, totalling roughly half the size of the generations immediately before

Figure IV
Determinants of GDI per consumption unit



Sources: Insee, National Accounts and long employment and labour force series; authors' calculations.

and after them, meant far fewer transitions from employment to retirement, resulting in a more dynamic working-age population and a less dynamic retirement-age population. The ratio of working-age population to total population thus increased sharply over this five-year period, before plateauing until 2006, when an opposite phenomenon started to take effect: the beginning of the transition to retirement of large generations of baby boomers, a trend that is expected to continue until the mid-2030s.

The effect of the employment rate is the reverse of the evolution of the unemployment rate, increasing especially during the period of rising mass unemployment from the mid-1970s to the 1990s. The effect was to cut GDI/CU by around 9% compared to what it would have been with the near-zero unemployment rate of the early 1960s, but which is obviously no longer a credible benchmark since this was a period when the labour market and unemployment insurance operated very differently to what they have become today. Full employment corresponds to an unemployment rate of around 5%, if we refer to the levels achieved in a relatively large number of comparable countries, but with the possibility of negative resulting effects on apparent labour productivity insofar as unemployment has a greater impact on the least productive workers.

The effect of the labour force participation rate is more irregular, mixing upward trends (increase in the female participation rate) and downward trends (increase in the duration of studies) and significant fluctuations covering almost the entire period. Its first phase, which began in the late 1960s, went hand-in-hand with the implementation of Malthusian policies aimed at reducing unemployment by reducing labour supply, achieved mostly through early retirement policies and the lowering of the normal retirement age. These policies were subsequently reversed in the 1990s, and markedly so in the case of early retirement, with the employment rate of the 55-59 age group returning almost to the levels seen in the 1970s, while the increase in the normal retirement age, mainly affecting the participation rate of the 60-64 age group, was also a significant factor despite being more gradual.

Combined with the impact of the macro distribution of GDP between household GDI and that of other agents whose profiles have been discussed

above, the combined result of the four effects was a decline in GDI/CU of around 20% compared to GDP per worker employed, with the bulk of the decline occurring during the period from the first oil shock to the late 1990s.

From Average Individual GDI to GDI by Living Standard Groups

The evidence pointing to GDI per CU stagnating over the past ten years largely provides a basis for reconciling the messages about overall economic growth and perceived standard of living: the former has remained positive despite seeing a very sharp slowdown, and its positive effects had to be distributed among households comprising a growing non-working population and of smaller size, thereby limiting the benefits of the economies of scale enjoyed by larger households. The two phenomena are not unrelated since the reduction in average household size is also partly a result of demographic ageing, even if it cannot be reduced to it. The increase in the labour force participation rate was significant but not sufficient to offset these two underlying trends. Finally, over the past decade, the perception that purchasing power has stagnated has been further amplified by the up and down movement that affected the share of household GDI in the GDP or the GDI of the economy as a whole. Household GDI did not immediately adjust to the 2009 production shock. The adjustment, which occurred later, was more abrupt.

Nevertheless, aside from these cyclical episodes, GDI per consumption unit does not point to a downward trend in living standards. If such is the perception, other factors must be taken into account. One such factor could be the fact that the price measure used to deflate nominal GDI tends to underestimate real increases in prices and the cost of living. However, this thesis is based on a common confusion between the two concepts: the price index is aimed at measuring changes in baskets of goods providing a constant service over time (Box) and does not take into account changes in consumption standards that mean that people are no longer satisfied with the standard basket consumed some 50 years ago. The concept of perceived standard of living mixes these two dimensions. Determining by how much purchasing power increased between two dates and establishing the extent to which households

Box – **Price and Cost of Living, Purchasing Power and Well-Being: Fifty Years of Controversy and Some Clarifications**

What meaning should we give to the notion of a rise in purchasing power over the long term? What is meant by the fact that it appears to have increased 2.8-fold between 1960 and today? The measure of nominal income raises no major issues, involving direct and relatively reliable observations. The debate is over price measurement and its connection with the broader concept of cost of living. This is a long-standing debate, with several key moments over the last fifty years (Touchelay, 2014; Jany-Catrice, 2018, 2019). The suspicion that price increases tend to be underestimated was particularly strong during the period of high inflation in the 1970s. It was then revived by the changeover to the euro in 2002 – a changeover that had the lasting effect of widening the gap between perceived and measured inflation. Many avenues have been investigated to account for this discrepancy (Accardo *et al*., 2011), and two reports published in the late 2000s proposed to remedy the gap by broadening the range of indices put forward by Insee. It was during this period that the notion of constrained expenditure was put forward, as was the idea of communicating both on a global GDI and on GDI per consumption unit (Quinet & Ferrari, 2008; Moatti & Rochefort, 2008).

But there is also the suspicion of an inverse bias of overestimation of price increases and, therefore, an underestimation of growth. This suspicion was expressed in the US in the late 1990s by the Boskin Report, the implications of which are discussed by Lequiller (2000) for France. It has re-emerged in recent years with the debate around the mismeasurement of growth. The thesis is that the statistical system underestimates the contribution to the standard of living of new forms of production made possible by the development of the digital economy or, more generally, by the renewal of goods and services as a whole (Blanchet *et al*., 2018). In France, this position is illustrated by the work of Philippe Aghion (Aghion *et al*., 2018).

Behind all these debates and questions, there are often differences of opinion on what is the object of measurement. Measuring prices or living standards are complex subjects that can be approached in several ways. It is therefore important to clarify the object of the discussion.

The basic approach to measuring prices takes economies as given, without any consideration for the renewal or diversification of the goods produced and consumed. In this framework, there are two radically different ways of measuring price changes between two dates: the Laspeyres index and the Paasche index, which weight price changes between two dates by the quantities of goods consumed either in the first period or in the second period. Let us consider the Laspeyres index. What the index measures, and the resulting concept of purchasing power, can be interpreted very simply. The price index tells us by how much the nominal income must be increased in order to be able to consume the ➔

Box (contd.)

same quantities of goods between the first and the second period. If the index increased by 10% between the two periods, and if the nominal income increased by 30%, the implication would be that purchasing power increased by 130/110, i.e. an increase of around 20%: the new nominal income means a consumer is able to buy 20% more of everything that he or she purchased in the first period, in identical proportions.

However, this approach raises two problems. The first is that it is clearly not applicable if the list of goods changes over time: buying 20% more of all the items purchased in the first period makes no sense if some of these goods have disappeared and been replaced by others. The second problem is that even if the list of goods remains unchanged, the index ignores the fact that, in the face of variable price increases, households may redeploy their spending in a way that serves to limit the decline in living standards, at least for those goods that are substitutable for each other. This was one of the points highlighted by the Boskin Report.

The Paasche index takes into account all these redeployments since it considers the consumption structure of the second period, taking into account behavioural adjustments. But this goes too far in the other direction. Let us suppose, for example, the borderline case of a good whose price increases to such an extent that consumers stop purchasing it. While a loss of purchasing power would obviously occur, the Paasche weighting would ignore the price increase. Therefore, the truth must lie somewhere in between the messages delivered by the Laspeyres and Paasche indices. Moreover, the Paasche index is by no means better suited than the Laspeyres index when the list of goods changes over time.

Chaining has gradually emerged as a response to these two problems, becoming systematic since the 1993 edition of the System of National Accounts. By reviewing the list of goods and their weightings annually, both the renewal of goods and the effects of gradual substitution between these goods, whether substitutions between permanent goods or between successive generations of goods are taken into account. In doing so, we enter the realm of another family of price indices, the constant utility price indices (CUP; see Magnien & Pougnard, 2000; Berthier, 2003; Clerc & Coudin, 2010; Sillard, 2017), theorised since the 1930s under the alternative name of COLI or cost-of-living index (Konus, 1930). A CUP does not measure the cost of maintaining exactly the same level of consumption of each good, but rather the cost of maintaining the utility provided by the reference basket of goods over time, incorporating redeployment between existing products or new products. In broad terms, therefore, the measurement of prices over time by a CUP tells us by how much nominal budgets have to change to maintain the same level of services or utility in the face of a changing set of goods and associated prices. The increase in purchasing power is the difference between the increase in monetary income and the increase of the constant utility budget.

However, the extent to which substitution effects should or should not be taken into account remains a matter of debate. More generally, the notions of CUP and COLI have been criticised for making the concept of price index more opaque (Jany-Catrice, 2019). There has also been some reluctance among price statisticians themselves to use the term COLI explicitly since it can lead to confusion with a broader view of the concept of cost of living, which is generally the understanding of the concept found among the general public, which tends to focus on a concept of price that measures changes in the cost of the basket consumed on a "regular" basis by different types of households. The term 'constant utility price index' also has the disadvantage of suggesting a close connection between measures of living standards and well-being, which is precisely what national accountants seek to avoid.

However, these arguments do not provide sufficient grounds for abandoning this conceptual framework. On the contrary, we may argue that the framework helps to better explain the connections between the main interpretations of the concept of cost of living (Triplett, 2001).

In this case, a distinction can be made between two definitions of the concept of cost of living. The CUP and COLI are measures of the cost of living premised on two crucial assumptions that clearly define their scope: the first assumption is that preferences remain stable over time, while the second assumption is that the socio-economic environment in which individuals' choices are made also remains stable. Let us suppose that the level of demand rises to obtain a given level of satisfaction, or let us suppose a change in the external environment that requires additional expenditures. These effects will not be captured by the CUP, despite the fact that they all serve to increase the cost of living – in the broad sense, i.e. the sense in which the concept is generally understood by the public. It is this type of increase that can be measured, for example, by standard budgets that evolve over time: the spending needed to lead a life in line with the times is clearly not what it was in 1960. The use of the notion of constrained expenditure or its proxy, "pre-committed" expenditure, is based on the same idea.

A similar distinction can be drawn between the measurement of purchasing power, or living standards, and the measurement of the broader notion of well-being. Perceived well-being depends not only on objective consumption options, but also on both consumption standards, which are in constant evolution, and factors outside market exchanges that are not taken into account by standard price and income measures. Some of these external factors contribute positively to the standard of living, such as the provision of non-market public services, and this is precisely what AGDI seeks to capture. However, other general environmental factors impact negatively on the quality of life at a given level of monetary income and market prices.

This analytical framework may also help to clarify the ongoing debates over the mismeasurement of growth. These debates only make sense if we have a common definition of what we want to measure. If it is a CUP or a COLI that is being measured, the question is to check to what extent price statisticians are able to approach this benchmark. For example, statisticians generally →

Box (contd.)

assume that, in periods of coexistence on the market, the prices of the goods of successive generations are in price ratios that reflect their marginal utilities. In principle, this overlaps with the CUP approach. We can explore the extent to which this hypothesis is valid.

This framework also provides guidance on how to handle the case of new goods that are free of charge, which do not naturally fall within the scope of national accounts. The emergence of free substitutes for paid goods may be seen as a borderline case of price decline and can be approached using a constant utility approach: in the case of free goods, the question for purchasing power is to measure by how much nominal income must vary in order to benefit from the same quality of service in the absence or presence of such free goods (Brynjolfsson *et al.*, 2019). Moreover, the same kind of approach can be used, if desired, to improve the valuation of the other form of non-market goods in the accounts, namely public services.

However, we see, by contrast, how a better consideration of these new goods can fail to answer the question of trends and changes in well-being. For example, the analytical framework developed by Aghion *et al.* (2018) to demonstrate the underestimation of growth uses a representation of consumer preferences that assigns intrinsic value to the diverse range of goods offered to consumers (Khder & Lee, forthcoming). Yet it can also be argued that the multiplication of goods and services offered is precisely a factor in the evolution of preferences that serves to limit the scope of the "constant utility" approach.

Overall, the aim is not to define a single criterion for measuring living standards, but to clarify what each proposed or manageable index actually measures. The concept of the purchasing power of gross disposable income used in the national accounts focuses on a specific field – covering the field of goods and services falling within the scope of monetary exchanges – and quantifies the ability to obtain a basket of such goods that provides a service which remains roughly constant from one period to the next, with a structure of preferences that remains largely unchanged. Other approaches can then be proposed to enrich or correct this measure by taking into account other dimensions of living conditions.

translate this increase in terms of perceived standard of living represent two equally valuable, but fundamentally different, exercises. It is the former that is of interest here.

The other explanation is that an average stagnation necessarily conceals a mixture of individual downward and upward trends[1]: the negative perception of the former would outweigh the positive perception of the latter. This factor undoubtedly plays a role at the micro level.

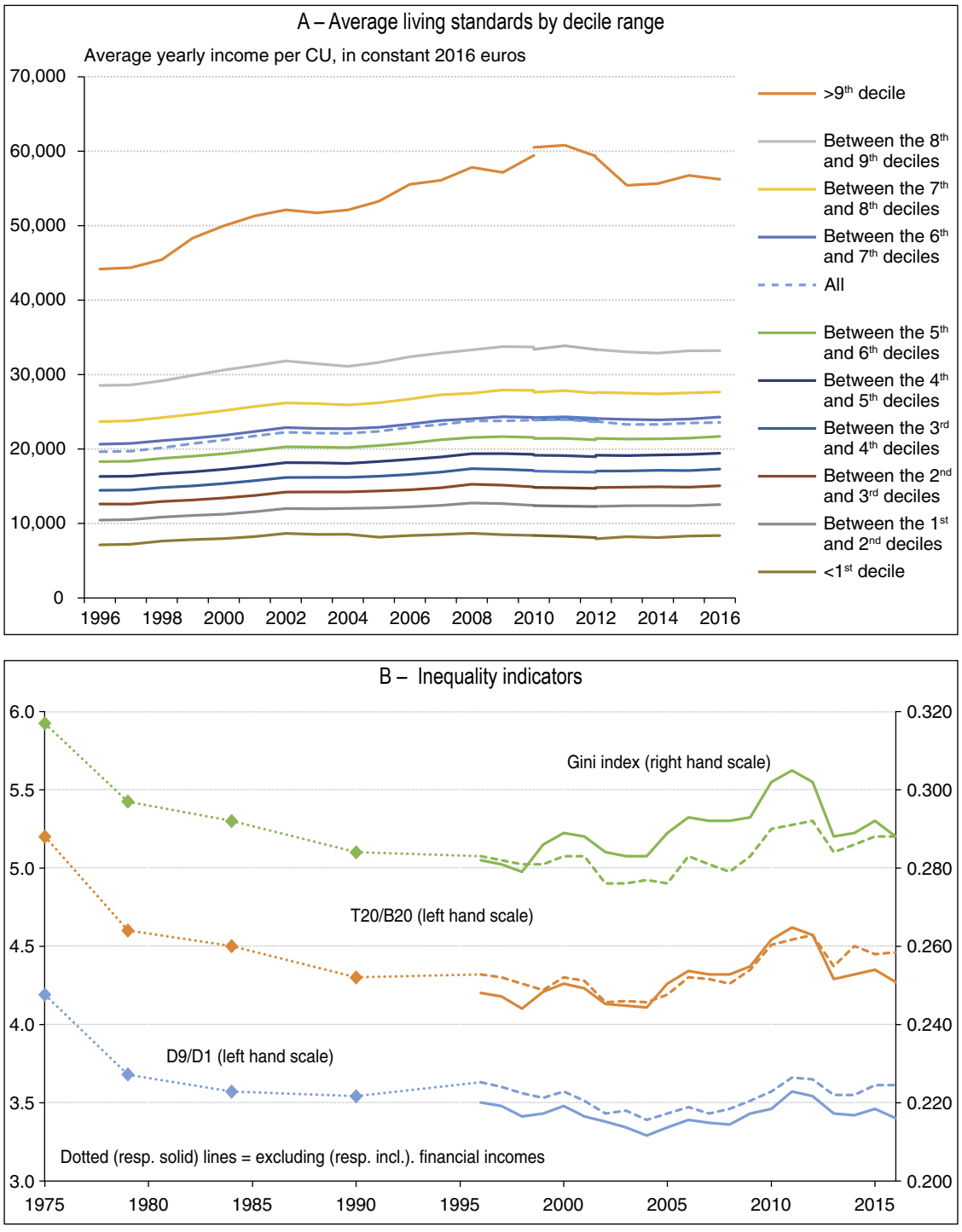
On the other hand, a secondary explanation of the perception is that average stagnation conceals a trend towards rising inequality. These inequalities may be considered according to different axes. Only two of these axes will be considered here: the vertical axis, which compares the changes in the standard of living of the least well off and the most well off, and the age axis, which is worth isolating given the role that the effects of demographic structure have played over the period and given that a major focus of recent debates over purchasing power has been the question of the relative purchasing power of pensioners.

In either case, going beyond the average requires looking at data other than those provided by national accounts, the one provided by household income statistics. The main source in France is the *enquête Revenus fiscaux et sociaux*, ERFS (or Tax and Social Incomes Survey), which uses a slightly different definition of GDI, in particular because it excludes the imputed rents of owner-occupied dwellings and is also limited to metropolitan France. However, the average changes are very similar. Figure V-A shows the change in the average standard of living and within ten interdecile ranges since 1996. Figure V-B shows various resulting inequality indicators since 1975: the ratio between the level above which we find the richest 10% and below which we find the poorest 10% (interdecile ratio D9/D1), the ratio of average living standards for the top and bottom 20% (ratio T20/B20) and also the Gini coefficient.

Over the period 1996 to 2016, the change in the average standard of living of the entire population was very similar to the changes in GDI per consumption unit reported in the national accounts, and the trends are roughly parallel for the different standard of living ranges. Thus, the interdecile ratio D9/D1 changed little over the period as a whole. However, the gaps are more pronounced if we look at the average living standards of the upper and lower deciles, with a stagnation in living standards starting a little earlier for the most disadvantaged decile (from the beginning

1. According to Accardo (2016), over the course of one year, around 25% of individuals see their income improve by 10% or more, while the same proportion see their income decrease by 10% or more.

Figure V
Distribution of living standards



Sources: Insee-DGI, *enquêtes Revenus fiscaux* from 1975 to 1990; Insee-DGI *enquêtes Revenus fiscaux et sociaux* retropolated from 1996 to 2004; Insee-DGFIP-Cnaf-Cnav-CCMSA, *enquêtes Revenus fiscaux et sociaux* from 2005 to 2016.

of the 2000s), and a relatively marked rise in the living standards of the former until the beginning of the 2010s, before a decline attributable to the changes to capital taxation introduced in 2013: their introduction into the common income tax scale is likely to have led to a change in the way shareholders are remunerated, with a decline in the share of profits directly distributed to households in favour of other forms of indirect remuneration to shareholders, including reinvestment of income in the company and share repurchases increasing the value of shareholder portfolios. An increase in corporate GDI is observed during the same period. A systematic redistribution of corporate

GDI to households in proportion to the shares held by households may neutralise some of the effects of tax optimisation, as proposed in the Distributional National Accounts methodology (Alvaredo *et al*., 2016).

In any case, with or without this neutralisation, the rise in inequality over the period remains far more limited than in most other developed countries and is far from bringing back the levels of inequality that prevailed in 1975 (Blasco & Picard, 2019). The increasing public contribution to, or socialisation of, household GDI discussed above certainly contributed to the decline in inequality in the first half of the period and to the fact that it remained contained in the second half.[2]

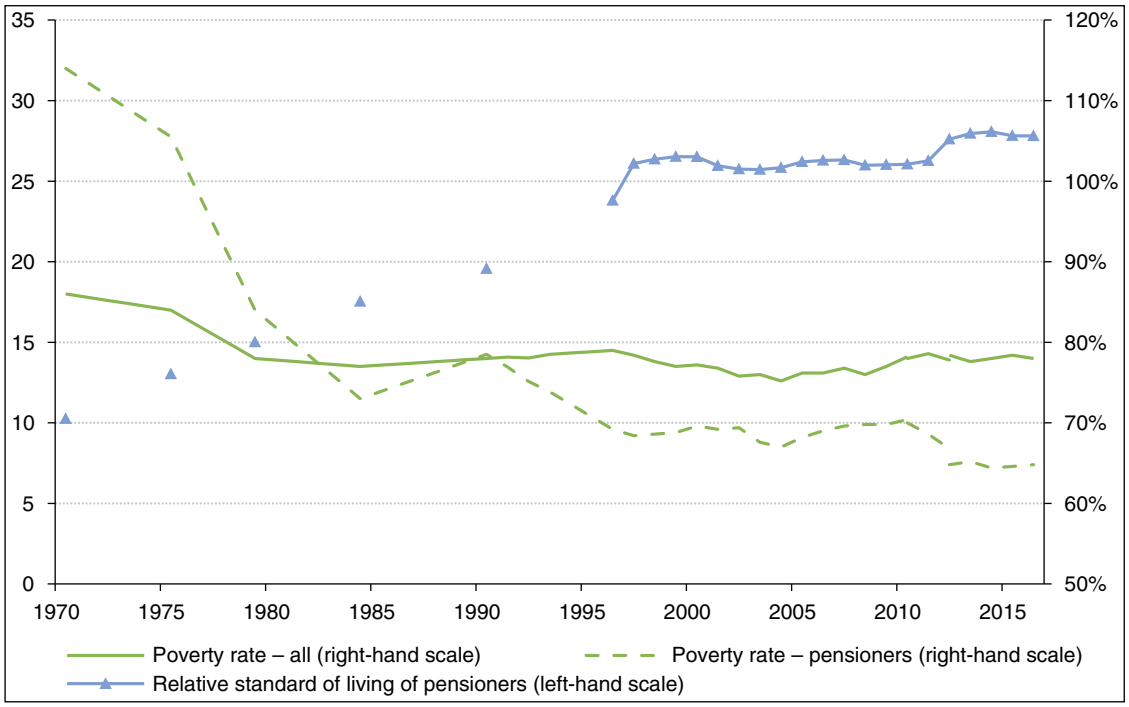
The Distribution of GDI between Workers and Pensioners: Towards the End of the *Status Quo*?

What about the age axis or, more specifically, the distinction between households whose reference person is retired and the population as a whole? Since 1996, the living standards of the two categories have been very similar (Figure VI). Of course, the observed parity in living standards is only true on average and by taking into account the number of consumption units within households. Pensions are on average lower than earned income, although retired households are smaller than younger ones. The level of pensions also varies widely, reflecting wage inequalities and career differences throughout working life. However, they provide more effective protection against the risk of poverty than for the population as a whole, a situation that contrasts sharply with the prevailing situation in the early 1970s, before the implementation of policies designed to enhance rights that simultaneously increased the relative standard of living of pensioners and reduced their poverty rate below that of the population as a whole (Blasco & Labarthe, 2018; Conseil d'orientation des retraites, 2019).

These policies, combined with the lowering of the statutory retirement age, have led to a sharp increase in the share of the provision for old-age/survival as a proportion of GDP (Figure VII), from 5 to 14 percentage points of GDP. They

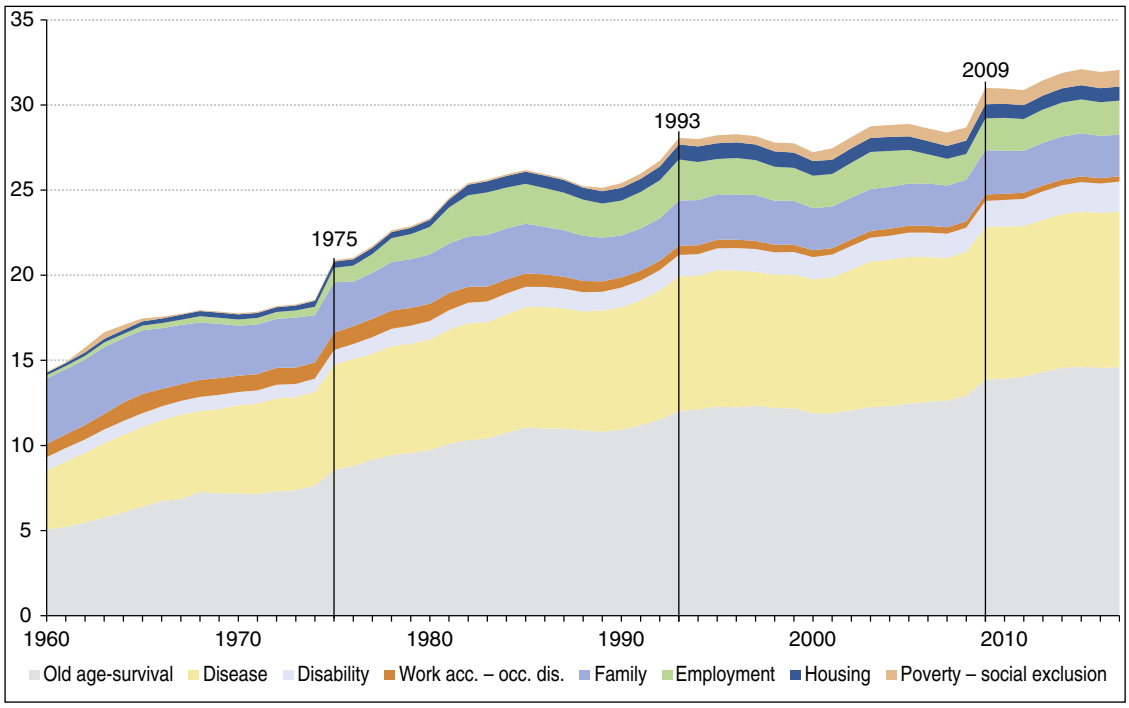
2. Over the period 1990-2015, with the allocation of undistributed corporate profits to households and a slightly different indicator, the ratio of the average income of the richest 10% to the poorest 50%, Bozio et al. *(2018) indicate near stability in France (with the ratio fluctuating around 5) and an increase of nearly 50% in the United States, with the ratio rising from 8 to just under 12.*

Figure VI
Relative standard of living and poverty rate of pensioners



Sources: Insee-DGI, *enquête Revenus fiscaux et sociaux* retropolated from 1996 to 2004; Insee-DGFiP-CNAF-CNAV-CCMSA, *enquête Revenus fiscaux et sociaux* from 2005 to 2016. Series breaks in 1996, 2010 and 2012.

Figure VII
Social expenditure as a percentage of GDP



Sources: Drees, Social Protection Accounts.

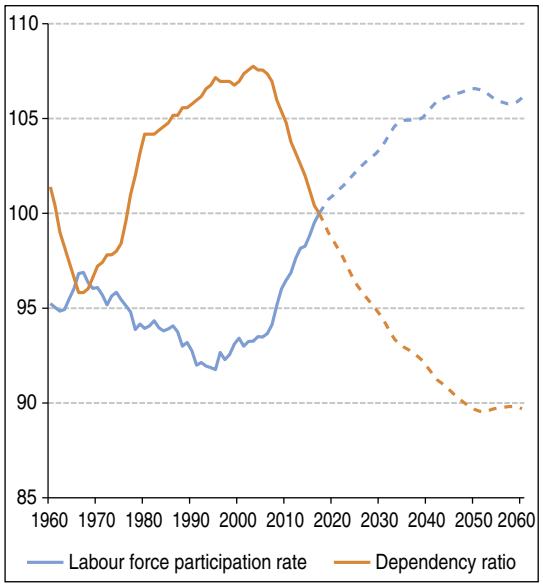
were one of the main factors driving the increase in the publicly funded share of household GDI observed above. At this stage, the progress seen has only been slowed down by the reforms introduced since the early 1990s: although significant, the increase in the retirement age has not been sufficient to offset the increase in the share of people aged 60 and over and the increase in the rights accumulated by generations increasingly enjoying full careers.

The Future of Purchasing Power: Some Questions

Of all the matters presented here, the issue of pensions is the topic that lends itself most easily to prospective analysis. It may be presented in the terms already used in Figure IV-B. Among the factors accounting for GDI per CU used in this figure, we can rely on projections of the demographic ratio up to 2070 (Blanpain & Buisson, 2016). Labour force projections (Koubi & Marrakchi, 2018) are also available, and can be used to forecast changes in the employment-to-population ratio for the 20-59 age group, under the conventional assumption of a constant unemployment rate. These labour force projections incorporate the effects of pension reforms on the employment rate of older workers, with the retirement age expected to tend towards 64 or 65 in the long term and employment rates before that effective retirement age assumed to reflect this lag, assuming that it is the distance to the retirement age rather than the age itself which, in the long term, determines the labour force participation of senior workers (Hairault *et al.*, 2006).

With a new base of 100 in 2018, we see that the effect of the retirement of successive generations of baby boomers continues, gradually softening until 2035 (Figure VIII) – a negative effect only partially offset by the expected increase in the labour force participation rate. Cumulatively, the combined effect of the age structure and the employment rate represents a drop of around five percentage points in terms of living standards in the long term. This would represent a decline in purchasing power for the entire population if it were distributed equally across the population as a whole. With reforms aimed at stabilising the share of pensions in GDP, the adjustment will affect pensioners alone and, being carried over to a population representing around a quarter of the total population, it is automatically four times higher. This is the figure resulting from the various existing simulations of the effects of the reforms on the standard of living of pensioners, the intensity of the effects nevertheless depending strongly on the assumption of future productivity

Figure VIII
Contributions of the employment rate and demographic dependency ratio to changes in average GDI per CU



Source : Blanpain & Buisson, 2016 ; Koubi & Marrakchi, 2017; calculs des auteurs.

growth. The reason is that the decline in the relative purchasing power of pensioners is mainly due to the indexation of the main parameters of the system on prices, the impact of which is weaker or stronger depending on whether growth is rapid or slow (Marino, 2013; Conseil d'orientation des retraites, 2019). The decline in the purchasing power of pensioners is lower if growth is lower, but is more pronounced with a faster growth rate, even leading to a decline in the level of pensions as a share of GDP. Basically, the alternative is between an increasing share of a slowly growing cake along with the associated tax increases and a stable or decreasing share of a faster growing cake.

* *
*

The issue of income distribution between workers and pensioners is just one of the issues raised by the future of purchasing power, but it is very illustrative of the tensions we can expect to see over the coming decades. When pensions first emerged as a major issue in social debates in the early 1990s, it was widely believed that productivity gains could make the solution painless. What was and remains a valid projection is that by 2040 the number of pensioners will double compared to a roughly constant working population. However, the prospect of seeing productivity also doubling over the same horizon was not unrealistic. Therefore, this suggested that it was possible to guarantee the same standard of living for twice as many pensioners without the need to increase contribution rates or the retirement age. But this ignored that what is expected of a pension system and, more generally, of the entire system of transfers is to meet targets of relative standards of living for all the groups concerned by redistribution.

But there has been more than that. The growth rate has weakened steadily throughout the period under review. Over the last decade, it has only just managed to maintain the average standard of living, despite the rise in labour force participation rates: the issues of absolute and relative living standards have thus come to overlap. Income levels tending to stagnate on average or within large population groups necessarily mean both absolute and relative declines in living standards affecting part of the population, except in a world where relative individual positions would be perfectly constant.

Would a return to productivity gains at a faster pace help to ease this pressure? This prospect seems highly uncertain, especially since the question also arises as to the nature of these productivity gains. Some of the sources of activity that are generally thought of when describing what future growth will look like are relatively different from the factors that drove growth during the "Glorious Thirty Years". During this period, growth mainly consisted in producing a growing range of goods while using more labour-saving methods and with a limited concern for the externalities induced by such production. It has already been pointed out how the impact on perceived well-being has largely been cushioned by the fact that changes in the supply of goods and services led to similar changes in consumption standards: herein lies the difference between the concepts of purchasing power and standard of living. This factor is expected to continue to weigh on perceptions of living standards.

However, another factor is that future production will also in part be compelled to reduce the negative external effects of growth, in the form of what national accountants call defensive expenditures, i.e. activities that do not improve well-being but prevent it from deteriorating. The accounting and conceptual framework used in this retrospective analysis should provide a basis to explain the ambiguity of future growth: more constrained

expenditure, or collective expenditure that is difficult to individualise and whose financing will tend to widen the gap between household GDI, AGDI and production as measured by GDP, whether this financing requires increases in direct or indirect taxes. This type of tension, which has fuelled the social debate over the past year, is likely to continue. □

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Income and Wealth Inequality in France: Developments and Links over the Long Term

Bertrand Garbinti* and Jonathan Goupille-Lebret**

Abstract – This article sheds light on the long-term development of income and wealth inequality and the link between them in France. Following a sharp decline in inequality that began at the beginning of the First World War, a trend towards inequality has emerged (and continues) since the mid-1980s. The historical perspective makes it possible to illustrate how small changes in inequality in savings, returns or earnings can have strong long-term effects on wealth concentration. Two other major trends have been observed since the 1970s. One is the narrowing of the gap in labour income between men and women – although it remains high. The other is the increased difficulty, for those who only have access to labour income, to access the highest wealth brackets. Finally, our comparisons between France and the United States show that wealth and income inequalities were comparable or even lower in the United States before the 1970s. That country has since become much more unequal.

JEL Classification: D31, E01, E21, N3
Keywords: income inequality, wealth inequality, gender inequality

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The issue of income and wealth distribution has become of primary importance for researchers, policy makers and citizens. The issue serves as the prism through which debates on meritocracy, equal opportunities and social justice, notions that are at the heart of the French social model, are focused.

Studying the development of wealth and income inequalities is a difficult exercise, due to the multitude of factors involved. Inequalities are partly the result of individual decisions: thus we can consider labour supply behaviours over the life cycle, choices in terms of savings, investment and wealth transfer, and portfolio choices. They are also influenced by major social, economic and technological changes in society. These changes may be sudden and temporary (world wars and industrial and financial revolutions or crises), but they may also be part of slower developments, reflecting trade union struggles or more structural changes in our societies, such as the democratisation of the education system or the development of paid work among women. Finally, they may result from active public policies (regulation and deregulation of the capital market, development of compulsory contributions and minimum social standards and minimum wage). All these factors are likely to affect the degree of income and wealth inequality and the perception thereof in our society in different proportions and over different time periods.

Understanding and analysing the development of economic inequality therefore requires placing them in a precise economic, historical and social context and understanding their dynamics. This article on income and wealth inequalities forms part of this approach and provides an overview of their long-term development in France.[1] The analysis is mainly based on two recent articles by Garbinti *et al*. (2016; 2018). It is also based on work by Piketty (2001) and Piketty *et al*. (2006, 2014, 2018), which provide additional insights into these developments. Finally, we use the American series created by Saez & Zucman (2016) and Piketty *et al*. (2018) to compare the trajectories of income and wealth inequality in France and the United States. This article is an opportunity to present several important results and to put them into perspective.

First of all, the First World War marks the beginning of a significant reduction in wealth and income inequalities due to the combination of economic and political shocks of unexpected magnitude. Then, since the mid-1980s, we see a return of the concentration of wealth and the soaring of the highest salaries. However, the wealthiest individuals and the highest paid workers are far from forming a homogeneous group and, since 1970, we witness an increasingly significant dichotomy between the highest fortunes and the highest labour incomes. In particular, it has become increasingly difficult to access the highest wealth brackets with only labour income. In addition, since the 1970s, the inequality of labour income between men and women has steadily declined, as a result of women's increasing participation in the labour market. However, this inequality remains significant due to women's still very limited access to the highest salaries.

Finally, wealth and income inequalities were comparable or even lower in the United States before the 1970s. That country has since become much more unequal. Furthermore, even though national income per adult is 30% higher in the United States, this does not mean that the entire population there benefits from better salaries: the income received by the poorest 50% in the United States is significantly lower than that received by the poorest 50% of the French population.

The rest of the article begins with a review of the concepts, data and methods, then the subsequent sections are devoted successively to changes in wealth, changes in national pre-tax national income, the development of the link between income and wealth; a final section is dedicated to the comparison with the United States.

Concepts, Data and Methodology[2]

Concepts of Income and Wealth

The series presented here are based on national accounts concepts. The reason for this choice is not that we believe that the national accounts concepts are perfect, but rather that it is the only existing framework within which the concepts

1. See Atkinson & Bourguignon (2000; 2015), Atkinson et al. *(2011) and Zucman (2019) for reviews of the international literature on long-term inequality.*

2. We present in the most overarching and accessible way possible a summary of the methods used to create historical series of income and wealth. A more detailed presentation of the methodology is provided in the Online complement C2. Link to the Online complements at the end of the article.

of income and wealth are defined consistently on an international basis.[3]

National pre-tax income (abbreviated as pre-tax income hereinafter) is our base concept for studying the distribution of income received. It is equal to the sum of labour, capital and replacement income (retirement pensions and unemployment benefits) before taking into account taxes, duties and transfers.[4] To avoid double counting, social contributions financing replacement income are deducted from labour income.

The concept of wealth used is that of personal net wealth. It is defined as the sum of financial and non-financial assets, minus debt, held by the household sector in the national accounts and it is measured based on a breakdown into seven asset classes: non-financial assets are separated into professional assets and property assets, with the latter then being separated into residential property and rental property. Financial assets are separated into four categories: deposits (including current accounts), liabilities (including loans), shares and life insurances.

Wealth and income are calculated for individual adults (over 18 years old). Income and wealth inequality can be represented according to three alternative approaches to the observation unit: inequality between households, inequality between adults and an intermediate level between these two polar opposites, which we call "equal-split adults". For couples, it consists in allocating half of the wealth and income to each partner. This is what we have chosen here. Representing inequality between households can, in effect, be problematic when seeking to study the development of inequality in the long term or between countries, because the comparison of different sized households can artificially generate a higher level of inequality (or lower, depending on the ratios of couples and singles). Representing inequality between adults seeks to correct this bias. However, this approach implies the absence of redistribution of income and wealth within couples. The concept of equal-split adults, in accordance with which income and wealth are divided equally between partners, makes it possible to overcome these limits and is, therefore, our reference observation unit.[5] It is worth noting that the selection of the most appropriate observation unit depends on the type of inequality studied. When we present the development of inequality of labour income between men and women, the most appropriate observation unit will be the labour income actually received, individually, by each member of the household.[6]

Data and Methodology

The construction of the series presented in this article is based on several data sources and methodologies, which are detailed together with the hypotheses, variants and robustness checks in the two reference articles (Garbinti *et al*., 2016, 2018). Here, we present only a summary version.[7]

First, the construction of the national income and wealth series for the years 1970-2014 is mainly based on the use of the tax micro-data available since 1970. They make it possible to obtain the distribution of taxable incomes at individual level. This "taxable income" does not correspond exactly with the national pre-tax income. The difference between the two comes from three components (untaxed labour income, untaxed capital income and taxes on production), which are imputed to correspond to flows measured in national accounts. The wealth series are obtained by combining the capitalization method

3. These concepts are defined directly based on the international System of National Accounts (SNA 2008). A more comprehensive presentation of the concepts used can be found in Alvaredo et al. *(2016).*

4. It is important to note that this concept of income, which is consistent with that of national income in national accounts, includes undistributed corporate income. Indeed, the profits of companies may be distributed (in the form of dividends) or not distributed. Not taking into account undistributed profits would overlook such income generated by the economy, which may or may not be distributed for tax-related reasons. Given the differences in taxation between countries and variations over time, it seems preferable that a long-term view does not exclude such income. Between 1990 and 2014, undistributed corporate financial income represents an average of 2.9% of national income (2.2% between 1970 and 2014). Such income is negative after the second oil crisis (-1.1% on average between 1980 and 1983) and then virtually nil between 2012 and 2014 (0.3%). When said income is negative, it decreases capital income (which leads to a reduction in inequality, since the holders of such income are the wealthiest) and, when it is positive, it increases capital income. Financial income and, in particular, undistributed income, have contributed to the rise in inequality seen between 1984 and 2008 (see Online complements, Figure C2-IX). Link to the Online complements at the end of the article.

5. Figure C2-VIII in Online complements makes it possible to compare the development of inequality according to the observation unit selected (household, adult, "equal-split" adult). Income inequality among "equal-split" adults is always lower than inequality between households and between adults and, therefore, constitute a lower limit. There are other ways to distribute income and wealth within the household, by taking into account, for example, special marital arrangement, the division of household chores and childcare, economies of scale, etc. However, the introduction of such approaches would go far beyond the framework of this article.

6. Other concepts, which are not presented here, are also used to check the robustness of the results: we have also calculated series by taxable household and series taking into account individual labour incomes, with the equal-split then being applied only to capital income.

7. More detailed versions that provide a more comprehensive presentation of the assumptions made can be found in Garbinti et al. *(2016; 2018). The codes are also available online: https://wid.world/document/b-garbinti-j-goupille-t-piketty-data-files-wealth-concentration-france-1800-2014-methods-estimates-simulations-2016/ and https://wid.world/document/data-files-income-inequality-france-1900-2014-evidence-distributional-national-accounts-dina-wid-world-working-paper-201704/.*

and allocations from survey data. The so-called capitalization method makes it possible to reconstruct asset amounts based on the capital flows observed in income tax returns and the corresponding asset amounts observed in the national accounts. This method can only be used for capital income reported in the income tax returns and, therefore, cannot be used to impute amounts from principal residences, life insurance and current accounts. The use of Insee's Wealth survey (*enquête Patrimoine*) and Housing survey (*enquête Logement*) makes it possible to allocate these assets according to the characteristics of the households, using a method similar to "hot-deck" methods (see Online complements).

Before 1970, the national income series were based on income tax income tabulations produced annually since 1915 by the French Ministry of Finance. These tabulations make it possible to produce series based on the non-parametric Pareto interpolation method developed by Blanchet *et al*. (2017).

Lastly, the wealth series from between 1800 and 1970 are very broadly based on the series developed by Piketty *et al*. (2006). They are the result of work using inheritance data together with a traditional method in the literature (known as the "estate multiplier" method) that makes it possible to deduce the wealth of living individuals based on that of the deceased.

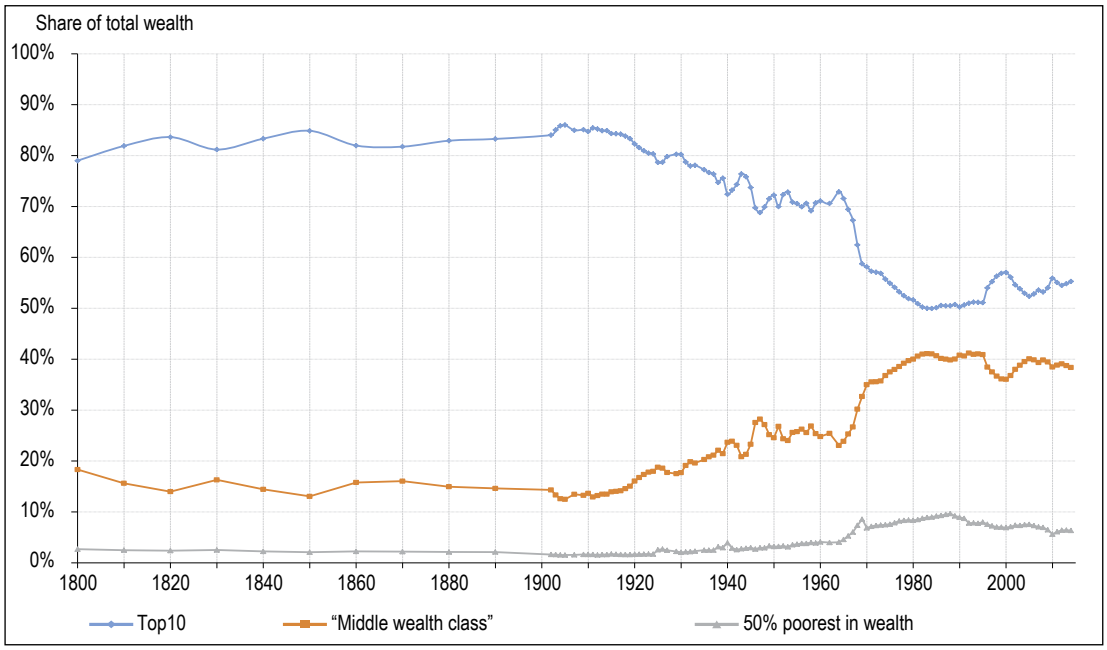
There are multiple benefits to the various methods developed. Firstly, they make it possible to create series that offer a long-term perspective on the development of wealth and income inequalities in France. We present those results first. Then, from 1970 onwards, it is possible to enrich the analysis by studying the joint development of income and wealth. Finally, the consistency of the series with national accounts allows comparisons between countries and we use this characteristic to compare the long-term developments of inequality in France and the United States.

Wealth Inequality 1800-2014

Figure I shows the long-term development of wealth inequality (1800-2014). It represents the total shares[8] of wealth owned by three

8. This Figure, as others after, presents shares. To complete this information and better illustrate the magnitude of inequalities, levels (of assets, income) are provided in the reading notes.

Figure I
Concentration of wealth in France, 1800-2014



Reading note: The share of total wealth held by the Top10 (the wealthiest 10% individuals) was around 80% throughout the 19th century, then fell from 85% in 1910 to 50% in the mid-1980s. In 2014, the average net wealth per adult is €197,000, and on average €1,075,000 for the Top10, €25,000 for the 50% poorest in wealth and €189,000 for the "middle wealth class" (defined as the 40% of individuals whose wealth is between the poorest 50% and the richest 10%).
Sources: Data and graph from Garbinti *et al.* (2016).

population groups: the most wealthy 10% of individuals (called the Top10), the 50% of individuals at the bottom of the distribution (called "50% poorest in wealth") and the 40% of individuals situated between these two groups (called the "middle wealth class").

Three periods appear clearly. Throughout the 19th century and until 1914, an extreme level of wealth concentration persists. The richest 10% hold almost 80% of the total wealth, while the poorest 90% share the rest of the wealth. Therefore, there is no middle class yet.

The First World War marked the beginning of a period of sharp decline in inequality. This change is spectacular: the share of wealth held by the richest 10% decreases from 85% in 1910 to 50% in the mid-1980s. At the same time, the share held by the middle wealth class increases sharply, from 14% to 41%. This striking decrease in inequality between those two dates actually corresponds to two distinct periods and different mechanisms. During the interwar period, the wealth of the richest is subjected to a serie of major negative shocks: destruction of capital during the conflicts, development of progressive taxation on income and inheritances, periods of depression and inflation.[9] The wealth of the middle class also decreases, but proportionally less than that of the wealthiest, which automatically results in a reduction of inequality. From 1945 onwards, and more particularly from 1968 onwards, there is a different trend at work. The wealth of these two groups increases, but that of the middle wealth class increases more quickly than that of the wealthiest. Following the events of 1968, wage growth and the decline in the wage hierarchy lead to a greater capacity to accumulate wealth for the middle class (see below).

The decline of inequality that began at the beginning of the 20th century ends in the mid-1980s. Then, the share of wealth held by the richest 1% increases continuously.[10] This trend reversal coincides with the deregulation of the financial markets and, more broadly, the so-called "3-D" (Disintermediation, Decompartmentalisation and Deregulation[11]) policies introduced in the early 1980s. This results in a sharp increase in the weighting of financial assets within the total wealth[12] and within the wealth of the wealthiest (Figure II). Financial assets become predominant at the top of the distribution of wealth from the 1990s[13] onwards, while housing remains the main asset held by the middle wealth class. This strong polarisation of the composition of wealth causes significant short-term fluctuations. Indeed, the level of inequality is increasingly sensitive to the changes in the differential price of these assets (property *vs* financial). This appears clearly around the 2000s, when the CAC 40 reaches its historical high before collapsing following the bursting of the internet bubble, whereas housing prices continue to rise. The increase in housing prices, together with the negative shock affecting financial assets, results in a decrease in inequality between the middle wealth class and the wealthiest individuals. However, the effect is ambiguous and there is no way to conclude that any increase in property prices is a positive factor in reducing inequality. In fact, though an increase in housing prices seems to automatically "enrich" households that are already homeowners, it also acts as an obstacle to access to ownership for households that are not homeowners, in particular for the youngest.[14] Another effect, highlighted in particular by Carbonnier (2015), is that housing bubbles, through their impact on the price of the middle class's main residence, result in an artificial decrease in the measured inequality.

We have seen that the dynamics of wealth inequality have been strongly affected by the historical, political and economic events throughout the 20th century. To better understand the underlying economic mechanisms, we use a simple formula that breaks down the determining factors of the level of long-term wealth inequality (Box). This formula makes it possible to illustrate the role of three key factors in the development of wealth concentration: inequality in labour income, in the rates of return of assets and in saving rates. The aim of this exercise is not to predict the future but to understand the main factors driving the

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9. Piketty et al. *(2018) show the important role of the introduction of progressive taxation on the end of the "rentier society" that prevailed in Paris in the 19th century.*

10. Based on Wealth surveys (not adjusted to national accounts), Chaput et al. *(2011) also find an increase in inequality in France between 2004 and 2011. More recently, Ferrante* et al. *(2016) find a slight fall in gross wealth inequality between 2010 and 2014, which is also consistent with our series, which show a certain stability in net wealth between those two dates (the share of the Top10 decreases from 56% in 2010 to 55% in 2014).*

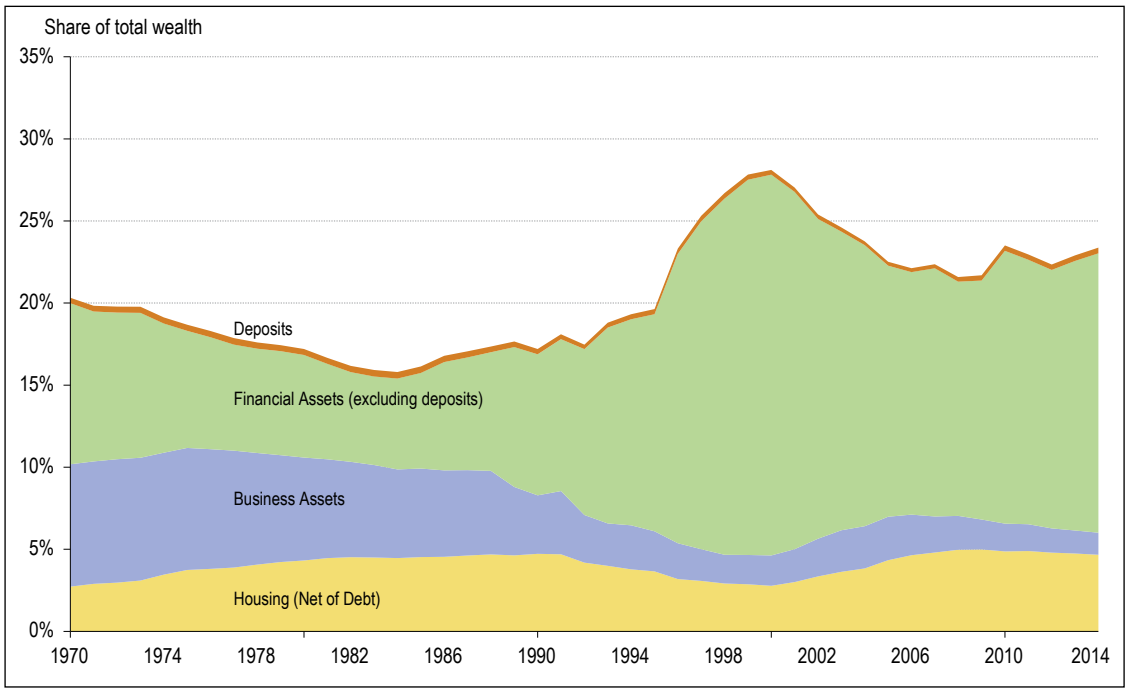
11. According to the expression coined by Bourguignat (1986).

12. See Online complements, Figure C2-I.

13. This increase occurs in parallel with the increase in the power of life insurance within the French economy. See, for example, Goupille-Lebret & Infante (2017) for further details.

14. See, for example, Bonnet et al. *(2018) who show that the share of homeowners among the most underprivileged young households has fallen since the 1970s while it has increased among the wealthiest.*

Figure II
Breakdown of the share of wealth of the Top 1% in France, 1970-2014



Reading note: From the 1990s onwards, the weight of financial assets in the total assets of the Top 1% (the wealthiest 1% individuals) became predominant. In 2014, the net wealth per adult in the Top 1% is €4,614,000.
Sources: Data and graph from Garbinti *et al.* (2016).

change in inequality dynamics that occurred in the mid-1980s. We study the development of these factors since 1970 before focusing on their impact on the level of long-term wealth inequality.

The share of labour income held by individuals in the Top10 has changed little. Between 1970 and 2014, the latter possess around 18% of the total wealth. Likewise, differences in returns between the portfolios of different wealth groups appear stable over this period (see Online complements, Figure C1-II). The wealthiest achieve higher returns, due to portfolio differences – for example, they have more financial assets with higher returns than deposit accounts or housing assets. However, the difference in returns with the other groups is constant over time. In contrast, the synthetic saving rates developed very differently before and after 1980. It is no surprise that saving rates differ according to wealth groups, with the richest saving more (see Online complements, Figure C2-III). However, although the difference between the saving rates of the Top10 and the rest of the population appears constant until the mid-1980s, it then widens with the rise in the saving rate of the richest individuals, while that of the rest of the population decreases. The poorest 90% (in terms of wealth) save more during the 1970s than from the mid-1980s, with the poorest 50% even having a saving rate of virtually zero. This structural change appears to be an important element in explaining the increase in wealth concentration that has occurred since the 1980s. Saez & Zucman (2016) observe the same type of change in saving rates in the United States.

A significant limitation of our approach is that it does not make it possible to establish a precise diagnosis of the changes in these synthetic saving rates. In Online complement C1, we propose several elements to provide an explanation; however, our data are insufficient to fully investigate this issue.

We then use the values calculated for saving rates, rates of return and labour income inequality to simulate the inequality trajectories predicted by our formula (Box). A first simulation predicts the level of inequality that would be reached if the average values observed over the 1984-2014 period were to persist (Figure III). The upward trend in inequality previously observed would then continue in a constant manner, until a particularly high level

Box – **Wealth Inequality in a Stationary Equilibrium**

The change in the wealth of a wealth group *p* (for example, the Top10 if *p*=10%) can be shown using the following accumulation equation:

$$W_{t+1}^{p} = \left(1+q_t^p\right)\left[W_t^p + s_t^p\left(Y_{Lt}^p + r_t^p\, W_t^p\right)\right]$$

where W_t^p and W_{t+1}^p denote the average wealth in *t* and *t*+1 of the wealth group *p*, Y_{Lt}^p denotes their average labour income in *t*, r_t^p denotes the average rate of return of their portfolio, q_t^p denotes the average capital gains rate (defined as the difference between the average increase in the price of the assets and inflation) and s_t^p denotes the synthetic saving rate in *t*. This equation makes it possible to calculate the synthetic saving rates based on other values observed.

Garbinti *et al*. (2016) derive the following formula based on this equation, which reflects long-term wealth inequality or wealth inequality in a stationary equilibrium (defined in economics, as a standard, as a situation in which economic variables such as growth, saving rate, wealth/income ratio, etc., develop at a constant rate):

$$sh_w^p = \left(1+\frac{s^p r^p - sr}{g - s^p r^p}\right)\frac{s^p}{s}\, sh_{YL}^p$$

where sh_w^p (or sh_{YL}^p) is the share of wealth (or of labour income) held by the wealth group *p*, *g* is the economic growth rate, s is the aggregate saving rate, *r* is the aggregate rate of return, s^p is the synthetic saving rate of the wealth group *p* and r^p is the rate of return of its portfolio (depending on the composition of the latter).

This expression provides highly intuitive results. For example, if there is no inequality in returns or saving rate between the different groups ($s^p = s$ and $r^p = r$), then $sh_w^p = sh_{YL}^p$: wealth inequality is equal to labour income inequality. However, if the wealthiest have higher rates of return and saving rates than the rest of the population ($s^p r^p > sr$ and $s^p/s > 1$), then labour income inequality is increased by a factor that leads to a multiplicative dynamic. The role of growth as a brake on this dynamic also seems clear: when *g* increases, the first ratio decreases, lessening the multiplicative effect. If growth is infinite, the ratio disappears and the previously accumulated wealth no longer matters, only inequality in labour income and savings matter.

We define synthetic saving rates in the same way as Saez & Zucman (2016). We observe the variables W_t^p, W_{t+1}^p, Y_{Lt}^p, r_t^p and q_t^p in our series and, from there, we calculate s_t^p as the synthetic saving rate that makes compatible the development of the observed wealth in one year within a wealth group *p* with the wealth observed the following year. We call this the "synthetic" saving rate because it must be considered as a form of average saving rate (taking into account all intergroup mobility effects). Obviously, that does not mean that all individuals in the wealth group *p* save the same amount. Here, we are not attempting to study this mobility process, *per se*. We are focusing on this approach using the synthetic saving rate to perform simple simulations to illustrate some of the main forces involved. It should also be noted that these saving rates include direct and indirect savings by individuals and, in particular, undistributed profits (as indirect savings). The synthetic saving rates calculated here appear to have a gradient and levels that are consistent with previous studies on French individual saving rates (see, for example, Garbinti & Lamarche, 2014; Garbinti *et al*., 2014).

of inequality is reached, close to that at the start of the 20th century: the richest 10% holding a share of around 80% of the wealth. Conversely, if the economic conditions (saving rates, rates of return and income equalities) of the years 1970-1984 had persisted beyond that period, the decrease in inequality observed until the mid-1980s would have continued until a low level had been reached (with the richest 10% holding a share of around 45% of the wealth, cf. Figure III).

This is not, of course, a matter of attempting to predict the future development of inequality, as a sharp increase would certainly not go unnoticed and could lead to political, institutional and economic measures aimed at containing it. Rather, it is a case of illustrating how differences between the key factors in the development of wealth inequality can lead to strong multiplicative effects, which take decades to come to fruition.

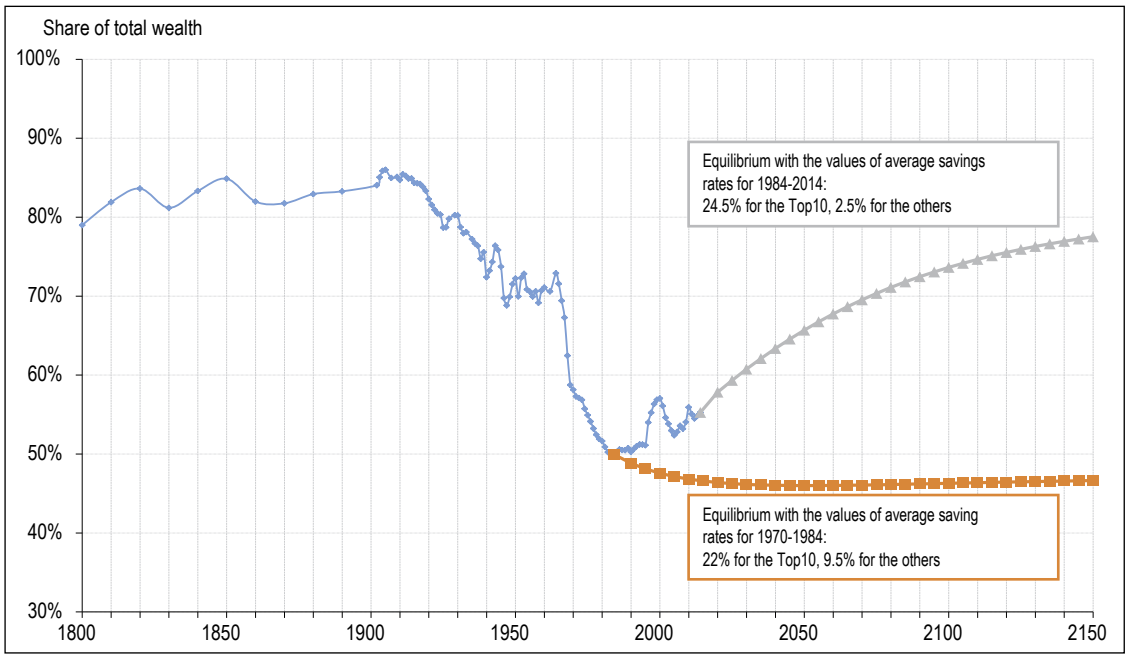
Income Inequality 1900-2014

Before studying the development of income inequality and how growth has benefited the different population groups, it is useful to bear in mind the overall developments of national income per adult[15] in France.

Between 1900 and 2014, it grew considerably, from EUR 5,000 in 1900 to EUR 35,000 in 2014.[16]

15. National income divided by the adult population.
16. All figures are expressed in EUR at their 2014 value.

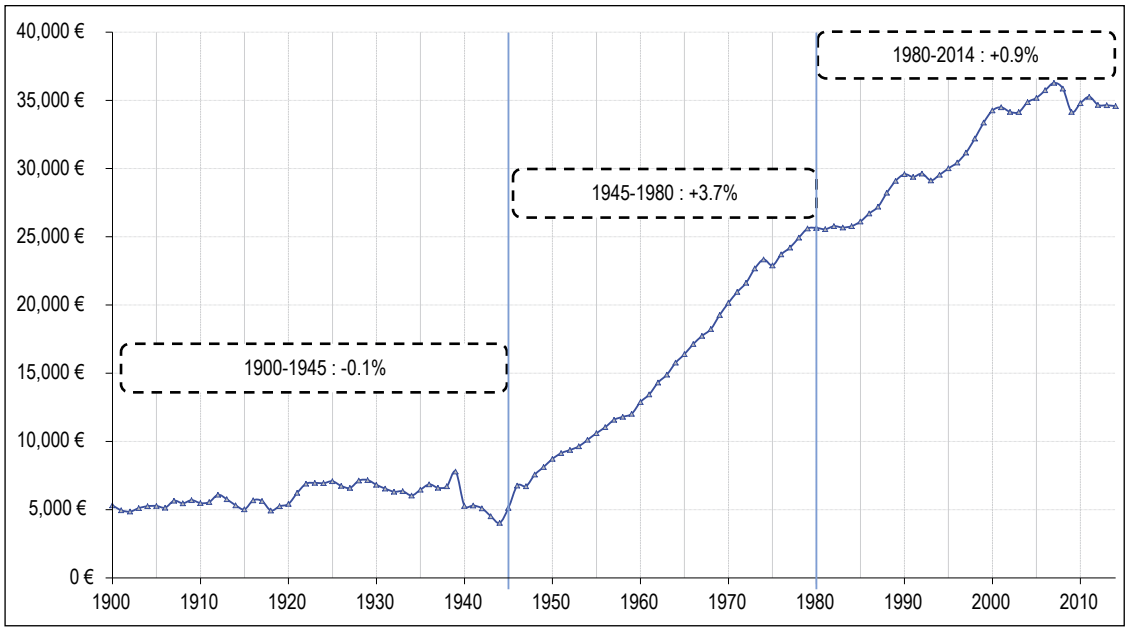
Figure III
Share of wealth held by the Top10 at the equilibrium, 1800-2150



Reading note: Top10 refers to the wealthiest 10% individuals.
Sources: Data and graph from Garbinti *et al.* (2016).

This increase was not continuous and occurred mainly between 1945 and 1980, i.e. during the post-war boom (Figure IV). Indeed, while the growth rate for national income per adult was negative between 1900 and 1945 (-0.1% per year), it grew by 3.7% between 1945 and 1980 and then divided by almost four between 1980 and 2014 (0.9% per year).

Figure IV
The irregular increase in national income per adult in France, 1900-2014 (in Euros 2014)



Notes: National income (GDP - Capital Depreciation + Net Foreign Income) divided by the adult population.
Reading note: Between 1980 and 2014, national income per adult increased by 0.9%. It averages €34,580 in 2014. Between 1900 and 2014, the growth rate of national income per adult is 1.9% per year.
Sources: Data and graph from Garbinti *et al.* (2017).

These developments in aggregate national income do not fully reflect the developments in income inequality. From 1900 to 1945, the collapse of income inequality is as striking as that previously observed for wealth inequality (Figure V). The share held by the Top10 decreases by 50% in 1914 to 30% in 1945.[17] This fall in income inequality is very closely linked to developments in wealth: the collapse of very high incomes is a collapse of capital incomes. Therefore, this double reduction in inequality is due to common factors (depression, inflation, the destruction of capital, etc.).

From 1945 to 1983, the development of income inequality is more uneven than the development of wealth inequality. From the end of the Second World War onwards, the wage hierarchy is rebuilt and the proportion of capital within the French economy recovers[18], resulting in an increase in income inequality.[19] The events of May 1968 mark the end of this upward trend. Following the significant rise in the minimum wage[20], it will increase steadily, raising purchasing power by 130% between 1967 and 1983. The wage hierarchy is then compressed, resulting in a reduction in income inequality.[21]

From 1982-1983 onwards, faced with steadily rising unemployment, successive governments will decide that minimum wage increases will henceforth be much smaller in order to reduce the rate of increase in the cost of unskilled labour. This marks the end of the period of decreasing income inequality that began in 1968. From the early 1980s, the share of income held by the richest 10% increases slightly. In contrast, very high incomes experience a much more significant increase. The share of income held by the top 1% increases from 7% in 1983 to 11% in 2014, representing an increase of over 50% (Figure VI). The higher the position in the distribution of income, the stronger the increase. Another indicator makes it possible to grasp the extent of the reversal that occurred

17. In the first paragraph dedicated to wealth, individuals are classed in accordance with their net wealth. In this paragraph dedicated to income, they are classified according to their (pre-tax) income. Although there is some overlap, these categories therefore do not represent exactly the same individuals.

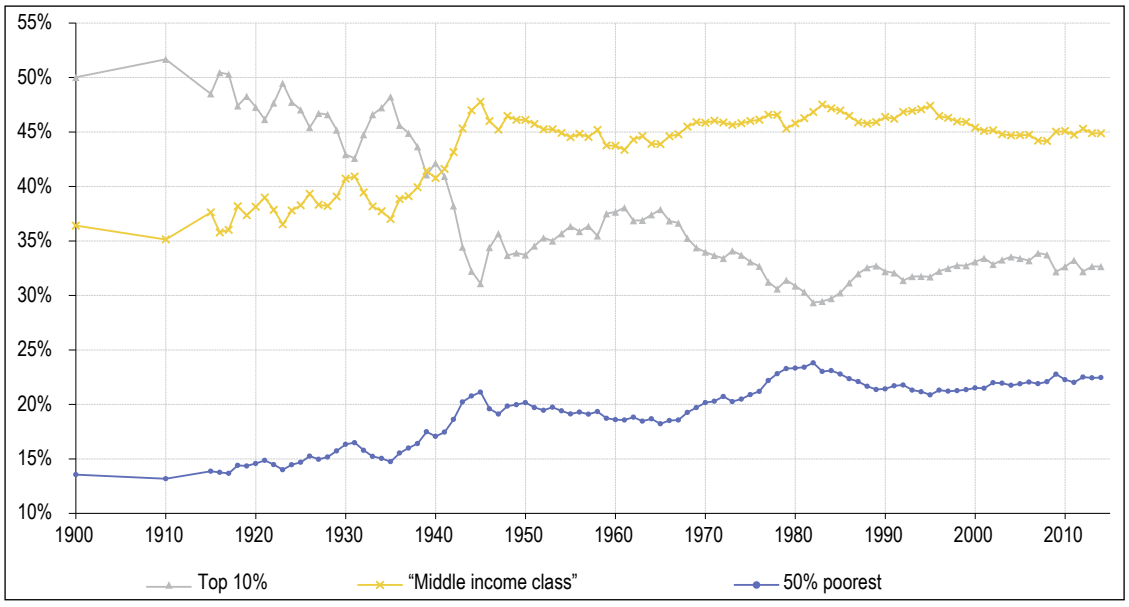
18. Several studies have highlighted the link between the proportion of capital within the economy (i.e. the proportion of the national income distributed as capital income) and income inequality, see Bengtsson & Waldenström (2018) or Piketty (2014, Chapter 6), for example.

19. During this period, high wages increased relatively faster than those of the lower and middle distribution groups, increasing wage inequality. Furthermore, the proportion of profit within the national income has increased, mainly benefiting the highest incomes. Thus, these two effects contributed to the increase in income inequality from 1945 to 1983.

20. 20% increase in EUR at a constant value.

21. The periodisation of political and economic life presented here is relatively standard and has been the subject of multiple studies (see Piketty, 2001, 2003).

Figure V
Share of income by wealth level in France, 1900-2014



Notes: Distribution of national pre-tax income (before taxes and transfers, with the exceptions of pensions and unemployment benefits) among adults. "Equal-Split" series (income of married couples divided by 2).
Reading note: Between 1914 and 1945, the income share of the Top 10% (the 10% individuals with the highest income) fell from 50% to 30%. In 2014, the average national income per adult is €34,580, and €112,930 on average for the Top 10%, €15,530 on average for 50% poorest and €38,800 on average for the "middle income class" (defined as the 40% of individuals whose income is between the 50% poorest and the 10% richest).
Sources: Data and graph from Garbinti *et al.* (2018).

in 1983: between 1950 and 1983, while actual income per adult increases at a rate of 3.5% per year for almost the entire population, high incomes experience an annual increase of 2.3% (see Online complements, Figure C2-IV). From 1983 onwards, the trend reverses. Very high incomes continue to grow at a rate of 2.2% per year, compared with less than 1% for the rest of the population.[22]

How can this recent increase in inequality be explained? The increase in very high incomes, which was particularly pronounced between 1983 and 2000, derives primarily from the combination of two factors specific to capital income. First, we observe a significant increase, of almost 30% over the period, in the proportion of capital income within the economy. As such income is predominantly held by those with the highest incomes, its increase naturally leads to an increase in inequality. Then, over the same period, we observe a greater concentration of these incomes. The share of the total capital income owned by the 1% of individuals with the highest incomes increases from 26% in 1983 to 35% in 2000. This increase in the concentration of capital income is linked to the increase in the concentration of wealth observed during this period. This can be explained through the high level of inequality in terms of rates of return and saving rates (cf. Box). A detailed analysis of the determining factors of the increase in the share of capital income within the economy and of the increase in the concentration of capital income within the highest income groups is beyond the scope of this article; however, interested readers may refer to Autor *et al.* (2017) and Benhabib & Bisin (2018).

The Increasing Concentration of Labour Income

Although the increase in high incomes can be explained mainly due to factors specific to capital, since the start of the 1990s, we also observe a significant increase in the concentration of labour income (see Online complements, Figure C2-V). Therefore, other explanations must be used to enable a complete understanding of this phenomenon.

Technological changes leading to changes in the labour demand have sometimes been advanced to explain this phenomenon: the education system would take time to adapt to this demand for new skills or to a higher demand for skilled labour. Therefore, there would be a period with

*22. This decrease and then increase in inequality is also observed by Boiron (2016), who studies living standards based on Household tax and social income survey (*enquête Revenus fiscaux et sociaux*, not adjusted in line with national accounts). Over the most recent period and despite a different methodology, our results are comparable with those of Cazenave (2018), who shows that between 2013 and 2014 the share of the 1% of the highest incomes increased slightly (+1.5% and +6.3% for the top 0.1%), while our series conclude that there is a certain degree of stability between these dates.*

Figure VI
Share of income of the 1% highest incomes in France, 1900-2014

Notes: Distribution of national pre-tax income (before taxes and transfers, with the exceptions of pensions and unemployment benefits) among adults. "Equal-Split" series (income of married couples divided by 2).
Reading note: The share of income of the 1% highest incomes rises from 22% in 1900 to 7% in 1983 and then to 11% in 2014. In 2014, the average national income per adult is €34,580 and €374,200 for the 1% highest.
Sources: Data and graph from Garbinti *et al.* (2017).

a shortage of certain qualifications, leading to a significant increase in the salaries of individuals with the most in-demand skills. This type of explanation, based on the "race between technology and education" (Goldin & Katz, 2009) is more appropriate in the United States (where the share of income held by the Top10 has increased extremely strongly since the 1980s) than in France, where it is mainly the very high incomes (from the top 0.1%, or even the top 0.01%) that have soared. However, this theory is of interest in highlighting the importance of investment in the education system and, more broadly, of public policies in the field of education (cost of studies, continuing professional development, etc.) as ways of affecting pre-tax income inequality.[23] The role of the financial sector has also been examined. Financial deregulation is thought to have created a greater complexity of tasks, resulting in higher salaries and the emergence of annuities, which would explain the very high salaries observed in this sector. However, this does not exhaust the issue: for example, Philippon & Reshef (2012) estimate that the share of the increase in wage inequality due to the financial sector in the United States since 1980 is between 15% and 25%, leaving 75% to 85% of the increase unexplained.[24]

Therefore, further explanations are required. The decline of trade unions and collective bargaining processes has probably played a role. In particular, the pay[25] of very senior executives seems to follow an astonishing logic: several studies have shown that it had little to do with their performance but depended above all on positive external events (hence the term "luck-based pay").[26] In this context, the very process of negotiating very high incomes and the incentives to pay more or less to senior executives become of primary importance. Tax changes concerning very high incomes have also been noted as potentially having a decisive role. A strong link has been established between the reduction in taxation on very high incomes and the increase in inequality.[27] The reasoning is as follows: during negotiations on their pay, senior executives will be all the more inclined to demand increases because they are taxed at a low rate on such additional remuneration, and a board of directors that needs to make a decision regarding an increase will probably be reluctant to grant it if it knows that it will be taxed at 80% or even 90%, as was the case in Britain and the United States from the 1940s to the 1970s (and around 70% in the 1980s). Therefore, changes in taxation play a significant role on the methods of determining the income of senior executives.[28]

Persistent Labour Income Inequality between Men and Women

At present, we are analysing the development of labour income inequality between men and women.[29] The increase in the proportion of women within the active population is effectively a groundswell, which began in the 1960s, and is likely to affect the development of income inequality between individuals. After having fluctuated at around a third of the labour force, the proportion of women rises steadily to reach almost half of the working population by the end of the 20th century (see the article by Marchand & Minni in this issue). However, this growth has also been achieved with a significant increase in part-time work (see, for example, Afsa & Buffeteau, 2006), which has limited catching-up in terms of labour income.

The analysis of income inequality conducted so far is based on the concept of equal-split adults. Such an approach which consists of equally dividing income within couples does not make it possible to study the effect of women's increased participation in the labour market on inequality or, more generally, the development of inequality between the sexes. Unlike the rest of the article, our analysis here is therefore based on individual series of labour income actually received by each household member.

Figure VII shows the development of the ratio of men to women work income, by age, between 1970 and 2012. The gap has narrowed

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23. On the importance of the primary redistribution system on income inequality in France, see Bozio et al. *(2018).*

24. Recently, Boustanifar et al. *(2018) have studied salary increases in the financial sector between 1970 and 2011. While the financial sector represents only a 6% share, on average, of the total skilled labour, they show that the increase in the wages of skilled workers in finance explains 31% of the average increase in the salaries of skilled workers in developed economies between 1980 and 2005. Financial deregulation is the most important element in explaining this increase: "the significant increase in ICT intensity in finance can be explained, mainly, due to the broadening of the range of banking activities to include risky and complex activities on the financial markets (trading, market making, transfer of risks to derivative products markets, etc.), enabled by the removal of regulatory barriers and a relaxation of supervision. This increased complexity of their activities has allowed skilled workers to increase their bargaining power and, consequently, to obtain extra pay." (Reshef, 2017).*

25. The pay of very senior executives can take the form of both labour income (salary) and capital income (dividends and stock options, in particular).

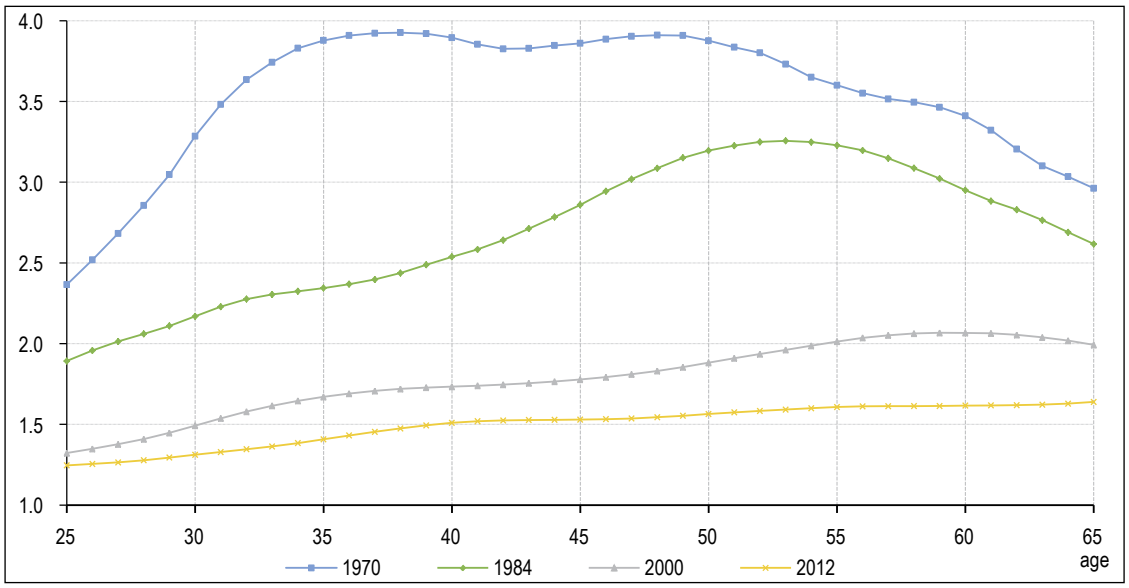
26. See, for example, Bertrand & Mullainhantan (2001). Garvey & Milbourne (2008) confirm this analysis and show that executives are not penalised in the event of "bad luck".

27. See Piketty et al. *(2014).*

28. See also Piketty (2014), Chapter 9.

29. We limit ourselves here to income inequality. Our methodology does not make it possible to identify wealth levels. Indeed, very broadly, wealth is obtained based on the capitalization of capital income reported together with tax returns. For information on wealth inequality between women and men, see for example Frémeaux & Leturcq (2013; 2016).

Figure VII
Gap in work income between women and men in France, 1970-2012



Notes: Ratio between the average work income of men and women, including non-participants in the labour market. Work income includes wages, pensions, unemployment benefits and 70% of the self-employed mixed incomes. Mixed income includes (by definition) both work income and capital income. As is standard practice, 30% of this income is considered to be a remuneration for capital and 70% for work.
Sources: Data and graph from Garbinti *et al.* (2018).

considerably since the 1970s, but it remains significant.

In 2012, at 25 years of age, men receive an average[30] of 1.25 times more pre-tax income than women of the same age, and 1.65 times more at 65 years of age. The fact that women are less likely to be promoted to the highest paid jobs over the course of their careers (cf. Gobillon *et al.*, 2015) plays certainly a significant part in this difference.

This gap has been much more marked. In the 1970s, men between 30 and 55 years old earned 3.5 to 4 times more than women of the same age. However, less than one in two women received labour income at that time (see Online complements, Figure C2-VI).

While the income gap between men and women has narrowed considerably over time, it nonetheless remains clear that women still do not have access to the highest paying jobs (see the article in this issue by Meurs & Pora). In 2012, only 30% of women were among the 10% of individuals receiving the highest labour incomes. They account for only 16% within the top 1% and 12% in the top 0.1%. This proportion indeed increases gradually over time, but at a very moderate rate. For illustrative purposes, if we extrapolate the trend observed since the mid-1990s, we reach the conclusion that it would take until 2102 for parity to be seen within the top 1% and until 2144 for parity within the top 0.1% (Figure VIII).

The Changing Links between Wealth and Income from Capital and Labour

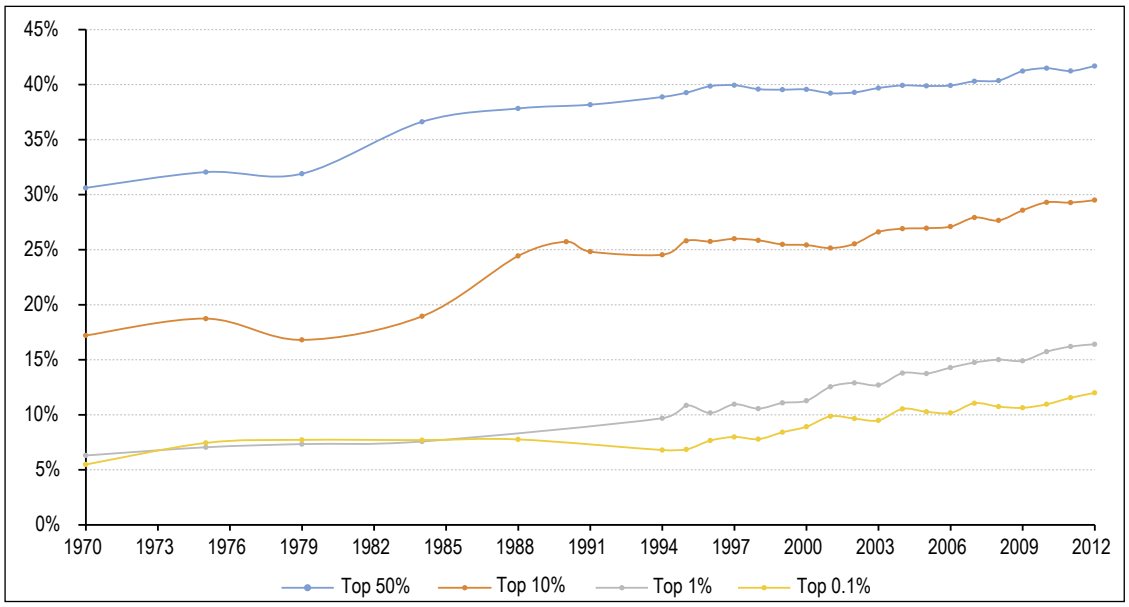
The trends identified above suggest the link that exists between capital income, labour income and wealth. In France, as well as in other countries, there have been few studies concerning this link, due to a lack of data. One advantage of the series used here is that they make it possible to study jointly how income and wealth develop.

To understand the composition of the income of the wealthiest individuals, we have shown the proportion of all capital income received by the wealthiest 1% of individuals and the proportion of labour income (Figure IX, the blue curve and orange curve, respectively). Two findings emerge.

First of all, capital income is highly concentrated, more so than wealth. The wealthiest 1%

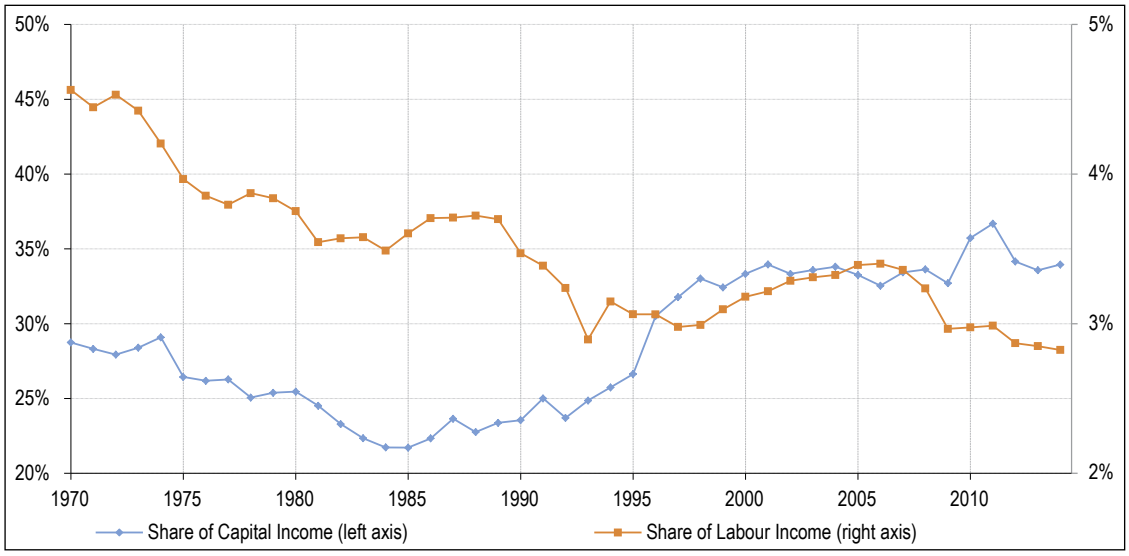
30. *All individuals are considered here, whether in employment or not.*

Figure VIII
Share of women in the highest work income groups in France, 1970-2012



Reading note: In 1970, 6% of women were in the 1% highest work incomes (Top 1%), 10% in 1994, 16% in 2012. If the trend observed since the mid-1990s was extrapolated, they would be 50% in 2102. Following this trend, it would take until the year 2144 to achieve parity in the highest fractile (Top 0.1%, the 0.1% highest).
Sources: Data and graph from Garbinti *et al.* (2017).

Figure IX
Share of work income and capital income received by the wealthiest 1% in France, 1970-2014



Reading note: In 1970, the 1% wealthiest received 28.7% of total capital income and 4.6% of labour income. In 2014, they received respectively 34% and 2.8%.
Sources: Calculations by authors based on data from Garbinti *et al.* (2016).

of individuals receive between 30% and 35% of total capital income, while they hold between 20% and 25% of the total wealth. Their share of labour income is much lower (between 3% and 5%).

Then, the shares of capital and labour income followed diametrically opposite directions. The share of labour income received by the wealthiest 1% of individuals has fallen constantly, from 4.6% in 1970 to less than 3% in 2014 (which is a decrease of 38%). In contrast, the share of capital income has increased significantly since the mid-1980s, growing by 56% between 1984 and 2014. Most of this increase occurred between 1984 and 2000, which corresponds to

a period of a strong increase in the concentration of capital income and of the proportion of capital within the economy. Therefore, this increase in the proportion of capital within the economy has mainly benefited individuals with wealth and has increased income concentration.

The following formula makes it possible to analyse how the correlation between the owners of the highest wealth levels and the owners of the highest incomes (from labour and capital) has developed over time.

$$sh_{Y_{tot}}^{p,w} = (1-\alpha) sh_{Y_L}^{p,L} \frac{Y_L^{p,w}}{Y_L^{p,L}} + \alpha sh_{Y_K}^{p,K} \frac{Y_K^{p,w}}{Y_K^{p,K}}$$

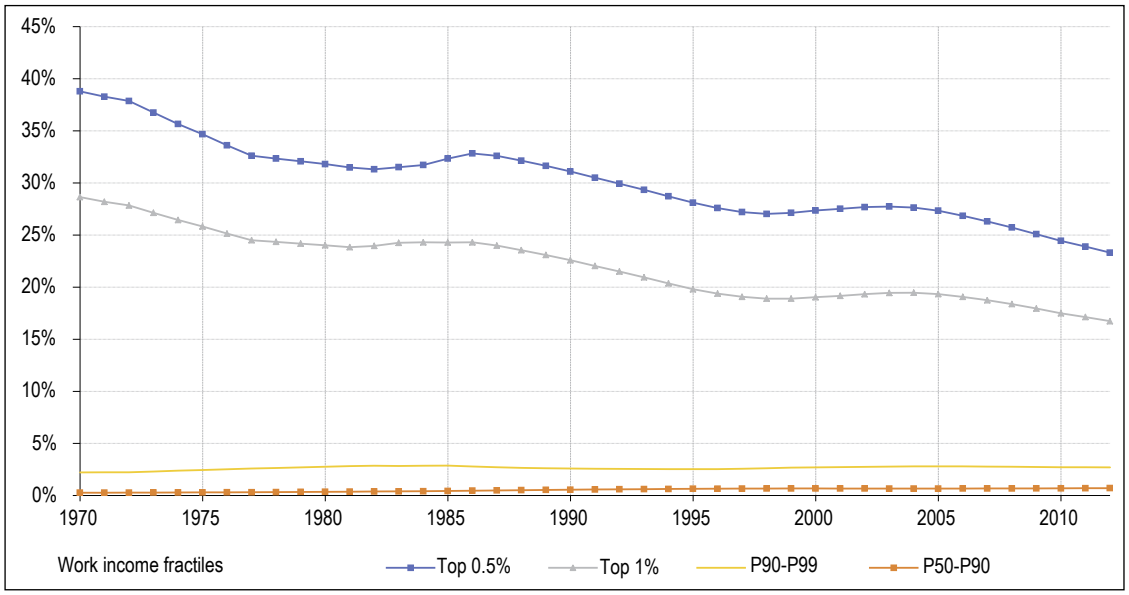
$sh_{Y_{tot}}^{p,w}$ means the share of total income held by the p% of the wealthiest individuals (the Top10 wealthiest individuals, where p=10%) and $sh_{Y_L}^{p,L}$ (or $sh_{Y_K}^{p,K}$) the share of labour income held by individuals receiving p% of the highest labour (or capital) incomes. The alignment coefficient $\frac{Y_L^{p,w}}{Y_L^{p,L}}$ (or $\frac{Y_K^{p,w}}{Y_K^{p,K}}$) is the relationship between the total labour (or capital) income held by the wealthiest p% of individuals, and the total labour (or capital) income held by the richest p% in terms of labour (or capital) income. This ratio shows the extent to which those holding the highest labour (or capital) incomes also hold the highest wealth. A coefficient of 1 means that the p% of individuals receiving the highest incomes are also the wealthiest p% of individuals. A coefficient of 0 means that these two groups do not overlap.

The alignment coefficients for the Top 1% are shown in Figure C2-VII in the Online complements. For capital income, these coefficients are above 0.9 for the entire period and virtually 1 from the mid-1980s: the wealthiest individuals are also the individuals with the highest capital income. At the same time, the alignment coefficient for labour income decreases from 68% to 59%. Thus, greater polarisation seems to be emerging between the wealthiest individuals, on the one side, and the "working rich", on the other.

Figure X confirms this result very clearly. For the 1% of individuals with the highest labour incomes, the probability of belonging to the group of the 1% of wealthiest individuals has fallen, from 29% in 1970 to 17% in 2012. The decrease is of the same order for individuals receiving the highest 0.5% of labour incomes: 39% of them used to belong to the wealthiest 1% of individuals, but only 23% of them do in 2012.

Two contradictory effects could be in opposition here. On the one hand, the recent increase in

Figure X
Probability of individuals with the highest work incomes to belong to the wealthiest 1% in France, 1970-2012



Notes: P90-P99 refers to the 9% of individuals with work income between the highest 1% and lowest 90%. P50-P90 refers to the 40% of individuals with work income between the highest 10% and lowest 50%.
Reading note: In 1970, the 0.5% highest work incomes had a 39% probability of belonging to the wealthiest 1%; this probability was 23% in 2014.
Sources: Data and graph from Garbinti *et al.* (2017).

very high labour incomes could make it easier for people receiving these incomes to accumulate large amounts of wealth. At the same time, significant increases in both the wealth/income ratio within the economy[31] and the flows of inherited assets[32] make it more difficult for people with only labour income to access the highest wealth levels, if they do not have any family fortune. Our results suggest that it is this second effect that is the most important. This result is consistent with estimates by Piketty (2011), who compares the living standards of individuals with the highest incomes with those of individuals receiving the highest inheritances and concludes that the living standards of the richest heirs have recently caught up with those of the richest earners of labour income.

Comparisons between France and the United States

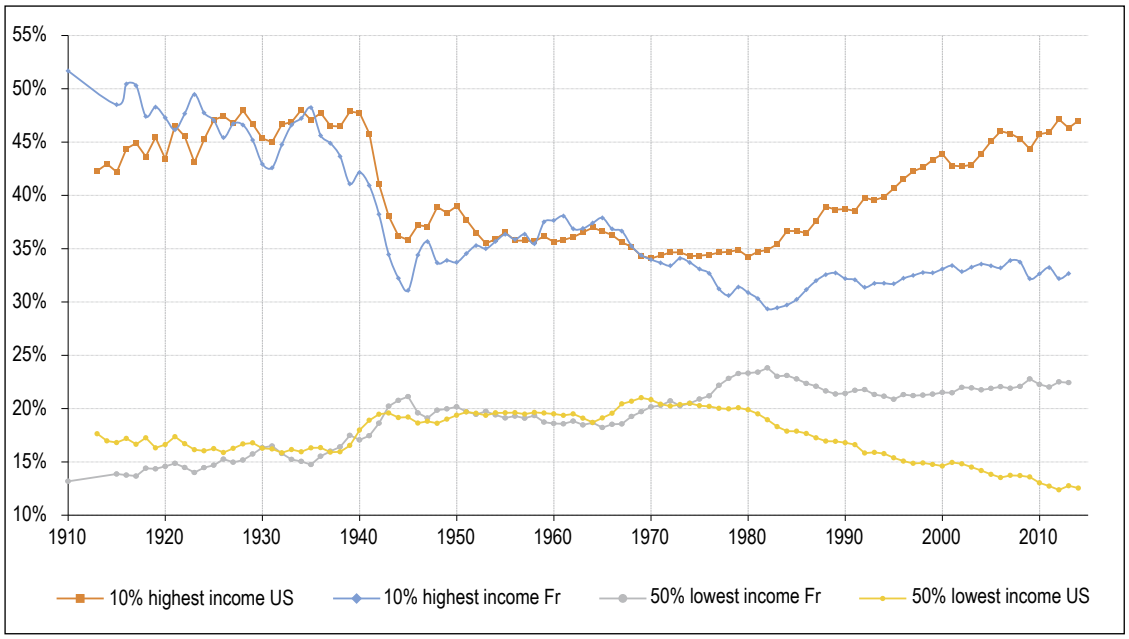
One of the advantages of creating series that are consistent with the national accounts is to allow comparisons between countries and over time through a unified framework. For pre-tax income inequality, we compare our series with those produced, using a similar methodology, by Piketty *et al*. (2018) and, for wealth inequality, with those produced by Saez & Zucman (2016).

Since the 1980s, pre-tax income inequality has increased substantially more in the United States than in France (Figure XI). However, France appears more unequal than the United States until the First World War, whether in terms of pre-tax income or wealth. During the years 1960-1970, the levels of income inequality were roughly similar in both countries; at present, the United States has become much more unequal.

This divergent evolution is interesting because it highlights how differences between countries in terms of inequality can vary considerably over time and depend on the institutional and political regimes specific to each country's history. The explosion of inequality in the United States from the 1980s is probably the result of a complex combination of factors such as changes in labour market rules

31. *See, for example, Piketty & Zucman (2014).*
32. *See Alvaredo* et al. *(2017) for an estimate of the recent increase in the share of inherited assets as part of the accumulated wealth.*

Figure XI
Share of income held by the 10% highest and 50% lowest income in France and United States, 1910-2014



Notes: Distribution of national pre-tax income (before taxes and transfers, with the exceptions of pensions and unemployment benefits) among adults. "Equal-Split" series (income of married couples divided by 2).
Reading note: Between 1910 and the Second World War, the share of income held by the 10% highest income in the United States was around 45%, then fell to around 35% until 1980, before rising. In purchasing power parity, in 2014, the average national income per adult in the 10% highest incomes in the United States is €248,810 (€112,930 in France) and €13,280 for the 50% lowest (€15,530 in France).
Sources: Data and graph from Garbinti *et al.* (2018).

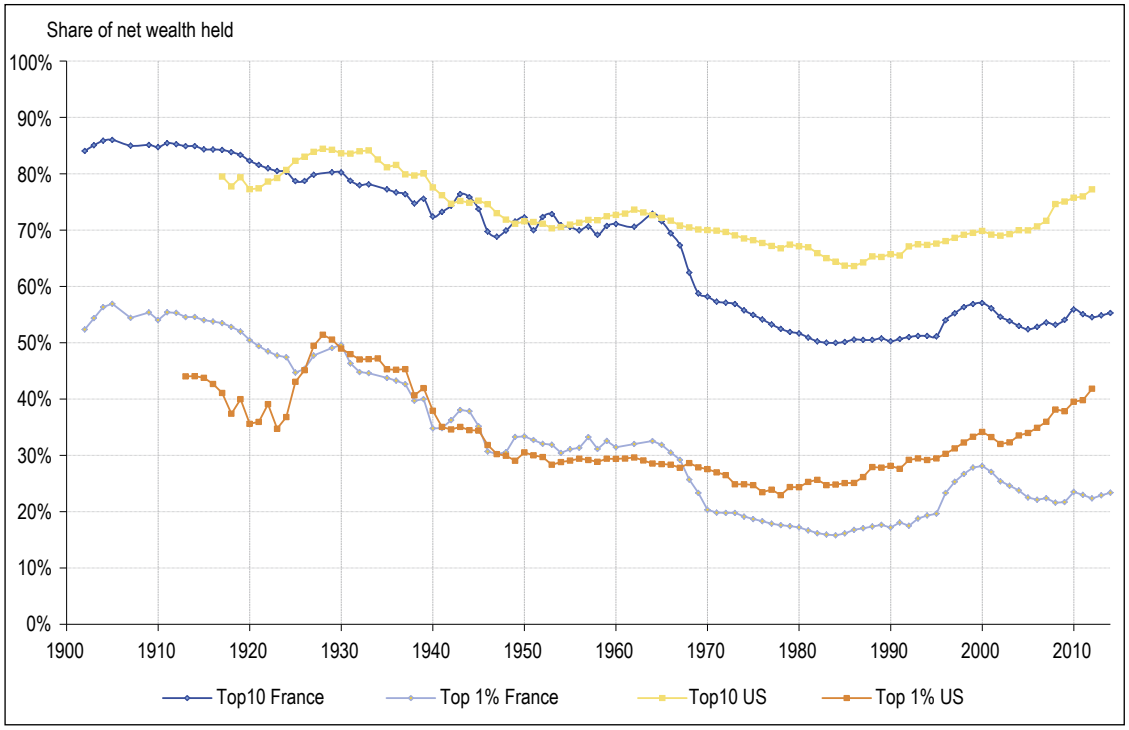
(including a significant decrease in the Federal minimum wage[33]), a highly unequal education system (with a widening funding gap between the best universities and the rest), or even changes in rules of governance and incentives that influence the setting of remuneration for the most senior executives (with, in particular, a very significant fall in top marginal income tax rates).[34]

This high level of inequality is sometimes presented as not being of primary importance: given that the United States has a national income per adult around 30% higher than that of France, its level of inequality would not necessarily be a problem if everyone there received higher incomes than in France. This is clearly not the case: in 2014, the poorest half of the French population has pre-tax incomes 20% higher than in the United States.[35] This difference is considerable.[36] The highest national income per adult observed in the United States does not, therefore, translate into higher economic well-being for the entire population. The finding is even worse: the poorest half of the American population receives less than half that of the poorest half of the French population.

These pre-tax series also make it possible to observe the fall in the share of income received by the poorest 50% of Americans since the 1970s. This share is collapsing, falling from 21% to 12.5%. This is the opposite to the development for the highest incomes and is very different to that observed in France. While the incomes received by the poorest 50% were higher in the United States in the years 1950-1960 and despite the rise in unemployment in France since the 1970s, the actual average income (excluding inflation) of the poorest 50% has not increased in the United States since those same 1970s and has gradually been overtaken by that of the French. Once again, this suggests that institutional and

33. The Federal minimum wage remained frozen between 1980 and 1990, under the Ronald Reagan and George Bush (Snr) administrations, without review to take account of inflation, resulting in a significant fall in its purchasing power in real terms. Following two small increases (end of the Bush administration and under Bill Clinton), it was again frozen by George W. Bush for ten years. It was then reviewed multiple times under Barack Obama (see Figures 9.1 and S9.2, Piketty, 2014).
34. See Piketty (2014) and Piketty et al. *(2014).*
35. In a project that is currently ongoing (Bozio et al.*, 2018) we show that, after tax, this difference is lower but still exists (it is around 5%).*
36. For this comparison to be meaningful, it is made in euros of PPP (purchasing power parity), based on coefficients calculated by the OECD. There may be a certain degree of uncertainty in how to evaluate these coefficients. However, given the size of the difference between France and the US, variations in the coefficient used would not affect our conclusion.

Figure XII
Wealth concentration: France *vs* US, 1900-2014



Note: The Top10 refers to the 10% highest wealth level.
Sources: Data and graph from Garbinti *et al.* (2016).

policy differences can contribute to significant differences in the distribution of income, opportunities and well-being for large segments of the population. This also suggests that these institutional and policy differences can have a strong effect on pre-tax inequality and not only on inequality after taxes and transfers.

Lastly, to compare wealth inequality between the two countries, the shares of the total net wealth held by the richest 10% and 1% in France and the United States are shown in Figure XII.

As with income, wealth inequality were higher in France than in the United States at the start of the 20th century. The trend then reversed and those inequality subsequently became much higher in the United States. The analysis framework presented in the first section allows for interpretation of this development. The lower level of inequality in the United States at the start of the 20th century could be the result of a "New World" effect: at that time, the American population was rising very quickly and the concentration of wealth there was probably far from stable. For the recent period, the significant increase in income inequality in the United States may easily have resulted in a much higher level of wealth inequality and may also have contributed to an increase in saving rate inequality within the population. Thus, the stagnation of the incomes of the poorest 50% in the United States could explain the very low level of saving observed by Saez & Zucman (2016).

These questions, which are fundamental to our understanding of the economic developments at stake here, are not settled at this stage. They need to be studied in further detail, in particular with the help of series covering more countries.

* *
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In this article we have presented a historical perspective of the development of income and wealth inequality based on the construction of long-term series combining tax, survey and national accounts data.

The trends highlighted and the comparison with the United States have made it possible to highlight that the level of inequality can vary significantly over time and between countries, according to historical events and policy orientations. Events such as the World Wars or the Great Depression have led both to massive destructions of capital and to the emergence of new political regimes leading to less inequality. The slowdown in growth and ideological changes since the 1980s have led to a new rise in inequality that seems to be ongoing. We have seen how minor changes in inequality in saving rates, rates of return or labour income can have significant long-term effects.

New series available in the World Inequality Laboratory database (wid.world) should make it possible to extend the results presented here on these crucial issues. First of all, by supplementing the results on pre-tax income with studies on the redistributive effect of the tax system. Then, as encouraged by comparisons between countries, by seeking to understand the effect of public policies, such as education and health policies, for example, on pre-tax inequality. □

Link to the Online complements: https://www.insee.fr/fr/statistiques/fichier/4253029/510-511-512_Garbinti_Goupille-Lebret_complements_FR.pdf

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The Major Transformations of the French Labour Market Since the Early 1960s

Olivier Marchand* and Claude Minni**

Abstract – This paper looks at the major changes in the French labour market since the 1960s. Over this period, the labour force has steadily increased, primarily owing to demographics (the post-war baby boom). The labour force also saw increasing female employment, higher qualifications and a reduction in the length of working life at both ends. Three factors have driven changes in labour market trends in the last 50 years: economic globalisation, the emergence of ICT and development of automation, and the growth of the service economy, particularly financial services. For their part, employment policies have sought to "enrich" the employment content of growth. After the 1974 break in the growth trend, the interaction of labour supply and demand led to rising unemployment and increasing diversity in employment statuses. The growth of short-term and very-short-term contracts, as well as arrangements falling between salaried- and non-salaried employment, illustrate a significant increase in employment precariousness.

JEL Classification: E23, E24, J11, J21, J23, J24, J26, J64, J80
Keywords: working population, employment, unemployment, labour market, employment status

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Between 1960 and 2018, the number of jobs in metropolitan France increased from 20 million (including conscripts) to over 27 million, while the workforce grew from 20 to 30 million over the same period. Unemployment, which hovered around 250,000 in the early 1960s, increased by a factor of 10, and frictional unemployment became mass unemployment.

Over half a century, the labour market has seen significant change. In the early 1960s, France was experiencing full employment, with periodic strains on productive capacity due to a shortage of available labour. The labour force at that time was overwhelmingly male and with large shares of manual workers with limited qualifications. The large industrial enterprise, with working arrangements inspired by Fordism and Taylorism, was the dominant model. Furthermore, permanent and full-time employment contract, for a single employer, was the norm.

Today, the working population includes a much higher proportion of women (over 48%) and has become more service-oriented (over 80%); it has also become more qualified but it has aged. The unemployment rate stood at over 9% in mid-2018; labour market activity that falls between employment and unemployment has become much more common, working hours are less uniform, and production units are more decentralised: in one word, employment seems more "fragmented". The constraints associated with work have gradually changed as employment has become more flexible (e.g. employment status, working hours, working arrangements, etc.) and the established notion of job security has been challenged.

Staring from these snapshots of the labour market, taken 50 years apart, the aim of this article is to retrace how we have moved from one to the other. To this aim, we review the profound changes in the working population, the shifts in employment trends linked to structural changes in the economy, before looking at the profile of today's labour market.

Changes in the Labour Force

Having plateaued for 50 years until the early 1960s, the labour force in France began growing at a rapid rate. Two key factors drove this growth until the late 1990s: first, the arrival of baby boomers into the labour market and, in the early stages, significant levels of immigration; second, increasing numbers of women in intermediate age-group entering the labour market. On the other hand, falling labour market participation among younger and older age groups had curbed this growth. The 2000s are characterised by a reversal of demographic trends, which became negative by the end of the decade, as well as a sharp slowdown in the growth of female labour force participation, the impact of which was cancelled out by the early 2010s. The two key engines of labour force growth have therefore stalled, but they have been largely replaced by increases in the participation rates of older workers, the effect of which became positive from the 2000s onwards. A breakdown of variations in the active population highlights these marked trends (Table 1).

The Baby Boomers Wave

In terms of demographics, the early 1960s represented a shift from previous years labour market, with the arrival of baby boomers in place of the earlier generations who were much fewer in number, as well as returnees from Algeria (almost 300,000 entered the workforce in 1962) and foreign workers in significant numbers, at least until 1975. However, changes in the supply side of the French labour market over the last 60 years have been primarily driven by demographics; the trajectory of the early baby boomers, those born just before 1950 and now aged around 70, is an illustation of this. They completed secondary-level education at the end of the 1950s and entered the labour market in the early 1960s, which, alongside immigration and the arrival of returnees from Algeria, alleviated supply-side pressures related to a shortage of labour. However, this continued momentum had other consequences, initially on the school and university system (including the outburst of "May 68") and subsequently on the employment system. Gradually, the younger generation took the place of the earlier generation who had not yet left the labour force. In the 1990s and 2000s, it limited the opportunities for subsequent generations to enter the labour market. The shock wave continued, as the pensions of baby boomers weighed on their children, who were born in the 1970s and 1980s and were fewer in number.

Significant Reduction in the Length of Active Life at Both Ends until the Early 2000s

On account of demographics and changes in labour market participation, the composition of the active population has changed considerably

since the early 1960s (Figure I)[1]. In line with the sharp increase in educational attainment that characterised the period, the proportion of people aged 15-24 in the labour force fell considerably, from roughly one in five in the 1960s to less than one in ten (9.6%) in 2018; most of this reduction was observed between 1970 and 1995. At the other extreme, until the late 1990s, older employees had strong incentives to exit the labour market before the normal retirement age, which fell from 65 to 60 in 1983. The proportion of the active population aged 55 or over fell from

1. A detailed presentation of the data used in the article can be found in the Online complement C1. Link to Online complements at the end of the article.

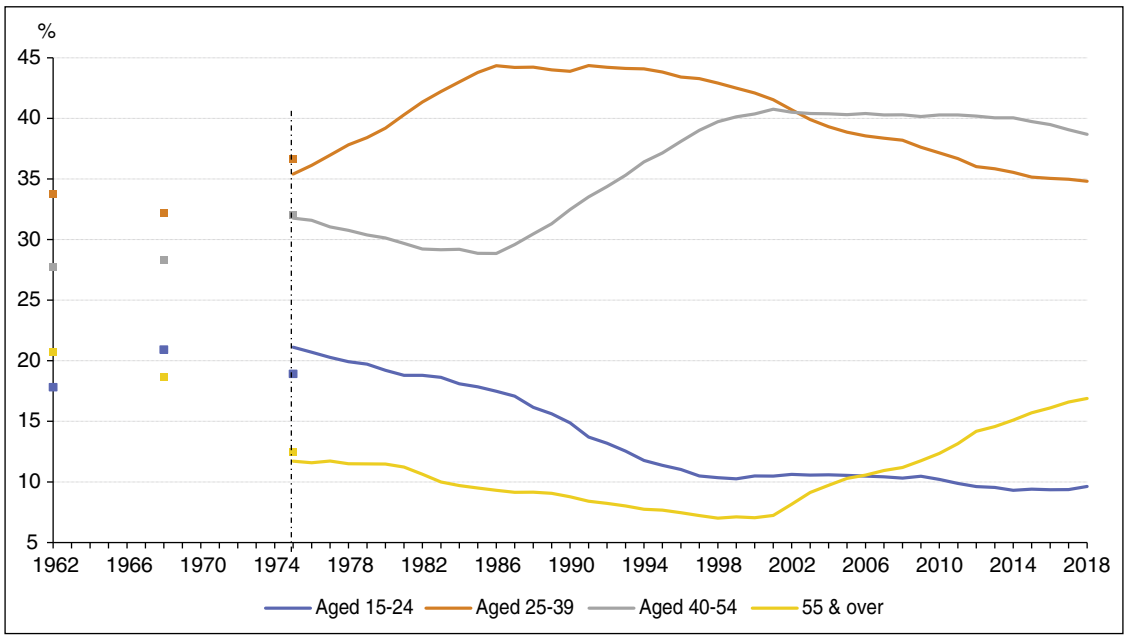
Tableau 1
Contributions of Demographics and Participation Rates to Changes in the Working Population

(Average annual change, in %)

	Labour force	Demographic effect	Participation effect				
	Total	Total	Total	Aged 15-24	Men Aged 25-54	Women Aged 25-54	Aged 55-69 *
1962-1968	+0.7	+1.3	-0.5	-0.2	-0.0	+0.1	-0.4
1968-1975	+1.0	+1.1	-0.1	-0.3	+ 0.0	+0.6	-0.4
1976-1985	+0.9	+1.0	-0.1	-0.2	-0.0	+0.5	-0.3
1986-1995	+0.5	+0.7	-0.2	-0.5	-0.0	+0.4	-0.0
1996-2008	+0.9	+0.6	+0.4	+0.1	-0.0	+0.2	+0.2
2009-2018	+0.4	-0.1	+0.5	+0.0	-0.1	+0.0	+0.5

* 55 and over until 1975.
Notes: The population is broken down by five-year age group and by sex, applying the participation rate at the start of the period to annual changes in the total population, and the total population at the end of the period to annual changes in the participation rate. Employment status as reported at the time of the Population census until 1975, in the ILO meaning after. Before 1976, changes in the active population are measured between two Population censuses and averaged per year; then after the changes correspond to the average yearly change (e.g. average annual change from 1976/1975 to 1985/1984 for the period 1976-1985).
Reading Note: Between 2009 and 2018, the active population aged 15-69 increased by a yearly rate of 0.4%, resulting from -0.1% due to the demographic effect and +0.5% due to the participation effect.
Coverage: Metropolitan France, population aged 15 or over (age on 31 December) until 1975, France excl. Mayotte, population aged from 15 to 69 (exact age) from 1975 onwards.
Sources: Insee, Population census (1962, 1968, 1975), and Employment survey long series (1975 onwards).

Figure I
Working population by age



Coverage: Metropolitan France until 1975, France excluding Mayotte, from1975 onwards.
Sources: Insee, Population census until 1975, Employment survey long series (*enquêtes Emploi*) from1975 onwards.

approximately 20% in the early 1960s, to 7% in 2000. It subsequently rebounded to around 17% in 2018, as the baby boomer generation gradually entered the older age groups and as government reforms of both early retirement for older workers (introduced from the 1970s onwards) and pensions (reforms in 1993, 2003, 2010, 2013) took place, their full impact on the participation rate among those aged 55-64 being reached in 2008 to 2012 (Minni, 2019). Participation among seniors therefore increased sharply, with an average annual increase in the workforce since 2009 of 154,000; this has caused the total working population to continue to increase in the last decade, at an average rate of 0.4% per year (117,000).

Until 2000 in France, and to a far greater extent than in other developed countries, we observe an increasing concentration of the population of working age in intermediate age groups (see Box). In the late 1990s, 82.5% of French people of working age were aged between 25 and 54, as opposed to 60% in 1962. While this proportion amounted to 73.5% in 2018 due to the effects of demographics and labour market participation among seniors, we can speak here of a particular French-style model of age management, in which, schematically, only one generation works at a time, that of the 25-54 age group (Elbaum & Marchand, 1993).

In addition to this increasing concentration of the labour force in the 25-54 age group, we should also note the increase, from the mid-1980s onwards, in the share of the active population aged 40-54. This ageing of the labour force required companies to make substantive changes in their management of future employment requirements and skills needs.

Sharp Increase in Female Participation: Towards Parity

The upturn in paid employment among women in intermediate age groups started in the mid-1960s, alongside the decline in fertility rates. The proportion of women in the working population is now close to parity (48.3% in 2018), up from approximately one-third in the 1960s. The significant increase in the proportion of women in the labour force, which continued for as long as the generations born after 1945 had not fully replaced their elders in the labour market, resulted from factors related to the needs of businesses in certain sectors or certain occupations, and the expectations of women themselves as a result of their higher levels of education and training.

The increase was the result not only of a larger proportion of young women entering paid employment, but also greater continuity in their careers: unlike the previous generation, young women in the labour force interrupted their careers less often and for shorter periods when having children (and better "juggled" career and family life by working part-time).

Box – **Entry and Exit From the Labour Force**

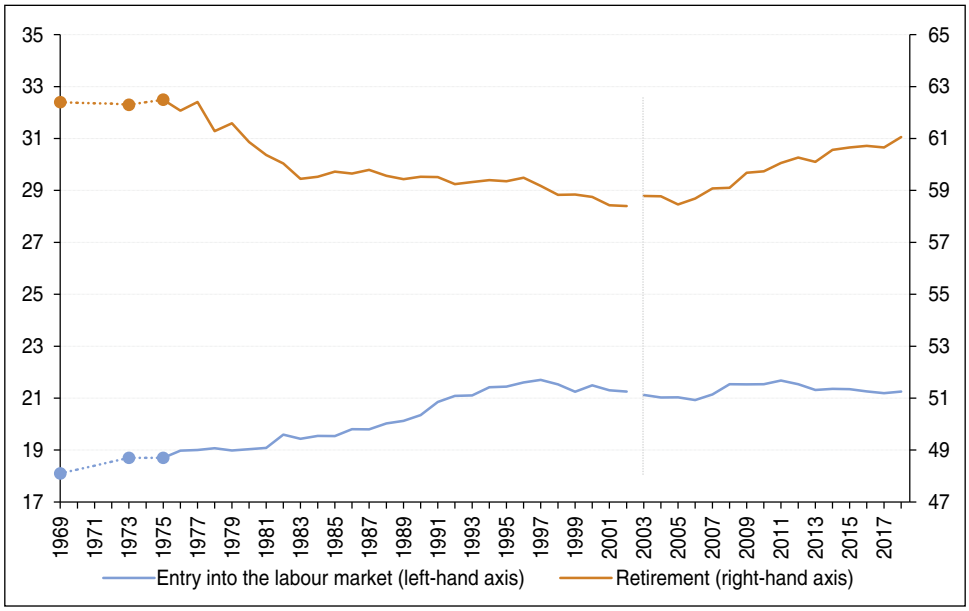
On the basis of a three-stage schematic model (education - employment - retirement), we use Insee employment survey data to calculate an average age of entry into the labour market based on observing the initial transition from economically inactive to economically active (unemployment or employment), and, analogously, an average retirement age. The average duration of "working life" i.e. the number of years of activity (employment or unemployment) is then measured by the difference between both ages. Figure A below shows the progression of what we could call the "current" average career duration, i.e. the difference between the average age of entering the labour market and the average retirement age on a given date. It is a notional duration (by analogy with life expectancy in demographics, for example) as it is not the same people observed on entry and on retirement, and which implicitly relates to only those who have a full and uninterrupted career.

On this basis, we observe that, from the late 1960s to the early 2000s, the "current" average career duration fell from over 44 years to 37 years. It subsequently stabilised and even slightly increased in the last ten years due to the increase in the average observed retirement age (one-and-a-half years later in 2018 than in 2008 for the general pension scheme according to the CNAV). 60% of this reduction in 30 years can be explained by reductions in the average retirement age; 40% by the increase in the average age of entry into the labour market. The first factor was influential between 1977 and 1983, when early retirement arrangements peaked; the second factor at the start of the period (extension of compulsory schooling from 14 to 16) and between 1985 and 1995 (voluntary continuation of initial education).

The three stages in the schematic model have changed length considerably over the last 50 years. As well as the marked reduction in the length of economic activity (the composition of which has seen an increase in the share of unemployment), the start and end points of a working life have become less straightforward. For young people, the process of entering the labour market occurs later, →

Box *(contd.)*

Figure A
Average age of labour market entry and retirement, 1969-2018



Notes: Occupation as reported in the employment survey (*enquête Emploi*); exact age; data on the date of survey until 2002, annual average thereafter. Those leaving (entering) the labour market are defined as persons aged 50 or over (30 or under) in the labour force (in training, unpaid training, military contingent) 11 months prior to survey (12 months before 2003) and inactive (active) on the date of survey. Linear interpolation between 1969 and 1973 and between 1973 and 1975.
Reading note: In 2018, the average age of persons (aged 30 or under) entering the labour market is 21.3 years, and the average age of persons (aged 50 or over) leaving the labour market is 61.1 years, compared to 18.7 and 62.5 respectively in 1975.
Coverage: Metropolitan France.
Sources: Insee, 1969, 1973, 1975-2018 Employment surveys (*enquêtes Emploi*).

is longer and more chaotic, often with movements back and forth between the labour market and education, which makes the age at which someone leaves education and enters the labour market somewhat blurry.

In addition, final departures from the labour market, which used to typically involve a direct transition from employment to retirement at the statutory age, can now involve processes that are more complex and prolonged. This is largely due to the increase in unemployment and the introduction of measures to accompany the end of working life (e.g. state schemes or negotiated early retirement schemes). The gap has widened between the age of cessation of employment, which has fallen, and the age of drawing a pension, which was largely unchanged on 1983 (the year in which the normal retirement age fell from 65 to 60) in the early 2010s. Lastly, although still a largely uncommon practice, those who receive a pension or benefit from early retirement schemes may also engage in occupational activity: in 2018, this was the case for 6% of those in retirement or early retirement and aged between 60 and 69.

Finally, if we take into account that mobility during working life has also become more frequent, we can conclude that in 50 years, instability has been growing at all stages of working life. But this has affected various categories of population to very different degrees, depending in particular on their gender, level of training or qualification and the social affiliation that is often linked to it.

Rising Educational Attainment

From the early 1960s until the mid-1990s, labour force participation among those aged under 25 fell for both men and women. The extension of compulsory schooling from 14 to 16, which took effect in 1967-1968, was an initial factor; from the mid-1980s onwards, the effect of soaring educational attainment at secondary and tertiary level began to take hold[2]. The increase in the level of initial training among the wider population is reflected in the average age for completion of studies, which went from 14.5 around 1960 to over 20 today – with girls having largely outperformed boys during these years. The percentage of people of working age with a qualification equivalent to

2. *The rapid increase in vocational training schemes is also notable (measured from 1975 onwards): by 1993, the number of young people aged under 26 in vocational training had reached 128,000 (DARES, 1996).*

or higher than baccalaureate level increased from under 10% in 1962 to 60% in 2018 – again with girls outperforming boys (Figure II).

However, this marked increase in educational attainment is only partly reflected across the whole labour force, because the replacement of older workers with fewer qualifications by younger, more qualified workers, occurs only slowly. Furthermore, over this period, the system of continuous training and education did not play a full part, notably with respect to older workers and those with few qualifications. In France, the bulk of education and training is delivered within the education system, with little or no continuation in learning and training in the first years of employment, or even throughout one's working life. The transformation in qualification levels among the French labour force is not yet complete, but it does attest to the scale of investment allocated to education, which has helped to close the gap between the working population in France in the middle of the last century and many other developed countries (OECD, 2017).

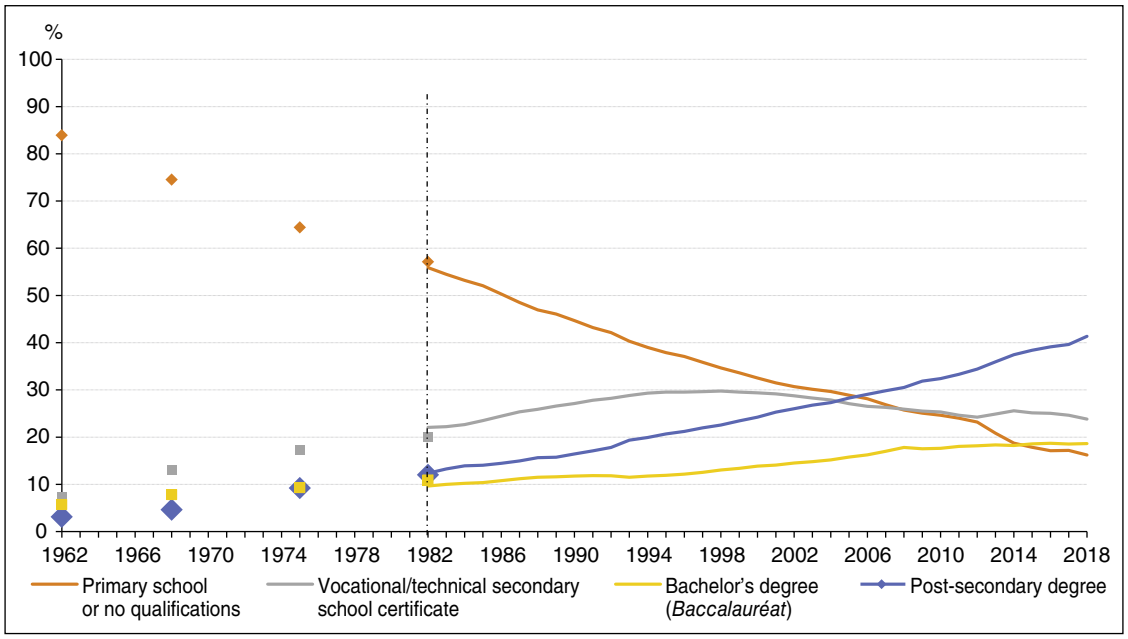
The Rising Share of Skilled Occupations

The increase in female labour market participation and the significant improvement in levels of education among the working population are reflected by changes in the social structure: the number of manual workers, overwhelmingly male, fell by approximately one million between 1962 and 2018 and accounted for only 6.3 million, or 21.6%, of the labour force by 2018, down from almost 40% in 1962 (Figure III). The least qualified component of this group has shrunk the most. On the other hand, the number of clerical, sales and services employees, overwhelmingly female, increased from 3.5 million to 8.2 million and their respective proportions of the working population from 18% to 28%, reaching 30% during the 2000s. Associate professionals, and managers and senior intellectual workers increased further, accounting for 25.2% and 17.6% respectively of the active population in 2018 (by around 12 pct. points compared to 1962).

The increase in teachers, technicians, engineers and managers can be explained by the growth in information and communication technologies, demand for efficient human resource management, expansion of commercial and/or sales and technical operations within companies and investment in education, health and social services.

Lastly, with the number of farmers continuing to fall, along with the number of craftspeople, shopkeepers and company managers, the self-employed categories have seen a marked overall

Figure II
Working population by level of qualification



Notes: Activity status as reported in the survey, age on 31 December until 1982; ILO definition for annual average from 1982 onwards.
Coverage: Metropolitan France until 1982, France excl. Mayotte from 1982 onwards.
Sources: Insee, *division Emploi* (1987) until 1982; Employment survey long series (*enquêtes Emploi*) from 1982 onwards.

decline over the period, particularly before the mid-1970s, but less so subsequently. The proportion of this group stabilised at around 7-8% in the 2000s, having accounted for more than one quarter of the active population in the early 1960s. However, in some sectors, such as services and construction, self-employment has held firm since the 1980s and has even risen slightly since the mid-2000s, challenging the idea of a fully salaried workforce as envisaged in the last century.

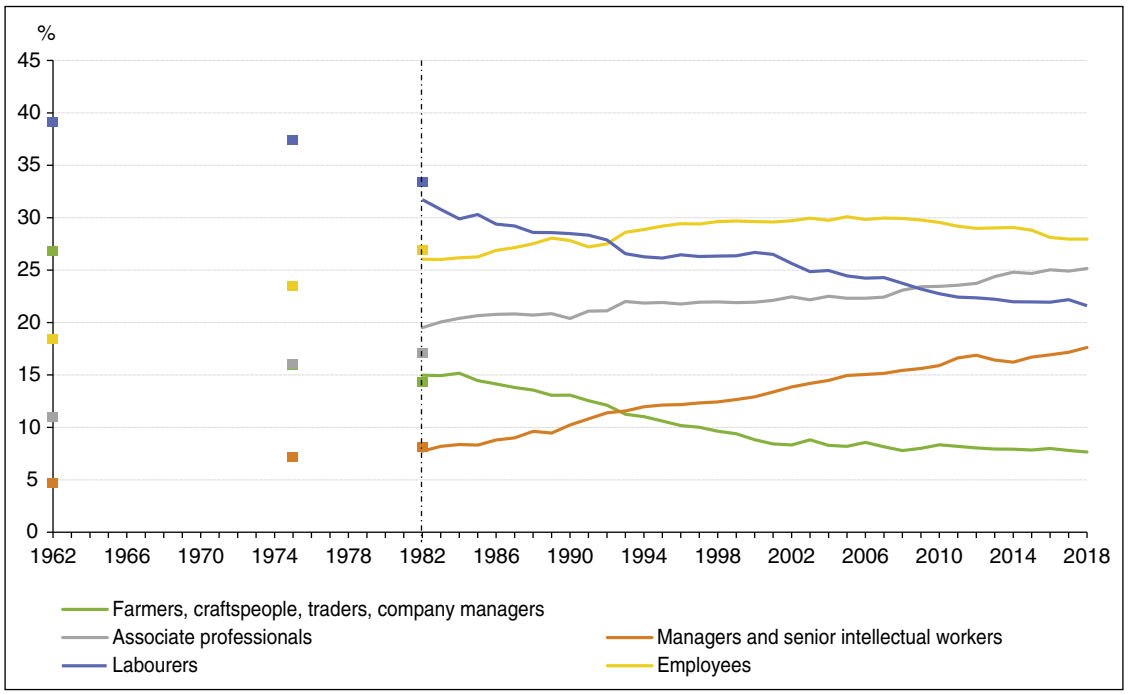
A Radically Different Context

In the background of the profound changes in the labour force described above, three key factors have radically altered the system of production: globalisation, information and communication technology, and the growth of the service economy. Alongside this, productivity growth stalled, while employment policies took a decisive turn in the mid-1970s.

Globalisation, Advances in Technology, Rise of Services

Throughout the 1960s and early 1970s, France's increasing economic openness (following the creation of the European Economic Community in 1957), combined with the emergence of a consumer-oriented internal market, initially stimulated growth in the supply and demand for labour. This development was accompanied by major sectoral and geographic restructuring by companies to face increasing international competition, with a focus on objectives of profitability and competitiveness. This restructuring, encouraged by State support, led to an increase in both occupational mobility and (often temporary) unemployment, and a broadening of the available labour pool (e.g. young people, women, immigrants). The oil crises in the 1970s would lead to a prolonged slowdown in global economic growth, while the globalisation in trade, which increased, intensified competition between economies. The 1990s represented the next stage in the process, marked by the acceleration of the implementation of the European single market, the 1992 signing of NAFTA (North American Free Trade Agreement) and the creation of the WTO in 1995 (World Trade Organization, replacing the GATT – joined by China in 2001). France, which was not adequately prepared for international competition, saw a profound transformation of its productive system, completely changing its employment and skills needs. Gradually, globalisation led to outsourcing and relocation of low-skilled, labour-intensive industries such

Figure III
Working population by socio-professional group



Coverage: Metropolitan France until 1982, France excl. Mayotte from 1982 onwards.
Sources: Insee, *division Emploi* (1987) until 1982; Employment survey long series (*enquêtes Emploi*) from 1982 onwards.

as textiles, and to new employment management, in particular increased flexibility which resulted in widening inequality among employees.

The second decisive factor in companies' changing labour demand began to have an impact in the United States before reaching Europe: the "third industrial revolution", i.e. the growth and spread of information and communication technologies (ICT). Earlier technological advances towards automation and computerisation in the 1970s and 1980s had often led to reduction in labour-intensive production, reassigning a portion of employment to tasks such as design (upstream) or maintenance and monitoring (downstream). The combined effect of the technological changes of the last 30 years and globalisation are even more conducive to fundamental changes in employment. Both phenomena are mutually reinforcing and have a more structural impact, intensifying labour market polarisation with, at one extreme, a small number of highly skilled (e.g. knowledge-based jobs, conception), highly paid and high-productivity jobs, and, on the other, low-skilled service jobs that are often insecure and poorly paid, which feature tasks that are difficult to be automated (e.g. services to individuals, caregivers, etc.). Of the two phenomena, advances in technology have narrowed the scope of occupations, evidenced by secretarial jobs or service roles in banking.

However, there is ongoing debate regarding the trend affecting the proportion of low-skilled professions in France over the last 30 years. Verdugo (2017) observes that between 1993 and 2010, both low-skilled and high-skilled groups saw their share of employment increase at the same rate (4 percentage points), at the expense of middle-ranking jobs (-8 percentage points). On the other hand, Berger & Pora (2012) argue that those at the lowest end of earnings or skills in France have lost out between 1988 and 2014, unlike those in countries such as the United States. But they do not take employees of private employers, which is a fast-moving sector, into account: domestic help and childcare assistants saw the largest increases in employment over that period. Providing an answer to the question regarding the change in low-skilled employment then depends on the scope, the period under consideration and the source used. Using the classification for socio-professional categories at aggregate level and differentiating between skilled and unskilled white collar and blue collar workers (Chardon, 2002), we observe that the proportion of the skilled white collar sub-group (managers and senior intellectual workers) recorded constant growth over the period 1982-2018 (10 percentage points). For the less skilled (lower level white collar employees and unskilled manual workers), the conclusion is less clear[3]: after falling by more than three percentage points between 1982 and the early 1990s, their share remained constant at around 21%.

A third significant development in the last 50 years, linked to globalisation, is the increasing role of service sectors, particularly financial services, in the regulation of the economy. Related to the globalisation of trade and the free mobility of capital, the increasing role of financial services in the economy has radically altered the principles and norms on which the global economy operates. Financial performance indicators inform decision making at all levels of the business (Chambost, 2013) and financial markets heavily influence management practices at companies. To the extent that this new form of "corporate governance" often favours investments with short-term returns over long-term programmes, national interests, in particular jobs, have become expendable: policies aimed at reducing costs and outsourcing non-core company operations often result in job losses.

The Overall Slowdown in Labour Productivity

The extent of annual job creation is closely linked to the growth rate in the wider economy: between 1962 and 1973, GDP in France increased by 5.7% annually while employment grew by 0.7%; between 1974 and 1991, during which time two oil crises occurred, GDP grew by just 2.6% annually and employment by 0.5%. Over the period 1992-2007, employment was boosted by measures aimed at reducing labour costs and by the economic upturn between 1997 and 2001 (2 million jobs created in four years), only to subsequently slow once more as growth conditions deteriorated. Lastly, the 2008 financial crisis has cast a shadow over the last ten years (Table 2).

We can thus observe the marked reversal in annual labour productivity growth (per capita GDP) which fell by 90% between the 1960s (5%) and the 2010s (0.5%). The reduction in average per capita productivity growth after the 1974 break is in part due to the change in the composition of employment among the major

3. *See Goux & Maurin, in this issue.*

sectors: continuous decline in industry from its high point in 1974, greater resilience in construction and the take-off of the tertiary sector; the "distribution" of gains between productivity and employment appears more favourable to the latter in the services sector than in construction and, even more, than in industry. However, within each major sector, the slowdown in productivity gains is the same. This is not unique to France and has been observed in almost all developed countries, reflecting the increasing interdependence of national economies (Sode, 2016).

In terms of hourly labour productivity (GDP per hour worked), the finding is slightly different on account of the fall in annual working hours linked to the transition from a 40-hour to a 39-hour working week and later to a 35-hour working week, as well as the growth in part-time work (on the evolution of work duration since the 1970s in France, cf. Raffin & Yildiz, 2019). This reduction raised productivity growth by half of a percentage point over the whole period, except in the last ten years during which annual working hours stopped falling. However, the findings converge over the long-term: whether in terms of per capita or hourly productivity, productivity gains have fallen between each sub-period, which suggests very limited potential growth.

The Role of Labour Market Policies

The fall in labour productivity growth was in part linked to policy measures which, from the 1990s onwards, aimed at increasing the employment contents of growth. This means that, for a given level of economic growth, the number of full-time and part-time jobs created was then much higher than in previous decades. This was driven by three main factors: first, measures to reduce labour costs introduced in 1993 and supplemented from 1995-1996; second, incentives to reduce working hours, either through developing part-time work or through general reductions in working hours (introduced under the 1996 Robien Act and expanded under the Aubry Acts of 1998 and 2000); and third, the creation of jobs in non-market services (mainly youth employment contracts introduced in 1997).

More generally, the last 50 years have seen a scale-up in employment policy initiatives to accompany demographic, economic and social developments experienced in France over this period (see Online complement C3: "Cinquante ans de politiques d'emploi"). Until the first oil crisis, employment policy mostly consisted of measures to support changes in the productive system and in the labour market. However, the trend break of 1974-75 and the resultant increase in unemployment marked a key turning point in government policy. Once the conventional instruments to combat unemployment were perceived as ineffective and it was considered that a return to previous employment standards would not be possible, there was a radical change in the objectives and policy instruments, which rapidly increased in number and scope. Policies developed between 1975 and 1995 focused primarily on addressing the most urgent labour market imbalances and containing the increase in unemployment.

In the 1990s, it slowly became apparent that the government would need to supplement specific policies, which up to that point had consisted of high-level structural measures to reduce labour costs for all low-paid (assumed low-skilled) jobs. The focus of the employment policy shifted to initiatives that could contribute to this reduction: lowering employers' social contributions for low-wage jobs became a key policy instrument in France. Between 2000 and 2016, the cost of this policy initiative increased

Tableau 2
Growth, Productivity and Employment

(Annual change in %)

	1962-1973	1974-1991	1992-2007	2008-2018
GDP	+5.7	+2.6	+2.1	+0.9
Employment	+0.7	+0.5	+0.8	+0.4
Productivity per capita	+5.0	+2.1	+1.3	+0.5
Hours worked per capita	-1.0	-0.9	-0.4	-0.2
Hourly productivity	+6.0	+3.0	+1.7	+0.8

Coverage: France.
Sources: Insee, National accounts – Base 2014 (2017 semi-def; 2018 provisional)

from €15bn to almost €50bn (at 2016 prices) while the cost of specific employment supports reached €10bn. In other words, general relief measures represented 85% of all supports in 2016 vs. 55% in 2000.

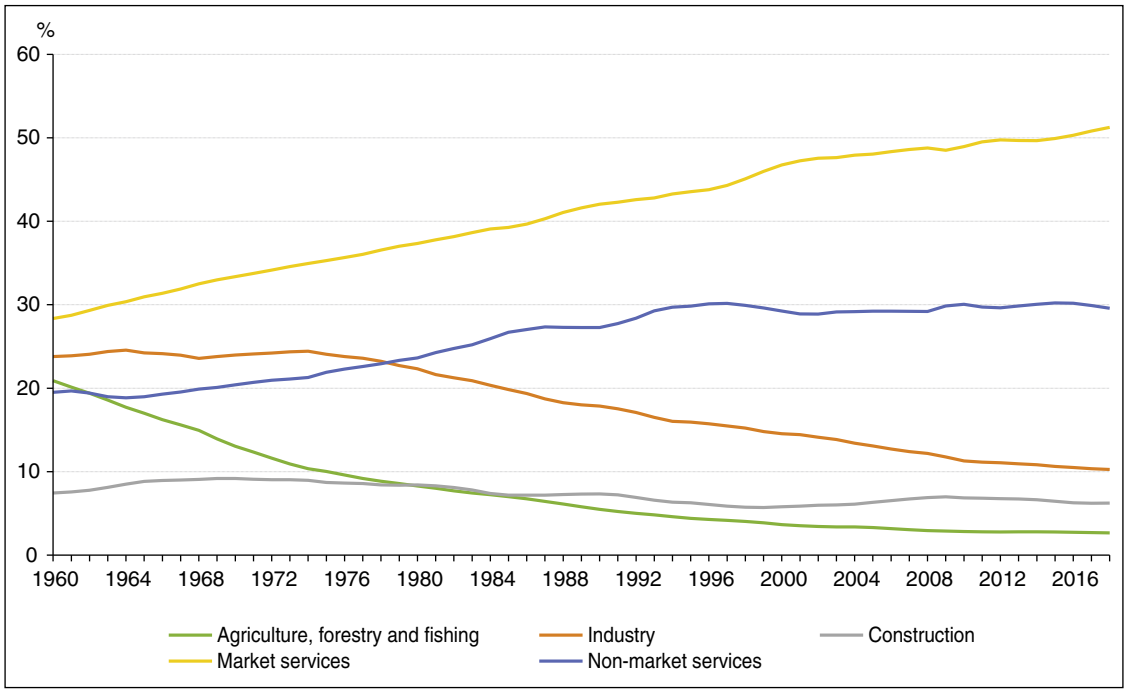
Effects on employment: from large industrial companies to service SMEs

France's transition from a rural, agrarian society to a post-industrial society where the vast majority of workers are employed in services took place over almost two centuries (Marchand & Thélot, 1997). Today, the service sector accounts for around 80% of jobs, industry and construction 17% and agriculture 3%, as opposed to 48%, 31% and 21% respectively in the early 1960s (Figure IV). In terms of numbers employed, this represents a loss of over three million jobs in the primary sector and one million in the secondary sector, while 13 million jobs were created in the tertiary sector. Part of this movement is however attributable to outsourcing tertiary operations formerly carried out in-house by manufacturing companies.

The Rise of Services in the Economy

Industry saw continuous reductions in employment from late 1974 onwards (2.5 million fewer jobs by 2018); however, this trend appears to be reversing in recent years. The few industrial branches seeing their employment numbers increase over the period 1960-2018 include the "energy, water, waste management and remediation" branch (63%); agri-food, which saw a fairly steady but modest increase (12%) despite public health incidents affecting a number of sub-sectors; and pharmaceuticals, where employment numbers have held steady since 1978 after increasing by half over the previous 18 years. Textiles, clothing and leather-footwear, coking and refining, and extractive industries all saw sharp falls in employment since 1960. In other branches, employment fell steadily from 1975 onwards, having increased in earlier years, with total job losses of between one-third and one half since 1960. Employment in construction also entered a downturn in 1974 but, unlike industrial sectors, sharply increased once again in the second half of the 1980s (7%) and particularly in the ten years prior to the 2008 financial crisis (34%). Numbers fell again until 2017, but at a slower rate than in other industrial sectors, before a moderate increase in 2018.

Figure IV
Employment by sector of economic activity



Coverage: France.
Sources : Insee, National accounts - Base 2014 (2017 *semi-définitif* and 2018 *provisoire*).

Lastly, while the number of agricultural producers continues its relentless decline (400,000 today, down from over 3 million in 1960), albeit at a slower rate as the minimum threshold approaches, the number of salaried workers has remained stable at between 320,000 and 350,000 since 2008, significantly lower than almost one million in 1960.

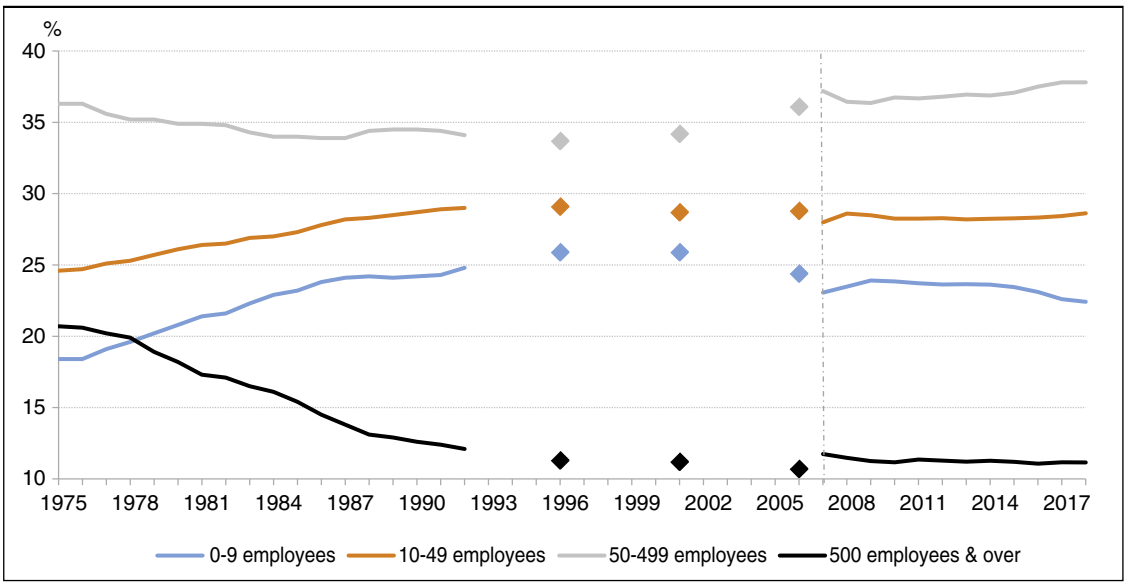
When discussing the service sector, it is increasingly important to distinguish between market services, which accounted for 14.4 million salaried or non-salaried jobs in 2018, and non-market services (e.g. employment in state, regional government and hospitals and employment in private-sector education, health care and social action organisations), which accounted for 8.3 million. Within market services, there are also significant variations between sectors with high turnover (e.g. retail, services to individuals and businesses, etc.) and sectors where the average length of service among staff is considerably higher (e.g. major national companies, banks, insurance companies, etc.). The experiences of these different areas of the tertiary sector are in marked contrast. Market services remain the most dynamic, for both services to individuals and companies (with temporary employment). Non-market services, having seen significant employment growth until 1985, subsequently created increasingly fewer jobs – if we exclude the major contribution of public employment schemes (e.g. community work, solidarity employment and in particular subsidised youth employment contracts). In financial services and insurance, the rate of job creation slowed dramatically between the 1980s and 2000, before increasing once more.

Decentralisation of Production

In line with the rise of the service economy, the share of small organisations in salaried employment increased in France after the first oil crisis, breaking with a secular trend – excluding the 1930s crisis (Figure V). The phenomenon was particularly pronounced in industrial sectors, where large units lost jobs and underwent restructuring (e.g. break-up, subsidiary creation rather than merging), outsourced or subcontracted their operations, or even closed in favour of small industrial or service units. This was reinforced by the transition of the economy towards services because, on average, industrial firms are considerably larger than service-oriented companies. However, the shift from large entities to SMEs also took place in industry, construction and market services.

The overall trend seems to be fading out during the 1990s and halted in the 2000s: the proportion

Figure V
Shares of employees by company size



Coverage: France excl. Mayotte; market sector excl. agriculture, energy, armaments, public transport, postal services, telecommunications and public health until 2006; market sector, excl. agriculture, forestry and fishing, excl. extra-territorial activities and employees of private individuals employers from 2007 onwards.
Sources: Unedic until 2006, Acoss 2007 onwards.

of salaried employment in units with 500 or more employees fell from 21% to 11% between 1975 and 1996 before stabilising; at the same time, the proportion of employment in small units with under 50 employees increased from 43% to 55%, holding steady thereafter (Sources: UNEDIC until 2006; ACOSS 2006 onwards). Some tertiary sub-sectors such as retail or hotels, cafés and restaurants are an exception to this trend; small retail businesses were replaced by medium and large supermarkets, individual hotels by large chains, resulting in some homogenisation with a trend towards medium-sized units (50-500 employees).

Mass Unemployment and the Rise of New Forms of Employment

By definition, the number of unemployed is obtained ex post by the difference between the number of people in the labour force and the number of people in employment. But unemployment is not just a balance: its level can influence participation decisions, as well as employment conditions. Mass unemployment has thus disrupted the behaviour of job providers and job seekers, and extended the "halo" around unemployment.

Towards Mass Unemployment After the Growth Trend Break of 1974

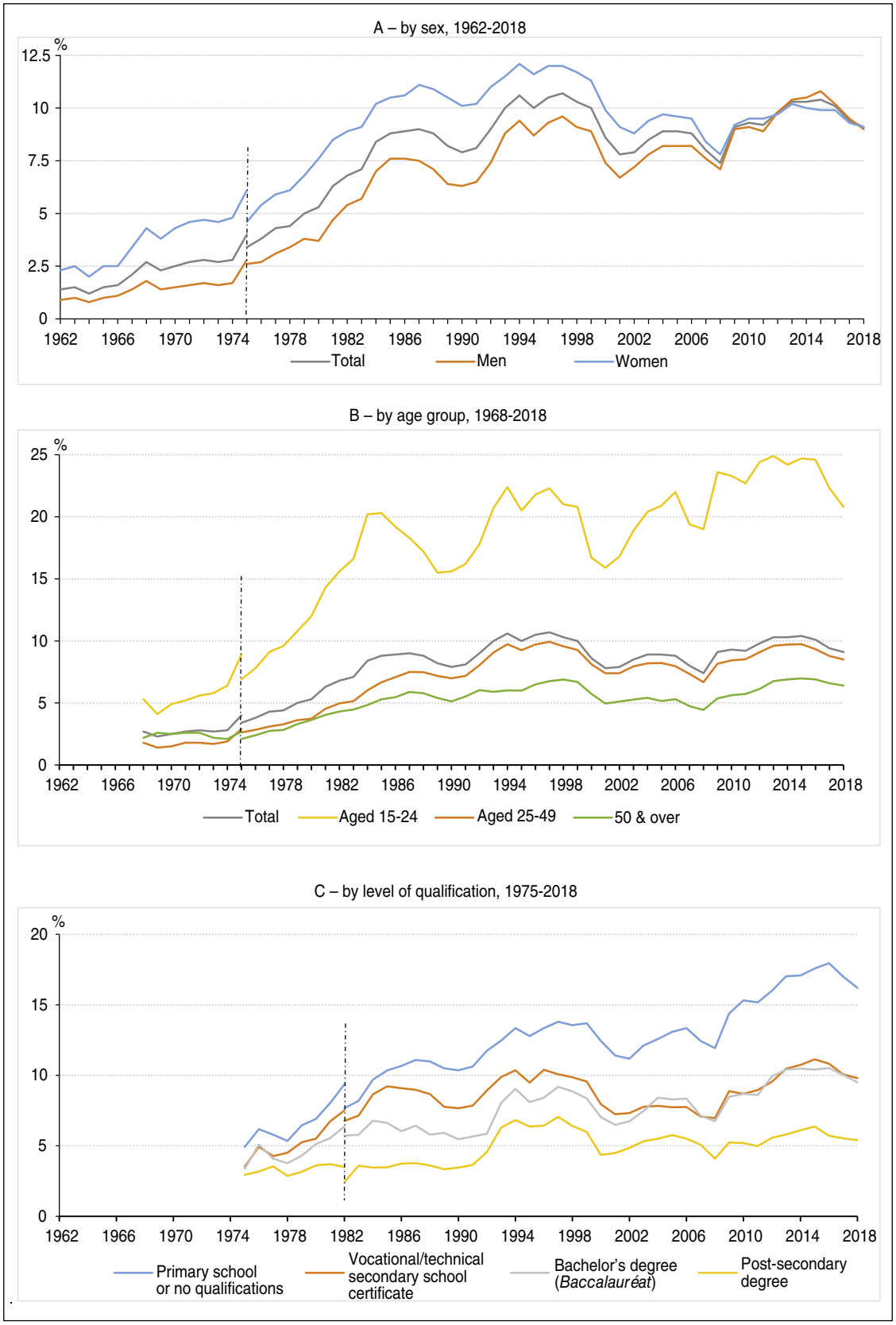
Changes in the working population, which grew uninterrupted for 50 years, and in employment, were reflected by sharp increases in unemployment. While unemployment stood at just 2% in the mid-1960s, it increased moderately from 1967 onwards (Figure VI-A), but with a reduction in its average duration, suggesting that most unemployment was frictional. The unemployment rate would subsequently soar in after the first oil crisis of 1973, passing the one-million mark in 1977 (4.3% of the workforce) and the two-million mark (8.4%) in 1984 after the second oil crisis. The unemployment rate climbed to 9% in 1987, then to 10% from mid-1993 to mid-1999 (with the exception of the second semester of 1995), and between late 2012 to early 2016. At no point did it fall back below 7.5%, despite favourable economic conditions in the late 1980s and late 1990s, as well as in 2006 and 2007. Since 2015, however, the unemployment rate has been on a downward trend but still exceeds 9% on average in 2018. The contrast is stark, between the baby boomer generation who encountered no problems in entering the labour market on the one hand, and the subsequent generation who experienced major difficulties in finding the stable employment to which it could aspire with their level of education on the other.

The different sub-groups of the population have been affected to varying degrees. One of the most striking developments of the recent period has been the convergence of men and women unemployment rates. While women have been at a structural disadvantage, the gap stood for a long time at three or four percentage points during periods of economic recovery. However, from the early 1990s onwards, the gap began to close, falling below two percentage points in 2002, to below one percentage point in 2007 and had even inverted by 2012 (Figure VI-B). This convergence can be explained by the higher level of education among women, and the increasing number of jobs in the tertiary sector where the share of women is than the average – or, particularly, in industrial sectors.

On the other hand, significant disparities remain in unemployment by age. Over the whole period, the youth unemployment rate has been higher than that for over-25s. However, this divergence became more pronounced after the economic trend break in 1974; despite measures introduced since the first *Pacte pour l'emploi des jeunes* (Youth employment pact) of 1977 to facilitate their entry into the labour market, the increase in unemployment has disproportionately affected young workers (Figure V-B). The youth unemployment rate also shows higher-than-average fluctuations; during each economic downturn, the unemployment rate among the under-25s rose above 20%, reaching close to 25% between 2013 and 2016. Yet it also fell rapidly during the second half of the 1980s, between 1997 and 2001, and most recently. Young people are overrepresented among job applicants and where they are employed, it is most often in sectors and with employment arrangements that are the most sensitive to short-term economic fluctuations: they therefore represent an adjustment variable for the labour market. It should however be noted that, for young people, the unemployment rate is much less significant than the share of unemployment, i.e. among all young people, not those in the workforce only (see Online complement C1). A majority of those aged 15-24 continue their studies without entering the labour market and, in 2018, just 7.8% of the age group as a whole were unemployed, almost the same as the proportion for those aged 25-49.

At the opposite extreme, the unemployment rate among seniors is considerably lower than

Figure VI
Unemployment rate



Notes: ILO definitions as interpreted until 2002 and average age in the year for years 1968-1975; current interpretation of ILO definitions and exact age from 1975 onwards. 'Primary school or no qualifications' include holders of a certificate of primary education or lower secondary school certificate (formerly BEPC).
Coverage: Metropolitan France until 1975 (1982 by level of qualification), France excl. Mayotte from 1975 onwards.
Sources: Insee, Employment survey long series (1987 series until 1974, current series 1975 onwards).

for those aged 25-49, while there was almost no difference in the second half of the 1970s. The relative advantage of seniors became more pronounced until the mid-1990s, before moderating thereafter. By contrast with young people, older workers unemployment is not linked to higher risk of becoming unemployed (or vulnerability), but to major difficulties in finding a job if unemployed (low employability). Since the 1970s, the vulnerability of those aged 55 or over to unemployment remained very low, while the share of long-term unemployed in this age group increased significantly, from approximately 40% in the early 1970s to almost 60% in 2018.

After 1974, the increase in unemployment was also very uneven depending on the level of education (Figure VI-C), and between socio-professional groups. The range of unemployment rates widened considerably: for those with few or no qualifications, albeit increasingly few in number, the increase was high following the 1974 economic trend break and unemployment rates rose above 15% after the 2008 financial crisis; on the other hand, for those with higher education levels, rates have remained at around 5% since 2000. The unemployment rate among managers remained relatively low throughout the period: 1% in 1974, 3% in 1985, just over 5% at its highest between 1993 and 1998, and between 3 and 4% in the last 20 years. However, the rate for unskilled workers increased by around 15 percentage points over the same period, affecting one in five in the labour force in 2018. Essentially, since 1974, manual workers, particularly the least qualified, and, to a lesser extent, clerical, services and sales workers with no qualifications have been most affected by the increase in unemployment.

A Widening Unemployment "Halo" and More Frequent Short-Term Contracts

The new order of the productive system has challenged the concept of stable, full-time employment with strong social protection, as flexible employment have not affected the whole working population. It is in fact possible to distinguish, within new working arrangements and labour management practices that have emerged as the productive system has restructured, between internal and external flexibility. Internal flexibility that includes multi-skilling, occupational training, career development, mobility within the company and adaptation of working hours and conditions to economic constraints, have most often benefited a core of permanent full-time staff. External flexibility, which involve recruitment on short-term contracts with the risk of unemployment at the end of fixed-term or temporary contracts, have most often affected older and younger workers.

However, an increasing number of those with no job and who are seeking work do not meet the ILO criteria to be classified as unemployed. Such circumstances on the fringe of unemployment have become much more common in recent decades, indeed to such an extent that an international definition of this "unemployment halo" was adopted by the International Conference of Labour Statisticians at the ILO in October 2013. The category is difficult to estimate statistically and standardised time-series only date back as far as 1990; in 2018, it accounted for 1.6 million people, 3.8% of those aged 15-64. Over the last 30 years, the number of people within this category has fluctuated cyclically but less than the numbers of unemployed. Between 1990 and 2018, both indicators increased in more or less the same way, but in the most recent period between mid-2015 and late 2018, the number of unemployed fell by 16% in metropolitan France, while the halo "expanded" by almost 3%. Women are more likely than men to be in this "halo" despite the fact that they are less impacted by unemployment than men since 2012. Seniors are less exposed to the risk of unemployment and are less likely to fall within the halo, while they are more likely to be found in the category of discouraged workers.

There is another space between employment and unemployment that has increased considerably as precarious employment and underemployment have continued to rise. Temporary employment contracts (short- and fixed-term contracts) became much more common from 1976 onwards, during the economic recovery following the first oil crisis. The share of these contracts in total employment increased in particular between 1982 and 2000 (6.7 percentage points, vs 1.5 percentage points between 2000 and 2018). Their increase is more a matter of hiring flows (9 out of 10 new hires are temporary contracts) than of existing jobs stocks; however, their share in total employment has increased from 5% in the early 1980s to 13.5% in 2018 (Figure VII). Their rise has been fuelled and strengthened by employment policy measures aimed at encouraging job seekers to (re-)enter the labour market as trainees or in short-term jobs. Within companies, temporary positions are currently used to adjust employment to fluctuations in activity. At the structural

level, this form of employment has become an increasingly common method of recruitment and is part of the management of companies' human resources, even for skilled positions.

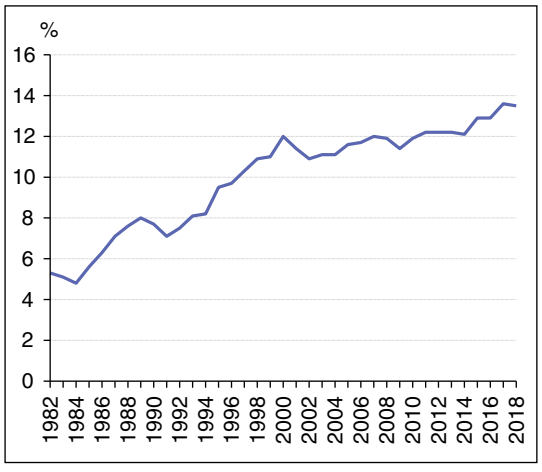
Furthermore, over the past 15 years, fixed-term contracts, short-term contracts, i.e. contracts shorter than three months, and particularly those under one month, represent an increasing share of all appointments made in a year, most likely in connexion with the gradual expansion of the "*CCD d'usage*", a de-regulated form of short-term contract introduced in the 1990s (Barlet & Minni, 2014). Among short-term contracts, single-day short-term contracts have increased sharply since 2001. However, over the same period, the proportion of people on short-term contracts has remained stable, which suggests a sharp increase in turnover during the period and therefore more frequent transitions between employment, unemployment and inactivity, affecting young people in particular (Jauneau & Vidalenc, 2019).

Part-Time Employment

Part-time employment is somewhat different, on account of its diversity and its high concentration on women (see Pak & Zilloniz, 2013; Milewski, 2013). Part-time work grew considerably between 1975 and 2000, contributing to the underlying trend of reduction in annual working hours. Almost non-existent in the 1960s, today it accounts for 18.5% of total employment (Figure VIII), and it is overwhelmingly female: over 80% of part-time positions are held by women, while almost 30% of women (as opposed to 8% of men) work part time. Its increasing prevalence, in particular in the 1990s, has contributed significantly to the rise in female labour force participation (see Afsa & Buffeteau, 2006) and to the increasing representation of women in paid employment (Meurs & Pora, this edition). Since the early 2000s, its progression is only due to men.

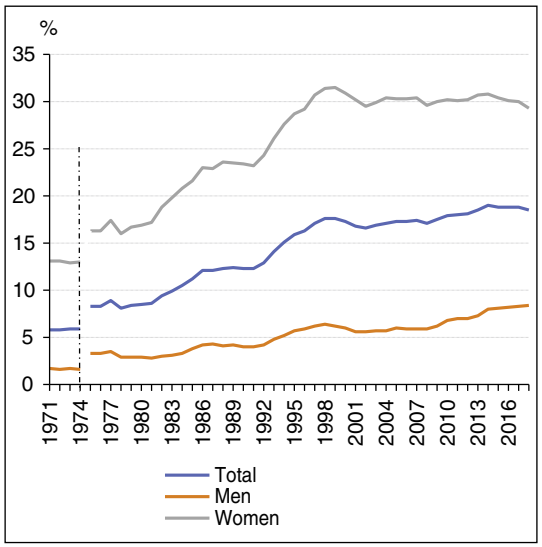
The "voluntary" or "unvoluntary" nature of part-time work has been the subject of much discussion in France (for a brief overview of the discussion, see CESE, 2014). There is no official definition of "constrained" part-time employment, but it is generally considered to be due to not being able to find a full-time position. Under this criterion, part-time employment is mostly "chosen", but this is becoming less so. The growth of part-time employment has primarily affected low-skilled occupations in the tertiary sector (e.g. retail, hotels, cafés and restaurants, services to individuals, etc.), driven by the growing need for flexibility on the part of employers. Part-time employment in this case is often combined with fixed-term employment: in 2018, 23% of part-time employees were on fixed-term or temporary contracts, vs 13% of full-time workers.

Figure VII
Proportion of temporary contracts



Notes: Temporary contracts: temporary and fixed-term contracts (including public service fixed-term contracts, apprentices and seasonal workers).
Coverage: Metropolitan France before 1975, France excl. Mayotte after. Employed people according to the ILO definition.
Sources: Insee, Employment survey long series (1987 series until 1974, current series 1975 onwards).

Figure VIII
Proportion of part-time employment



Coverage: Metropolitan France before 1975, France excl. Mayotte after. Employed people according to the ILO definition.
Sources: Insee, Employment survey long series (1987 series until 1974, current series 1975 onwards).

Underemployment related to working hours was defined by the ILO as consisting of two types of employment situation: those who work part-time and would like to work more and are available to do so, and those who are temporarily laid off at the time they are surveyed. In 2018, 1.6 million people were underemployed, in particular those with no qualifications, young people and women. Alongside the growth of part-time employment, their share in total employment increased from 4.0% in 1990 to 6.6% in 1999. It stood at 6.0% in 2018, down 0.7 percentage points on 2013.

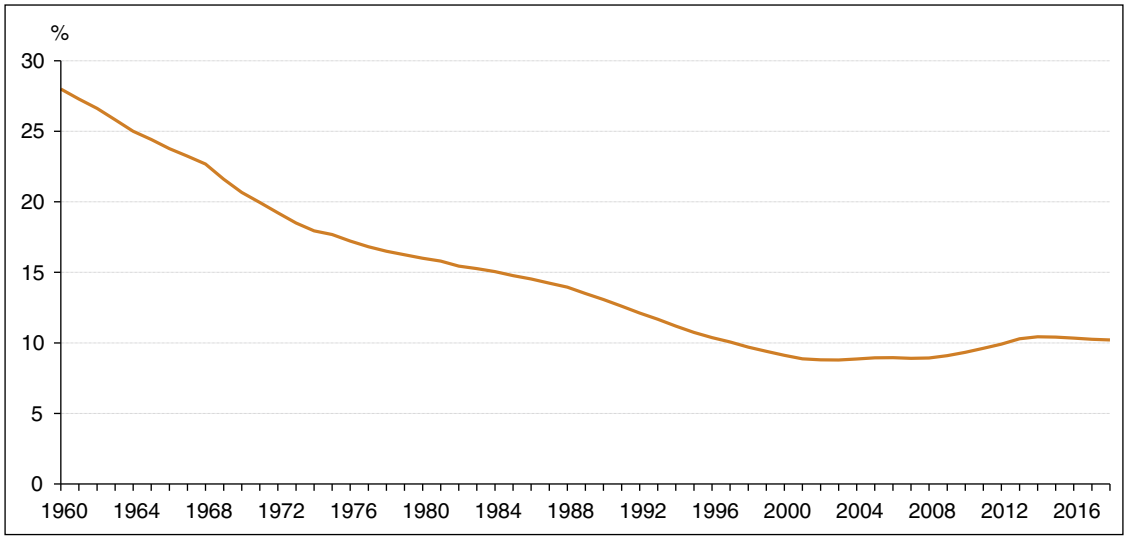
Employees or Self-Employed: Increasingly Difficult to Separate

After a continuous decline from 1960 until the early 2000s, the share of self-employment stabilised at around 8% until 2010 before a slight recovery (Figure IX). Self-employment may have been a means of adapting to and escaping from mass unemployment. It has also led to the introduction of new corporate policies, for example some companies have reduced their staff numbers to focus on their core operations and outsourced peripheral operations to subcontractors. A number of public policies encouraging people to set up businesses have, since 2003, facilitated the creation of new companies (La Boetté, 2019). Lastly, the introduction in 2009 of the "*auto-entrepreneur*" status (re-labelled "*micro-entrepreneur*" in December 2014[4]) led to renewed growth in self-employment in service sectors and, in some professions, micro-entrepreneurs have, in just a few years, come to occupy the space held by traditional forms of self-employment.

In the process, salaried employment and self-employed categories have become less differentiable: the notion of salaried employment is increasingly difficult to define, due to the growing challenge of establishing a clear subordinate relationship between the principal/customer and the worker, which is integral to correctly defining the contract between both parties. Both categories have changed in tandem, resulting in wide variety of situations poorly captured by statistics (CNIS, 2016) Employment on the fringes of salaried status has grown, either in the form of jobs that are increasingly loosely based on salaried status and the protections that it offers, or in the form of bogus self-employment or false subcontracting. For example, in construction, companies offered strong incentives to some of their workers to become self-employed, which may allowed to substantial reduction in labour costs by circumventing legal and regulatory requirements; however, those new self-employed remain most often fully tied to their former employer, who in effect is their sole customer. Situations such as these are common in other sectors such as haulage or large-scale retail. More recently,

4. In mid-2018, 1.35 million people were classed as micro-entrepreneurs, 780,000 of whom recorded positive turnover in the second quarter of 2018. Income generated by this new form of employment is usually meagre; three-quarters of micro-entrepreneurs who reported an income in 2016 earned less than €680 per month. These incomes are therefore often supplemented by income for salaried employment.

Figure IX
Share of self-employment



Coverage: France.
Source : Insee, National accounts – Base 2014 (2017 *semi-définitif* et 2018 *provisoire*).

various occupational arrangements have emerged, such as multiple employment, employers' groups, umbrella companies and digital brokerage platforms, often users of their micro-entrepreneur worker base, which raise the issue of social protection arrangements of these workers, which are weaker than those of salaried employees.

The diversification of employment arrangements has led the ILO to revise its 1993 definition by adopting a resolution concerning statistics on work relationships at the 20th International Conference of Labour Statisticians in 2018 (see Online complement C2 and ILO, 2018). The ILO, keeping the 10 basic categories of the International Classification of Status in Employment (ICSE) developed two new classifications: firstly, the "ICSE according to type of authority", which provides a high-level distinction between independent and dependent workers (which include salaried workers) by referring to socio-economic circumstances; secondly, the "ICSE according to type of economic risk", which makes a high-level distinction between workers who are in employment for profit and those who are in employment for pay (not all of whom are considered employees). The difference between these two classifications lies in how they address intermediate categories between traditional salaried and non-salaried workers, such as dependent contractors, family workers, company owner-managers. In both cases, the employee group is sub-divided into four categories according to the type and duration of the contractual relationship with their employer. The main challenge now consists of revising survey questionnaires in order to be able to measure the new categories in a way that facilitates international comparison. For an illustration of this, we can cite the recent study by Babet (2019) that uses an additional employment survey module regarding forms of self-employment: one in five self-employed people, more than 600,000 people, are economically dependent on another entity, whether this be a customer, upstream organisation or intermediary. This type of self-employment then imposes constraints, especially it limits autonomy as regards task content, working hours and price setting.

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Over the past 50 years, the labour market has been profoundly transformed. Alongside the underlying trends (arrival of baby boomers onto the labour market, increasing levels of salaried employment among women, higher educational attainment, accelerated decline of agriculture, the onset of shorter working hours), a few key moments have led to profound changes: the first oil crisis represented the first trend break that ended the post-war economic boom, ushering in a prolonged period of weak growth after 1974. The sudden slowdown in GDP and labour productivity growth was accompanied by the steady increase in unemployment and the emergence of precarious employment. It also marked the beginning of the downturn in employment in industry and of the share of manual workers among the working population. The trend break of 1974 also marked the beginning of more substantive employment policies.

The second oil crisis led to significant shifts in economic policies, with in the early 1980s, policies aimed at containing unemployment, then in the mid-1990s the introduction of policies to enrich the employment content of growth. The 1990s ushered in the emergence of the so-called "new economy", based on knowledge, communication and information, with the online and digital revolutions disrupting the way companies operated and working arrangements. Lastly, the subprime crisis of 2008 had a brutal effect on the world economy and, in turn, the French economy, dashing earlier hopes of a return to "high-quality full employment" (Marchand, 2002). The last ten years have also seen an end to the positive contribution of demography to labour force growth, now only supported by increases in the retirement age – a further indication of the ageing labour force, albeit much less pronounced in France than in Southern or Eastern Europe, or further away, as in China or South Korea.

Many of the drivers of profound changes in the labour market described here have then declined in or came to a halt by the year 2000. They have left a labour market characterised by a high diversity in employment arrangements and circumstances, where insecurity has become more common. □

Link to the Online complements: https://www.insee.fr/fr/statistiques/fichier/4253035/510-511-512_Marchand_Minni_complements_FR.pdf

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Gender Equality on the Labour Market in France: A Slow Convergence Hampered by Motherhood

Dominique Meurs* and Pierre Pora**

Abstract – In France since the 1970s, the growth in labour force has been driven largely by that of women's participation in the labour market and the fact that they interrupt their careers less often after motherhood. Their level of education has also risen considerably, and they have, on average, been more highly educated than men since the 1990s. But these developments did not result in reducing the gender pay gap to what might have been expected: the average hourly wage gap in the private sector has remained around 20% since the mid-1990s. In this average gap, the share explained by differences in human capital (education, experience) was cancelled out and even reversed between 1968 and 2015. The persistence of the wage gap now appears to be mainly linked to the consequences of motherhood. A child's arrival causes mothers a loss of annual income largely due to adjustments in their working time. This penalty is higher for mothers whose wages are at the bottom of the wage distribution.

JEL Classification: J13, J16, J31
Keywords: gender inequalities, gender wage gap, motherhood penalty, event study

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In France, the current Presidency of the Republic has promoted equality between women and men as a major project (*grande cause*) of this five-year term. The emphasis placed on this issue is not new, as evidenced by the numerous studies, official reports and legal provisions adopted since the 1960s. On the narrower issue of equality of pay on the labour market, a paradox emerges: notwithstanding the increasingly detailed laws on the occupational equality practices to be implemented by employers, and despite significant changes in the number of women present in the labour market and their qualifications, the gender pay gap is only narrowing very slowly. How can this phenomenon be explained? Standard economic explanations based on differences in human capital, i.e. qualifications and experience, can no longer account for the pay gaps identified. Today, the consequences of parenthood on careers appear to be the principal obstacle to occupational equality between men and women.

In this paper, we review, firstly, the legal background to gender equality in pay and the long-term changes in men and women labour market participation in France. We then set out various measurements of the raw pay gaps and their development since 1967. We then move on to a statistical analysis of the average gaps over the long term. We will see that traditional statistical tools explaining the gap by differences in observed productive characteristics are less and less effective in accounting for the gap. Of the numerous lines of analysis of the gender pay gap, the impact of maternity on careers is the one emerging today as the primary obstacle to earnings convergence between women and men. In the second part of the paper, we estimate the consequences of a maternity (and paternity) on participation, hours worked and hourly pay in the ten years following the birth for the population as a whole, then according to the position in the wage distribution. We show that the impact of maternity leads to adjustments in terms of participation, hours worked and hourly pay to the detriment of mothers, these effects being much more pronounced for those with fewer qualifications.

A Legislative Framework Reinforced Since the 1960s

Concern in relation to equality in pay between women and men is nothing new, as demonstrated by the numerous official reports on the subject (Majnoni d'Intignano *et al*., 1999; Grésy, 2009) and the laws and decrees adopted in the last fifty years requiring employers to eliminate pay discrimination and, more widely, fostering occupational equality between women and men. The Law of 22 December 1972 established the principle of equality in pay between women and men in the Labour Code. From the 1980s onwards, a series of laws would pave the way for negotiations on this issue within companies and sectors. The Law of 13 July 1983 (*loi* Roudy) on occupational equality introduces the obligation to draw up a comparative status report providing harmonised statistical indicators to discuss with trade union organisations during negotiations on occupational equality; such discussions became compulsory, on an annual basis at company level and on a quarterly basis at sector level, following the Law of 9 May 2001 (*loi* Génisson), and the obligations have been extended since the Law of 23 March 2006 and the Decree of 18 December 2012. The Law of 4 August 2014 (*loi* Valaud-Belkacem) on effective equality between men and women goes beyond the scope of the company in seeking to combat gender inequality in the private and public spheres as well as in the labour market, focussing on the balance between family life and work.

With the under-representation of women at senior management level becoming increasingly apparent, further steps were taken to foster occupational equality between women and men with the Law of 27 January 2011 (*loi* Coppé-Zimmerman) requiring a minimum proportion of women (40% as at 1 January 2017) on boards of directors of listed companies, and, as of 2012, in state-owned companies; the obligation extends to the public service as of 1 January 2013 for appointments to senior management positions (covering around 6,000 positions).

Finally, the Decree of 8 January 2019 for the implementation of an index of equality in pay between women and men (*Index de l'égalité salariale entre les femmes et les hommes*[1]) breaks with the earlier approaches, which had in common the prescription of rules for employers. Here, companies are asked to calculate and publish a single, standardised indicator, and have an obligation to achieve a minimum score of 75 out of 100 points over three years, with the threat of financial sanctions if they fail to do so (1% of the total wages bill if the company does

1. *Established in Law No 2018-771 of 5 September 2018.*

not achieve 75 points).[2] The score is constructed on the basis of several weighted criteria (pay gap, increases and promotions per position and age band, application of the legal obligation to pay an increase upon return from maternity leave equal to the increase granted to other employees, number of women among the ten most highly paid employees). Like any composite index, the method of calculation is open to discussion and may be improved. Currently, for the part relating to pay, only hourly earnings excluding bonuses and allowances are compared, which eliminates part-time work and bonuses while these are two key factors in pay inequality between women and men (Coron *et al*., 2019). But there is clearly a shift away from the previous legislation: the issue is not to be able to show that the statutory rules are being formally applied, but that the operation of the company leads to "actual" equality of pay between women and men, i.e. as measured by the index.

Converging Behaviours in the Labour Market since the 1960s

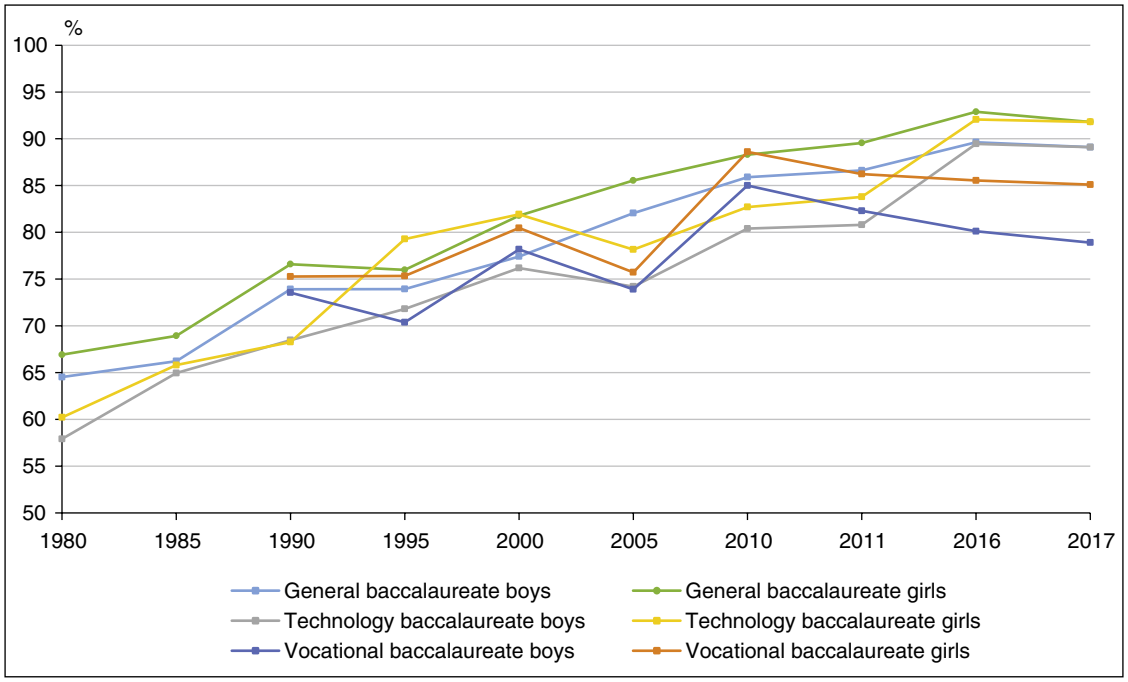
All of these provisions apply to working populations the composition of which has changed profoundly since the 1960s, with a convergence of behaviour on the labour market between women and men. We consider here some major indicators of these long-term developments.[3]

The first, very simple, indicator shows that France, like most OECD countries, has seen a marked increase in overall educational attainment since the 1960s, and that proportionately this has benefited girls rather than boys. One of the indicators of this development is the proportion of people holding the Baccalaureate in each generation. This increased from 20% in 1970 to 79% in 2017,[4] with girls consistently achieving higher rates, regardless of the type of Baccalaureate (Figure I).

It should be noted that by 1971, the rate of girls holding the Baccalaureate had caught up with that of boys, reflecting the equality in access to higher education, as noted by Baudelot & Establet (1992) – who also noted that the gender mix was not fully achieved in terms of the fields of higher

2. This index was first implemented within companies with over 1,000 employees, then as of 1 September 2019 applied to all companies having over 250 employees.
3. For more detailed explanations of these changes, see Ministère du travail *(Ministry of Labour), 2018.*
4. See the DEPP time series, Ministère de l'Éducation Nationale *(Ministry of National Education).*

Figure I
Baccalaureate completion rate for candidates, by gender and baccalaureate type



Coverage: Metropolitan France plus overseas departments, including Mayotte from 2011 onwards.
Sources: MEN-MESRI-DEPP/Océan database and survey 60 on the final results of the MAA baccalaureate/Ministry of Agriculture database.

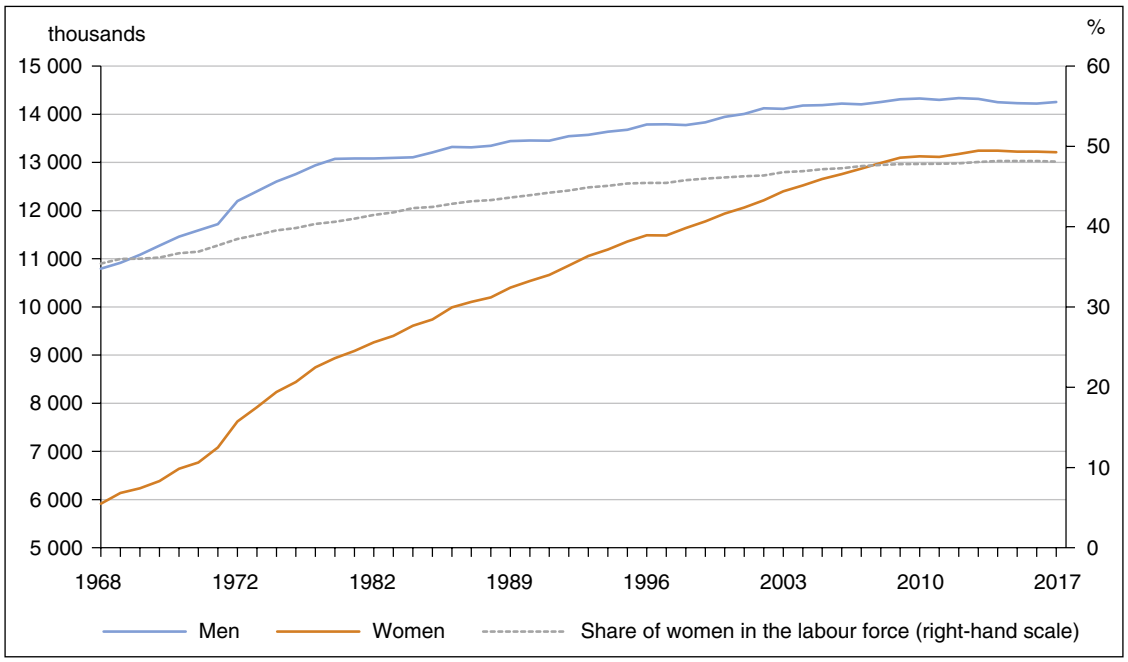
education. These differences have diminished, but have not disappeared.

The second notable trend of the period 1968-2017 is the steady increase in absolute terms in labour market participation among the 20-59 age group (Figure II), particularly before the 2000s. The huge increase in the labour force (from 16.7 million to 27.5 million) was driven primarily by women: for this age group, the number of men in the labour force increased by a factor of 1.3 between 1968 and 2017, while the number of women increased by a factor of 2.2. As a result, the proportion of women in the labour force increased steadily, rising from 35% before 1970 to near parity (48%) at the end of the period (see also Marchand & Minni, this issue). Over the generations, women have also had an increased presence on the labour market during their lifetimes, and their probability to work between the ages of 25 and 54 has increased steadily (Minni, 2012).

In addition to the rise in female labour market participation rate and continuity of participation, women's risk of unemployment has become equivalent to the risk for men. In the 1960s, unemployment was close to zero for men aged between 20 and 59; France was is in full employment for this age group. By contrast, in the same period, women's unemployment rate was around 5% (Figure III). It subsequently increased in parallel for men and women from the 1970s onwards and by the end of the 1990s, it was 12% for women and almost 9% for men. During the 2000s, the parallel alignment of the two curves disappears. The male unemployment rate increases at a faster rate than the female rate, and the two rates are broadly equal since the 2008 crisis at just under 10%.

The trend described above of women's growing rate of participation in the labour market is reflected in the proportion of women amongst employees, with near parity (49%) achieved in 2015; in the private sector, the proportion of women increased from less than a third before 1970 to almost 45% by the end of the period (Figure IV). In the 1990s, this increase in the proportion of women in employment is closely related to growth in part-time employment: the proportion of female full-time employees rises more slowly than the proportion of female employees on the whole, particularly in the private sector (Afsa & Buffeteau, 2006). The growth in part-time employment is linked to the policy of exemptions from employer contributions introduced for part-time jobs in 1992, along with the potential to combine reductions in charges for jobs paid close to the minimum

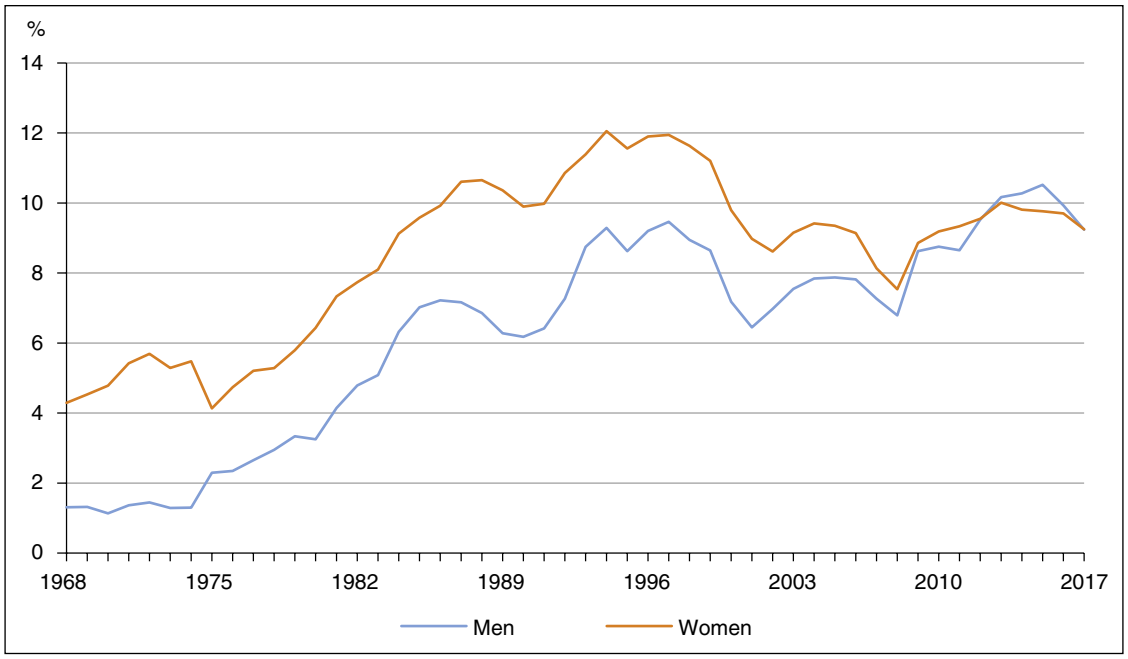
Figure II
Labour market participation, 20-59 age group



Coverage: 20-59 age group - metropolitan France.
Sources: Insee, Labour Force Surveys (*Enquêtes Emploi*).

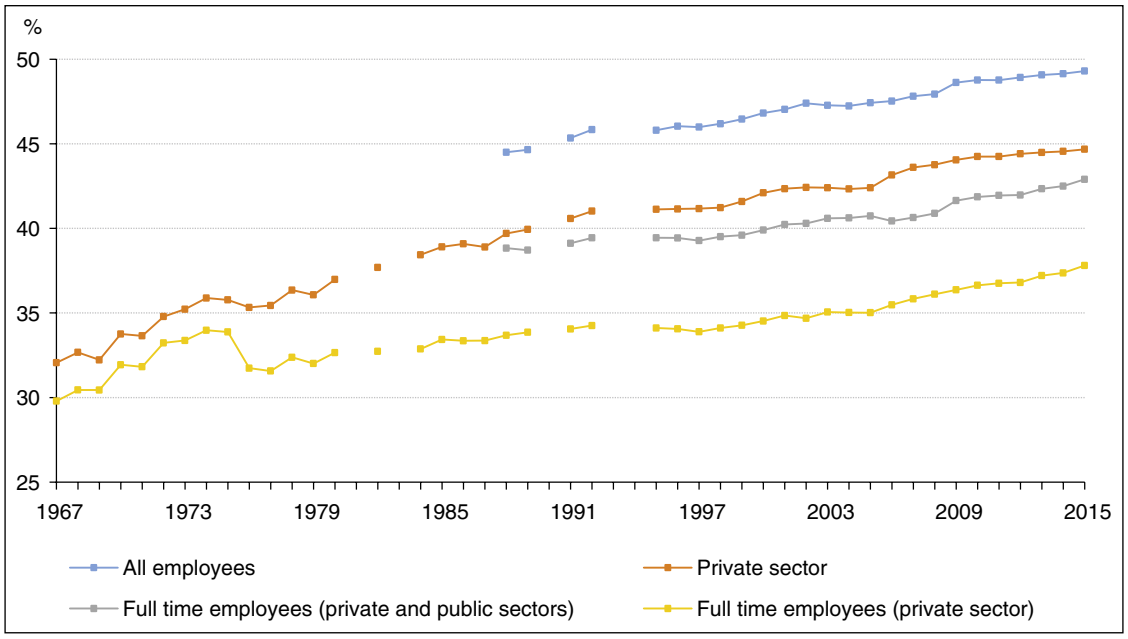
wage until December 1997. The exemptions for part-time workers were discontinued in 2003 (*amendement* Fillon), but they undoubtedly had a ratchet effect; the proportion of part-time female employees in the private sector has since remained stable at close to 30%. If we look at

Figure III
Unemployment rate, 20-59 age group



Coverage: 20-59 age group - metropolitan France.
Sources: Insee, Labour Force Surveys (*Enquêtes Emploi*).

Figure IV
Proportion of women in all employees, 20-59 age group



Notes: Data for years 1981, 1983 and 1990 are not available. Data for years 1993 and 1994 are not exploitable.
Coverage: Metropolitan France, all employees aged between 20 and 59, where the number of days of paid work in the year exceeds 45, excluding agriculture.
Sources: Insee, DADS panel.

full-time private sector employees, the increase in the proportion of women is less pronounced: at the end of the period, they only represent 36% of all employees.

A Gradual Progress Towards Equality in Pay Since 1967

The convergence of women's and men's behaviour in terms of labour market participation has not resulted in the net trend of reduction of the gender pay gap which might have been expected. But, before tracing developments since 1967, concepts and sources used must be clarified. Comparing men's and women's wage appears simple *a priori*, this variable being available in numerous databases. But in practice, it is impossible to give a unique figure for the raw gender pay gap. This is due to several possible methodological options: what coverage should be used? Which sources should be used? Should differences in working time be taken into account or not? These questions are associated with the issue itself: women and men do not work equally across all sectors, with the same numbers of working hours and the same duration over the year. Depending on the options retained, the variations in the raw gap are considerable: for example, in 2015, depending on whether we consider the hourly wage of all employees or the earnings from employment received during the year, the raw ratio of women's to men's wage is 85% or 77%,[5] that is a divergence of almost ten points.

The main sources allowing to study changes to individual pay over the long term provide information of two kinds: either reported by the employees themselves (or the person in the household questioned) as in the *enquête Emploi* (the French Labour Force survey); or based on administrative data from employers, the information being set out in the DADS and its various satellites (see Box 1).[6] The *enquête Emploi* has been widely used in statistical studies of inequality between women and men because it has the advantage of covering the entire population, including inactive persons, but it has the disadvantage of a lack of precision in terms of income and length of time worked. Further, wages are only available in level form from 1990 (previously the information was only on wage brackets). The "DADS" data, which remained difficult for researchers to access for a long time, have the advantage of being accurate in terms of both the composition of pay and length of time worked, and of providing information since 1967, which means that it is the source with the longest historical record of pay; its disadvantage is that it only covers the private sector over the long term (that is since 1967), the public sector being added in 1988, and employees of individual employers in 2009. The inability to go back further than 2009 for hourly pay in the public sector and 1995 for all employees represents a severe limitation in the study of differences in pay between women and men in view of the far higher proportion of women in the public sector than in the private sector (62% and 46% respectively in 2017, see DGAFP, 2017[7]).

We present a series of indicators of the change in women to men ratio of net annual earnings, all based on the DADS, varying the coverage according to the availability of data. We start with the wage income of all employees (full-time and part-time) in the private sector over the period 1967-2015 and for employees in all sectors from 1988[8] onwards (Figure V). Before 1970, in the private sector, women's average wage income was less than 60% of men's average wage income. This ratio rises throughout the period studied, reaching 73% in 2015. When all sectors are taken into account, i.e. including wages paid in the public sector, inequalities between women and men are slightly less pronounced: the ratio of women's average wage income to men's is 77% in 2015.

To illustrate the impact of working time differences on these ratios, we examine several measures of the wage gap between women and men (Figure VI). First, we consider the ratio of daily wages (wage income divided by the number of days worked) for all employees, then on the restricted scope of full-time employees – and, there again, since 1967 for the private sector and all sectors since 1988. Then we consider the ratio

---

5. Sources: DADS, 2015.

*6. There are other surveys which provide information on pay, but they are more recent (ECMOSS – an annual survey on labour costs and pay structure undertaken by Dares, at 18,000 entities since 2005 with a sample of employees from each entity) or they are one-off surveys (*enquête Familles et Employeurs *Insee-Ined 2004-2005 (Insee-Ined family/employers survey)) or they provide aggregated information (ACEMO). Other promising sources are now available such as the ERFS (*enquête sur les Revenus Fiscaux et Sociaux*, a survey on household income) but they do not go back any earlier than 2005 (or 1996 for the ERF, the first version of the ERFS). Lastly, the European panels (firstly the ECHP and then EU-SILC) were set up in 1994, but pose problems with calculating hourly pay (the income declared is one year behind as compared with the working hours reported).*

7. Analyses of the difference in the gender pay gap between the private and public sectors can be found in Arulampalam et al. *(2007), Lucifora & Meurs (2006), and Gobillon* et al. *(2018).*

8. Only employees who have worked more than 45 days are retained here and in the rest of the article, to limit the problems related to the measurement of very low volumes of work in the DADS on the one hand, and to work on a population of individuals who are relatively regularly present in paid employment on the other hand.

of hourly wages of all employees (from 1995 for the private sector, and from 2009 for all sectors).

The ratios measured on the basis of the daily wages of full-time employees and on the basis of the hourly wages of all employees appear very similar over the period 1995-2015; the daily full-time wage therefore seems to be a good basis for measuring similar working time wage gaps over a long period. In 1967, this ratio was

Box 1 – **Data and Definitions**

DADS-EDP Panel

The DADS-EDP panel results from matching the DADS "all-employees" panel with the *Échantillon Démographique Permanent* (EDP, a demographic panel, based on the Population Census). The "all-employees" panel includes data from two administrative sources: the *Déclarations Annuelles de Données Sociales* (DADS, based on compulsory annual employers' declarations on the employees at their entities) and State payroll files.

The all-employees panel provides information on a number of employee characteristics (e.g. sex, year of birth), their jobs (e.g. type of contract, date of appointment, wage and bonuses, number of days worked, hours paid) and the entities where they are employed (e.g. economic sector, company size, location).

The EDP is a socio-demographic panel developed since 1967; it is based on of civil status certificates (e.g. births, marriages, deaths) and surveys for individuals born 1 and 4 October. The sample quadrupled in size in the 2000s with the addition of individuals born between 2 and 5 January and the first four days of April and July. The all-employee and EDP panels (forming the DADS-EDP panel) are matched through a registration index number (the NIR, *Numéro d'Inscription au Répertoire*); the matched data allow us to determine the level of education reported by employees in surveys, as well as their children's year of birth. However, as no information was available before 2002 for individuals born in January, April and July, and the information was incomplete for children of individuals born on 2 or 3 October (Couet, 2006), we matched individuals born on 1 or 4 October, then reconstructed data for employees born on 2 or 3 October. To recreate data on births of children of individuals born on 2 and 3 October, we use comprehensive Census data from between 1990 and 1999, available in the EDP. Specifically, we complete 1982 to 1997, absent from birth certificates, using data on births collected in the Censuses.

Coverage

The DADS coverage, and therefore of the all-employee panel, is not constant over time. Accordingly, the data used covers private sector employees from 1967, and public sector employees are only included from 1988. In the private sector, employees of individual employers are only included from 2009. The information on the number of hours paid is only available from 1995 for the private sector, public hospitals and local and regional authorities, and only from 2009 for the State civil service.

Unlike the DADS, the DADS-EDP panel covers all employees in all sectors (that is including the public service) since 1988, which allows us to describe the pay gap between women and men for "all sectors" from that year onwards.

In order to obtain long series which are as consistent as possible over time, we work on different coverage depending on the data available: firstly, earnings paid by the private sector, which are available from 1967; secondly, we construct series relating to earnings paid by all sectors (public and private), for which the period covered starts in 1988.

Measuring Pay

For each coverage, we construct three pay series:

- A series on earnings, which corresponds to the sum of all earnings paid to employees, since 1967 for the private sector and from 1988 for the "all sectors" series;

- For full-time employees only, a series of daily wage, i.e. the ratio of annual earnings to the number of days worked in the year, covering the same periods;

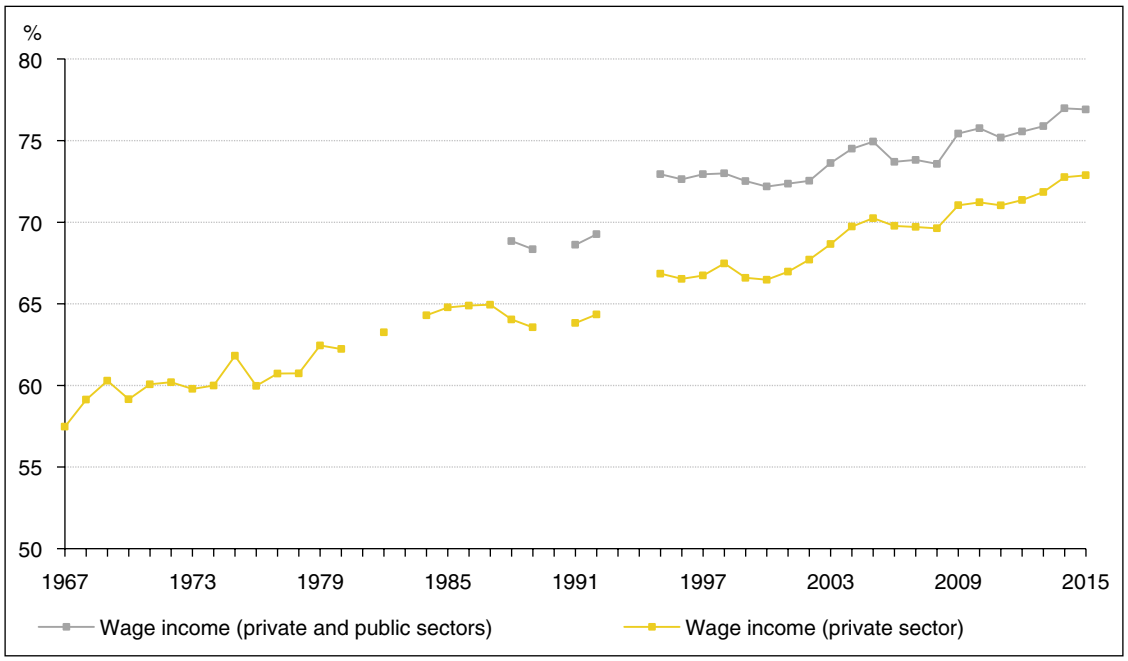
- For all employees (full-time or part-time), a series of hourly wage, i.e. the ratio of annual earnings to the number of paid hours over the year; it can only be constructed from 1995 for the private sector, and 2009 for the "all sectors" series.

Earnings are measured in terms of net pay. Net pay includes all pay from all employers to an individual in a given year, net of all social contributions (that is, including the CSG and CRDS). This amount therefore represents the earnings received by employees, as opposed to labour costs for employers.

We use the paid hours entered into the all-employee panel database. Paid hours correspond to hours for which the employee is paid by the employer, including additional hours and overtime. For employees paid a fixed daily rate, the employer does not report paid hours, which are instead imputed on the basis of the number of paid days (salary period) while ensuring that the hourly pay is consistent for this imputation.

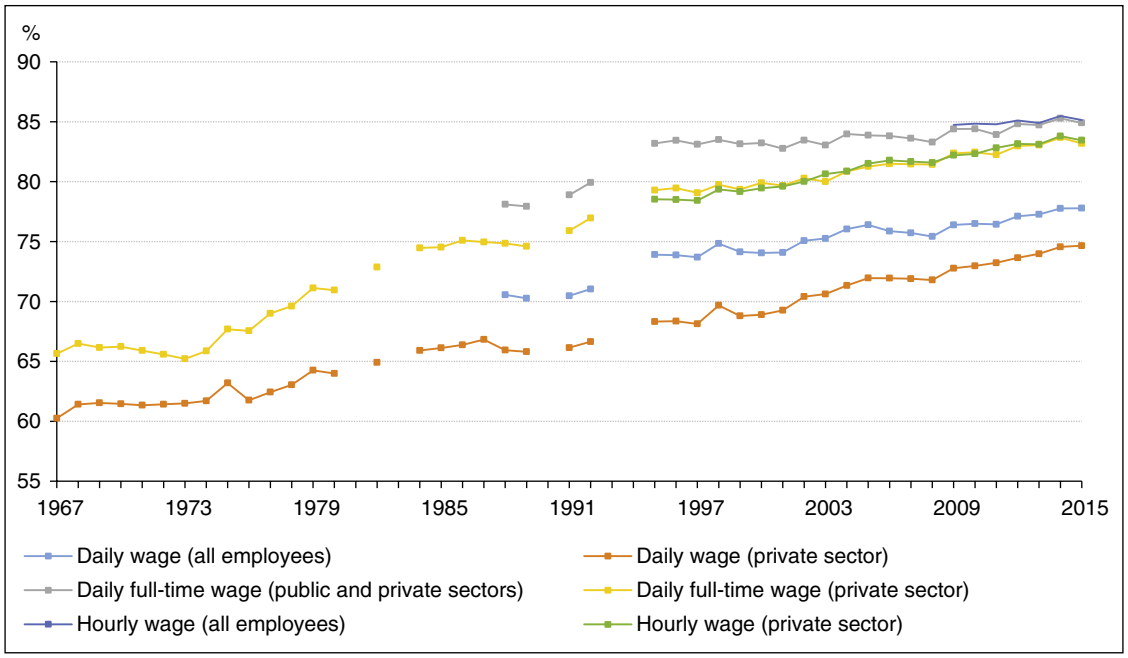
Payment of maternity leave is excluded from the earnings. In principle, paid hours are equal to 0 for the period of maternity leave, but not days (salary period). One notable exception relates to employees on a fixed daily rate, for whom the employer does not report the hours when completing the declaration. For these employees, hours are then allocated based on the salary period and hourly pay. As such, paid hours during the year in which maternity leave is taken are probably overestimated for these employees (and the hourly pay underestimated).

Figure V
Ratio of female-male wage incomes, 20-59 age group



Notes: Data for years 1981, 1983 and 1990 are not available. Data for years 1993 and 1994 are not exploitable.
Coverage: Metropolitan France, all employees aged between 20 and 59, where the number of days of paid work in the year exceeds 45, excluding agriculture and employees by private employers.
Sources: Insee, DADS panel.

Figure VI
Ratio of female-male daily wages, 20-59 age group



Notes: Data for years 1981, 1983 and 1990 are not available. Data for years 1993 and 1994 are not exploitable.
Coverage: Metropolitan France, all employees aged between 20 and 59, where the number of days of paid work in the year exceeds 45, excluding agriculture and employees by private employers.
Sources: Insee, DADS panel.

around 65% in the private sector; it increased substantially in the 1970s to 80%, remained at this level overall in the 1990s and increased slightly in recent years to finish at 83% in 2015. For employees in all sectors, the ratio is a little higher (85%).

These developments, generally favourable to women in the labour market, have had long term repercussions on pensions. The ratio of women to men pensions has effectively increased over the generations, from 55% for the cohort born in 1934 to 62% for the cohort born in 1942 (Aubert, 2012). Box 2 provides an analysis of pension inequality between currently retired women and men, which shows the positive impact of the extension of careers (and of higher reference salaries) for different generations.

The Wage Distributions Converge Over Time, but Less for Upper Deciles

To expand on this overview, we look at how wages distributions have altered over time. Figure VII sets out the distributions of daily wages for women and men in full-time employment for four years of the period under review. In 1967, the curve that represents women's wage distribution is clearly slanted to the left compared to that for men, reflecting the gender segregation of jobs and the fact that women, including those working full time, are concentrated in lower-paid jobs. In 1975, both distributions start to converge, particularly for the lowest earnings, albeit still skewed against women. Between 2000 and 2015, there is almost no change in the distributions. For low wages, both curves now almost overlap, and

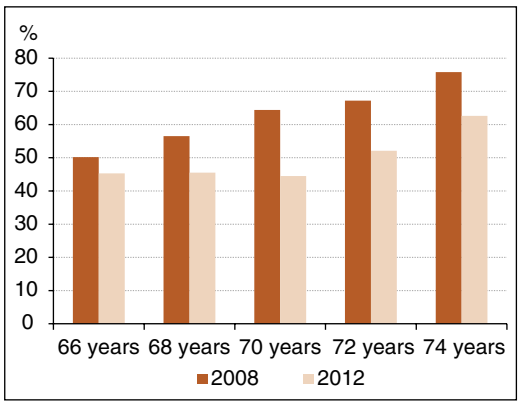
Box 2 – **Pension Inequality Between Women and Men - Slow Convergence**[(a)]

Inequalities in pay between women and men have a knock-on effect on pensions, which essentially depend on the actual previous career. Gender differences in pensions can be expected to decrease as the gender pay gap narrows. Of fundamental importance to this trend are the extension of contribution periods and the reference salary – and these two factors are likely to become even more crucial when the reform being discussed currently is implemented, and will affect the generations who are currently at the start of their careers.

What is the situation for the currently retired generations? To what extent have the changes identified since the post-war period affected differences in pensions between women and men? To answer this question, we use the years 2008 and 2012 of the *Échantillon Interrégime des Retraites* (EIR, pension sample across all schemes). This standardised data has the advantage of covering all pension schemes and amounts paid and enables the overall pension amount to be reconstituted for a sample of individuals, including persons having multiple pensions. We consider here retired persons under the general scheme (CNAV) and under the three components of the civil service: State (SRE), local/regional authorities and hospitals (CNRACL), that is over 90% of retired persons. The average pension for women under the general scheme represents around 50% of the pension for men in both 2008 and 2012. The gaps are less pronounced among former civil servants, in the SRE (over 80%) as well as in the CNRACL (around 75% for persons having a single pension, over 80% for persons having multiple pensions). The average gaps narrowed slightly between these two dates, irrespective of which pension scheme is considered.

Considering two different years enables us to differentiate the "cohort" effect from the "age" effect and to examine the average pension amount for a single age on two different dates (2008 and 2012). We only take into account the pension to which a person is directly entitled (excluding any survivor's pension) in order to focus on the links between the nature of the past career and the pension amount. The variations in pension gaps between 2008 and 2012 by cohort show a narrowing of the average gap between women and men of the same age (Figure A). The relatively low ratio for 66 year-olds is due to the fact that all economically active persons have not yet retired and that this situation is more relevant to highly-qualified men earning high salaries; for older persons (72 and 74 year-olds), the highest ratio relates primarily to a selection effect: women who have had a career are relatively rare in these generations.

Figure A
Average retirement pension gap between women and men in 2008 and 2012, by age



Source : Drees, *Échantillon Interrégime des Retraites*, 2008 and 2012.

(a) This Box shows part of the results of the report of Bonnet et al. *(2016) for UNSA-IRES and the associated working paper (2018).*

the gap in average wages between women and men is apparently due to the higher number of men in upper deciles.

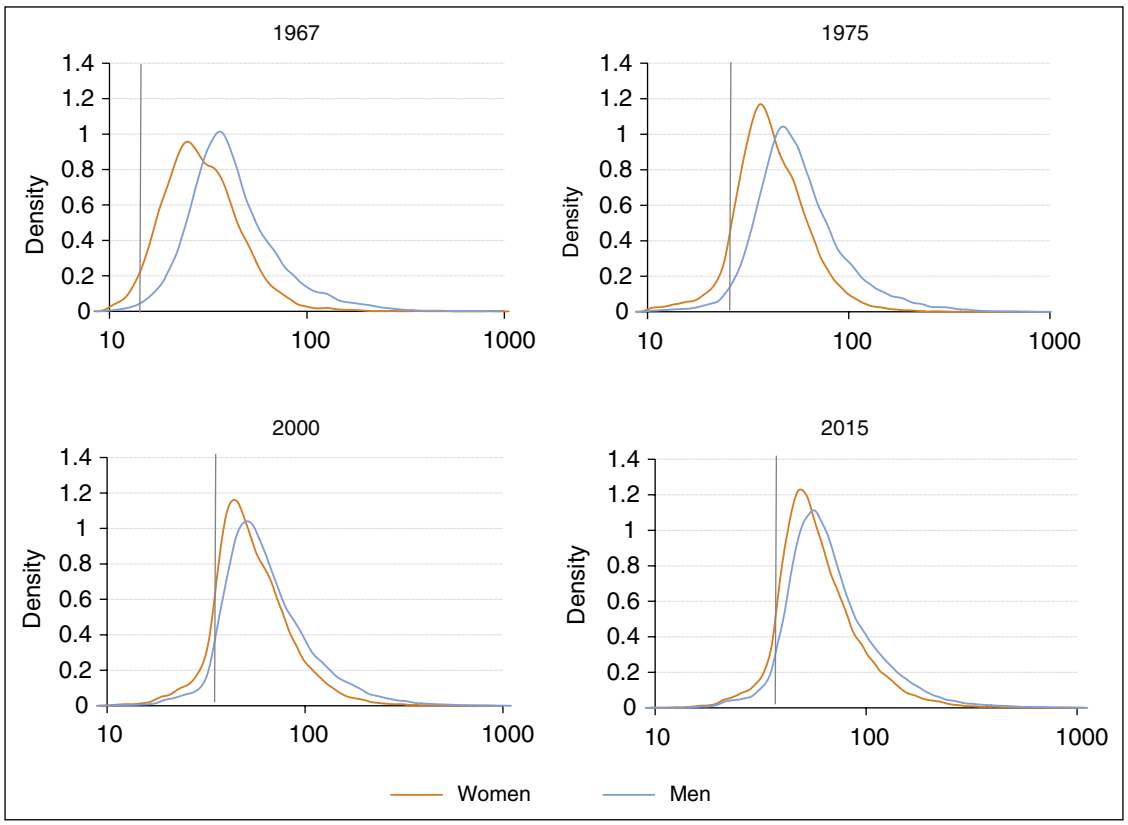
For a more detailed picture of changes in these distributions over time, Figure VIII shows the ratio of women to men daily wages for different percentiles of the distribution. During all the period, the gap is much smaller at the bottom of the distribution. Up to the median, the women to men ratio has notably increased in the 1970s, from around 70%-75% to over 90% from the 1980s onwards. This trend reflects the impact of the minimum wage, which limits gender pay gaps, and that effect extends beyond the median, up to the 75th percentile. For the highest wages (90th and 95th percentiles), three findings emerge: at the end of the period, the gender wage gaps are higher than at the bottom of the distribution (81% and 79% in 2015 for the 90th and 95th percentiles respectively); they have continuously decreased since the late 1960s; they have continued to fall during the 2000s, reflecting the increasing number of women in the highest-paid jobs during this period.

The Standard Methods of Decomposition of Average Pay Gaps

Statistical analysis of the sources of pay gaps between women and men has generated numerous economics studies, notably since the 1970s, with the wide distribution of methods of decomposition of the average divergences in pay (for a recent survey of all of these methods, see Boutchenik *et al*., 2019).[9] Since Oaxaca (1973) and Blinder (1973), it has become common practice to decompose the average pay gap between two groups (e.g. men and women, native and immigrant) into two components,

9. We only present the most usual methods of decomposition and do not deal with methods to decompose the pay gap across the whole wage distribution by constructing counterfactuals (for a survey of these methods, see Fortin et al.*, 2011).*

Figure VII
Distribution of full-time daily wages by gender, 1967, 1975, 2000, 2015 (2015 euros)



Notes: The density of hourly wages (in euros 2015) by sex is estimated by Gaussian kernel. The vertical bars represent the full-time daily net minimum wage for each year.
Coverage: Metropolitan France, all employees aged between 20 and 59, where the number of days of paid work in the year exceeds 45, excluding agriculture and employees by private employers.
Sources: Insee, DADS panel.

one corresponding to the average differences in productive characteristics of the two groups (e.g. education, experience, seniority, etc.), the other corresponding to differences in the return to these characteristics, or the unexplained component, of the pay gap. Formally, the wage gap between women and men can be expressed as follows:

$$Y_m - Y_f = \left(X'_m - X'_f\right)\beta_m + X'_f\left(\beta_m - \beta_f\right) \qquad (1)$$

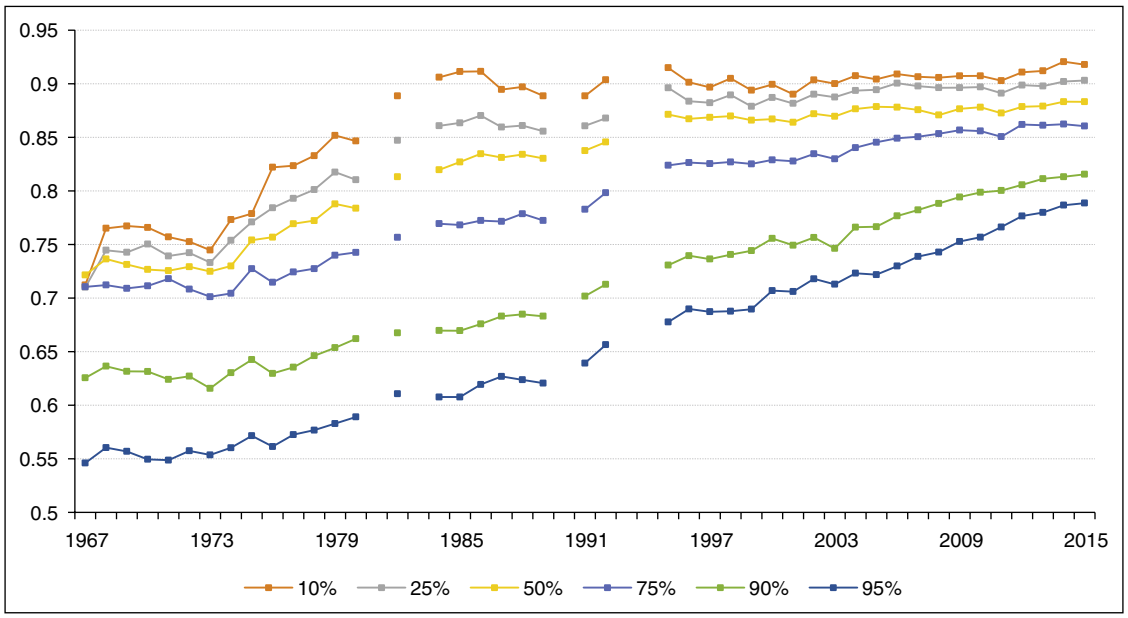
where Y is the average estimated wage of male (m) and female (f) employees, X is the vector of the means of these characteristics and β the returns to these characteristics, estimated in separate earnings equations for women and men. Should the structure of both populations be identical for the X variables considered, any wage differential could only result from a difference in the return of these characteristics, which is often considered as a measurement of pay discrimination. Reciprocally, should the average estimated returns of the characteristics be equal, the pay gap would be explained entirely by structural effects, which themselves may result from other types of inequality (e.g. access to education, accumulation of experience, etc.).

All decomposition methods face the problem of determining the "norm" – i.e. the returns to characteristics taken as reference – and the corresponding weighting. In equation (1), differentials in returns are weighted by the mean of female characteristics and differentials in characteristics are weighted by estimated male returns. A number of other options have been used in this decomposition (see Oaxaca & Ransom, 1994), in particular in Oaxaca & Ransom (1988), which is now the most often used. The underlying basis for this methodology is to define a non-discriminatory standard for the returns to individual characteristics and to measure the advantage to men, the disadvantage to females and the component resulting from differences in characteristics against this standard. In practice, the non-discriminatory standard β_N is based on the estimation of a wage equation for the entire population under consideration, irrespective of the sex of individuals. The decomposition of the pay gap at the mean can therefore be written in three parts:

$$Y_m - Y_f = \left(X'_m - X'_f\right)\beta_N + X'_h\left(\beta_h - \beta_N\right) + X'_f\left(\beta_N - \beta_f\right) \qquad (2)$$

The first term on the right hand side corresponds to the "explained" component of the pay gap. The two other terms represent the advantage resulting from being a man (higher returns than the "norm") in relation to the "standard" β_N and

Figure VIII
Ratio of female-male daily wages by position on the wage distribution



Notes: Data for years 1981, 1983 and 1990 are not available. Data for 1993 and 1994 are not exploitable.
Coverage: Metropolitan France, all employees aged between 20 and 59, where the number of days of paid work in the year exceeds 45, excluding agriculture and employees by private employers.
Sources: Insee, DADS panel.

the disadvantage due to being a woman, with the total of both terms representing the unexplained component of the gap.

There are two main methodological issues with this approach. The first is determining the specification of the wage equation. The greater the number of control variables, the smaller the unexplained component becomes, but the "explained" component may then include differences not accounted for in the equation – e.g. occupational segregation that is, the fact that with the same level of qualifications, women have less access to higher-paid employment. The second issue relates to the selection bias, specifically the probability of having a job is not equal between women and men. Not taking these differences into account could lead to biased estimates of the returns to individual characteristics and, therefore, measurements of discrimination. Heckman's "two-step" procedure (Heckman, 1979) is a frequently used method where the population in which pay is observed is not a random sample of the reference population. Its implementation nevertheless implies that information on the entire potentially employed population is available.

Differences in Human Capital No Longer Explain the Pay Gap Between Women and Men

Studies on the decomposition of the pay gap between men and women came to light rather late in France. One of the pioneering papers was that of Sofer (1990) which examined the effect of segregation of jobs by sex on the pay gap. Since then, numerous papers have presented decompositions of the pay gap (Meurs & Ponthieux, 2000; Meng & Meurs, 2001; Meurs & Ponthieux, 2006; Muller, 2012; Bozio *et al*., 2014; Chamkhi & Toulemonde, 2015). It is difficult nonetheless to compare the results or to identify trends in development of the explained (or unexplained) component, because the relative magnitude of the components depends on the data used, the concept of pay (annual, monthly, hourly), the coverage (private or public sector, or both, firms' size, etc.), the characteristics used in the analysis and the decomposition technique. For example, for the same year observed (2012), Bozio *et al*. (2014) obtain an unexplained component in the order of 25%, compared with around 10% in Chamkhi & Toulemonde (2015).

We propose below an illustration of the long-term evolution of the contribution of the differences in human capital to the gender wage gap, using the DADS, which allow us to go back to 1967. Compared to the work just mentioned, the wage equation adopted is therefore "poor" in characteristics, close to Mincer's (1958) original model. We cannot correct for the selection bias because we only observe employees and not the whole population. Wages are thus estimated as a function of education and experience, without any other explanatory variables. The idea here is to follow over a long period the share of the gender pay gap explained by these two factors representing human capital, while being aware that the unexplained share comes mainly from occupational segregation. The decomposition is carried out on the average daily wage gap (in logarithms) for full-time work in the private sector, for which we have the longest series (1967-2015). Measures of education and experience are based on the matched data from the DADS panel and the EDP (cf. Box 1).

Education is measured based on the highest diploma declared in the census. Six levels of diplomas are retained: Primary School Certificate and equivalent, Brevet (a secondary school certificate) and equivalent, CAP or BEP (technical degrees from secondary school), Baccalaureate (all types combined), Bac+2, Bac+3 and more. Figure IX shows the shares of employees holding each of these types of diploma as the highest. Three main changes are clear: the collapse among employees (men and women) of the share of the least qualified; a higher proportion of men than women with secondary school technical degrees (CAP, BEP); and a higher proportion of women than men with at least the baccalaureate, including Bac+3 degrees from the 2000s onwards.

With regard to experience, unfortunately it is not possible to calculate actual experience, because the date of first employment is not recorded for older generations. We therefore measure potential experience, which is the difference between an individual's age and his/her likely age when he/she entered the labour market, based on his/her education level. This is a fairly standard approach, because data enabling actual experience to be measured are rare.[10] It is clearly an imperfect measurement, which tends to overestimate experience, and, due to the more frequent interruptions to their career, that of women more than men,[11]

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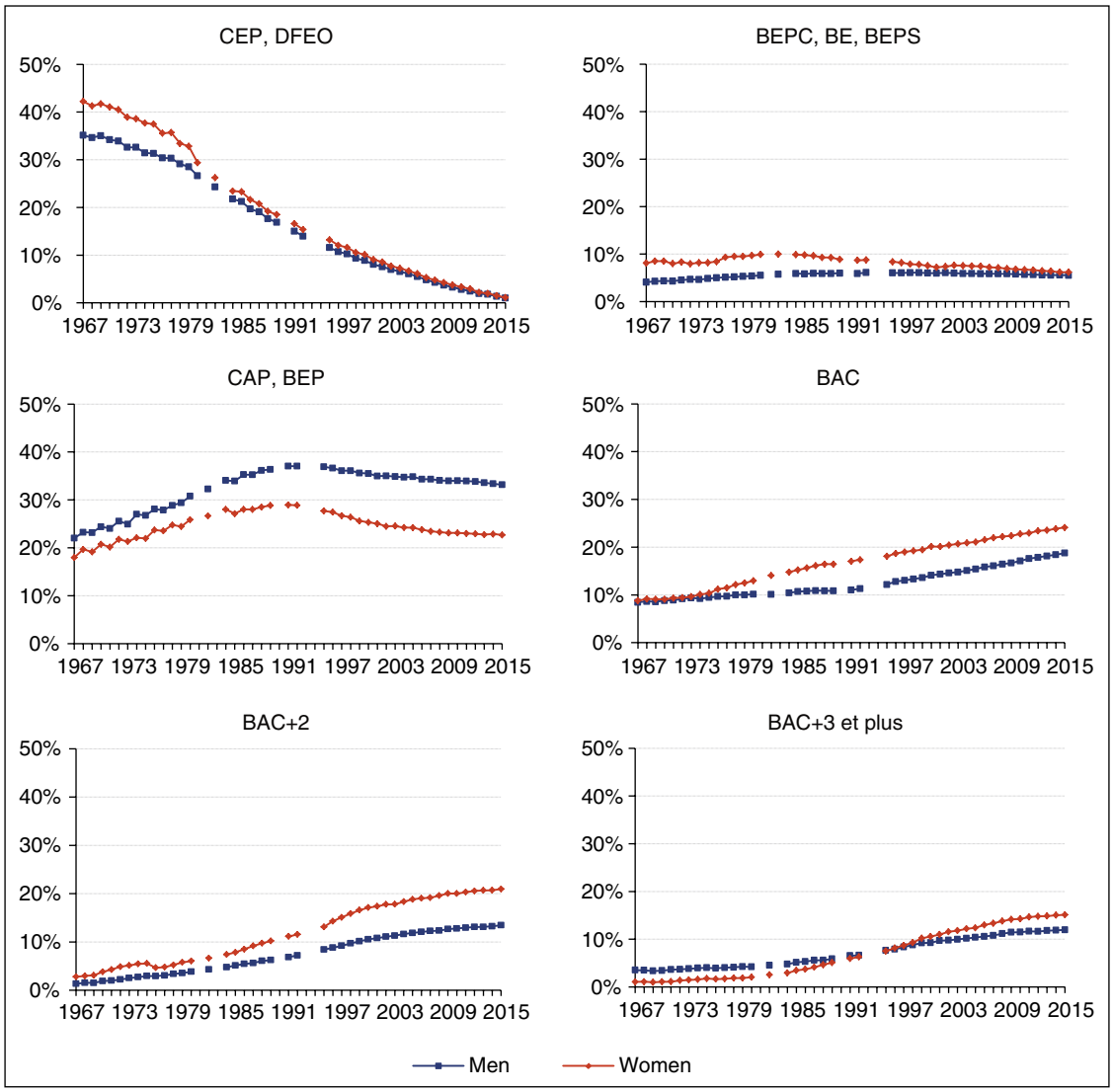
*10. We can mention the "*Jeunes et carrières*" survey of 1997, which supplemented the Labour Force survey for that year (http://www.progedo-adisp.fr/enquetes/XML/lil.php?lil=lil-0047), and the "*Familles et employeurs*" (Families and employers) survey of 2004 (www.efe.ined.fr), which both provided retrospective calendars.*

11. Which leads to the returns to experience being underestimated and pay discrimination being overestimated (Regan & Oaxaca, 2009).

notably at the start of the period. Figure X, which represents changes to potential experience of employees in our coverage, demonstrates that it has become practically equivalent between women and men at the end of the period.

Figure XI represents the evolution, from 1967 to 2015, of the gender wage gap, its share explained by differences in human capital gaps (diploma and potential experience) and the "unexplained" component (i.e. not explained by human capital differences). The raw gap between the average daily wages of women and men was at its highest, around 35% in the early 1970s. Then it decreased fairly steadily until the early 1990s, reaching a plateau around 15%. The part explained by differences in human capital is positive in the 1970s, and represents about 5% of the wage gap; in other words, in that period, part of the raw gap (14 points of the total gap) results from women's lower level of human capital than men's, to which was probably added an important selection effect. In the 1980s, differences in education and experience fade and the corresponding share of the wage gap becomes therefore increasingly small. From the late 1990s onwards, the explained share of the

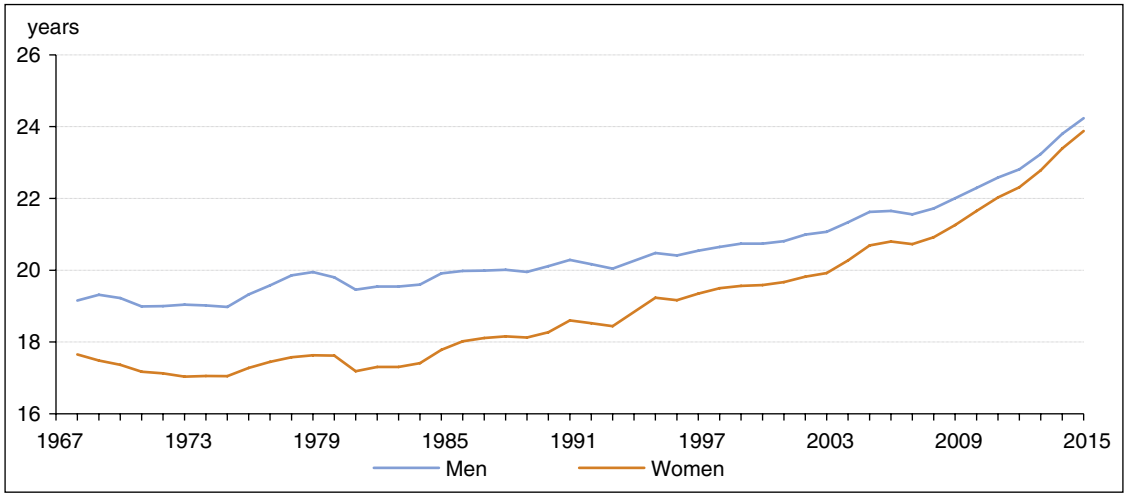
Figure IX
Diploma level by gender and year among full-time private sector employees



Notes: Data for years 1981, 1983 and 1990 are not available. Data for years 1993 and 1994 are not exploitable. CEP, DFEO: primary school degree; BEPC, BE, BPS: secondary school degree; CAP, BEP: vocational degree; Baccalauréat: general and vocational baccalaureates; BAC+2: first cycle college education; BAC+3: college education second degree and over.
Coverage: Metropolitan France, all employees aged between 20 and 59, where the number of days of paid work in the year exceeds 45, excluding agriculture and employees by private employers.
Sources: Insee, DADS-EDP panel.

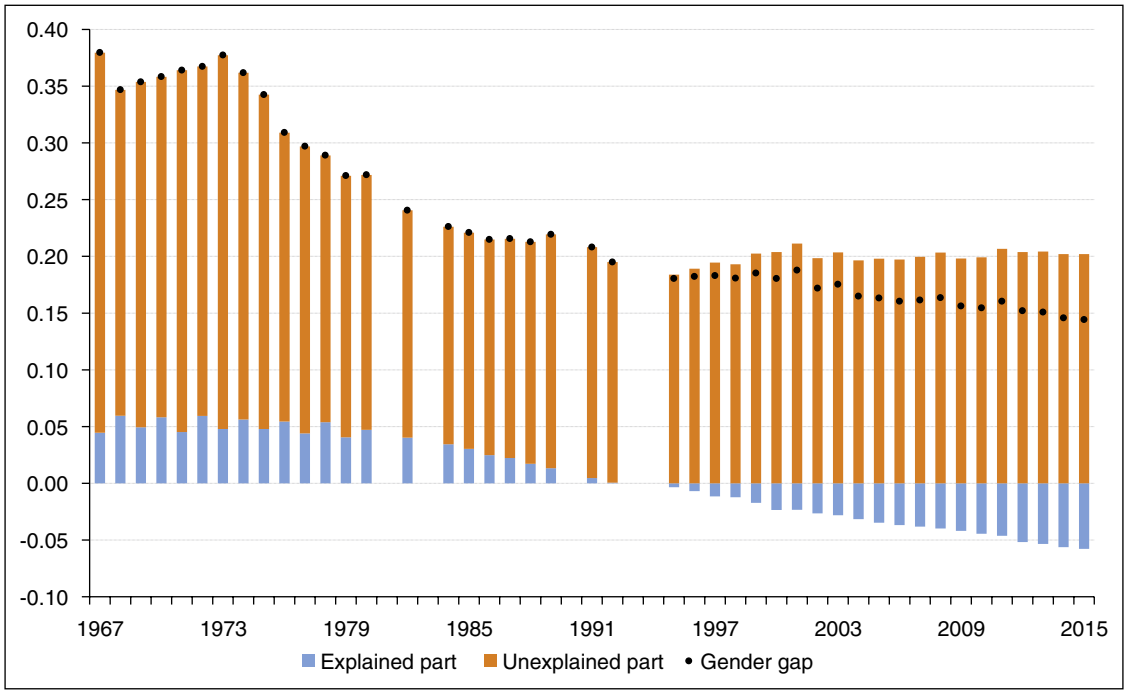
gap even becomes negative, and increasingly so, reaching -5% at the end of the period: this means that on average among full-time employees, women's average human capital, measured by qualifications and potential experience, has become higher than that of men. The rest of the wage gap, the "unexplained" part, most likely reflects occupational segregation: with identical qualifications and experience, women work in lower-skilled jobs or in lower-paying sectors.

Figure X
Potential experience by gender and year among full-time private sector employees



Notes: Sample includes only individuals born in an even year; series with a 2-years moving average.
Coverage: Metropolitan France, all employees aged between 20 and 59, excluding agriculture.
Sources: Insee, DADS-EDP panel.

Figure XI
Decomposition of average full-time daily wage gaps (log)



Data for years 1981, 1983 and 1990 are not available. Data for years 1993 and 1994 are not exploitable.
Sources: Insee, DADS-EDP panel.

Motherhood: An Obstacle to the Convergence of Women's and Men's Wage

How do we explain why the growing human capital advantage on the part of women is not reflected by a reduction in the pay gap through a more balanced distribution of women and men between sectors and jobs?

Various explanations have been offered, from the choice of educational specialisation (far more boys study engineering, and far more girls study humanities), to psychological traits (as women are more risk adverse, they are less likely to enter the highest-paying occupations[12]), to social norms[13] which result in occupational segregation to the disadvantage of women, etc. There is no doubt that job segregation has tended to diminish, but it still remains high: measured using the Duncan index[14], it stands at 51.6% in 2013 compared with 56% in 1982 in relation to classification in 86 roles (Dares, 2015). All these lines of analysis are consistent with the intuition that wage inequality is built up over time, from school through to choice of job and career progression within a company. In these life trajectories, a number of studies since the late 1990s underline the role played by motherhood to explain the fact that women's progress in education and experience does not translate into higher pay. A group of studies has therefore explored, using panel analysis, the extent of a long-term wage penalty on mothers compared with women who have not had children (the family pay gap).[15] In this line, Meurs *et al*. (2010), using employment histories from the Insee-Ined survey *Familles et Employeurs*, find that women who interrupt their career are disadvantaged compared with women (with or without children) who have continuously pursued a full-time career; but they also find that women who have no interruption are also penalised compared with their male counterparts, which cannot be explained by differences in actual occupational experience. Other research in France has focussed specifically on the impact of parental leave (Piketty, 2005; Lequien, 2012; Joseph *et al*., 2013), all of which conclude that the longer the parental leave, the higher the wage penalty. Lequien (2012) estimates that each additional year of parental leave results in a wage penalty of between 7% and 17%, depending on whether or not part-time employment is included in the model specification.

In Denmark, Kleven *et al*. (2018) recently revisited the approach of maternity-related wage penalty, using a quasi-experimental event study approach applied to the entire population of Denmark (economically active and inactive persons) over a long period. They show in particular that the proportion of earnings inequality between women and men explained by a penalty resulting from having children doubled between 1980 and 2013, increasing from 40% to 80% of the gender earnings gap. In other words, the pay gap between women and men is primarily the result of having children and of the knock-on effects in terms of participation, working hours and career development.

Mothers are Penalised After Their First Child by the Cumulative Effect of Participation, Working Hours and Sluggish Growth in Hourly Earnings

What about France? The effect of births on women's professional activity appears very clear: based on the 2004-2005 Insee-Ined survey *Familles et employeurs*, Pailhé & Solaz (2006) show that among working women, nearly 40% will modify their activity after a maternity (change in status, hours, work intensity or withdrawal from the labour market). How does this affect wages?

We follow here the analytical framework of Kleven *et al*. (2018), with an event study approach. We apply it to a balanced panel of individuals whose labor earnings from the private sector are tracked over time; we further impose that these individuals worked for at least one year and have all had a child during the period in question (see Box 3). Our approach is also in line with prior studies by Coudin *et al*. (2017, 2018, 2019), who estimate the maternity-related wage penalty using the same database. Their main conclusions highlight the role of human resources policies in companies and their differentiated impact on women and men to explain the wage gap that has widened over the years between mothers and fathers. Mothers, in particular at the birth of the second child, will be more likely to be in companies that offer more flexible working hours, are closer to their home, and are less-highly paid.

In continuation with those studies, we extend the analysis to the wage income; we therefore

12. For a research survey on the links between psychology and economic behaviour, see Bertrand (2010).
13. The reference on this topic is Akerlof & Kranton (2000).
14. The Duncan & Duncan index is used to synthesise the degree of occupational segregation; it goes from 0 (no segregation, the proportion of women and men is the same, in all occupations, as on average in the relevant population) to 100 (complete segregation).
15. The most authoritative paper on this topic is Waldfogel (1998). For a literature review on this topic, see Ponthieux & Meurs (2015).

consider labour supply decisions on the extensive margin (whether or not to participate) and intensive margin (number of hours worked) when describing the impact of parenthood on earnings. The consequences of parenthood are identified by estimating the effect of the arrival of the first child. This effect aggregates all the consequences of the transition from childlessness to parenthood, including the consequences of subsequent births. The penalty we find can therefore be considered as a minimum in relation to all the consequences of motherhood on wages.

The period of the analysis (2005-2015) is a relatively institutionally stable period in terms of family policy, in particular parental leave. The most significant reform, the creation of a unique benefit programme for early childhood (PAJE) merged a number of benefits (the birth grant, family allowances, a childcare subsidy, and an allowance (CLCA) for parents who take a break from paid employment or move to part-time hours), was introduced on 1 January 2004. For the first child, the maximum duration of CLCA is six months, that immediately follow maternity (or paternity) leave.[16] Parental leave may

16. *The maximum amount paid for the first six months where the parent opts to take leave in one instalment is on a flat-rate basis and was €573 in 2015.*

Box 3 – **Computation of the Penalty Effect of Parenthood**

The effect of the birth of the first child on earnings is estimated, based on Kleven *et al.* (2018), using an "event-study" approach, which makes it possible to differentiate the effect of childbirth from other life-cycle effects and from the long-term growth of income over generations, detected by effects specific to an individual's age and year of birth. For the limited scope of individuals *i* with at least one child, we first of all regress the earnings in the private sector, observed each year (level and not logarithm, including 0 where the individual did not work in the private sector that year) on the time period in which the birth of the first child occurs (using the final year before birth as the reference), age and year of birth:

$$Y_{ist}^{g} = \sum \alpha_j^g 1_{t=j} + \sum \beta_k^g 1_{ag_{it}=k} + \sum \gamma_y^g 1_{s=y} + v_{ist}^{g} \quad (1)$$

where t denotes the period in which the event takes place, ag_{it} the age of individual i on the date in question, s the year of birth and g the employee sex. This regression provides, secondly, an estimate of the penalty associated with childbirth, by comparing α_j^g to the counterfactual earnings in the absence of a child, estimated as the average of earnings predicted by regression (1) to which the term related to childbirth refers:

$$P_j = \frac{\alpha_j^g}{E\left(\sum \beta_k^g 1_{ag_{it}=k} + \sum \gamma_y^g 1_{s=y} | t=j\right)} \quad (2)$$

This estimation can then be extended to other outcomes such as labour market participation by limiting it where necessary (for the number of paid hours or hourly pay) to individuals employed in the private sector. For paid hours, limiting it strictly to individuals with a positive number of paid hours makes it possible to substantiate decisions on the intensive margin, rather than an aggregate of decisions on the extensive and intensive margins. On the other hand, for earnings, it is desirable to re-aggregate labour supply decisions on the extensive and intensive margins, as well as the effect on hourly earnings: this is the aggregate effect that can subsequently be decomposed. For this reason, zero values for earnings are included in the analysis of earnings.

This estimation is carried out based on longitudinal data (balanced panel), which includes all individuals who have worked at least one hour between 2005 and 2015 and who had their first child between 2005 and 2015. For years in which those employees held at least one salaried position in the private sector, earnings are taken from the all-employee panel limited to the private sector. For years in which those employees did not hold any position in the private sector, a zero level of earnings is assigned.

The heterogeneity in penalties relating to maternity highlighted by Pora & Wilner (2019) is based on an approach similar in its intention, but not in implementation. This method involves considering earnings with the life-cycle, long-term growth and business cycle effects taken out. The effect of childbirth is then estimated in double-difference, by comparing the change in earnings (including zero values for individuals not working in the private sector) from the final year before birth, used as a reference, to any other year, between individuals who have had their first child and individuals (of the same sex) who do not have children. This double-difference estimation is implemented separately in cells corresponding to the rank in the hourly wage distribution prior to the birth: each individual is assigned his/her rank in the distribution of his/her generation's hourly wage average over the five years prior to the reference year. This approach makes it possible to obtain the childbirth effect, which depends on the rank in the wage distribution before the birth of the child. It is also compatible with an accounting decomposition of earnings between participation, days worked, paid hours per day and hourly wage.[(a)] The authors also show that replacing the control group of individuals without children by a group of individuals who also have a child, but whose children were born on different dates, which is an identification approach closer to that of Kleven *et al.* (2018), yields essentially the same results.

(a) *Plus a selection term relating to the fact that individuals employed on a given date do not necessarily have the same earnings in the reference year as those who are not employed.*

be extended until the child is three years old, but leave is unpaid in such cases.

In order to have a rather homogeneous group of employees in terms of labour market participation, we applied a more strict definition of participation; in addition to having more than 45 days of paid employment per year, we apply a minimum requirement in terms of hours per day (more than one-eighth of statutory working hours) on average during the year[17] and exclude hourly pay rates below 95% of the hourly minimum wage. Based on the matched DADS-EDP data, we are able to identify the children's dates of birth. We focus on the effect on total earnings (i.e. including zero salary values for individuals who are not employed in the private sector in a given year), from the birth of the first child for the following ten years. We consider that relative falls in total earnings may have three causes: participation (whether or not to take a break from employment after the birth), the number of hours worked (possible transition to part-time or fewer days worked in the year) and the effects on hourly earnings (e.g. due to time frames for promotions).

Figure XII represents the effect of the birth of the first child between 2005 and 2015 on these three margins. Based on the methodology used by Kleven *et al*. (2018), we compare parents (mothers and fathers separately) by the number of years since the event, controlling for the effect of age (i.e. life cycle) and the year of birth to take account of changes in earnings between generations. The baseline 0 denotes the year of the event (birth of the first child) and is the reference for measuring the impact before and after on the various values, separately for women and men. The chart details the difference in outcomes between those who had their first child in year zero, in relation to their counterparts who did not experience the same event in the same year; results are reported for each of the preceding five years and subsequent ten years.[18]

Ideally, the estimated coefficients for this panel should be zero before year zero (no pre-trend), which would lend weight to the interpretation that observed divergences would be only linked the "birth" event (cf. Box 3). This condition is not met (the coefficients are significantly different from zero), neither for women nor for men. However, the trends for women and men are parallel, suggesting that the widening gap between women and men is indeed related to the entry into parenthood. Moreover, the magnitude of the pre-trend is very small compared to the changes that follow the event. For both men and women, pre-trends are mainly due to an increase in participation, with no differences in paid hours and hourly wages.

More generally, the birth of the first child does not affect fathers' total earnings (despite a paternity bonus eight years later, but it is weakly significant). Whether considering participation, paid hours or hourly wage, becoming a father does not result in any significant change.

This is quite the opposite for women. The birth of the first child results in a relative decline in total wage earnings of 40% in year zero (this reduction includes time spent on maternity leave, for which allowances are not included into the earnings measured by the DADS panel[19]), and a subsequent sustained salary penalty of 30%. This fall is caused by a combination of three components identified above, namely reduced participation (break in employment), a sustained fall in paid hours (the marked reduction in year zero is linked to maternity leave) and an hourly wage penalty that appears with a delay, and can be interpreted as resulting from reduced presence at work that can have negative consequences for career and promotion prospects. This penalty widens over time to reach about 20% by the end of the period.

Negative Effects of the First Child Especially at the Lower End of the Earnings Distribution

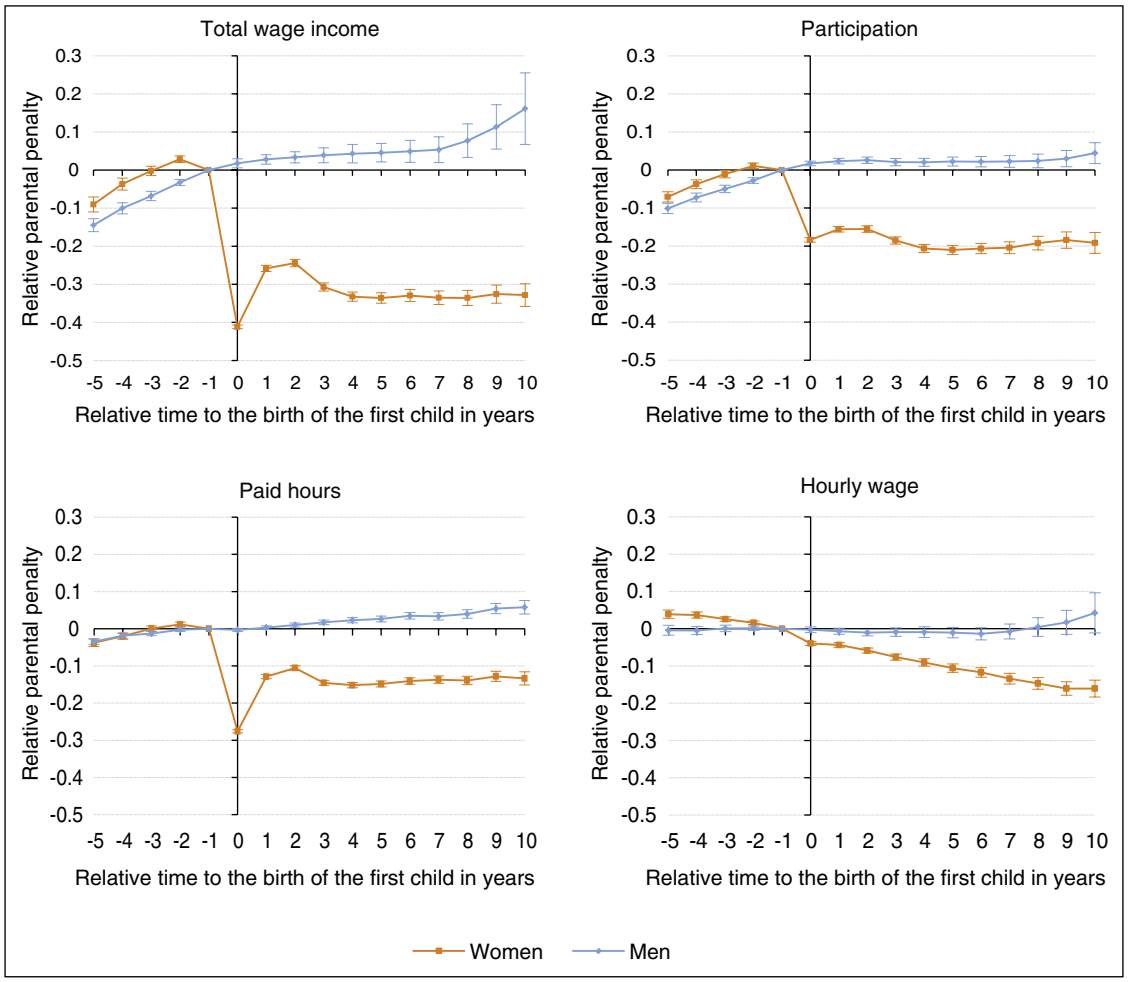
A limitation of the above analysis is that it presents an average impact, for all types of employees and regardless of pay levels. However, the choice between career and family life does not arise in the same terms according to the wage level and career prospects. Family policies also play a role in parents' occupational choices after childbirth: the option to take paid parental leave after the birth of the first child at a fixed rate of just under €600 is more attractive for employees paid close to the minimum wage than for those in higher-paid jobs; conversely, the cost of child care is more easily covered for high wages. It is therefore useful to examine the salary penalty following the birth of the first child based on the mother's salary level.

17. The data indicate the number of hours worked in the year, a total below full-time hours corresponds either to part-time hours, or to fewer days worked in the year.
18. For example, we compare for period +1 the women who had a child in the previous year, irrespective of the actual year (2005, 2006, etc.), with those who will have one subsequently.
19. Excluding continued salary payments by the employer under some collective bargaining agreements.

We maintain the earlier approach, in which we track changes in earnings, participation, hours worked and the hourly wage before and after the birth of the first child, but with a slightly different the counterfactual now consists of employees who did not have children during the period. The results presented below, on the effects by rank in the wage distribution draw on those of Pora & Wilner working paper (2019).The hourly wage is calculated for each year and age, which enables us to order groups of employees by year and age according to their position in the hourly wage distribution, then assigning each to an earnings category. Here, we create twenty categories (P0-P5, P5-P10, etc.), for all employees (men and women) present in t–1 (one year before the birth) using observations in the five years prior to the birth, provided that they were present at least twice in the four previous years. For each group (the group remains unchanged regardless of changes in wage after the birth) we estimate the effect of the birth of the first child on the wage of mothers by comparison with those who did not have children (cf. Box 3). We do not show results for fathers since we do not observe any effect for paternity, whatever the rank in the wage distribution.

Components of the overall effect on total wage include, as above, participation, working time (in hours and days over the year), hourly wage, to which we add a "selection" effect. This corresponds to the fact that employees observed in a given period, $t+k$, may not have had the same prior earnings as those who opted out. We expect this effect to be positive (i.e. the highest paid stayed longer) – which is what is actually obtained.

Figure XII
Impact of the birth of the first child on total wage income and its components



Coverage: Metropolitan France, private sector employees aged between 20 and 59, excluding agriculture, who have worked at least one hour in the private sector between 1995 and 2015. For the graphs on paid hours and hourly wage: if the number of hours per day exceeds one-eighth of statutory working time and daily wage exceeds 95% of the hourly minimum wage.
Sources: Insee, DADS-EDP panel.

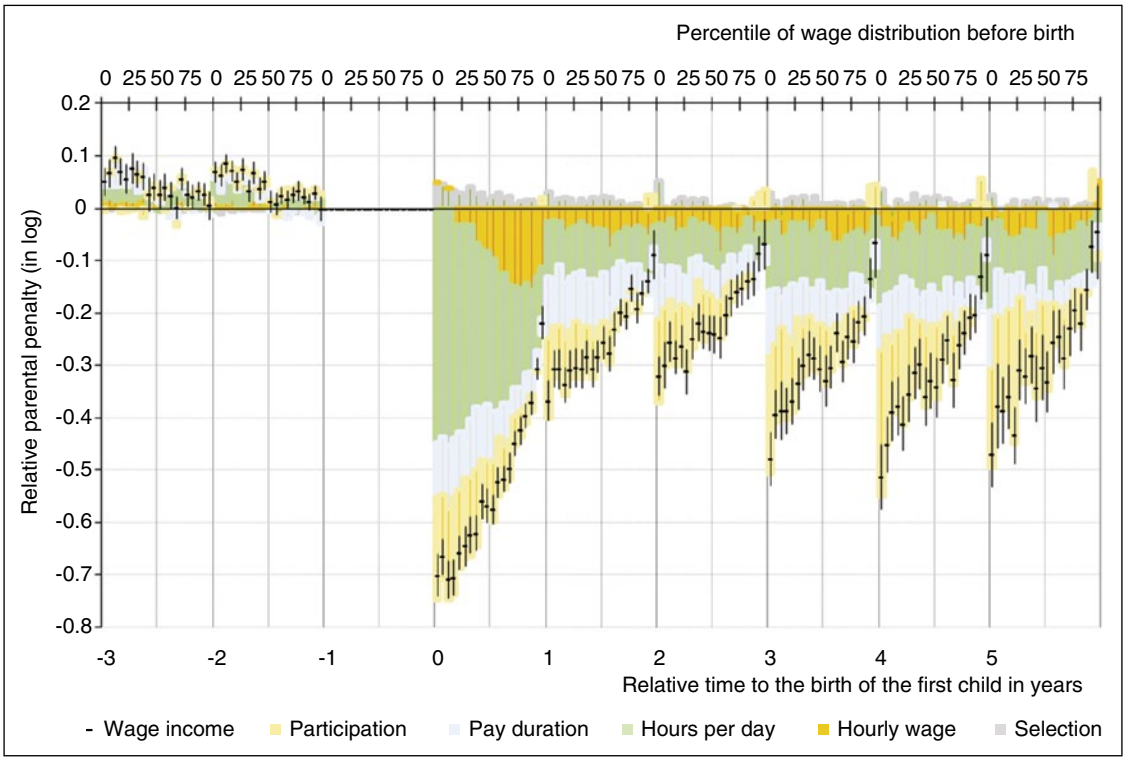
Figure XIII clearly shows that the overall penalty after childbirth is much greater for low wages than at the top of the distribution, throughout the period in question. In the lowest category of the distribution, childbirth results in a loss of earnings of 70 log points in the year following childbirth by comparison with those who did not have children, 45 log points one year later, and 50 log points at the end of the period. However, women at the upper end of the distribution also experience a loss of earnings of 20 log points in the first year and 5 points one year later; note that there is no further penalty in relation to the control group five years later.

As earlier, this approach comparing a "treated" group with an "untreated" group requires the absence of a pre-trend, and this is not the case here; we find significant positive differences in changes in earnings in favour of mothers before childbirth. However, as in the previous case, the magnitude of these differences is limited (less than 10 log points), and small compared with the changes observed after the event.

The analysis of the components of the loss in wage income helps understanding the source of heterogeneity in earnings changes. In summary, the lower the hourly wage before childbirth, the more it leads to changes in women's labour supply, on the extensive margin by discontinuing work and reducing the number of days worked per year, as well as on the intensive margin, for example by moving to part-time hours. Therefore, the arrival of a first child reduces the probability of being employed the following year by 20 log points for the bottom decile, but has almost no effect on participation for the top decile.[20] However, changes in working hours (part-time) affect all groups almost through to the top of the distribution. Lastly, across the entire distribution, the wage penalty, very

20. On the other hand, participation among upper deciles tends to be higher in the "mothers" group when compared to the control group from t+3 onwards, but the difference is only marginally significant

Figure XIII
Effects of the birth of the first child on earnings by position on the wage distribution



Reading Note: Five years after the birth of their first child, women who before birth were among the 5% of the lowest paid employees have a 38% (exp(-0.47)-1) lower wage income than if they had not had this child. This loss of income is explained by lower labour force participation (-17%=exp(-0.19)-1), shorter pay duration (number of paid days) (-10%=exp(-0.11)-1), lower number of paid hours per day (-15%=exp(-0.16)-1) and lower hourly wages (-3%=exp(-0.03)-1).
Coverage: Metropolitan France, private sector employees excluding agriculture, employees of personal employers, apprentices and trainees.
Sources: Insee, DADS-EDP panel.

pronounced in the first year[21], falls back to a level around 5 log points in t+1 which increases slightly over time for upper deciles.

* *
*

Since the late 1960s, the situation of women in the labour market has changed radically in terms of participation and education. This has been reflected in a reduction in the gender pay gap, but this trend appears to have slowed down considerably since the mid-1990s. How to restart progress towards gender equality in the labour market? There is clearly no longer any significant improvement to be expected in terms of education and participation, even though less gendered qualifications would be positive for women's earnings, in particular for high-skilled jobs. There is also progress left to be made to reduce occupational segregation and differences in promotion between men and women. However today, it seems that no progress can be made without taking account of the impact of maternity, which appears to be the main obstacle to occupational equality in France.

A major lever to restart the movement towards eliminating the gender pay gap could then be to eliminate the penalty associated with reducing hours worked (e.g. part-time hours, breaks in employment), itself strongly linked to time constraints associated with parenthood and the persistent unequal sharing of domestic tasks within households. What can policy-makers and companies do to effect change? Goldin (2014) argued that reorganizing and standardizing work and tasks – including skilled tasks – at company level could be one solution, because if employees become more replaceable, there would be no grounds for disproportionate financial rewards for a longer presence in the workplace. However, although equality in hourly wage could be achieved this way, there would still be inequality in total earnings related to adjustments in hours worked sustained by mothers, with repercussions on living standards and pensions. Another policy would be to target the supply side, by easing the combination of family and working life and by including fathers in this approach. The current arrangements for paternity leave in Europe are consistent with this approach; however, in France, the fixed rate paid for parental leave rather than in proportion to actual earnings is an obstacle to its development, and it indirectly penalises mothers, particularly those earning close to the minimum wage. □

21. At the top end of the distribution, the decomposition of the effect of childbirth on salary earnings into the effect on paid hours worked and the effect on the hourly salary may be biased by the difficulty to take into account maternity leave for managers with a salary package

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Forty Years of Change in Labour Supply and Demand by Skill Level – Technical Progress, Labour Costs and Social Change

Dominique Goux* and Éric Maurin**

Abstract – In France, the proportion of unskilled non-manual jobs is higher today than forty years ago, especially in personal service sectors. However, these unskilled jobs are only growing in occupations where employers enjoy significant reductions in social contributions and only in periods when these reductions are implemented. Throughout the same period, the diffusion of new technologies systematically appears to be favourable to higher- and intermediate-level occupations. Technological change contributes less to a polarisation between higher-level and lower-level jobs than to the emergence of a society where intermediate-level jobs take an increasingly central place. However, the joint rise in higher and intermediate level jobs is not strong enough to absorb the influx of high-school and college graduates. An increasing number of graduates are forced to compete with less educated workers in lower-level job positions. The result is both an increase in the occupational downgrading of graduates and the persistence of very high unemployment rates for non-graduates.

JEL Classification: J21, J24, J31
Keywords: technological change, labour cost, occupational structure, polarisation, unemployment

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Over the last decades, the social landscape in France has completely transformed. As many studies have already highlighted, manual occupations and lower-level non-manual occupations have collapsed, while higher-level non-manual occupations (managers and professionals) have risen dramatically[1] (Marchand, 2010; Goux & Maurin, 2012). Within the lower-level groups, significant reconfigurations are taking place: some of the occupations not among the lowest paid are losing ground, while some of the lowest paid are growing, particularly in personal service sectors (Ast, 2015).

Together, these changes seem to be consistent with the hypothesis that technological change is now contributing to polarising employment and society and to leaving employees with only two options, poorly paid personal service jobs on the one hand and higher-level, non-manual employment on the other, with the middle stratum of the workforce condemned to disappear (Autor *et al*., 2003; Goos & Manning, 2007; Goos *et al*., 2009).

At the heart of this hypothesis is the idea that the jobs most exposed to technological change are not necessarily the lowest-skilled jobs, but those that require employees to perform "routine tasks", i.e. tasks involving following procedures that are easy to specify and schedule in advance, irrespective of how complex or abstract they may be. Many intermediate-level occupations are said to be full of these "routine tasks" (such as accounting), whereas numerous jobs among the lowest skilled require employees to carry out tasks that are simple, but which cannot be specified or scheduled in advance (in the personal care sector in particular). This disconnection between the skills required to perform a job and the tasks involved is said to be the key to understand modern technological developments, those that favour higher- and lower-level jobs, but are unfavourable towards intermediate-level jobs.

Although difficult to test empirically, yet dominant in the literature, this hypothesis of technological polarisation serves a dual political purpose: on the one hand, by giving technological change a key role, it lends a certain inevitability to the changes in the occupational structure, irrespective of the institutions in place and the political choices made; on the other hand, by identifying intermediate-level jobs as those that are most threatened by technological changes, this hypothesis has the scaremongering nature of the ideas heralding a future without middle classes, a future where nothing remains but a face-off between the upper and lower strata of society.

Before we can endorse these hypotheses, several questions still need to be answered, including that of the role played by policies reducing labour costs for the lowest-paid jobs. When addressing the question of the mechanisms likely to explain changes in the occupational structure, one crucial question arises, namely that of the change in the relative costs of the different types of jobs for employers. Put simply, the relative decline in one specific type of job (for example, skilled manual jobs) can only be interpreted as reflecting adverse technological changes to the extent that the cost of that type of jobs for employers has not increased when compared with other types, in particular those likely to replace it. If the relative cost increases, the diagnosis becomes unclear as the decline could result from adverse changes in either technology or relative costs.

Numerous studies have already highlighted the fact that the relative wages of higher-level occupations (managers or professionals) have experienced a falling trend in France over recent decades (Insee, 2018a; Babet, 2017; Charnoz *et al*., 2013; Verdugo, 2014). Figure I-A shows the change in wages of the main occupation groups between 1990 and 2018 (see Box for a presentation of the data used). It confirms that the wages of higher-level occupations are dropping while those of lower-level non-manual workers and manual workers are experiencing the most significant increases, contributing to a significant narrowing of the wage hierarchy.

While the drop in relative wages of higher-level occupations could be interpreted as a drop in the relative cost of those jobs to employers, Figure I-A could be said to offer a simple explanation for the rise in these occupations within companies: they have become less costly with the influx of new graduates onto the labour market, which has encouraged employers to gradually replace other forms of employment with managerial and professional positions. Likewise, while the increase in the relative wages of the lower-level occupations could be interpreted as an increase in their relative cost for employers, Figure I-A could be said to be consistent with one of the key elements of the technological polarisation

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1. Building on the French classification of occupations, we will distinguish higher-level occupations (managers, professionals), intermediate-level occupations (technicians, foremen, associate professionals), lower-level non manual occupations (sales employees, lower-level clerical employees, childminders, etc.) and manual occupations. In the French classification, the first group (higher-level occupations) corresponds to the category Cadres, *the second to the* Professions Intermédiaires, *the third to the* Employés *and the last one to the* Ouvriers. *Among these last two groups, we will distinguish skilled and unskilled occupations (*Ouvriers qualifiés *et* Ouvriers non qualifiés *as well as* Employés qualifiés *et* Employés non qualifiés*).*

Box – **Data and Calculation of Labour Costs**

This study is based on the French Labour Force surveys (LFS) conducted from 1982 to 2018. Between 1982 and 2002, the surveys were generally carried out in March, whereas since 2003, information has been collected continuously throughout the year.

For each respondent, in addition to the usual sociodemographic characteristics (gender, age, education), the LFS also provide detailed information on the activity status (employed, unemployed, not economically active), the employment status for those who work (employee/self-employed, private-sector/public sector, i.e. state and local authorities), the occupation, employer's industry, monthly wage received and working hours (full or part-time, part-time percentage).

In the 37 surveys conducted, the occupation is coded in the French classification of occupations (PCS, standing for *Professions et catégories socioprofessionnelles*). This classification was revised in 2003 but this only affected the most detailed level of the classification (four-digit level) without changing the more aggregated levels (two-digit level). The surveys therefore make it possible to describe the change in the French occupational structure using the two-digit classification over a 37 years period. However, we must highlight that the changes in the coding procedures associated with the change in classification of occupations in 2003 (and the transition from one survey generally carried out in March to a continuous survey conducted throughout the year, also in 2003) make it difficult to interpret the changes per socio-professional category between 2002 and 2003. Therefore, the graphical analyses do not show the change between 2002 and 2003.

We have distinguished between managers and professionals (item 3 of the one-digit PCS, named "higher-level occupations"), technicians, foremen, associate professionals (item 4 of the one-digit PCS, named "intermediate-level occupations"), skilled manual workers (items 62, 63, 64 and 65 of the 2-digit PCS), unskilled manual workers (items 67, 68 and 69 of the two-digit PCS) and lower-level non-manual employees (item 5 of the one-digit PCS). Within the category of lower-level non-manual employees, we distinguish unskilled non-manual occupations, which include sales workers, hotel and restaurant workers, childminders, home help workers (items 55 and 56 of the two-digit PCS). We have also differentiated between personal service employees (item 56, which includes hotel and restaurant workers, childminders, home help workers) and other unskilled non-manual employees (item 55, including sales workers). Finally, within personal service employees, we have also distinguished between childminders, home help, domestic workers and cleaning staff employed by private individuals (PCS 2003 = 563a, 563b and 563c or PCS 1982 = 5631 and 5632) and other personal service employees (the other PCSs within the two-digit category 56).

Since 1982, the LFS also collects information on employees' monthly wage. But detailed information on wages is only available from 1990 onwards (until 1989, the survey only provided wage brackets – with 19 brackets – an information which is not accurate enough for our study). Note also that since 2003, this information is only available for one third of the sample (the "incoming 1/6th" sample and the "outgoing 1/6th" sample). Therefore, from 2003 onwards, wages (and labour costs) are estimated on the basis of one third of the sample.

Employment and wages are estimated in full-time equivalent, using the information available on the employment time-status (full-time or part-time) and for part-time employees, the part-time percentage.

Calculation of Labour Cost

For each employee, we estimate the labour cost using the available information on the monthly wage, working hours (full-time or percentage of full-time), social contributions (and caps for the corresponding year), and distinguishing between *cadres* (broadly the category working in "higher-level occupations"), and *non-cadres* (broadly all the others) – this distinction going with significant differences in social contributions, particularly for pensions. We also deducted the general measures of social contribution reduction measures applicable for the corresponding year (see Ourliac & Nouveau, 2012, for an inventory of these measures).

In the case of home help, childminders, domestic workers and cleaning staff employed by private households, we have also estimated a net cost of the tax reductions and additional social contribution reductions granted to their employers (whether directly or via a company). With regard to childminders, we assumed that the private individuals had been exempt of (employee and employer) social contributions since 1991 (AFEAMA, an assistance scheme for families employing approved childminders) and ignored any other financial assistance (such as the AFEAMA supplement, which depends on the number and age of the children looked after and also, from 2001 onwards, the employer's income) (Daniel, 2003). In the case of the other jobs in this category (home help, domestic workers, etc.), we have assumed that a given employee had only one private employer (or user) who benefitted from the maximum tax reduction (or tax credit) associated with employing a domestic worker given the caps in force (Article 199 sexdecies of the French General Tax Code). We ignored any other financial supports (for example, such as the AGED, a specific support for childcare aimed only at childcare jobs carried out in the employer's home, which are difficult to identify in the survey).

The LFS allows for the indirect identification of childminders within the occupations grouped into the "childminders, babysitters, domestic workers" PCS (PCS 5631, then 563a and 563b in PCS 2003) since 1994. We used the criteria proposed by Algava & Ruault (2003), namely people working as "childminders, babysitters, domestic workers" who work at their own home and who are neither self-employed nor employed by the state or local authorities.

To assess the quality of our estimations, we compared them with the series of labour costs calculated by Insee using administrative data (the DADS) and social legislation (Insee, 2013). Reassuringly, our estimations and those of Insee give a very similar image of the change in the different deciles of the labour costs distribution. For example, the first decile increased between 1990 and 2010 by +48% according to our estimations and +50% according to Insee. Likewise, the last decile increased by +70% according to our estimations and +68% according to Insee. The ratio of the last decile to the first increased by +13% according to Insee and +15% according to our estimations.

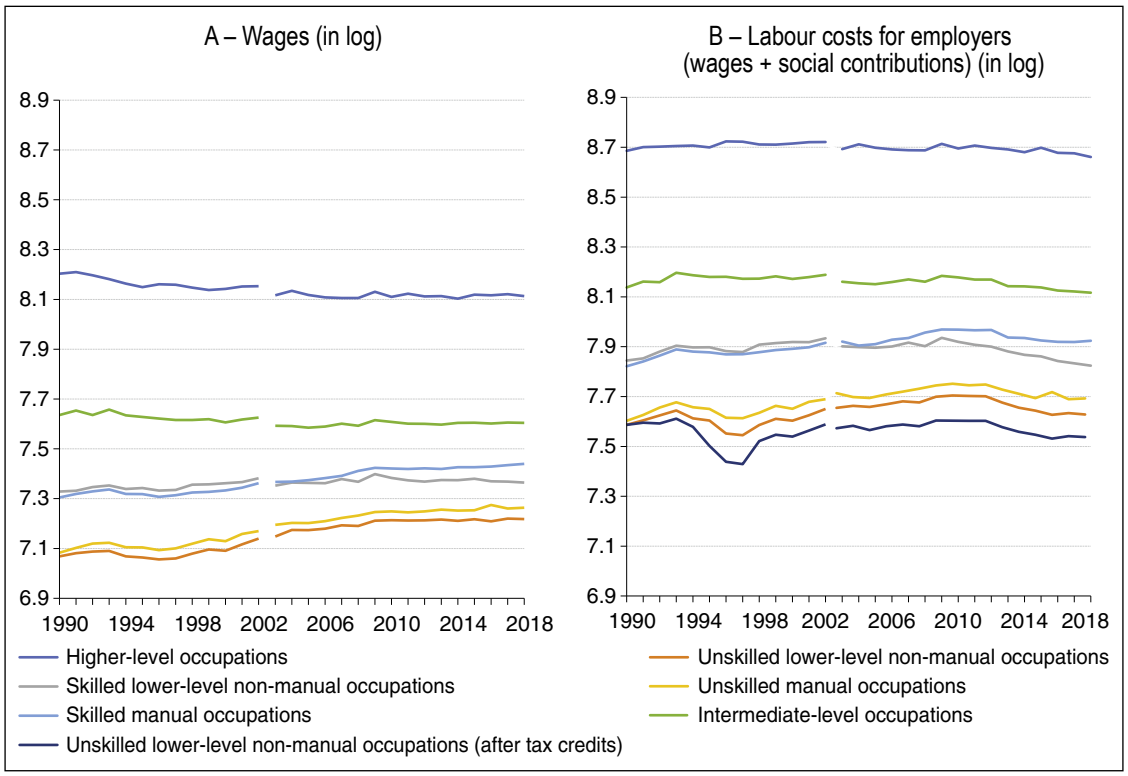
hypothesis: the proportion of some lower-level occupations in total employment is growing even though their costs are rising, a development that is difficult to explain without the hypothesis that technological change is more favourable (or less unfavourable) towards these jobs than towards many intermediate or higher-level occupations. The problem here, however, is that wages only represent a part of the costs to the employer. These costs also depend on social contributions, which have become much more favourable to lower-level jobs since the start of the 1990s.[2]

To illustrate the importance of distinguishing between wages and labour costs, Figure I-B does not chart the change in wages of the main occupation groups but the change in corresponding costs for employers, once social contributions are taken into account. Figure I-B shows that the narrowing of wages has largely been offset by social contribution reduction policies aimed at the lowest-paid jobs.[3] While the difference in wages between higher- and lower-level occupations has dropped by more than 20% over the period examined, the difference in labour costs (wages + social contributions) has remained almost unchanged. If we take into consideration tax reductions and credits, from which employers in the personal services sectors benefit, we even find an increase in cost differences between higher- and lower-level occupations over the period examined.

Throughout this article, one of our main objectives will be to deepen this diagnosis by examining as accurately as possible the joint change in labour costs and relative employment of the main

2. *The data are from the Labour Force survey, which has only been providing detailed data on wages since 1990 (see Box).*
3. *Using administrative data (the* Déclarations Annuelles de Données Sociales *or DADS, from employers annual declarations) for the private sector over the period 1976-2010, Bozio* et al. *(2016) reach similar conclusions, namely a narrowing of the interdecile wage gaps more than offset by the social contribution reduction policies aimed at low earners. This diagnosis marries up with a former research carried out by Goux & Maurin (2000) between 1970-1993 using the surveys on training and vocational education* Formation et Qualification Professionnelle *(FQP).*

Figure I
Change in wages and labour costs per socio-professional category, 1990-2018



Notes: The change between the years 2002 and 2003 is difficult to interpret due to a discontinuity in the coding of the PCSs.
Reading Note: In 1990, the difference in log wage between higher-level occupations and unskilled lower-level non-manual occupations was 1.12 (where 1.12=8.20-7.08). In 2018, it was 0.90 (where 0.90=8.11-7.21), meaning a reduction of more than 20%. In 1990, the difference in the log of labour cost (wage+social contributions) between higher-level occupations and unskilled lower-level non-manual occupations was 1.09 (where 1.09=8.68-7.59). In 2018, it was 1.03 if we do not include tax credits and 1.12 if we do include them.
Coverage: Private sector employees.
Sources: Insee, Labour Force Surveys (*enquêtes Emploi*), 1990-2018.

occupation groups, so as to better understand the nature of the dynamics transforming society.

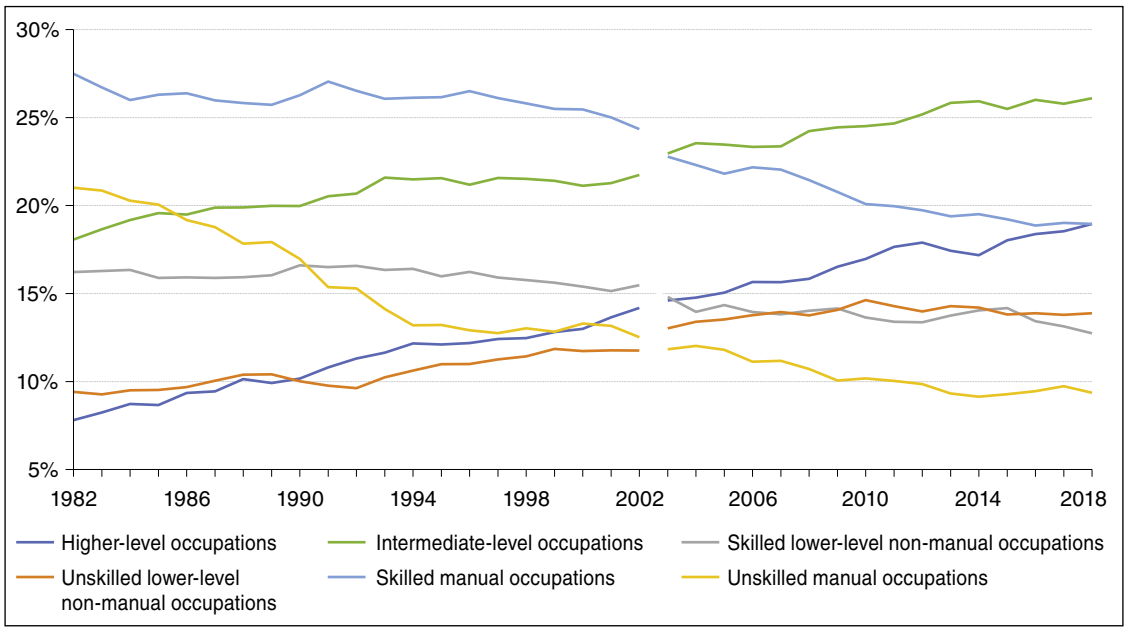
We will pay particular attention to factors likely to explain the dynamics contributing to the transformation of the lower-level categories of the workforce, whether this relates to the increase in some of the least paid jobs (such as personal service jobs) or the drop in some of the more paid jobs (such as skilled manual jobs or corporate administrative jobs). To preview our main conclusions, we do not find the data to be consistent with the hypothesis that technological change is behind these forms of employment polarisation. In fact, although some jobs among the least skilled have been gaining ground, this has occurred essentially in occupations and during periods where these jobs have been supported by significant public subsidies, considerably lowering their relative costs to employers. Once these specific cases are set aside, technological change seems almost systematically biased in favour of the more skilled occupations. In the last part of the paper, we will also show that the speed with which labour demand is changing in favour of higher- and intermediate-level occupations is still slower than the speed with which the level of education among the population is growing. In a context where labour costs have remained very stable, this rising gap between the supply and demand of skills explains both the increased downgrading of graduates and the persistence of high unemployment among non-graduates.

The Rise of Unskilled Non-Manual Jobs: A Political Choice

Unskilled non-manual occupations represent the lowest paid group of occupations.[4] One of the features of this group, however, is that it has experienced an increase in its share over the last few decades. Among the lower-level categories of the workforce, this is in fact the only sub-category that has a larger share of employment now than at the start of the 1980s, in contrast with manual workers (whether skilled or not) and with other types of (more skilled) lower-level non-manual workers (such as corporate administrative employees), all of which are shrinking (Figure II).

*4. Unskilled non-manual occupations include sales employees, hotel and restaurant workers, childminders, home help workers (2-digit items 55 and 56 of the French classification). For more information on the successive suggested definitions of "unskilled non manual" workers (*les employés non qualifiés*), see Bisault* et al. *(1994), Burnod & Chenu (2001) or Chardon (2002).*

Figure II
Change in the occupational structure, 1982-2018*



* Discontinuity in time series, see Box.
Reading Note: The share of employees holding skilled manual occupations in the private sector was 27.5% in 1982.
Coverage: Private sector employees.
Sources: Insee, Labour Force Surveys (*enquêtes Emploi*), 1982-2018.

This progression of unskilled non-manual employees reflects the general shift in labour demand from manufacturing industries towards service sectors, as these employees hold jobs situated almost exclusively within service sectors. If we focus on these sectors, the proportion of unskilled non-manual employees has, in fact, declined since 1982, although this has been far slower than that of other lower-level non-manual employees or manual workers (Table). A deeper examination reveals that this resilience of unskilled non-manual employees is essentially due to personal service workers (including mostly hotel and restaurant workers, childminders, home help workers), whose share has remained steady in service sectors and has risen considerably in the overall employment, particularly in the period prior to 2002.[5]

Even if this phenomenon is relatively limited, it is important to try and understand the drivers behind this resilience of the personal services occupations. Indeed, taking account of this phenomenon is the main reason behind the hypothesis that technological change is contributing to the polarisation of the occupational structure, namely to the joint rise in the share of higher-level occupations and the share of some lower-level occupations.[6]

However, an alternate hypothesis posits that personal service employment has been the main beneficiary of labour cost reduction policies implemented in France since the early 1990s, in particular in the childcare or home help sectors.[7] Parents who employ childminders have been benefitting from a total exemption from social contributions, complemented by a partial payment of the childminder's wage and a tax reduction, since the early 1990s. Since 1993, individual employers of home help have also benefitted from significant tax reductions, which were converted into tax credits in 2007. The implementation of the service employment voucher scheme (the *chèque emploi service*) in 1994 also considerably simplified hiring procedures for private employers.

To clarify the roles played by these policies, we have split the category of personal service employees into two subcategories: one grouping together childcare and home help[8] and the other

5. Throughout this article, we try to account for the break in the series that took place between 2002 and 2003, when the classification of occupations used in surveys was revised. This is the reason why the Table, for example, shows the changes before and after the 2002-2003 break separately.
6. Using administrative panel data (the DADS panel, which covers the employed population, excluding those employed by private employers), Berger & Pora (2017) found no trace of polarisation of the French occupational structure between 1988 and 2014. They found that the loweran occupation in the 1988 pay hierarchy, the less its share in employment increased between 1988 and 2014. This result is consistent with the idea that the only dynamic that is potentially consistent with the technological polarisation hypothesis is that of personal service employees.
7. These different schemes led to several assessments that generally highlight a significant impact on the rate of use of the schemes or on personal service employment, even though it is generally difficult to isolate the specific role of each scheme, as there are significant overlaps (see, in particular, Flipo & Olier, 1998; Carbonnier, 2009; Marbot, 2011; Marbot & Roy, 2014). See also the meta-analysis provided by Carbonnier (2015).
8. Including domestic workers and cleaning staff employed in private households.

Table
Change in the occupational structure, by industry

	Manufacturing and construction			Tertiary sector		
	Share in 1982 (%)	Change 1982-2002 (in pts)	Change 2003-2018 (in pts)	Share in 1982 (%)	Change 1982-2002 (in pts)	Change 2003-2018 (in pts)
Higher-level occupations	6.3	+4.8	+3.8	9.8	+6.4	+4.1
Intermediate-level occupations	16.8	+4.3	+5.0	20.1	+2.4	+2.5
Unskilled non-manual occupations	1.1	+0.3	+0.4	18.5	-1.0	-0.8
of which:						
Sales workers	*0.9*	*+0.4*	*+0.3*	*8.5*	*-1.0*	*-0.5*
Personal service	*0.2*	*-0.1*	*+0.1*	*10.0*	*-0.0*	*-0.3*
Other low-level non-manual occupations	8.4	-1.4	-1.7	24.8	-4.6	-3.7
Skilled manual occupations	37.9	+4.1	-4.1	17.5	-2.2	-1.0
Unskilled manual occupations	29.5	-12.1	-3.4	9.2	-1.0	-1.2

Reading note: Between 1982 and 2002, the share of higher-level occupations (managers and professionals) in private-sector tertiary employment increased by 6.4 points.
Coverage: Private sector, excluding agriculture.
Source: Insee, Labour Force Surveys (*enquêtes Emploi*), 1982, 2002, 2003, 2018.

grouping other personal service employees, in particular hotel and restaurant workers.[9] In so far as the first subgroup constitutes the main beneficiary of policies supporting personal services implemented from the early 1990s to the end of the 2000s, making a comparison of the change in these two subgroups across the last four decades can give an idea of the role played by these policies.

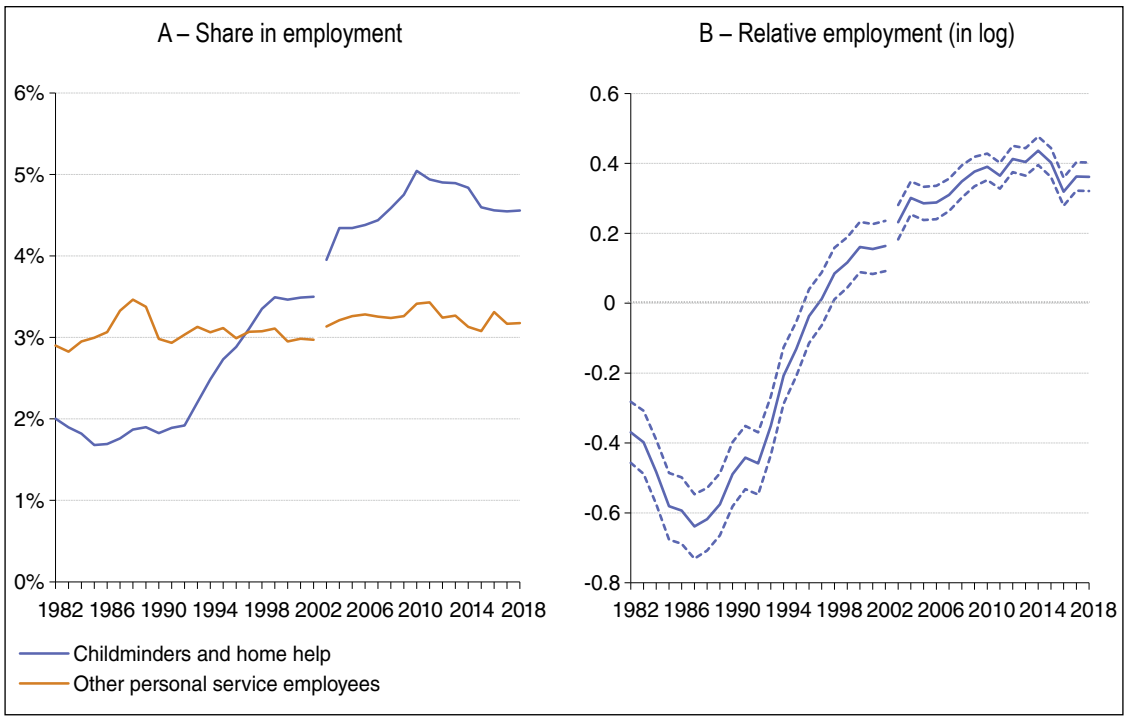
In terms of employment, Figure III-A depicts the change in the share in employment of home help and childminders on the one hand and that of other personal service employees on the other. In addition, Figure III-B shows the change in the ratio between these two proportions. In the 1980s, the proportion of these two groups of employees fluctuated, but no clear trend emerged. From the end of the 1980s/start of the 1990s onwards, which was also when the specific policies favouring childminders and home help were first implemented, everything changed: home help and childcare jobs soared, while other categories of personal service employment continued to stagnate. Between the end of the 1980s and the end of the 2000s, relative employment of home help and childminders doubled. Since the end of the 2000s, which coincided with the stabilisation of tax incentives, the growth experienced by these two groups of employees has plateaued, with home help and childcare employment even falling back. In 2018, relative employment of home help and childminders was still at the same level as in 2008.

Ultimately, not all forms of personal service employment have grown over the last 35 years, but primarily those targeted by public aid and only during the period in which that public aid increased.

To give a more accurate idea of the scale of this aid, Figure IV maps the change in relative labour costs (i.e. wages and social contributions) of the two subgroups after taking into account the

9. Childminders and home help covers items 563a, 563b and 563c of the PCS 2003 [occupations and socio-professional categories] (corresponding to items 5631 and 5632 of the PCS 1982). The other personal service employees are the other occupations in the two-digit item 56 of the PCS 2003 (or PCS 1982) classification.

Figure III
Employment of childminders and home help/other personal service employees, 1982-2018*



* Discontinuity in time series, see Box.
Reading note: The share of childminders and home help among employees in the private sector increased from 2% in 1982 to 4.6% in 2018. Over the same period, the share of other personal service employees increased from 2.9% to 3.2%. The log of the ratio between the share of childminders and home help and the share of other personal service employees increased from around -0.49 in 1990 to +0.16 in 2002.
Coverage: Personal service employees, private sector.
Sources: Insee, Labour Force Surveys (*enquêtes Emploi*), 1982-2018.

general measures for reducing social contributions as well as the specific tax measures taken in favour of home help and childminders.[10]

When we look at the relative labour cost of these occupations after application of the general measures only, we see that it follows a very slight upward trend throughout the period. But when we also take into account the specific measures taken in favour of home help and childminders, the curve shows a sharp drop in their relative cost over the period from 1990 to 2007, the very period during which relative employment soared. This period saw that cost drop from -9% in 1990 to almost -35% in 2007, before stabilising between 2008 and 2018.

Ultimately, it can be tempting to interpret the increase in the share of personal service employees in overall employment as a consequence of their lesser exposure to modern technological change. However, if this hypothesis were true, this would scarcely explain why this increase was almost exclusively focused on those occupations targeted by public aid and over the period during which that public aid increased. A more credible hypothesis seems to be that the share of personal service employees is very directly linked to this aid, which favours, among other things, the transition of home help and childcare jobs into the formal economy, without which they would have remained informal.[11] The emergence of a society in which the wealthiest fraction of the population is able to pay for the services of the most poorly paid is not an inevitable consequence of modern technological advances, but is, in many ways, a political choice.[12]

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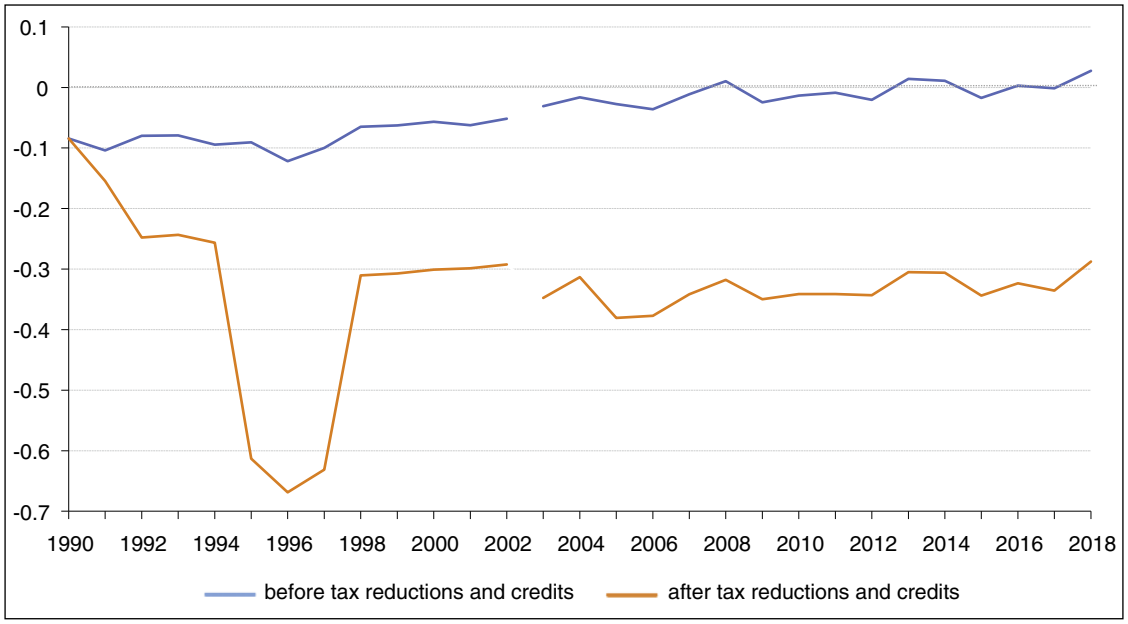
10. With the tax reductions granted to each private individual having been capped, the overall cost of home help for employers is even lower if there are several employers sharing the services of the employee (as that increases the chances of each one being below the threshold). In our calculations, we have, however, assumed that each job corresponded to a single employer, i.e. a conservative assumption in terms of the costs for employers represented by these jobs. Had we been able to consider the exact number of employers for each employee, the fall in costs would have been even greater.

11. According to Algava & Ruault (2003), the French Labour Force survey is fairly reliable to evaluate "formal" employment in the childminder sector, as shown by various administrative or tax sources. However, according to Marbot (2008), the actual increase in personal services (i.e. as estimated from data on actual household spending) represents less than half of that "formal" change. Together, these two studies suggest that the data from the Labour Force survey (or from sources such as the DADS) quite grossly overestimate the actual increase in personal services.

12. For a discussion of the drivers behind and the scope of this choice, see for example Carbonnier & Morel (2018).

Figure IV

Relative labour cost of childminders and home help/other personal service employees (in log), before and after tax reductions and credits, 1990-2018*



* Discontinuity in time series, see Box.

Notes: Between 1995 and 1997, the cap on domestic service expenditure eligible for a tax reduction was temporarily increased more than threefold, which explains the temporary, yet significant drop in the relative labour cost of childminders and home help observed, after tax reductions and credits, between 1995 and 1997.

Reading note: Between 1990 and 2002, after application of tax reductions, the log of the ratio between the cost of employing childminders and home help and the costs of other personal service employees dropped from -0.08 to -0.29, a reduction of more than 20%.

Coverage: Personal service employees, private sector.

Sources: Insee, Labour Force Surveys (*enquêtes Emploi*), 1990-2018.

Technological Change and the Demand for Skilled Manual Labour

Manual worker jobs are far from homogeneous. For example, in terms of socialisation and working conditions, it is very important to distinguish between manual workers in large capital-intensive companies and manual workers in small labour-intensive companies, including drivers, freight handlers or manual logistics workers.[13] Within each of these broad categories of manual workers, it is also crucial to distinguish between unskilled and skilled workers, considering that manual workers often begin their careers as unskilled before becoming skilled workers with experience, through internal promotion, resulting in a wage gain of around 20%.

Over the course of the last 35 years, the reduction in manual worker jobs has primarily affected unskilled manual workers, especially in capital-intensive manufacturing industry. Since the mid-1990s, the fall in unskilled manual jobs has slowed down while that of skilled manual jobs has sped up (cf. Figure II and Table). These switch-ups are anything but trivial, given that they are now fuelling the technological polarisation hypothesis, according which the new generations of technology are contributing to the destruction of more skilled jobs in favour of some of the least skilled ones.

Here again, before endorsing this hypothesis, it is worthwhile performing an analysis of the way in which employment and relative costs of skilled and unskilled manual workers have changed. In order to reach the conclusion that technological change is intrinsically detrimental to skilled manual workers, the share of skilled manual workers would have to drop when compared with that of unskilled manual workers without an increase in the relative costs of the former.

To explore this question, Figure V-A firstly maps the change (in the log) of relative costs of skilled and unskilled manual worker jobs for the period between 1990 and 2018. The Figure shows that the relative cost of skilled and unskilled manual jobs remained very stable over this period: the reductions in social contributions targeted at the lowest paid jobs contributed to maintaining the cost of skilled manual workers at between 20% and 25% higher than the cost of unskilled manual workers. We can also add that, over the same period, changes in employment adjustment costs were no longer particularly favourable towards skilled manual workers, as the share of short-term labour contracts (easier to create and remove) increased more slowly for skilled manual workers than for unskilled manual workers (especially over the period between 1990 and 2002; see for example COE, 2014).

Throughout this period, which saw the relative labour costs change in a way that was unfavourable to skilled manual workers, the change in the ratio between their numbers and those of unskilled manual workers gives a very direct image of the impact of demand factors and, in particular, technological factors, which affected the demand for manual worker skills within companies. However, Figure V-B shows that, after having increased significantly during the 1980s and early 1990s, this ratio stabilised, with the share of skilled manual workers in overall employment remaining around 70% higher than that of unskilled manual workers over the last twenty years. In other words, the change in the proportion of skilled workers among manual workers is fully consistent with the hypothesis of a technological change that was unfavourable towards unskilled workers until the mid-1990s, but it is not consistent with that of a change that was unfavourable towards skilled workers after that date.

For unskilled manual workers, skilled manual worker positions often represent a chance of internal promotion within their company, involving new supervision and control tasks. However, nothing seems to indicate that technological change has recently caused the substitution of unskilled manual workers for skilled manual workers within firms, which would have occurred if the digitalisation of production processes had made skilled manual workers more productive in carrying out their specific supervision and control tasks.

Eventually, we can highlight that two types of technological developments can affect the share of skilled workers among manual workers: technological changes affecting the distribution of the demand for skilled labour within each industry on the one hand (automation of production in the automobile industry, for example) and, on the other hand, technological changes affecting the distribution of the demand for labour across more or less skill-intensive industries. To separate, at least roughly, the two types of mechanisms, it is possible to break down the change in the share of skilled workers among manual workers

13. *The French classification of occupations makes a distinction between "*ouvriers de type industriel*" and "*ouvriers de type artisanal*".*

into two components: (i) the weighted average change in this share within the various industries (the "intra" component) and (ii) the change in the share due to the shift of manual employment between industries (the "inter" component).[14] When we carry out this breakdown exercise, we see that the stability of the share of skilled workers among manual workers since the start of the 1990s is the result of two opposing trends that balance each other out, namely an increase in the skill level of manual worker within industries offset by a shift in manual worker employment towards less skill-intensive industries. Over the course of the preceding period (1982 to 1993), the sharp increase in the skill level of manual workers was entirely explained by intra-industry shifts and the significant increase in manual worker skills within industry. Ultimately, if the proportion of skilled workers among manual workers stopped increasing by the 1990s, it is only because jobs began shifting towards industries that were less demanding in terms of manual worker skills.

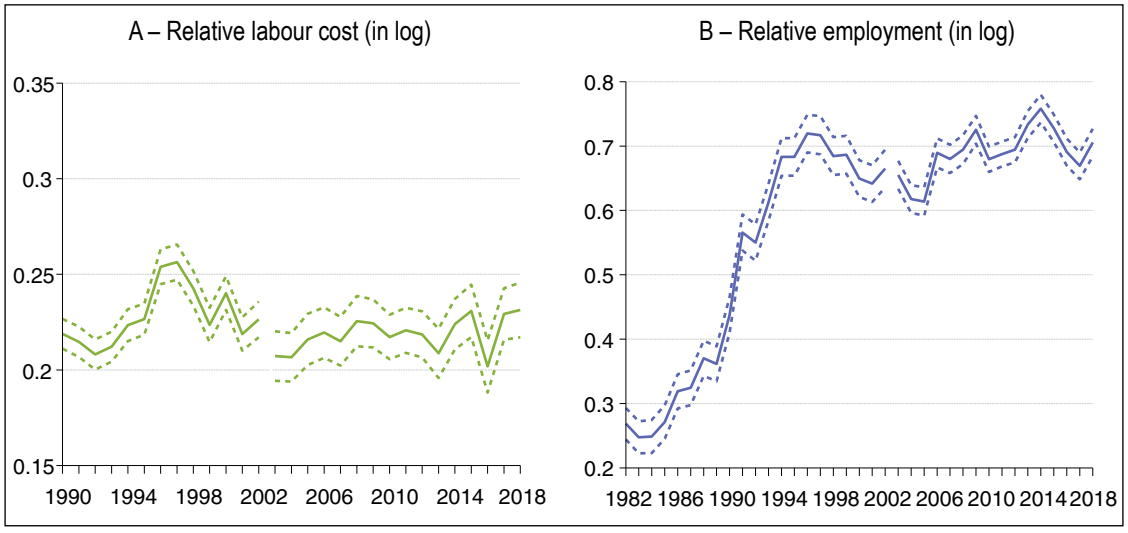
In addition to their effects on skill levels, inter-industry shifts also generated a major reconfiguration of manual worker employment: these jobs are decreasingly carried out in large capital-intensive companies and increasingly within small labour-intensive context.[15] In fourty years, the share of skilled workers in large capital-intensive companies has dropped almost four times more quickly than that of skilled workers in small labour-intensive companies (-37% *vs* -11%), while the share of unskilled workers in large capital-intensive companies has dropped 1.5 times quicker than that of unskilled workers in small labour-intensive companies (-54% *vs* -36%). These basic changes in working contexts are transforming the way in which manual workers are susceptible to union or political mobilisation[16].

14. Denoting p_{Qt} the share of skilled employment in manual employment at t, p_{st} the share of industry s in manual employment at t and p_{Qst} the share of skilled employment in the manual employment of industry s at t, we can write: $p_{Qt+1} - p_{Qt} = \sum_s (p_{Qst+1} - p_{Qst}) p_{st} + \sum_s (p_{st+1} - p_{st}) p_{Qst+1}$, with the component $\sum_s (p_{Qst+1} - p_{Qst}) p_{st}$ capturing intra-industry changes while component $\sum_s (p_{st+1} - p_{st}) p_{Qst+1}$ measures the inter-industry changes. One of the difficulties of this exercise is that the French classification of industries has changed over time. To overcome this difficulty, we have used the NAP 1973 classification grouped into 38 positions for the period 1982 to 1993, the NAF 1993 grouped into 36 positions for the period 1994 to 2008 and the NAF version 2 2008 grouped into 38 positions for the period 2008 to 2018 i.e. the number of sectors has remained between 36 and 38 over the course of the study period.

*15. In the following, we measure the share of (skilled or unskilled) manual workers in large capital-intensive contexts by aggregating (skilled or unskilled) occupations that fall in the "*ouvriers de type industriel*" broad category of the French classification. Conversely, we measure the share of manual workers in small labor-intensive contexts by aggregating (skilled or unskilled) occupations that fall in the "*ouvriers de type artisanal*" broad category of the French classification.*

16. For more on this reconfiguration of manual employment that began at the start of the 1980s, see for example Maurin (2002). See also the survey conducted by Beaud & Pialoux (1999) at Peugeot's Sochaux factories, which describes the rift between the generations of manual workers created by the sudden disappearance of the unionised and politically organised "working class" and the access of the new generations of manual workers to longer secondary education.

Figure V
Skilled/unskilled manual workers, 1982-2018*



* Discontinuity in time series, see Box.
Reading note: Between 1990 and 2018, the log of the ratio between the cost of employing skilled manual workers and the cost of employing unskilled manual workers fluctuated between 0.21 and 0.26. In 1990, the log of the ratio between the share of skilled manual worker jobs and the share of unskilled manual workers jobs rose to 0.46.
Coverage: Manual workers employed in the private sector.
Sources: Insee, Labour Force Surveys (*enquêtes Emploi*), 1982-2018.

The Rise in Intermediate-Level Occupations

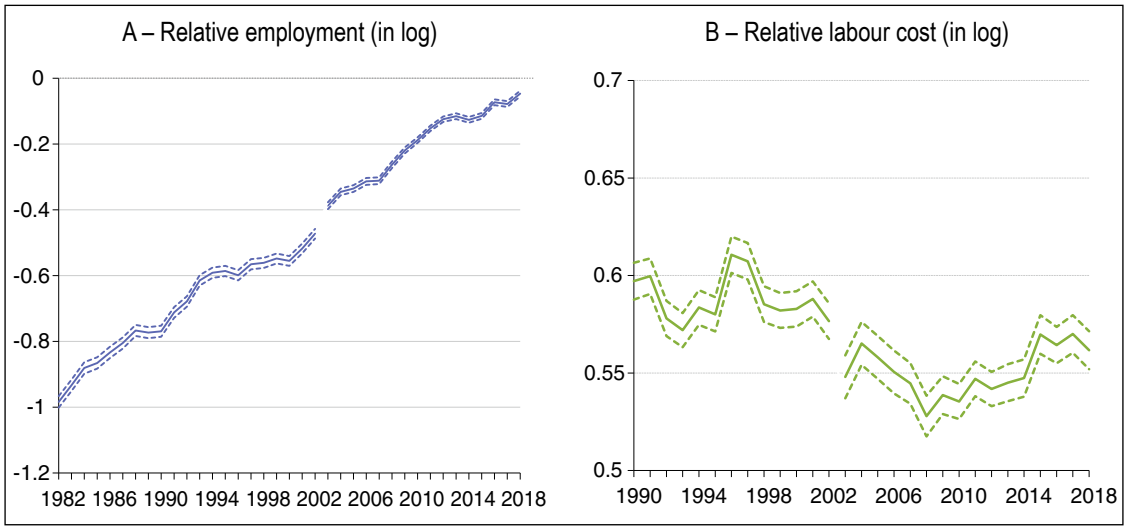
While the proportion of skilled workers among manual workers has remained stable over the last thirty years, the proportion of manual workers in employment has dropped sharply, as that of lower-level non-manual employees, especially if we exclude personal service employees, the specific momentum of which depends, as we have seen, on political choices.

To better quantify this shift towards intermediate- and higher-level occupations, Figure VI-A maps the change in the ratio between the number of employees in these occupations and the number of manual workers and the number of employees in lower-level occupations, between 1982 and 2018. This Figure confirms that this ratio has been increasing continuously for 35 years, from around 1/5 at the start of the 1980s to almost 1/2 today. In contrast, over the period between 1990 and 2018 (during which wages were observed in the Labour Force surveys), the relative costs of these two groups remained very stable, as shown by Figure VI-B. Taken together, these two figures suggest that the main cause of the major shift that is transforming society lies in the change in labour demand, which has seemingly been changing almost continuously in favour of intermediate- and higher-level jobs, to the detriment of manual workers and lower-level non-manual employees.

One idea often advocated today is that technological change is contributing not only to the destruction of lower-level jobs, but also to that of intermediate-level jobs (see for example OECD, 2019). Firms are now allegedly sacrificing their intermediate-level jobs increasingly in favour of higher-level jobs exclusively, i.e. managers or engineers. However, this is not exactly what Figure VII suggest. They show that higher-level positions increased significantly more rapidly than intermediate-level ones only until the early 2000s (Figure VII-A). Since then, the difference has closed up substantially, with intermediate-level positions now increasing almost as quickly as higher-level positions, while the relative costs of these two groups remain very stable (VII-B). In other words, the digitalisation of firms and the spread of new generations of communication technologies since the start of the 2000s do not seem to be having a detrimental effect on intermediate-level occupations (especially technicians). Instead, they even seem to favour these middle-class positions more than the previous generations of technology.

Catastrophist discourses about the decline of middle classes often uses an extensive definition

Figure VI
High- and intermediate-level occupations/lower-level occupations, 1982-2018*



* Discontinuity in time series, see Box.
Reading note: The log of the ratio between the share of high- and intermediate-level occupations and the share of lower-level occupations increased from around -0.98 in 1982 to -0.47 in 2002. In 1990, the log of the ratio between the cost of higher- and intermediate-level occupations and the cost of lower-level occupations was 0.6.
Coverage: Private sector employees (excluding personal service employees).
Sources: Insee, Labour Force Surveys (*enquêtes Emploi*), 1982-2018.

of them, aggregating social groups that are as disparate as associate professionals and skilled manual workers (or lower-level corporate administrative workers). Such an extensive definition leads to a mix-up of categories that have nothing in common in terms of their exposure to technological change (as we have seen) and nothing in common in terms of autonomy at the workplace or exposure to economic insecurity.[17] This approach ultimately leads us to foresee the end of middle classes when what is actually happening is a reconfiguration of the lower strata of the society. Taken in the original sense, i.e. as social classes of transition between lower strata (including farmers, manual workers and lower-level non-manual employees) and the upper strata (managers, engineers, company directors), the middle classes have never been so dynamic.[18]

Change in Labour Supply *vs* Change in Labour Demand

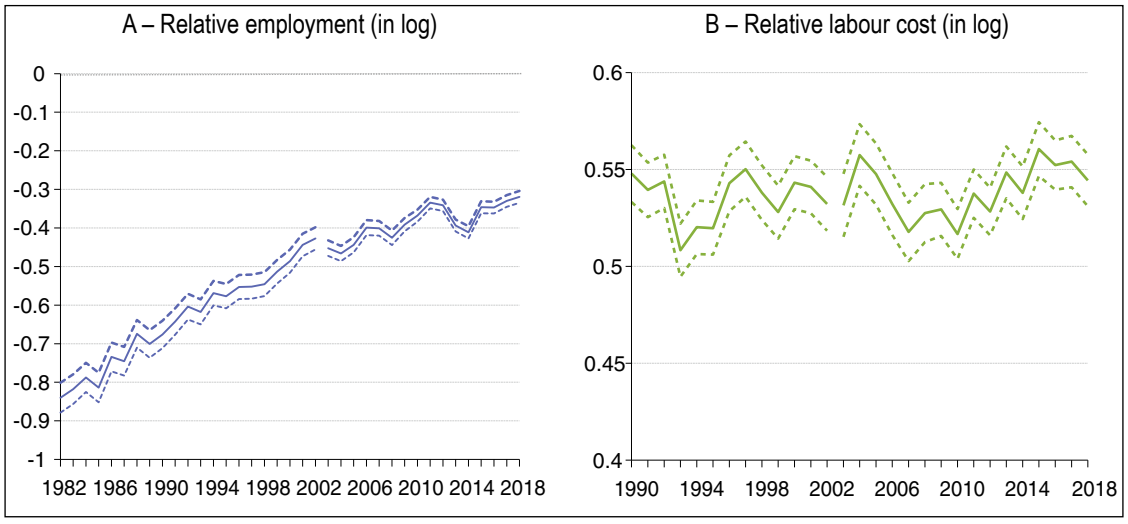
Ultimately, the major effect of technological change has remained more or less the same for close to fourty years, namely a transformation in labour demand in favour of jobs requiring higher skills, to the detriment of less skilled jobs, such as those of manual workers and lower-level non-manual employees. To what extent is this shift contributing to unemployment among those with the lowest levels of education and to their persistent difficulties in accessing work? And to what extent is this shift protecting those with the highest levels of education from the risks of occupational downgrading?

The answer to these questions depends greatly on the speed at which the proportion of graduates increases in the population of working age. The quicker this increase compared with the number of higher- and intermediate-level positions, the more graduates will be exposed to downgrading to lower-level occupations. And the greater the effective downgrading of employees with the highest levels of education, the greater the risk of unemployment for those

17. Over the last few decades, the unemployment rate among intermediate-level occupations has remained at around 5% while that among skilled lower-level employees (manual or non-manual) has fluctuated throughout economic cycles at levels close to twice as high, around 9% (Insee, 2018b). Within companies, lower-level employees are substantially more exposed to job insecurity than intermediate-level employees, even when we focus on the most skilled lower-level employees. They have less autonomy in their work and are much more likely to have to repeat the same actions and operations on a continuous basis (Beque et al.*, 2017). The differences in status are also shown in how they are allowed to use new technologies – even the more skilled ones – are much less likely to use connected digital tools (in particular portable tools) than intermediate-level workers (Mauroux, 2018).*

18. For more on these issues, see for example Goux & Maurin (2012). For more on the definition of the middle class as a crossroads of mobility between the working classes and upper classes, see Simmel (1896). For more on manual workers and lower-level non-manual employees forming heterogeneous "working classes" undergoing transformation but still increasingly distinct from intermediate-level and higher-level occupations, see Siblot et al. *(2015).*

Figure VII
Higher-level/intermediate-level occupations, 1982-2018*



* Discontinuity in time series, see Box.
Reading note: In 1982, the log of the ratio between the share of higher-level occupations and the share of intermediate-level occupations was -0.84. Between 1990 and 2018, the log of the ratio between the labour cost of higher-level occupations and the cost of intermediate-level occupations fluctuated between 0.51 and 0.56.
Coverage: Higher-level and intermediate-level occupations, private sector.
Sources: Insee, Labour Force Surveys (*enquêtes Emploi*), 1982-2018.

with the lowest levels. In a country where political choices are keeping the relative costs of the different types of labour inputs very stable, the supply and demand of labour is, in fact, adjusted essentially by rationing access to higher- and intermediate-level occupations for the most educated workers and access to any form of employment for the least educated ones.

To clarify these questions, Figure VIII shows the change in the proportion of high-school graduates (*baccalauréat* holders) among the population aged between 25 and 65 and shows that this almost tripled between 1982 and 2018, rising from around 20% to 55% over the period. At the start of the 1980s, there were four times as many high-school dropouts as high-school graduates in France.[19] However, by 2018, that ratio had completely flipped; there are now 20% more high-school graduates as high-school dropouts. Over the same period, the proportion of higher- and intermediate-level positions rose from 30% to around 45%, as Figure VIII shows. In other words, technology is increasingly developing in favour of intermediate- and higher-level employment, but the supply of graduates is increasing even more quickly.[20] Without a doubt, the creation of higher- and intermediate-level positions requires a supply of new graduates on the labour market; however, this condition is not sufficient: there is not one additional such positions for each additional graduate arriving on the labour market, especially in the short run. This results in a surplus of graduates and unprecedented risks of graduate downgrading, which are very specific to the periods of education expansion.

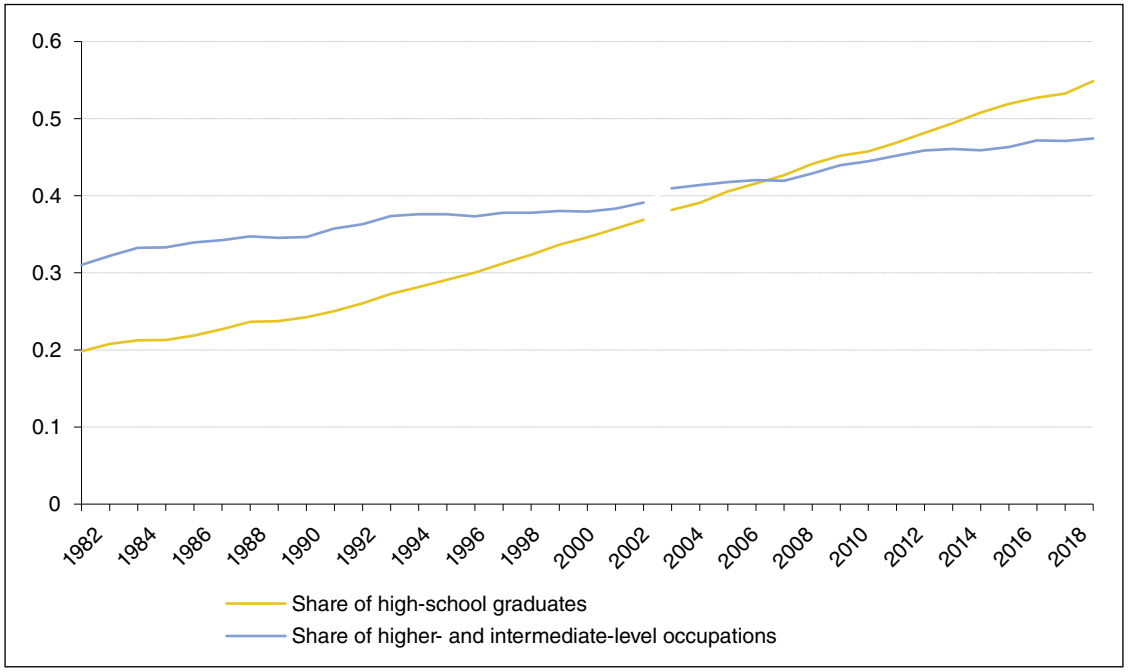
This surplus of high-school graduates can have two different consequences depending on the degree of competition between high-school graduates and high-school dropouts. If there is little competition, if high-school graduates tend to take higher- and intermediate-level jobs only, the gap in unemployment across high-school graduates and high-school dropouts could narrow as high-school dropouts will each have access to a growing number of job opportunities (as their

19. The term "high-school graduate" refers to people who have a baccalauréat degree and we use the term "high-school dropout" to refer to people who do not have a baccalauréat degree. In France, the baccalauréat is the secondary school leaving diploma that gives access to higher education.

20. The diagnosis is qualitatively similar if we focus on the rise in the number of college graduates: at the start of the 1980s, there were nine times fewer college graduates than people without a university degree, while in 2018, it is no more than 1.7 times fewer, i.e., a reduction by more than 5 of the ratio.

Figure VIII

Change in the supply high-school graduates and the demand for skilled work, 1982-2018*



* Discontisnuity in time series, see Box.

Reading note: The yellow curve shows the change in the proportion of high-school graduates (*Baccalauréat* holders) among 25-65-year-olds while the blue line shows the proportion of employees who hold higher-level or intermediate-level occupations.

Sources: Insee, Labour Force Surveys (*enquêtes Emploi*), 1982-2018.

number is dropping relatively more rapidly than the number of low-skilled jobs). Conversely, however, if competition is high, if graduates do not hesitate to apply for lower-level jobs to avoid unemployment, we could see an increase in the downgrading of graduates to lower-level positions, which could induce a rise in employment inequality between high-school graduates and high-school dropouts. Figures IX and X suggest that this latter scenario is the one currently at play, with an increase in both the downgrading of the most educated people and the persisting problems of access to employment for the least educated.

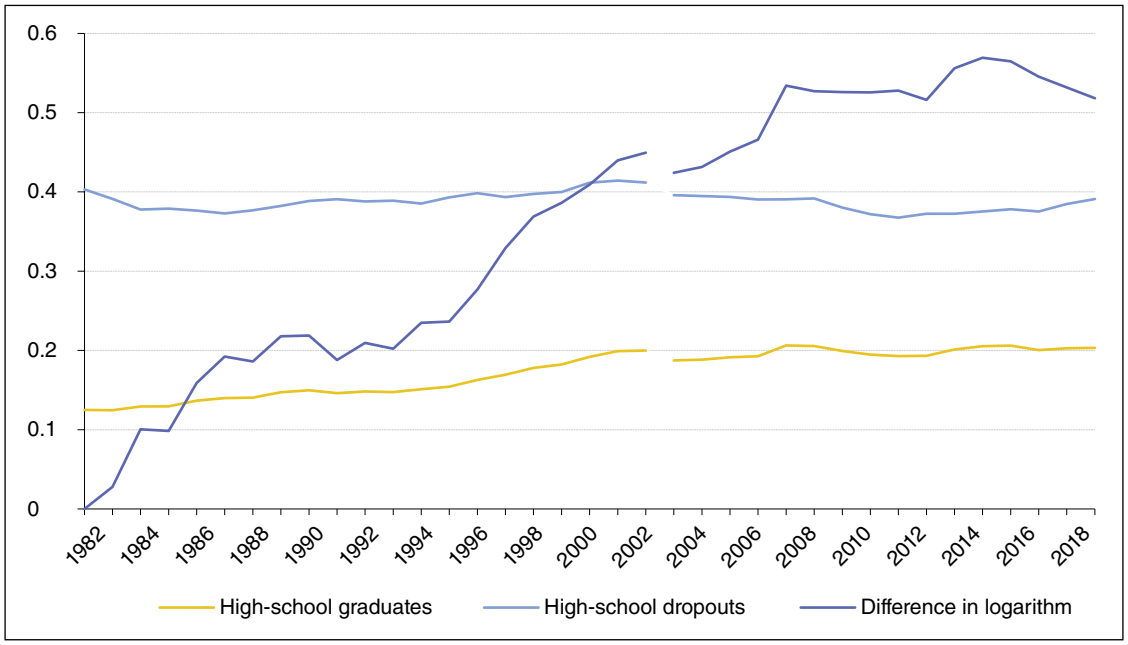
Figure IX therefore shows the change in the probability of high-school graduates and high-school dropouts holding lower-level occupations. It also describes the change in the difference (of the logs) of these two probabilities (using the difference value from 1982 as the reference) i.e. a measure of the change in the relative exposure of graduates to low-level positions.[21]

Among high-school dropouts, Figure IX shows that the proportion of employees holding lower-level occupations has remained stable (around 40%) throughout the period. Conversely, for high-school graduates, the same proportion has almost doubled (from 12% to 20%) over the period, which ultimately translates into a very sharp increase in the relative exposure to lower-level employment positions (twice as high at the end of the period than at the start). As the number of high-school graduates is increasing even more rapidly than the share of higher- and intermediate-level positions within employment, those individuals are increasingly required to perform lower-level jobs.

By depriving high-school dropouts from some of their job opportunities, these downgrading shifts are contributing to maintaining strong employment inequality across the most and the least educated workers. Figure X shows the probability of being unemployed for high-school graduates and high-school dropouts: for the latter, the likelihood of unemployment was much higher at the end of the period than at the start, while the reverse is true for the more educated workers. In addition

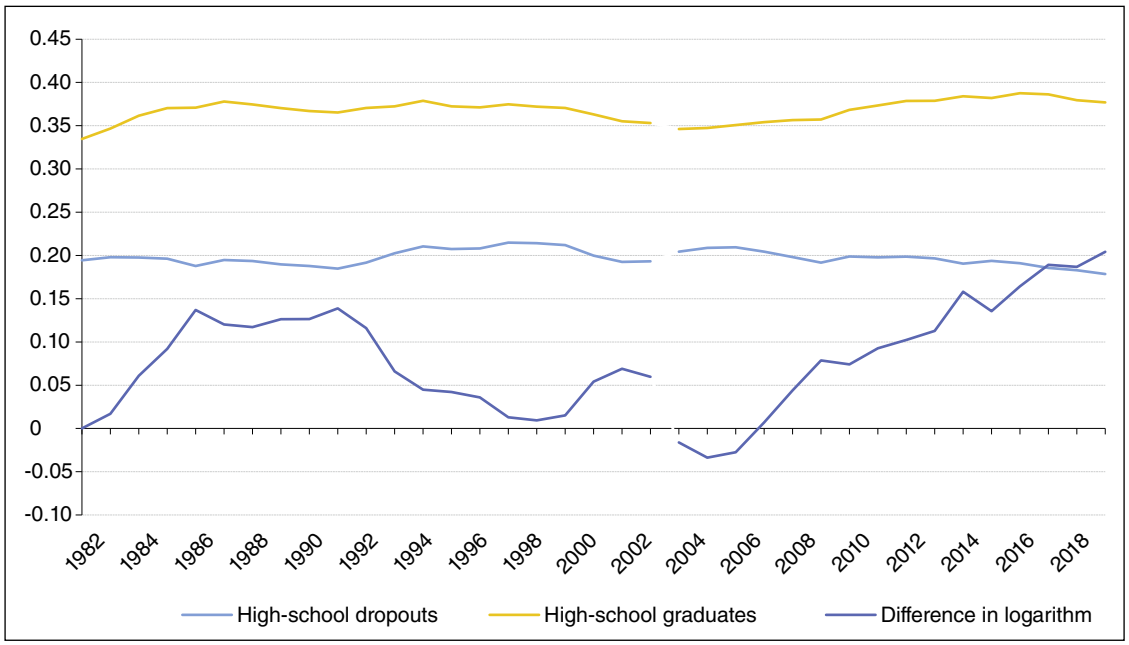
21. For a discussion of the different possible ways of measuring occupational downgrading (the French term is déclassement*) and how this is linked with the economic situation, see Nauze-Fichet & Tomasini (2002). For a discussion of the possible effects of the increase in the risks of downgrading on graduates' occupational choices, see Maurin (2009).*

Figure IX
The rise in the occupational downgrading high-school graduates 1982-2018*



* Discontinuity in time series, see Box.
Reading note: In 2018, 20% of high-school graduates (*Baccalauréat* and over) held manual or low-level non-manual occupations compared with 39% of high-school dropouts. The log of the ratio between these two percentages rose by +0.52 between 2018 and 1982.
Coverage: Individuals aged between 25 and 65.
Sources: Insee, Labour Force Surveys (*enquêtes Emploi*), 1982-2018.

Figure X
Persistence of employment inequality between high-school graduates and high-school dropouts, 1982-2018



Reading note: In 2018, 18% of high-school graduates (*Baccalauréat* and over) were not in employment compared with 38% of high-school dropouts. The log of the ratio between these two percentages rose by +0.20 between 2018 and 1982.
Coverage: Individuals aged between 25 and 65.
Sources: Insee, Labour Force Surveys (*enquêtes Emploi*), 1982-2018.

to very large fluctuations across the business cycle, employment inequalities across education groups (as measured by the ratio between their unemployment probabilities) appeared to be much higher in 2018 than at the start of the 1980s (Figure X). This is ultimately the paradox of the education expansion scheme in France: it comes hand-in-hand with a reduction in the apparent returns on education in terms of wages, but an increase in terms of access to employment.

* *
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At the end of this analysis, it seems difficult to categorise the changes in the French occupational structure as a process of polarisation that will ultimately lead to the disappearance of intermediate-level occupations. In reality, these occupations (who make up the core of the middle classes) have never been as dynamic and now form the main social group in France. What is happening is not a disappearance of the middle classes, but a reconfiguration of the lower-level strata of the occupational structure, whose jobs are decreasingly carried out in large capital-intensive firms and increasingly within small labour-intensive context. Whilst their employment share drops and becomes a minority, the lower-level strata of the workforce are witnessing a change in the context in which they work, with significant consequences on the conditions of their unionised or political mobilisation.

On a deeper level, in terms of interpretation as opposed to description, it is also difficult to see the change in employment in France as an expression of a polarisation mechanism brought about by technological change. The joint change in the structure of costs and the structure of occupations suggests that technological change is still, in reality, almost systematically favourable to the most skilled jobs, even among manual workers or among lower-level non-manual employees. Although personal service jobs have experienced spectacular progress, this has essentially taken place during periods and in specific sectors where these occupations have benefitted from significant public aid. However, this aid plateaued over the past ten years and the share of these lower-level jobs stopped increasing, even starting to decline.

Finally, in a country where the relative costs of labour inputs have remained very stable and over a period in which the influx of graduates has

been faster than the increase in the demand for skills, we have shown that the adjustment in the supply and demand of labour has resulted in the rationing of access to higher- and intermediate-level occupations for high-school and college graduates and of access to any employment for high-school dropouts. This has led to an increase in the down-grading of graduates to lower-level occupations and persistent, very high levels of unemployment among high-school dropouts.

As a final point, we wish to highlight that it would not have been possible to carry out this long-term analysis of the French occupational structure if we had not had access to measurement tools that are comparable over time, such as the Labour Force surveys and the French classification of occupations (the "PCS" and its various levels of aggregation). In our view, it is crucial that this comparability over time be maintained in the future. □

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Artificial Intelligence, Growth and Employment: The Role of Policy

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Abstract – In this survey paper, we argue that the effects of artificial intelligence (AI) and automation on growth and employment depend to a large extent on institutions and policies. We develop a two-fold analysis. In a first section, we survey the most recent literature to show that AI can spur growth by replacing labor by capital, both in the production of goods and services and in the production of ideas. Yet, we argue that AI may inhibit growth if combined with inappropriate competition policy. In a second section, we discuss the effect of robotization on employment in France over the 1994-2014 period. Based on our empirical analysis on French data, we first show that robotization reduces aggregate employment at the employment zone level, and second that non-educated workers are more negatively affected by robotization than educated workers. This finding suggests that inappropriate labor market and education policies reduce the positive impact that AI and automation could have on employment.

JEL Classification: J24, O3, O4
Keywords: artificial intelligence, growth, policy, automation, robots, employment

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"The biggest harm that AI is likely to do to individuals in the short term is job displacement, as the amount of work we can automate with AI is vastly bigger than before. As leaders, it is incumbent on all of us to make sure we are building a world in which every individual has an opportunity to thrive."

Andrew Ng, Stanford University

Artificial intelligence (or AI) is typically defined as the capability of a machine to imitate intelligent human behavior. Hence AI can be seen as the latest form of automation, a fourth automation wave following the steam engine revolution in the 18th century, the combustion engine revolution in the early 20th century and the semiconductor and IT revolution in the 1970s-1980s. In this survey paper, we argue that the effects of AI and automation on growth and employment depend to a large extent on institutions and policies.

Thus, the next section is dedicated to discussing the effects of AI and automation on economic growth: on the one hand, as argued by Zeira (1998), Hémous & Olsen (2014), Acemoglu & Restrepo (2016) and Aghion *et al*. (2017), AI can spur growth by replacing labor which is in finite supply by capital which is in unbounded supply, both in the production of goods and services and in the production of ideas; on the other hand, AI may inhibit growth if combined with inappropriate competition policy.

In a second section, we discuss the effects of AI and automation on aggregate employment. We present and discuss Acemoglu & Restrepo's results (2017, hereafter AR-2017), and we build on their method to look at the effect of automation on employment in France over the 1994-2014 period. We estimate that the installation of one extra robot reduced aggregate employment by 10 workers at the employment zone level, and find an order of magnitude similar to AR-2017 – who found a loss of 6.2 jobs per extra robot in the US. We also find that non-educated workers are more negatively affected by robotization than educated workers. This in turn suggests that inappropriate labor market and education policies further reduce the positive impact that AI and automation could have on employment.

AI and Economic Growth

The Zeira Model

A benchmark model to think about the relationship between AI, automation, and growth is Zeira (1998). Here we reproduce the presentation of Zeira (1998) in Aghion *et al*. (2017), henceforth referred to as "AJJ". Zeira assumes that final output is produced according to:

$$Y = AX_1^{\alpha_1}.X_2^{\alpha_2}\ldots X_n^{\alpha_n}$$

where $\sum \alpha_i = 1$ and intermediate inputs X_i are produced according to:

$$X_i = \begin{cases} L_i \text{ if not automated} \\ K_i \text{ if automated} \end{cases}$$

While Zeira thought of the X_i as intermediate goods, they can also be viewed as tasks (Acemoglu & Autor, 2011). Hence, tasks that have not yet been automated can be produced one-for-one by labor. Once a task is automated, one unit of capital can be used instead (Aghion *et al*., 2017).

Automation spurs economic growth as it replaces labor – which is in finite supply – by capital which is in unbounded supply, as a basic production input. Indeed, letting K and L denote aggregate capital stock and labor supply respectively, then final output is ultimately produced (up to a constant) according to:

$$Y = AK^{\alpha}L^{1-\alpha}$$

where α reflects the overall share of tasks that have been automated.

Hence the rate of growth of per-capita GDP (i.e. of $y = Y/L$) is equal to:

$$g_y = \frac{g_A}{1-\alpha}$$

Automation (e.g. as resulting from the AI revolution) will increase α which in turn will lead to an increase in g_y i.e. to an acceleration of growth. One issue with this model however, is that it predicts a rise in capital share, which in turn contradicts the so-called Kaldor fact that the capital share tends to be stable over time.

The Acemoglu-Restrepo Model

Acemoglu & Restrepo (2016) extend Zeira (1998) by assuming that final output is produced by combining the services of a unit measure of tasks $X \in [N-1, N]$, according to:

$$Y = \left(\int_{N-1}^{N} X_i^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}$$

where tasks X_i are non automated, produced with labor alone when $i > I$, and are automated *i.e.* capital and labor are perfect substitutes when $i < I$. σ is the constant elasticity of substitution between tasks. With no major loss of insight, we can write:

$$X_i = \alpha(i) K_i + \gamma(i) L_i$$

where $\alpha(i)$ is an index function with $\alpha(i) = 0$ if $i > I$ and $\alpha(i) = 1$ if $i < I$ and $\gamma(i) = e^{A_i}$.

In the full-fledged AR-2017 model with endogenous technological change, the dynamics of I and N (i.e. the automation of existing tasks and the discovery of new product lines) results from endogenous directed technical change. Under reasonable parameter values guaranteeing that innovation is directed towards using the cheaper factor, there exists a unique and (locally) stable Balanced Growth Path (BGP) equilibrium. Stability of this BGP follows from the fact that an exogenous shock to I or N will trigger forces which bring the economy back to its previous BGP with the same labor share: the basic intuition is that if a shock leads to too much automation, then the decline in labor costs will encourage innovation aimed at creating new (more complex) tasks which exploit cheap labor.

What makes the capital share remain constant on this BGP is the fact that the automation of existing tasks is exactly offset by the creation of new tasks which require labor, at least initially. One special feature of this model is the assumption that technical progress $\gamma(i) = e^{A_i}$ multiplies labor, but not capital, even after automation takes place. Yet, it seems difficult to conceive of concrete examples where an automated production process would be replaced by a highly productive labor-intensive task.[1] Another feature is that the constancy of the capital share relies entirely on the continuous arrival of new labor intensive tasks. This prediction will be challenged in our section on AI and employment. The model by AJJ (2017), which also extends Zeira (1998), turns out to address these two objections.

Baumol's Cost Disease and the AJJ model

In the following model by Aghion *et al*. (2017), a greater fraction of tasks are being automated over time since there are no new labor-intensive tasks to compensate for the automation of existing tasks. This feature is shared by Zeira's model. Yet the complementarity between existing automated tasks and existing labor intensive tasks, together with the fact that labor becomes increasingly scarcer than capital over time, allows for the possibility that capital share remains constant over time.

More formally, final output is produced according to:

$$Y_t = A_t \left(\int_0^1 X_{it}^{\rho} di \right)^{\frac{1}{\rho}}$$

where $\rho < 0$ (*i.e.* tasks are complementary), A is knowledge and grows at constant rate g and, as in Zeira (1998):

$$X_{it} = \begin{cases} L_{it} \text{ if not automated} \\ K_{it} \text{ if automated} \end{cases}$$

Assuming that a fraction β_t of tasks is automated by date t, we can re-express the above aggregate production function as:

$$Y_t = A_t \left(\beta_t^{1-\rho} K_t^{\rho} + (1-\beta_t)^{1-\rho} L^{\rho} \right)^{1/\rho}$$

where K_t denotes the aggregate capital stock and $L_t \equiv L$ denotes the aggregate labor supply.

At the equilibrium, the ratio of capital share to labor share is equal to:

$$\frac{\alpha_{K_t}}{\alpha_L} = \left(\frac{\beta_t}{1-\beta_t} \right)^{1-\rho} \left(\frac{K_t}{L_t} \right)^{\rho}$$

Hence an increase in the fraction of automated goods β_t has two offsetting effects on $\frac{\alpha_{K_t}}{\alpha_L}$: first, a direct positive effect which is captured by the term $\left(\frac{\beta_t}{1-\beta_t} \right)^{1-\rho}$; second, a negative indirect effect captured by the term $\left(\frac{K_t}{L_t} \right)^{\rho}$ as we recall that $\rho < 0$. This latter effect relates to the well-known Baumol's cost disease: namely, as $\frac{K_t}{L_t}$ increases as a result of automation, labor becomes scarcer than capital which, together with the fact that labor-intensive tasks are complementary to automated tasks (indeed we assumed $\rho < 0$), implies that labor will command a sustained share of total income.

How about long run growth in this model? Let's first consider the case where a constant fraction of not-yet-automated tasks become automated

1. *In Hémous & Olsen (2016), new tasks do not feature a higher productivity for labor and add up to existing tasks instead of replacing automated tasks. As a result, their model predicts a decline in the labor share which matches quantitatively the decline observed in the US.*

each period, *i.e.* $\dot{\beta} = \theta(1-\beta_t)$. In this case, one can show that the growth rate converges to a constant in the long run.

Next, consider the case where all tasks become automated in finite time, i.e. where $\beta_t \equiv 1$ for $t > T$. Then, for $t > T$ aggregate final good production becomes $Y_t = A_t K_t$, so that, if capital accumulates over time according to $\dot{K} = sY - \delta K$, we get a long run growth rate equal to $g_Y = g_A + sA - \delta$, which increases unboundedly over time as A grows at the exponential rate g_A.

Automation in the Production of Ideas

AJJ consider the polar case where the production of goods and services uses labor only, whereas automation affects the production of knowledge. Somehow, this gets us closer to what AI is all about, over and beyond automation. Namely, AJJ assume:

$$Y_t = A_t L_t$$

with:

$$\dot{A} = A_t^{\phi} \left(\int_0^1 X_{it}^{\rho} di \right)^{\frac{1}{\rho}}$$

where, as before, $\rho < 0$ and

$$X_{it} = \begin{cases} L_{it} \text{ if not automated} \\ K_{it} \text{ if automated} \end{cases}$$

Assuming that a fraction β_t of "idea-producing" tasks are automated by date *t,* then the above knowledge growth equation becomes:

$$\dot{A} = A_t^{\phi} \left(\beta_t^{1-\rho} K_t^{\rho} + (1-\beta_t)^{1-\rho} L^{\rho} \right)^{\frac{1}{\rho}}$$

Let's first consider the case where a constant fraction of not-yet-automated tasks become automated at each period, i.e. $\dot{\beta} = \theta(1-\beta_t)$. In this case, one can show that:

$$g_Y = g_A = -\frac{1-\rho}{\rho} \frac{\theta}{1-\phi}$$

so that even though we assume decreasing returns to knowledge accumulation as in Jones (1995), i.e. $\phi > 0$, automation in the production of ideas maintains a positive long-run growth rate of (per capita) GDP.

Next, consider the case where all tasks become automated in finite time, i.e. where $\beta_t \equiv 1$ for $t > T$. Then, for $t > T$, the growth of knowledge satisfies the equation:

$$\dot{A} = A_t^{\phi} K_t$$

where:

$$\dot{K} = sY - \delta K$$

In this case AJJ shows that $A_t = Y_t / L$ becomes infinite in finite time. This extreme form of explosive growth is referred to as a "singularity".

Explaining the Decline in Growth

Given the predictions of theoretical models, why haven't we observed a growth outburst in developed countries, particularly in the US over the past decade, even though automation and AI are affecting a growing share of activities? One explanation for the absence of explosive growth may simply be that some essential inputs to production or research cannot be automated: in this case the Baumol's cost disease effect is back and holds growth down. Yet, this does not account for the fact that productivity growth has actually declined over the past decade.

Aghion *et al*. (2019), henceforth ABBKL, propose the following explanation. Suppose that there are two main sources of heterogeneity across firms in the economy. The first one is "product quality" which improves as a result of innovation on each product line. But on top of product quality, some firms – call them "superstar" firms – may enjoy a persistent "efficiency advantage" over other firms. Natural sources of such an advantage are the organizational capital, the development of networks, or the ability to escape taxation: these help superstar firms to enjoy higher mark-ups than non-superstar firms with the same level of technology. The story developed by ABBKL is that a technological revolution, by reducing the firms' cost of monitoring each individual activity, will induce all firms to expand their range of activities. However, since superstar firms enjoy higher profits on each product line than non-superstar firms with the same level of technology, the former will end up expanding at the expense of the latter. But this in turn will deter innovation by non-superstar firms, as innovating on a line where the incumbent firm is a superstar firm always yields lower profits than innovating on a line where the incumbent firm is a non-superstar firm. Thus overall, the technological revolution can result in lower aggregate innovation and lower average productivity growth in the long run, following an initial burst of growth associated

with the expansion of superstar firms into more product lines.[2]

This can explain why productivity growth in the US has declined continuously since 2005, after a burst of growth between 1995 and 2005, in the wake of the AI revolution following the ICT revolution. Moreover, it also accounts for the fact that, over the past decade, the average markup has markedly increased in the US, which was mostly due to a composition effect: namely, the share of higher-markup firms in the economy has gone up, but markups within firms have not shown any significant upward trend.

This explanation illustrates the fact that technological revolutions may have adverse effects on growth if institutions and policies do not adapt. Thus, ICT and AI have helped some superstar firms develop platforms/networks or social capital which in turn have acted as barriers to entry and/or innovation by non-superstar firms. The challenge is then to rethink competition policy so that the ICT and AI revolutions can fully deliver on their growth promises.

The above discussion has stressed the importance of appropriate institutions and policies for the impact of AI on growth. In the next session we analyze the impact of AI on employment, and there again we shall argue that institutions and policies matter.

Automation and Employment

Historical Background

Since AI is only in its infancy, empirical job data with hindsight are not available yet. Hence, empirical studies have focused on automation in a broad sense and on its impact on employment.

Early analyses showed an increase in technological unemployment based on a macroeconomic equilibrium analysis, but without a special focus on automation (Keynes, 1930; Leontief, 1952; Lucas & Prescott, 1974; Davis & Haltiwanger, 1992; Pissarides, 2000).

In the wake of the IT and computer revolution in the 1990s, authors tried to explain the polarization of the labor market. The canonical skill-biased technological change became a major subject of investigation: several studies explained a rising wage gap and a better return on education by a rising demand for skilled labor versus non-skilled labor (Katz & Murphy, 1992; Krueger, 1993; Autor *et al*., 1998; Bresnahan *et al*., 2002; Acemoglu, 2002; Autor & Dorn, 2013).[3] This skill-biased technological change hypothesis did not foresee a replacement of labor by capital, but rather supported the idea of complementarity between technology and skilled workers (see Acemoglu & Autor, 2011, for an overview).

Following the critic of Card & DiNardo (2002), and the seminal paper of Autor *et al*. (2003), the theory of skill-biased technology declined, in favor of a "routinization" hypothesis. The academic consensus shifted to a labor-replacing view of automation in routine tasks. The underlying assumption became that "traditional" automation replaces routine jobs, and creates more demand for non-routine jobs that require skills that cannot be performed by machines. Indeed, empirical facts show that automation gave rise to more high-skilled and low-skilled jobs[4], while crowding out medium-skilled jobs (Goos & Manning, 2007). Several studies highlight the structural change in the labor market and show the disappearance of manufacturing and routine jobs (Autor *et al*., 2003; Jaimovich & Siu, 2012; Autor & Dorn, 2013; Charnoz & Orand, 2017; Blanas *et al*., 2019).

Some authors have tried to go beyond the scope of "traditional" automation by questioning the feasibility of automating jobs given current and presumed technological advances. They notably relax the assumption according to which automation could not threaten non-routine jobs. Whereas Autor *et al*. (2003) argued that non-routine tasks such as legal writing, truck driving, medicine, selling, could not be substituted, this view has been questioned by Brynjolfsson & McAfee (2011) who advocate that automation is no longer limited to routine tasks, recalling the example of self-driving cars. Frey & Osborne (2017) have followed this path and estimated the probability of computerization[5] of 702 jobs. Their main conclusion showed that 47% of

2. On the slowdown of productivity growth and its link with the rise of corporate market power and firm concentration, see also Liu et al. *(2019).*
3. On the same issue, let's also mention Beaudry et al. *(2013), who highlight the declining demand for non-skilled workers, but through a different mechanism. They argue that the over-qualification of workers induces less demand for qualified workers, who are therefore "forced" to accept underqualified jobs, while non-qualified workers are kicked out of the labor market.*
4. Goos & Manning (2007) refer to them as "lovely" and "lousy" jobs.
5. Computerization is defined as job automation by means of computer-controlled equipment.

employment in the US is at risk of automation in the next ten or twenty years, whereas only 33% of jobs have a low risk of automation. They also showed that there was a strong negative relationship between, on the one hand, wages and educational attainment and, on the other hand, the probability of computerization. Frey & Osborne have been under harsh criticism: they ignore the task content of the jobs, and do not factor in the variability of a specific occupation across workplaces. Arntz *et al*. (2017) show that when factoring in the heterogeneity of tasks within occupations, only 9% of all workers in the US face a high risk of automation. Last, Frey & Osborne's method does not integrate the response of the economy in a general equilibrium model, i.e. the cost of automation, the response of wages, and the creation of new jobs. Despite technological advances, the cost of substitution between machines and labor could prevent firms from automating rapidly, especially if wages adapt. Moreover, other activities could develop and hire the redundant workers.

Being forward-looking without reasoning in a general equilibrium pattern seems unrealistic. Caselli & Manning (2019) criticize the fact that most current papers rely on a partial equilibrium analysis and do not draw on a formal model of the economy as a whole. Instead, they propose a very general framework for thinking about the effects of automation on different types of workers. They notably show that new technology is unlikely to cause wages for all workers to fall and will cause average wages to rise if the prices of investment goods fall relative to consumer goods.

The analyses of automation based on the routine-based technological change share one caveat: since their premise is that automation affects routine jobs, they do not question the measure of automation. Yet, getting an accurate measure of automation is crucial, and this is what recent studies have tried to do. Earlier studies were based on the measure of computers or IT (Krueger, 1993; Autor *et al*., 1998; Bresnahan *et al*., 2002), recent papers investigate other measures of automation like automation related patents (Mann & Püttmann, 2017), or the number of robots (Autor & Dorn, 2013; Acemoglu & Restrepo, 2017; Dauth *et al*., 2017; Graetz & Michaels, 2018; Cheng *et al*., 2019). It is on this latest strand of literature that we focus in the remaining part of this paper.

The Effect of Robots on Employment in the US

As regards the impact of robots on net employment, evidence is mixed. Chiacchio *et al*. (2018) report negative effects – one more robot per thousand workers reduces the employment rate in six EU countries by 0.16-0.20 percentage points. Yet, Autor *et al*. (2015) and Graetz & Michaels (2018) find no effect of automation on aggregate employment. On German data, Dauth *et al*. (2017) find no evidence that robots cause total job losses, but they show a significant negative effect on employment in the manufacturing industry: each additional robot per thousand workers reduces the aggregate manufacturing employment-to-population ratio by 0.0595 percentage points.

In their paper "Robots and jobs: Evidence from US Labor Markets", Acemoglu & Restrepo (2017) analyze the effect of the increase in industrial robot usage between 1990 and 2007 on US labor markets. They answer this question using within-country variation in robot adoption. The first part of the paper is dedicated to describing a theoretical model in which robots and humans are substitutes to derive equations and calculate the aggregate impact of robots on employment and wages. They show that, for each labor market, the impact of robots on jobs may be estimated by regressing the change in employment and wages on the exposure to robots and finally find that one more robot per thousand workers reduces the employment to population ratio by about 0.37 percentage points and wage growth by 0.73%.

In detail, AR-2017 focus on the 722 commuting zones covering the US continental territory. For each commuting zone, they gather employment and wage data, and build a measure of the exposure to robots. Then they run regressions on all commuting zones, in order to investigate the impact of this exposure on the change in employment and the change in aggregate wages, i.e. to estimate the following relationships:

$$\begin{cases} dlnL_c = \beta_L \cdot US\ RobotsExp_c + \varepsilon_c^L \\ dlnW_c = \beta_W \cdot US\ RobotsExp_c + \varepsilon_c^W \end{cases}$$

The best way to measure local exposure to robots would be to have a direct measure of the stock of robots in each commuting zone. Yet, no such data exist: the main source of data on robotics is provided by the International Federation of Robotics (IFR), which gathers worldwide data from robot producers, on sales,

the destination of sales and their classification by industrial sector. The main advantage of IFR data is to define a robot according to an ISO standard, which provides a homogeneous definition between industries. Indeed, a robot is defined as "an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications". The main feature of this definition lies in the autonomy of the robot to perform tasks. From these data, they deduce the stock of robots by country and by year from 1993 on[6], but only on a country – or a group of countries – scale. The IFR provides data on the stock of robots for 19 employment categories, i.e. 2-digit nomenclature data in the non-manufacturing sector and 3-digit data in the manufacturing sector. Graetz & Michaels (2018) were the first to use the IFR data. They estimated that the robotization process between 1993 and 2007 contributed to the annual labor productivity growth by 0.36 percentage points.

AR-2017 build a local index, which is based on the rise in the number of robots per worker in each industry on the one hand, and on the local distribution of labor between different industries on the other hand.

For each commuting zone, the index measuring the exposure to robots between 1990 and 2007 is inspired by the index measuring the exposure to Chinese imports, which has been developed by Autor, Dorn & Hanson (2013). The main idea underpinning this index is to exploit the variation in local industry employment structure before the period of interest, in order to spread a variable (robots, imports, etc.) which is only available at the national level. Autor *et al*. (2013) highlight the fact that the variation of the index stems from two sources: the share of the manufacturing employment, and the specialization in exposed industries within manufacturing. Since we want to capture the second source of variation, it is important to control for the share of manufacturing employment at the beginning of the period, as we will see in detail later. The measure used in the paper to measure the exposure to robots at the commuting zone level is:

$$RobotsExp_{c1993}^{2007} = \sum_{i \in I} l_{ci}^{1970} \left(\frac{R_{i,2007}^{US}}{L_{i,1990}^{US}} - \frac{R_{i,1993}^{US}}{L_{i,1990}^{US}} \right)$$

The sum runs over all the 19 industries i in the IFR data. l_{ci}^{1970} stands for the 1970 share of employment in industry i for a given commuting zone i. R_i and L_i stand for the stock of robots and the number of people employed in a particular industry i.

The variation of robots exposure between commuting zones is then used in order to explain the observed evolution of employment and wages. Several controls are included in the regressions. An important feature is to take into account changes in trade patterns. Acemoglu & Restrepo therefore use data from Autor *et al*. (2013) on the exposure to Chinese imports, and construct similar measures of the exposure to imports from Mexico. This local labor market exposure to import competition from China (Mexico) is once more calculated in an analogous fashion as in Autor *et al*. (2013), i.e. the national change in import volume from China (Mexico) per worker and per sector, weighted by the sectoral composition of employment in the zone. Another feature is controlling for growth of capital stock (other than robotics) and growth of IT capital. Other controls include the share of employment in routine jobs in 1990, a measure of offshoring of intermediate inputs, baseline differences in demographics in 1990, baseline shares of employment in manufacturing, durable manufacturing and construction, as well as the share of female employment in manufacturing. AR-2017 also construct estimates of the number of robot integrators in each commuting zone.[7] As they explain in their theoretical development, the empirical estimations are based on two patterns: a quite unrealistic pattern where commuting zones do not trade, and a more realistic pattern where trade between zones is taken into account. The underlying idea is that if an industry in a given zone adopts more robots, then it will become more productive and will export its cheaper product to its neighbors.

As underlined by Acemoglu & Retsrepo themselves, a major concern with their empirical strategy is that the adoption of robots in a given US sector could be related to other trends in that sector. Therefore, they use an instrumental method and make two-stage least squares estimates. Their method is similar to the method used by Autor *et al*. (2013) on US data and Bloom *et al*. (2015) on European data in order to estimate the impact of Chinese imports.

6. Yet, for the US, the repartition of robots is not fully detailed by manufacturing industry on the 1993-2004 period. The full detail is given from 2004 on. Outside manufacturing, the number of robots is available for: agriculture, forestry and fishing, mining, utilities, construction, education, research and development and services.

7. Companies that install and program robots for different industrial applications.

In the first stage, they regress the US exposure to robots on the exogenous exposure to robots in the other advanced European countries, calculated using the same approach as on US data, with the industry-level spread of robots in other advanced economies as an instrument for the adoption of robots in US industries. In the second stage, they regress the change in employment (resp. wages) on the instrumented exposure to robots. The main result is that the commuting zones the most exposed to robots have experienced the worst evolutions in terms of employment (resp. wages) between 1990 and 2007.

Under the assumption that there is no trade taking place between commuting zones, AR-2017 estimate that each additional robot per thousand workers reduces aggregate employment to population ratio by 0.37 percentage points and aggregate hourly wages growth by about 0.73%. If they take trade between commuting zones into account, and calibrate a macroeconomic model, they find that the magnitude of the estimates decreases and that one extra robot per thousand workers reduces the aggregate employment to population ratio by 0.34 percentage points and aggregate hourly wages by 0.5%. Adding control variables such as Chinese and Mexican import volumes, the share of routine jobs and offshoring has little impact on the estimates. Among other robustness checks, AR-2017 run IV regressions where they exclude the commuting zones with the highest exposure to robots (consequence of an important initial automotive employment in these areas). The estimates are quite similar to previous specifications, and they conclude that their results are not solely driven by highly exposed areas.

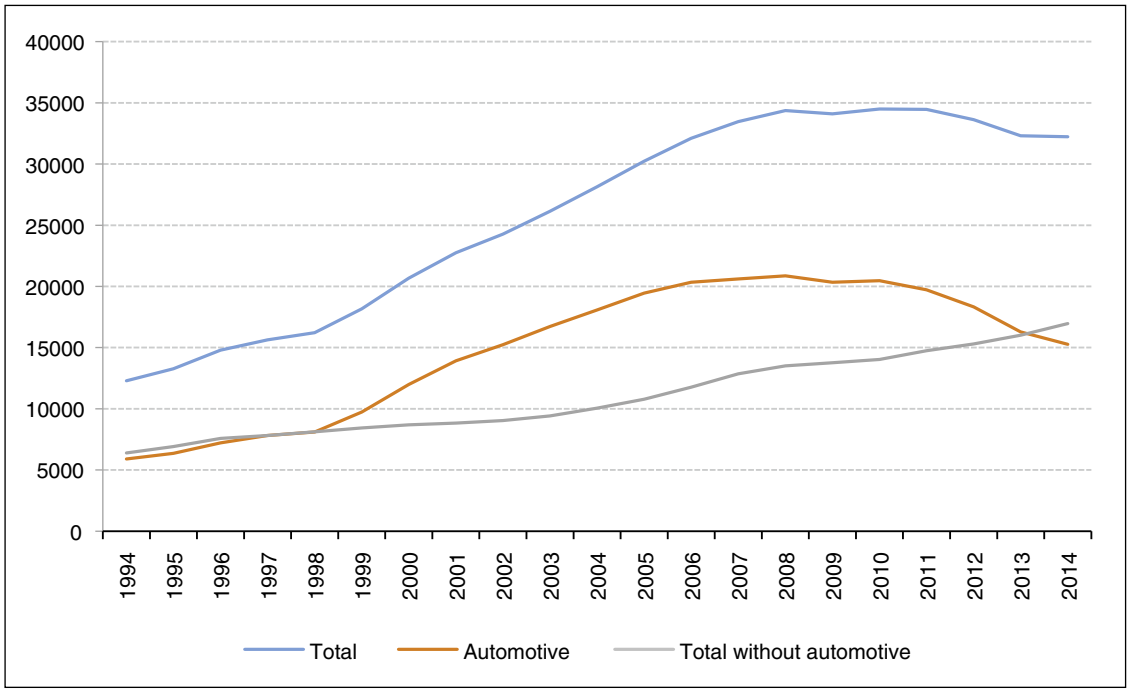
Robots and Employment in France

In this section, we reproduce the method developed by Acemoglu & Restrepo (2017) on French data over the 1994-2014 period, in order to compare the magnitude of the results obtained in France with those obtained using US data.

Figure I plots how the number of robots evolved in France from 1994 to 2014. Similarly to AR-2017, data on robots are provided by the International Federation of Robotics (IFR). The overall number of robots, pictured by the blue curve, grows steadily between 1994 and 2007, then stagnates from 2007 to 2011, and finally slightly decreases between 2012 and 2014.

In order to ensure the comparability of our results with those of AR-2017 or Dauth *et al.* (2017), we use a very close framework. We then

Figure I
Evolution of the number of robots in France (1994-2014)



Sources: International Federation of Robotics.

define the exposure to robots in a French employment zone[8] between 1994 and 2014:

$$RobotsExp_{c1994}^{2014} = \sum_{i \in I} \frac{L_{ic,1994}}{L_{c,1994}} \left(\frac{R_{i,2014}}{L_{i,1994}} - \frac{R_{i,1994}}{L_{i,1994}} \right)$$

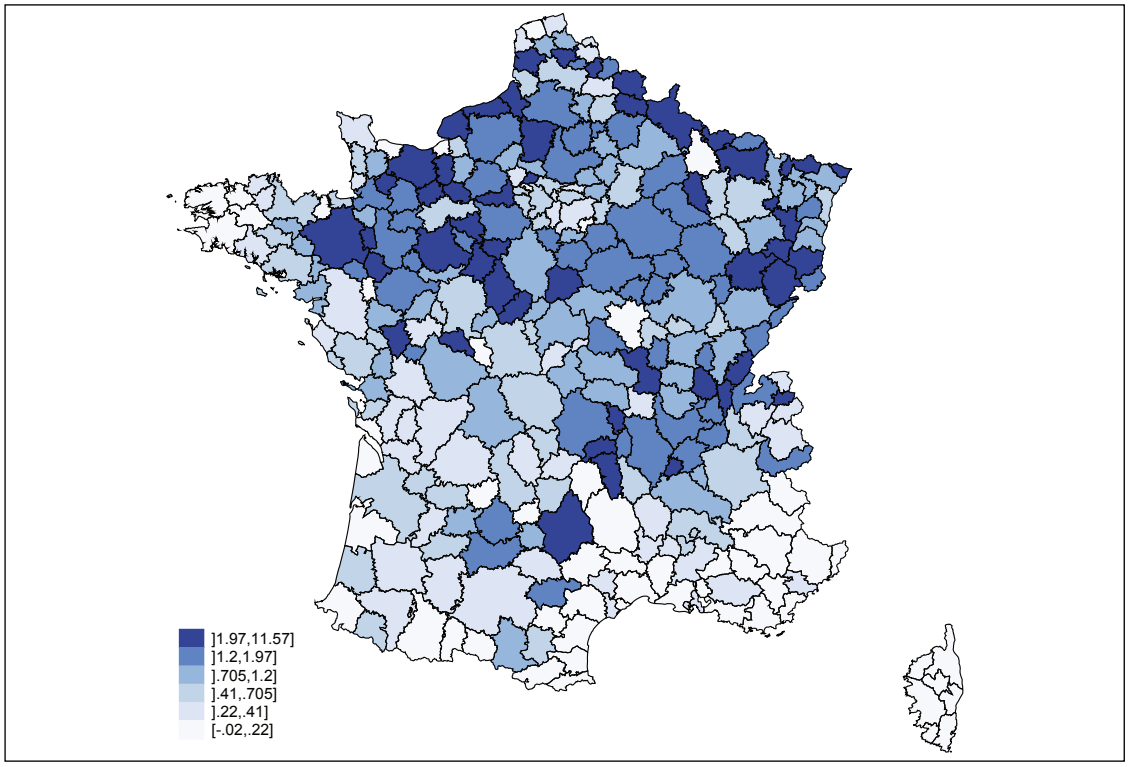
where $L_{ic,1994}$ refers to employment in the employment zone c in industry i in 1994, $L_{c,1994}$ refers to employment in employment zone c in 1994 and $L_{i,1994}$ refers to employment (in thousands) in industry i in 1994. $R_{i,1994}$ and $R_{i,2014}$ respectively stand for the total number of robots in industry i in 1994 and 2014. Data on employment are obtained from the French administrative database DADS.

Our index therefore reflects the exposure to robots per 1,000 workers between 1994 and 2014. Figure II plots the geographical distribution of the exposure to robots. The average exposure in France is 1.16 between 1994 and 2014, well below the average exposure in Germany of 4.64 during the same period. This exposure is also more homogeneous in France, with a standard deviation of 1.42 versus 6.92 in Germany. The order of magnitude of exposure to robots in France is closer to the exposure in the United States between 1993 and 2007. Figure II shows a fairly marked North/South divide. Indeed, while the North has high exposure rates, most southern employment zones have a rate close to 0. The Northeast, with a strong industrial heritage, but also the West (Normandy and eastern Brittany) are among the highly exposed regions. In the least exposed regions, one finds the entire Atlantic coast and the French Riviera.

In order to measure the impact of exposure to robots on local labor markets, we adopt a strategy similar to the one initiated by Autor *et al*. (2013) to investigate the impact of Chinese imports on local labor markets in the United States. Our variable of interest is the evolution of the employment-to-population ratio between 1990 and 2014. In the first and most naïve specification, we study the impact of exposure to robots on the evolution of employment-to-population ratio. This ratio is constructed from census data. However, it is important to control for other characteristics that may influence the evolution of the employment-to-population ratio. To do

8. According to the official definition provided by Insee, an employment zone is a geographical area within which most of the labor force lives and works. It provides a breakdown of the territory adapted to local studies on employment.

Figure II
Exposure to robots in France (1994-2014)



Sources: IFR; authors' calculations.

so, we construct two other exposure indices. First, an exposure index for information and communication technologies (ICT) *ICTExp*, built in a similar way as the exposure to robots index. The number of robots is replaced by the ICT capital stock in industry *i*. Data come from the EUKLEMS database. Second, we build an international trade exposure index *TradeExp* using the COMTRADE database. The number of robots is replaced by net imports from China and Eastern Europe (Bulgaria, Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Poland, Romania, Slovakia, Slovenia) in industry *i*. In some regressions, we also add a vector X_c of control for the employment zone *c*: demographic characteristics in 1990 (population share by level of education and population share between 25 and 64 years old), broad industry shares in 1994 and broad region dummies. Finally, we can write:

$$\Delta \frac{L_{c,1994}}{Pop_{c,1994}} = \alpha + \beta_1 RobotsExp_c + \beta_2 TradeExp_c + \beta_3 TICExp_c + \gamma X_c + \epsilon_c$$

Even if these control variables partially purge OLS estimations, an instrumental variable approach is necessary to discuss causal impact of robots on employment. In fact, one may imagine a shock, which we do not capture in our controls, but which may impact both the installation of robots at the local level and local labor markets characteristics. Always in a comparability perspective, we adopt the approach of AR-2017 and Dauth *et al*. (2017), according to which the stocks of robots in industries from *n* developed countries are used to build n indexes of exposure to robots. These *n* indexes are built with employment data from 1978, to avoid concerns about reverse causality: those pre-existing levels cannot be impacted by robot installations. We select the following countries: Germany, Denmark, Spain, Italy, Finland, Norway, Sweden and the United Kingdom. Data from North America (US and Canada) are not considered, because we only have information on the total number of robots before 2004, without any industry breakdown.

All the share variables (employment-to-population ratio, population share by level of education, etc.) are considered in percentage points in the following regression. Table 1 displays the results of the OLS regressions.

This table shows a negative correlation between exposure to robots and change in employment-to-population ratio. However, the correlation becomes non-significant in column (6) when we include all the controls and in column (7) when we exclude the commuting zones with the highest exposure to robots. In the first five columns where the correlation is significant, the magnitude of the effect ranges from -1.090 to -0.515.

In the instrumental variable regression shown in Table 2, the coefficients of robots exposure are

Table 1
The effect of robots exposure on employment, 1990-2014, OLS estimates

Dependent variable: Change in employment-to-population ratio 1990-2014 (in percentage points)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$RobotsExp_{1994}^{2014}$	-1.090*** (0.253)	-0.749*** (0.263)	-0.594** (0.239)	-0.515** (0.243)	-0.549* (0.294)	-0.398 (0.244)	-0.430 (0.324)
$ITCExp_{1994}^{2014}$		-3.099* (1.586)	-2.397 (1.594)	-2.495* (1.455)	-0.304 (1.620)	-0.165 (1.576)	-0.154 (1.588)
$TradeExp_{1994}^{2014}$		-0.743*** (0.247)	-0.690*** (0.215)	-0.825*** (0.239)	0.0857 (0.243)	-0.123 (0.278)	-0.124 (0.280)
Demographics			Yes			Yes	Yes
Region dummies				Yes		Yes	Yes
Broad industry shares					Yes	Yes	Yes
Remove Highly exposed areas							Yes
Observations	297	297	297	297	297	297	295
R-squared	0.058	0.090	0.198	0.205	0.249	0.407	0.406

Notes: Demographics control variables are population share by level of education and population share between 25 and 64 years old. Broad industry shares cover the share of workers in manufacturing, agriculture, construction, retail and the share of women in manufacturing in 1994. Broad region dummies refers to the 13 metropolitan regions of France. Highly exposed areas are Poissy and Belfort-Montbéliard-Héricourt. Robust standard errors in parentheses. Levels of significance: ***: p<0.01, **: p<0.05, *: p<0.1.
Sources: IFR, COMTRADE, EUKLEMS, DADS, Census data.

significant whatever the specification chosen, even the one with all the controls. The magnitude of first-stage F-statistics indicates that the weak instrument bias is unlikely to be a problem here. Moreover, we observe that the magnitude of the effects increases in comparison with those obtained by OLS. Column (1) begins with the regression without any control. The negative impact of exposure to robots on employment is massive: one more robot per 1,000 workers leads to a drop in the employment-to-population ratio of 1.317 percentage points. Column (2) adds controls on ICT and imports exposures. If the ICT exposure coefficient is not statistically significant, there is a negative impact of net imports on employment-to-population ratio, as in Autor *et al*. (2013) for the United States. The coefficient for exposure to robots remains of the same order of magnitude. Other controls are successively included in columns (3) to (5): demographic characteristics in column (3), broad region dummies in column (4) and broad industry share before 1994 in column (5). In each specification, the coefficient of exposure to robots remains negative and significant, even if its magnitude decreases slightly. On the contrary, the coefficient of exposure to imports becomes insignificant when we add information about the industry composition of the employment zones. Finally, column (6) combines all the controls and column (7) removes highly exposed areas. The effect of the exposure to robots is still negative and significant, even though its magnitude has been reduced in comparison with the specification without any control.

In our last specification, we obtain a negative effect of exposure to robots on employment: one more robot per 1,000 workers leads to a drop in the employment-to-population ratio of 0.686 percentage points. A quick calculation allows us to conclude that the installation of one more robot in a commuting zone reduced employment by 10.7 jobs.[9] The order of magnitude is similar to AR-2017, who found an impact of 6.2 fewer jobs for one more robot. According to the IFR, the number of robots in France increased by around 20,000 between 1994 and 2014. Our result implies a loss of 214,000 jobs (10.7*20,000) during this period due to robots.

Results focusing on the 1990-2007 period, like AR-2017, are presented in Table A1 in the Appendix. Using specification with all controls, we conclude that 1 more robot per 1,000 workers led to a drop in the employment-to-population ratio of 0.438 percentage points. This estimation is even closer to that of AR, who estimated a drop of 0.371 percentage points.

*9. Our exposure to robots is defined in "robots for 1,000 workers". According to the OECD, the average employment-to-population ratio was 0.64 in 2014. Hence, the installation of one more robot reduced employment by (0.686/100)*1000/0.64=10.7 jobs.*

Table 2
The effect of robots exposure on employment, 1990-2014, IV estimates

Dependent variable: Change in employment-to-population ratio 1990-2014 (in percentage points)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$RobotsExp_{1994}^{2014}$	-1.317*** (0.325)	-1.010*** (0.322)	-0.974*** (0.271)	-0.737** (0.296)	-0.790*** (0.300)	-0.686*** (0.241)	-0.986*** (0.351)
$ITCExp_{1994}^{2014}$		-2.569 (1.618)	-1.699 (1.578)	-2.094 (1.444)	-0.176 (1.590)	-0.0323 (1.518)	0.101 (1.538)
$TradeExp_{1994}^{2014}$		-0.670*** (0.242)	-0.589*** (0.211)	-0.773*** (0.230)	0.110 (0.240)	-0.0922 (0.276)	-0.0882 (0.279)
Demographics			Yes			Yes	Yes
Region dummies				Yes		Yes	Yes
Broad industry shares					Yes	Yes	Yes
Remove Highly exposed areas							Yes
Observations	297	297	297	297	297	297	295
First-stage F statistic	53.7	29.4	24.0	25.7	25.1	23.6	46.5
R-squared	0.055	0.087	0.193	0.203	0.248	0.405	0.400

Notes: Demographics control variables are population share by level of education and population share between 25 and 64 years old. Broad industry shares cover the share of workers in manufacturing, agriculture, construction, retail and the share of women in manufacturing in 1994. Broad region dummies refers to the 13 metropolitan regions of France. Highly exposed areas are Poissy and Belfort-Montbéliard-Héricourt. Robust standard errors in parentheses. Levels of significance: ***: p<0.01, **: p<0.05, *: p<0.1.
Sources: IFR, COMTRADE, EUKLEMS, DADS, Census data.

Finally, we investigate the possibility of heterogeneous employment effects of the exposure to robots across education levels. Since we only have this kind of information for individuals between 25 and 54 years old, we restrict our analysis to this population. The results are similar to those presented in Tables 1 and 2. Coefficients estimating the exposure to robots by education level are presented in Figure III (with confidence intervals of 90%). The Certificate of Professional Aptitude (CAP) and the Diploma of Occupational Studies (BEP) are both French professional education degrees. The lower the level of education, the greater the negative impact of exposure to robots. The impact is non-significant for people with high-school diploma. The effect is even positive, but not significant for college graduates. This heterogeneity emphasizes the key role played by education and the need for public policies. In order to limit the negative effects of technical progress on employment, public policies should notably aim at rising the education level and at promoting continuous training.

Discussion

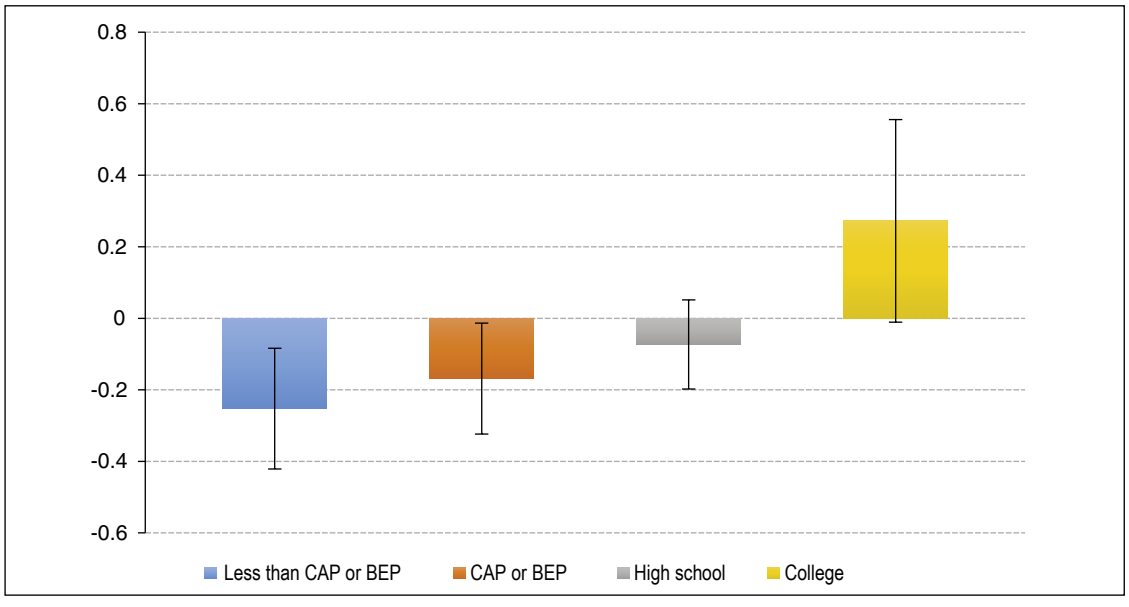
The analyses above raise several potential issues. First, are robots so different from other sources of automation? The IFR definition of robots is quite restrictive and does not include machines like automatic tellers, which replace human labor as well as robots. Taking a broader measure of technological progress into account would make it possible to use data over a longer period, i.e. to use more evidence from the past.

Another potential concern is that the analysis relies on the hypothesis that the number of robots installed by a given industry, divided by the importance of the industry in the commuting zone, is the same across commuting zones. Yet, robotization by a given industry may be more intense in commuting zone A than in commuting zone B even if the shares of that industry are the same in both regions.

A third potential concern is that variations in the robots exposure index across commuting zones are mostly related to the spatial distribution of automotive activities over the US territory in 1990, since industrial robots are predominant in the automotive industry – automotive robots account for more than one third of total robots. Using this variation to explain employment boils down to asking whether the importance of the automotive industry in a given commuting zone in 1990 can explain the evolution of employment in that zone over the twenty following years.

Indeed, most of the robotization took place in the automobile industry, and in the 1990s and the 2000s, the American automobile market

Figure III
The effects of robots exposure by education level



Notes: Confidence intervals of 90%
Sources: Authors' calculations.

experienced large-scale restructuring. Since the late 1980s, numerous automotive assembly facilities have relocated in the South of the United States, a region which previously had a small automotive presence. This has caused concern among the traditional automotive communities in upper Midwest and southern Ontario (Hill & Brahmst, 2003). Similar outsourcing trends occurred in the French automobile industry. If many closures took place in a commuting zone strongly specialized in automobile in the 1990s, then the negative relationship between exposure to robots and employment might just reflect the relocation of automobile plants. AR-2017 deal with that concern in two different ways. First, they exclude commuting zones with very high exposure to robotization, which presumably are also locations with high initial employment in the automotive industry. Doing so does not affect the basic regression results.[10] Second, they run OLS regressions where exposure to robots in automotive manufacture and exposure to robots in other industries are treated as separate regressors: they find that coefficients on the two regressors are quite similar. Overall, Acemoglu & Restrepo (2017) conclude that there is no concern with the predominance of industrial robots in the automotive industry.

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In this paper, we have surveyed recent work on artificial intelligence and its effects of economic growth and employment. Our main conclusion is that the effects of AI and automation on growth and employment depend to a large extent on institutions and policies. Yet, despite solid theoretical foundations on how to model automation and AI, and despite some compelling empirical work, we are still at an early stage in fully understanding all the welfare implications of these technologies.

In the first section, we have argued that while AI can spur growth by replacing labor, which is in finite supply, by capital which is in unbounded supply, it may inhibit growth if combined with inappropriate competition policy.

In the second section, we discussed the effects of AI and automation on aggregate employment: building on Acemoglu & Restrepo (2017), we have looked at the effect of robotization on employment in France over the 1994-2014 period. We find that robotization reduces aggregate employment at the employment zone level. We also find that non-educated workers are more negatively affected by automation than educated workers. This suggests that inappropriate labor market and education policies could reduce the positive impact of AI and automation on employment.

A natural next step would be to bridge the analysis in the two sections. We are currently working to this. Another avenue of research is to investigate how labor market characteristics can affect the nature of innovation, for example, whether the innovation is aimed at automation or the creation of new product lines.The former idea is explored in current work by the present authors, and the latter is explored in recent work by Dechezleprêtre *et al.* (2019). Other extensions, in particular on the effects of AI on consumption and well-being, await future research. □

10. Similar results are shown for France, cf. Table 2, column (7).

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APPENDIX

Tableau A1
The effect of robots exposure on employment, 1990-2007, IV estimates

Dependent variable: Change in employment-to-population ratio 1990-2007 (in percentage points)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$RobotsExp_{1994}^{2007}$	-0.382*** (0.119)	-0.344* (0.198)	-0.508*** (0.195)	-0.148 (0.197)	-0.560** (0.217)	-0.438** (0.198)	-0.633** (0.298)
$ITCExp_{1994}^{2007}$		-0.322 (1.613)	0.990 (1.611)	-1.274 (1.571)	2.844 (2.142)	1.845 (2.019)	2.184 (2.056)
$TradeExp_{1994}^{2007}$		-0.217 (0.319)	-0.285 (0.293)	-0.400 (0.324)	0.301 (0.347)	0.107 (0.383)	0.111 (0.391)
Demographics			Yes			Yes	Yes
Region dummies				Yes		Yes	Yes
Broad industry shares					Yes	Yes	Yes
Remove Highly exposed areas							Yes
Observations	297	297	297	297	297	297	295
First-stage F statistic	45.7	24.8	29.3	24.7	22.6	25.7	44.4
R-squared	0.004	0.007	0.075	0.129	0.144	0.293	0.284

Notes: Demographics control variables are population share by level of education and population share between 25 and 64 years old. Broad industry shares cover the share of workers in manufacturing, agriculture, construction, retail and the share of women in manufacturing in 1994. Broad region dummies refers to the 13 metropolitan regions of France. Highly exposed areas are Poissy and Belfort-Montbéliard-Héricourt. Robust standard errors in parentheses. Levels of significance: ***: p<0.01, **: p<0.05, *: p<0.1.
Sources: IFR, COMTRADE, EUKLEMS, DADS, Census data.

What Value Do We Attach to Climate Action?

Alain Quinet*

Abstract – In the course of policy-making to mitigate the effects of climate change, economists seek to attach a monetary value to actual or foregone carbon emissions. Charting a long-term pathway for carbon prices involves measuring the most cost-effective way to reduce emissions, assigning value to long-term investment, and having a benchmark against which to set priorities. The carbon neutrality target, as set out in the 2015 Paris Agreement, calls for higher carbon values in monetary terms than those historically obtained under Factor 4 targets derived from a cost-benefit approach. This paper looks at developments in carbon values over time, with an emphasis on their underlying methodologies and the role of uncertainty in valuation. It then sets out how carbon values can be used in policy-making to mitigate the effects of climate change.

JEL Classification: Q51, Q54
Keywords: carbon, climate, externality, uncertainty, irreversibility

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Our climate, considered by the founding fathers of economics as a free good, available in unlimited quantities, has gradually moved back into the category of economic goods, i.e. goods that are scarce. In a 1972 paper entitled "Is Growth Obsolete?", William Nordhaus and James Tobin launched a critique of Meadows' "The Limits to Growth", published in the same year under the auspices of the Club of Rome, which predicted the depletion of our natural resources. They argue that in the future, scarcity will not be in raw materials or energy sources – as prices will rise to prevent their over-exploitation – but in public goods, available at no cost and thus subject to excessive exploitation. In conclusion, they point to the need to focus on conserving free natural resources ("fresh air") rather than conserving "chargeable" natural resources: "There is no reason to arrest economic growth to conserve natural resources, although there is good reason to provide proper economic incentives to conserve resources which currently cost their users less than true social cost."

In the wake of Tobin & Nordhaus, a small group of economists began to model the economics of climate, to define the conditions of protecting earth's climate balance as a fragile public good. Climate economics addresses four essential aspects of climate change:

- Externality: unfettered markets distort price signals, because economic agents may emit greenhouse gases (GHGs) at no cost and overlook the impact of their emissions on current generations ("tragedy of the commons") and future generations ("tragedy of the horizon"). Where economists and decision-makers are aware of the externalities, as described in Pigou (1920), GHG emissions exceed all other known externalities in terms of their scale and impact;

- Externality as a global phenomenon: one ton of CO_{2e}[1] emissions has the same impact on climate, regardless of geographic origin. Historically, rich countries have imposed this externality on poor countries; however, the opportunities for reducing emissions at low cost, such as by addressing coal production, can now mostly be found in emerging countries. Designing effective and equitable incentives to overcome "free-rider" problems is one of the major challenges facing climate economists (Tirole, 2009; d'Autume *et al*., 2016);

- Inertia of climate externality: global warming is caused by an accumulation of GHG emissions in the atmosphere. GHG levels rise through emissions and fall through natural absorption (by seas, forests and other carbon sinks). The concentration of CO_2 alone was approximately 280 ppm before the start of the industrial revolution; today, it is over 400 ppm. The rise in global temperatures has already reached one degree Celsius. However, when emissions already accumulated are accounted for, temperatures are expected to rise by a further 1-3 degrees Celsius by the end of this century (IPCC 2014). The discount rate used to appraise the damage takes on particular importance in view of the lengthy time frames (Stern, 2006; Dasgupta, 2008);

- Uncertainty: the fight against climate change is confronted with multiple interrelated causes of uncertainty: scientific uncertainty, regarding the extent of temperature increases caused by higher concentrations of GHGs in the atmosphere (climate sensitivity); uncertainty over the impact of climate change, in particular the thresholds (or tipping points) beyond which systemic changes are at risk of occurring; uncertainty regarding technology that can be deployed to offset emissions and mitigate their impact. This uncertainty means that combatting climate change calls for a precautionary approach (Pyndick, 2006; Weitzman, 2007). Furthermore, incorporating the risk of serious and irreversible damage generates an option value for the most flexible solutions, i.e. those that facilitate changes in public policy in response to new information (Arrow & Fischer, 1974; Henry, 1974).

These four characteristics of climate change highlight the scale of the challenges faced by economists who carry out research in this area. Within a short period, climate economists have managed to adapt their traditional "toolbox" for addressing economic problems – managing externalities (Pigou, 1920), managing exhaustible resources (Hotelling, 1931), long-term welfare considerations (Ramsey, 1928), socio-economic value (Dupuit, 1844) – to a new and much larger problem. Economics has incorporated advances in climate science and other physical sciences, social sciences and decision-making, in order to model the impact of global warming on human activity, as well as the economic cost of addressing this phenomenon. It now boasts a rigorous methodological approach that has been the subject of numerous academic literature reviews, for example Pindyck (2013) and Heal (2017).

1. Tons of greenhouse gases (e.g. carbon dioxide, methane, nitrous oxide, etc.) are expressed here in equivalent tons of CO_2 (or CO_{2e}) warming potential.

There are, of course, points of contention within the profession, arising both from the scientific uncertainties that continues to undermine the accuracy of models (Stern, 2013; Pindyck, 2017) and the need to use traditional economic methods beyond their usual scope of application, as can be seen with the discount rate, which is used to give a present value to damage or actions that may last for decades or even centuries (Gollier & Weitzman, 2010).

Such debates are crucial to making progress towards a deeper economic understanding and analysis of climate issues. However, consensus has been reached around one point: no ecological transition is possible, and no credible policy to mitigate climate change can exist, if pollution remains cost-free and people remain unaware of the damage they impose on others. In other words, given the multitude of human activities and actors, minimum pricing of carbon is a necessary, though not sufficient, condition to effectively combat climate change (Stern & Stiglitz, 2017).

The goal of this paper is to shed light on how economists have gone about calculating the monetary value of a ton of actual or foregone CO_{2e} emissions and to provide an overview of the past and currently used estimates. This form of valuation is an essential benchmark if the aim is to determine the economic cost of pathways to be taken, as well as to define the range of appropriate actions and calibrate public policy regarding mitigation.

As no formal market price for carbon has been established, the value of carbon has been modelled by university researchers and public authorities. This paper sets out the range of carbon values consistent with meeting the targets set under the 2015 Paris Agreement, internationally and domestically (in France), in the context of the second committee for carbon shadow pricing in 2019 (Quinet, 2019). These levels exceed the threshold of $100 per ton of CO_{2e}, which raises additional questions. For example, how can these levels be reconciled with the lower and uncertain values derived from cost-benefit models? How can such values be incorporated in public policy-making?

Combatting Climate Change and the Depletion of Carbon Budgets

Carbon valuation can involve two approaches: "cost-benefit" and "cost-effectiveness".

The cost-benefit approach involves arriving at an overall discounted valuation of all short, medium and long-term damage caused by the emission of one tonne of CO_{2e}. The comparison between the marginal cost of damage and the marginal abatement cost[2] will determine the socially optimal path to reducing emissions. The value of carbon, known in this approach as "social cost of carbon", assigns a monetary value to the social cost of damage and, correspondingly, the welfare gain from a reduction in emissions. Adopting this approach acts in principle as a hedge against two risks: making too much effort for too little social benefit; and not making enough effort to attain a high benefit despite a low associated cost.

With the "cost-effectiveness" approach, an abatement target is exogenously set, and the level and trajectory of carbon values are set in order to reach that target in the most efficient way possible. In this case, the price of carbon is the dual variable of the quantitative constraint – for this reason, it is known as the shadow price of carbon. This approach may appear as a second best to the cost-benefit approach, but it abstracts from discussions over the cost and discount rate of damage and has a sound methodological basis – as applied to optimal management of non-renewable resources.

Carbon Budget Management

As the climate externality is related to the level of GHG concentration in the atmosphere, targets are expressed in terms of the carbon budget, i.e. the maximum net cumulation of CO_{2e} over a given period, at or below which rises in temperatures are restrained.

With this approach, the carbon value level depends on the size of the carbon budget, available carbon sinks, decarbonisation technology, achievable behavioural changes, as well as the availability of international flexibility mechanisms (e.g. purchasing emissions permits on international markets, availability of carbon sinks in other countries, etc.)

The slope of the carbon value trajectory is consistent with optimisation of a scarce natural resource. The price of the scarce resource will increase in step with its consumption due to its

2. The abatement cost is defined as the discounted cost difference between the decarbonisation action and the alternative baseline solution, equal to the greenhouse gas emissions prevented by the action. The cost difference is discounted as the abatement cost includes costs linked to the initial investment, but also costs linked to the purpose of that investment.

increasing scarcity. Specifically, the value of a ton of CO_{2e} is intended to increase along with the discount rate (Schubert, 2008; Chakravorty *et al*., 2008). This rule of optimisation, known as Hotelling's Rule (Hotelling, 1931), holds that the price of carbon rises at the interest rate thereby protecting future values (see Box). Correspondingly, it protects against the risk of creating an incentive to postpone efforts, as would be the case if the price grew faster than the discount rate – known as the "green paradox" (Sinn, 2015).

Applying Hotelling's Rule raises a number of operational issues. Research carried out in France by the most recent committee for shadow carbon pricing (Quinet, 2019) highlights the twin problems of setting a discount rate and managing the underlying investment dynamics (Gollier, 2019; Le Hir *et al*., 2019).

Gollier (2019) argues that the discount rate must include, in addition to the risk-free rate, a "climate beta", i.e. a risk premium that factors in the impact of climate policy on macroeconomic performance, specifically the incidence of the covariance between the marginal abatement cost and aggregate consumption.

Uncertainty over the carbon budget supports a higher initial value and a growth rate of value below the discount rate, in order to seamlessly absorb mid-point revisions to the carbon budget. This rationale is based on the negative correlation between the marginal abatement cost and consumption. Where the carbon budget revised downwards, this increases the marginal abatement cost (assumed to be increasing) and restricts consumption possibilities. If, on the other hand, the carbon budget is higher than initially envisaged, the marginal abatement cost will be lower and consumption higher. The negative correlation between the abatement cost and consumption leads to a negative "beta". This reasoning also applies where uncertainty affects decarbonisation technology: in the event of unforeseen advances,

Box – **Simple Theoretical Model of Carbon Budget Management**[(a)]

We make the following assumptions:

- Economic agents derive utility $U(R_t)$ from consumption of fossil fuels in time t;

- A discount rate ρ applies a weighting factor to these levels of utility as a function of time.

We then seek to solve the maximisation problem for an aggregate of all utility values derived over time through consumption of the fossil fuel.

$$Max \int_0^{\infty} e^{-\rho t} U(R_t) dt$$

Utility is maximised subject to three constraints:

$$\dot{S}_t = R_t$$

$$\dot{M} = \varepsilon R_t - \alpha M_t$$

$$M_t \leq Z$$

S_0, M_0, given that

The first constraint assumes that the extraction and consumption of resource R reduces finite stock S (existing global resources), for which the value is known in time t.

The second constraint assumes that the concentration of CO_2, M, increases with the level of emissions, which themselves are proportional to extraction of R (with a constant coefficient ε) and decreases with natural absorption of CO_2 (which is equal to a fraction α of the atmospheric concentration of CO_2).

The third constraint assumes that the atmospheric concentration must not exceed a level considered dangerous, denoted by Z.

Each constraint is allocated a coefficient in order to solve the equation, for which the economic rationale is as follows:

- $\lambda_t > 0$, denoting the implicit price of the resource (scarcity rent);

- $\mu_t > 0$, denoting the implicit value of the carbon inventory (carbon price);

- $\omega_t > 0$, multiplier linked to the concentration constraint. It adopts a zero value where the constraint is not met, and a positive value otherwise.

Under optimal conditions, the following relationships hold:

$$U'(R_t) = \lambda_t + \varepsilon \mu_t, \ \frac{\dot{\mu}_t}{\mu_t} = \rho + \alpha - \frac{\omega_t}{\mu_t}, \ \frac{\dot{\lambda}_t}{\lambda_t} = \rho$$

Scarcity rent increases on the optimal path at discount rate r:

$$\lambda_t = \lambda_0 e^{\rho t}$$

The carbon price increases on this optimal path at the discount rate plus the rate of natural carbon absorption in the atmosphere:

$$\mu_t = \mu_0 e^{(\rho + \alpha)t}$$

[(a)] *Report on carbon shadow pricing (Quinet, 2008).*

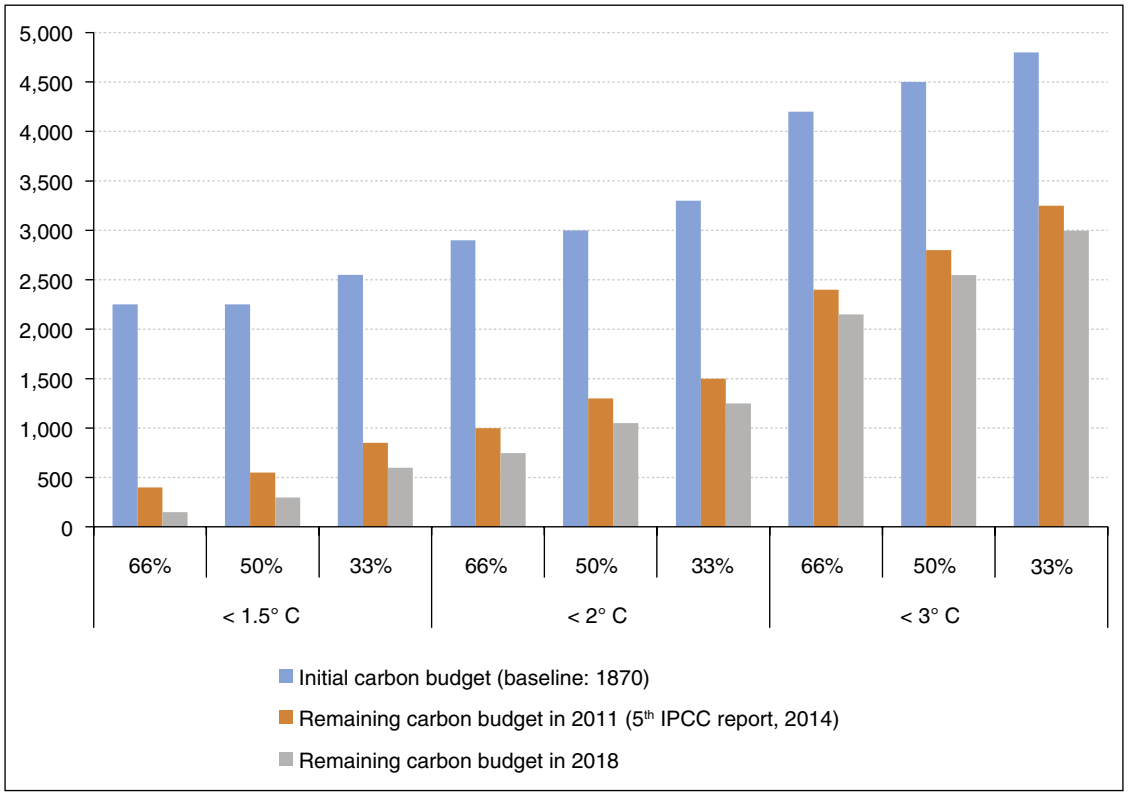
the future marginal abatement cost will be lower and consumption higher.

On the other hand, where macroeconomic conditions are the main cause of uncertainty, the correlation between the marginal abatement cost and consumption is positive. Where growth is higher than forecast, emissions will be higher, as will the marginal abatement cost as a consequence, resulting in a positive "beta" value. In this configuration, the benefit from an investment to reduce emissions increases over time, and is higher than the discount rate – returns from this investment thus take the form of a risk premium. The initial value of carbon is therefore lower and its growth rate higher than the discount rate.

The model put forward by Le Hir *et al*. (2019) develops Hotelling's Rule further by considering two stocks: the carbon budget, which depletes over time; and enterprises' productive capital, which is expected to gradually become "greener". Each stock is assigned a value – the value of carbon and the cost of capital allocated to carbon abatement. An unexpected downward revision to the carbon budget would result in an immediate and costly adjustment to the capital stock. This risk acts as an incentive to plan abatement and "green economy" investment activity, and thereby increase the initial value capital allocated to abatement.

The well-defined cost-effectiveness analytical framework must confront a new challenge, namely the rapid depletion of carbon budgets, as illustrated in Figure I below, which sets out the size of carbon budgets for three maximum-temperature targets and a range of probabilities. The fifth report of the IPCC, published in 2013 and 2014, demonstrated that in the absence of specific efforts to reduce emissions, the global carbon budget to limit temperature increases to 2°C would run out by the middle of the century (IPCC, 2014). The IPCC also noted that a conservative estimate of the potential volume of negative emissions would make the second half of the 21st century a viable target for achieving carbon neutrality, i.e. a balance between gross GHG emissions and carbon sinks such as forests, permanent grasslands and, in the longer term, technological solutions for geological carbon sequestration. These findings underpinned the 2015 Paris Agreement.

Figure I
Available carbon budgets under temperature minimisation targets (billions of tons of CO_2)



Notes: The percentages refer to probabilities of meeting temperature increase targets.
Sources: Quinet (2019).

Depleting the carbon budget by the middle of the century leaves little time for adjustments, which may have significant implications for designing an economic framework for transition:

- It is necessary to rapidly develop and deploy decarbonisation technology, for which the cost and emissions reduction potential are largely unknown at present. In certain sectors (e.g. steel, chemicals, long-distance freight, etc.) technical solutions aimed at achieving full decarbonisation do not exist, hence the critical role of carbon sinks in order to reach net zero emissions;

- It is necessary to minimise as far as possible the number of stranded assets, i.e. unamortised assets that emit GHGs which must be decommissioned in order to achieve carbon neutrality, such as coal-fired power plants. This means that efforts must be progressive enough to prevent decommissioning of existing assets and firm enough to dissuade the construction of new polluting assets;

- To reach net-zero emissions, it is necessary to engage in long-life or very-long-life investment projects (e.g. railway lines or electricity transmission lines). The residual economic value of new installations and equipment that can meet a net-zero emissions target by 2050 but that have not fully depreciated by that time must be considered when calculating their economic viability.

Sharp Upward Revisions in Carbon Values

Carbon values linked to decarbonisation targets are subject to significant upward revision in response to a dwindling carbon budget and more stringent targets. Table 1 below gives the mean world carbon prices based on simulations carried out by the IPCC, recognising that the dispersion is high around these mean values. Predictably, values rise as the urgency of decarbonisation increases. In addition, in the "1.5°C" scenarios, values pass the $100 mark by 2030, before "taking off" after 2030.

The table highlights the difficulties associated with modelling the transition towards a carbon-neutral economy. Models give plausible values through to 2030 and 2040, or alternatively until emissions have fallen broadly in line with "Factor 4" scenarios (i.e. reductions in greenhouse gas emission levels by a factor of four from 1990 levels). The robustness of model output declines as the years progress, the level of emissions falls and we approach the level at which reductions become harder to achieve and require structural, non-marginal changes, which models calibrated on the cost of existing or foreseeable technologies can no longer predict. Lastly, it is noted that the slope of value trajectories between 2030 and 2050 is markedly higher than under Hotelling's Rule, which suggests that the need for initial effort is underestimated.

A New and Robust Carbon Value Path for France That Meets the Carbon Neutrality Target

Under collective efforts set down by the Paris Agreement, France, in its Climate Plan of July 2017, set a target of net zero emissions in GHGs by 2050, with residual gross emissions to be absorbed by carbon sinks and any available carbon sequestration technologies. This target is more ambitious that the previous "Factor 4" target (reduction in emissions to one-quarter of their 1990 levels).

The cost-effectiveness approach offers a way of determining a carbon value for France in line

Table 1
Carbon value under IPCC calculations (in $ 2010 per ton of CO_2)

Scenario	Content	Carbon value in 2030	Carbon value in 2050
1.5°C	Probability of exceeding 1.5°C less than 34%	1,472	3,978
1.5°C low	Probability of exceeding 1.5°C between 34% and 50%	334	1,026
1.5°C high	Probability of exceeding 1.5°C between 50 and 67%	129	586
Lower 2°C	Probability of exceeding 2°C less than 34%	164	518
Higher 2°C	Probability of exceeding 2°C between 34% and 50%	56	169
Above 2°C	Probability of exceeding 2°C more than 34%	21	63

Notes: In each scenario, average value for a range of models and simulations.
Sources: IPCC (2018).

with this target. Following on from early research by Marcel Boiteux on shadow pricing, i.e. monetary values to be assigned by the State to welfare gains and losses (Boiteux, 2001), an initial study was carried out in 2008 to assign values to actions intended to prevent emission of one ton of CO_{2e} in respect of the Factor 4 target. The baseline was set at €100 (at 2008 values) per ton of CO_{2e} in 2030, subsequently rising under Hotelling's Rule to €250 (at 2008 values) in 2050 (Quinet, 2008). Ten years later, a second report (Quinet, 2019) updated this benchmark to account for the worldwide lag in reducing GHG emissions, the 2015 Paris Agreement, and potential advances in technology.

A Carbon Trajectory Based on State-Of-The-Art Analysis

It should be noted that no ready-made simulation exists that can mechanically produce a carbon value path. The new report puts forward a coherent carbon value trajectory established collaboratively by France's leading climate economists, which is of the highest attainable standard. In addition to the general principles of climate economics, it features two specific elements:

1) Simulations from five different models (Times, Poles, IMACLIM, ThreeME and NEMESIS). The cost-effectiveness approach adopted here does not require a model for the damage curve as the emissions reduction target is set by the Paris Agreement of 2015. Under this approach, only technological and macroeconomic dynamics, along with GHG emissions flows, are modelled. These models produce a path that reflects the marginal cost of reducing one ton of CO_{2e}, i.e. the marginal abatement cost, which tends to increase over time as the deployment of more cost-intensive technological solutions becomes necessary. These models make it possible to detail the investment and behavioural changes required to achieve carbon neutrality;

2) Forward-looking studies into technological and techno-economic solutions. Studies such as those carried out by the International Energy Agency (IEA, 2017), are used to assess the decarbonisation potential of various technologies, their speed of deployment and their cost. Based on this research, the report does not predict the arrival of "backstop" technology, i.e. replacement technology that can completely bypass fossil fuels at a stable cost. It does however postulate that a limited number of carbon sinks will emerge. To reach a target of full decarbonisation, it assumes that a portfolio of functional technologies (e.g. more widespread and direct use of carbon-neutral electricity or indirect use via the hydrogen energy vector, development of CO_2 capture and storage solutions) could be leveraged to achieve full decarbonisation through relatively high fuel switching prices.

A Target Value Increase from €100 to €250 in 2030

The report considers that a timescale of 2030 serves as the preferred anchor for a carbon value trajectory for two key reasons: firstly, a 10-year horizon is determinant in "anchoring" expectations and initiating an upsurge in "low-carbon" investment; secondly, with this timescale, the basis of economic forecasts and technological outlooks are relatively sound, although they of course remain uncertain.

Based on the modelling work completed, the report recommends the adoption of a carbon value of €250 (at 2018 values) in 2030, based on the current value of €54 in 2018, which therefore entails a catch-up phase. After 2030, growth in the carbon value reduces progressively, aligning with Hotelling's Rule at a public discount rate of 4.5% from 2040 onwards. The price in 2050 is €750.

A Value in Line with IPCC Estimates

The value proposed in 2030 is significantly higher than that of the current benchmark taken from the 2008 report (€100 at 2008 values, €110 at current values). This primarily reflects the lag and the corresponding increased ambition beyond "Factor 4", which entail high abatement costs or technological breakthroughs in a number of economic sectors, particularly agriculture (notably the need to adapt crop and livestock farming), in some industrial sectors (the need to find substitutes or disruptive technologies in essential production such as cement, chemicals and steel), and in long-distance transport (land, sea and air travel). The increase in carbon values also reflects the lack of international cooperation and flexible mechanisms at international level.

The value of carbon in France is within the range of values indicated in the IPCC's latest October 2018 report for targets under two degrees (see Table 1), which were revised sharply upwards to factor in the risk of rapid depletion of world carbon budgets.

An Outcome that is Sensitive to International Cooperation and Innovation

Determining a carbon value trajectory must account for uncertainty which increases further into the future as the scope for technological developments and diplomatic ini-tiatives expands. After 2030, the values suggested by the model may be revised downwards to reflect behavioural changes by actors who fully incorporate combatting climate change into their practices, or the availability of a broader portfolio of decarbonisation technologies.

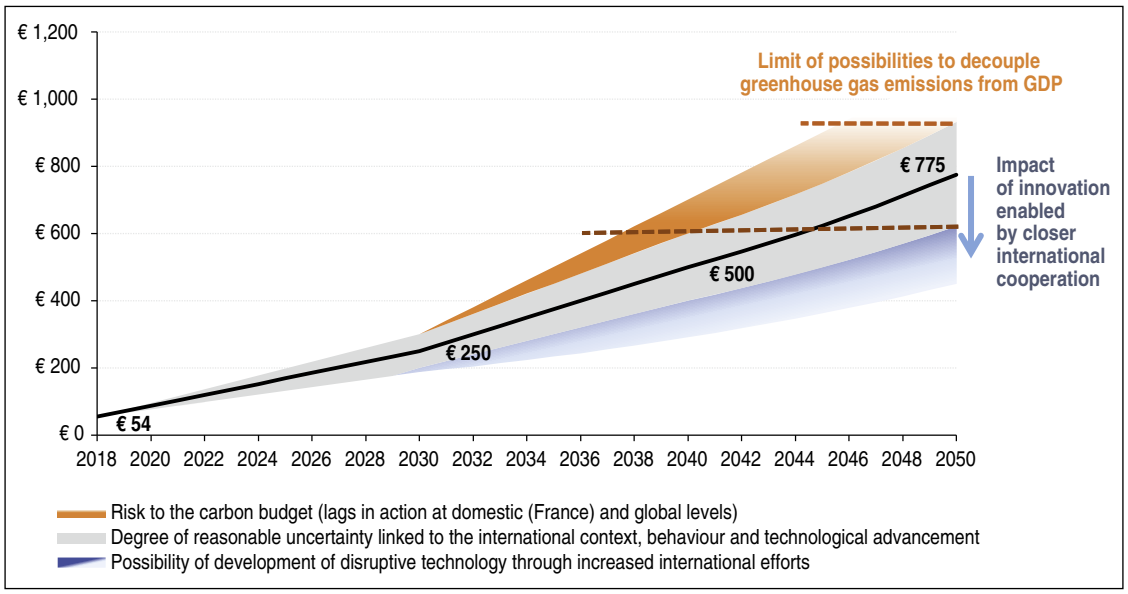
The sensitivity of results to the cost of technology is closely related to underlying assumptions of international cooperation. Research and innovation efforts that place greater focus on decarbonisation and are simultaneously engaged in multiple countries would have a powerful impact in terms of reducing the cost of technology, as can be seen at present in the case of renewable energy. Where multiple research bodies and companies in a number of countries become engaged in innovation projects, this should produce gains for individual countries: each country benefits from the emergence and dissemination of innovation throughout the world, along with the reduction in the cost of technology facilitated by learning effects and economies of scale, the so-called international spillover effects.

Overall, the assumption of technological breakthroughs through closer international cooperation would undoubtedly have little effect on the value of carbon in 2030, but would accommodate an expected sharp reduction in the carbon value beyond 2030 (from €750 to €450; see grey area in Figure II below). On the other hand, a deficit in international cooperation would not justify an upward revision in the already-high baseline carbon value in France (see orange area in Figure II below); any such revision would not stimulate the deployment of additional technologies within the same short timescale and could lead to restrictions in business activity and employment, with no sustainable benefit from the fall in the carbon intensity of human activity.

Issues Related to Upward Movement in Carbon Values

Cost-effectiveness approaches adopted either nationally or globally have resulted in much higher carbon values. These increases reflect the depletion of carbon budgets. They raise two basic questions: how do we reconcile these results with the lower values produced using cost-benefit approaches, and how can they be incorporated into public policy aimed at reaching the stated targets?

Figure II
Carbon price path - France



Sources: Quinet (2019.

Coordinating the Results from Cost-Effectiveness and Cost-Benefit Approaches

To understand the cause of the emerging gap between carbon values reached using cost-effectiveness approaches and those using a cost-benefit approach, it is instructive to set out the three main elements in calculating the marginal cost of damage.

Monetary Value of Damage

Modelling climate externalities essentially depends on two parameters: climate sensitivity, i.e. the increase in temperatures caused by increasing concentration of GHGs in the atmosphere; and the climate damage function, which captures the impact of rising temperatures on welfare. The cost of damage or cost of inaction is expressed in monetary terms but consists of both market costs (e.g loss of productivity and GDP, lower agricultural yields, destruction of productive capital due to natural disasters, etc.) and non-market costs (e.g. loss of biodiversity, destruction of ecosystems, etc.), to which we assign a monetary value. Assigning a value to damage is therefore subject to considerable uncertainty: how do we aggregate such a wide range of impacts and give a monetary value to what are in part non-market damages? Is the damage function multiplicative (i.e. is damage correlated to the level of GDP) or additive (i.e. is damage independent of the level of GDP)? What degree of convexity does the damage curve exhibit?

Discounting for Damage Caused Over Time

The marginal cost of damage caused in the future by the emission of one ton of CO_{2e} today must be discounted in order to be tracked to its present value. Over the very long term – a horizon much longer than that used in financial markets – the discount rate involves ethical choices: pure time preference, aversion to intra- and intergenerational inequality, assessing the long-term outlook and its attendant uncertainties (Stern, 2006; Gollier, 2012; Dasgupta, 2008). This is especially important in the context of global warming, given that large-scale changes are at risk of occurring by the end of the century.

Accounting for the Risk of Serious and Irreversible Damage, Over and Above Marginal Damage

Consideration of catastrophic risk leads, in various forms by way of an option value, to an increase in the mean value of damage (Hery, 1974; Weitzman, 2014).

Applying Cost-Benefit Analysis to Combatting Climate Change: Mission Impossible?

Cost-benefit analyses, which usually serve as the basis for all meaningful economic thought, have ultimately been few in number. The Stern report in 2006 generated discussion over the main parameters in cost-benefit calculations (Weitzman, 2007; Nordhaus, 2007; Sterner & Petersson, 2008). However, only a handful of integrated assessment models have been used in major international studies, notably DICE (Nordhaus, 2018), FUND (Anthoff & Tol, 2014) and PAGE (Hope, 2006).

These models are intended to overcome the major methodological issues that heavily influence the conclusions that they reach. In fact, ranges for the social cost of carbon are relatively broad – between \$30 and \$150 per ton of CO_{2e}. Table 2 sets out a non-exhaustive list of figures for the

Table 2
Social cost of carbon (per ton of CO_2)

	2015	2020	2050
DICE (values in \$ 2010)			
Discount rate of 4.25%	30	35	98
Discount rate of 2.5%	111	133	242
US IWG (values in \$ 2007)			
Discount rate of 3%	36	42	69
Discount rate of 2.5%	105	123	212

Sources: Nordhaus (2018), US Interagency Working Group (2016).

social cost of carbon from two recent major studies, and underlines the sensitivity of these figures to the choice of discount rate:

- Output from the DICE model, from updated research by Nordhaus (2018). This model is transparent in its assumptions and output;

- Analysis by the United States Interagency Working Group for the environment, based on the use of DICE, FUND and PAGE models (USIWG, 2016).

How can divergences between the cost-benefit and cost-effectiveness approaches be interpreted? Do they suggest that cost-benefit models minimise the cost of damage, or, conversely, that climate policy targets underestimate the cost of emissions reduction?

Traditionally, economists have sought to adjust for the difference in orders of magnitude in both approaches by using a low discount rate in cost-benefit analysis. This is the approach used in the Stern report, which features a very low time preference, systematically leading to carbon values close to valuations based on Factor 4 targets. It should be noted that valuations of carbon using cost-benefit approaches are more sensitive to the discount rate than those using cost-effectiveness approaches, where analysis covers much longer time horizons. Cost-benefit approaches tend to apply a discount factor to damage inflicted over a very long time horizon of between 100 and 200 years. Cost-effectiveness analyses generally look at much shorter time horizons, typically between one and three decades (2030 or 2050). As we have seen, using these approaches, the discount rate determines the slope of the carbon price path, not its initial level directly.

In addition to the discount factor, recent economic research suggests that cost-benefit approaches tend to underestimate the cost of damage and therefore apply much larger carbon budgets than those implicit in new climate change targets. Three interrelated reasons for underestimation exist:

- Models generally do not take account of all potential damage, some of which are difficult to assign a monetary value to because they have no direct impact on GDP and asset values, or do not factor in the most recent, more pessimistic valuations (Aufhamer, 2018);

- Climate change has traditionally been assumed to affect GDP through productivity, dwindling capital stock and destruction from natural disasters. However, an emerging body of research suggests that the growth rate can also be affected by a reduction in the capital stock or productivity gains, in particular in poor countries and countries vulnerable to climate change (Moore & Diaz, 2015; Dietz & Stern, 2015);

- Models use damage curves that are mildly convex, thereby underestimating the risk of disaster in the case of marked increases in temperature.

In this respect, a more fundamental criticism applies to the degree of relevance of cost-benefit analysis, which compares the marginal cost of action and inaction, typically using normal probability distributions. However, climate change includes non-marginal risks of catastrophic damage, with probabilities of occurrence considerably higher than those obtained from a normal distribution (Weitzmann, 2014; Van der Ploeg & de Zeuw, 2014). In his Dismal Theorem, Weitzman (2011, 2014) describes a scenario in which the social cost of carbon tends to infinity, where the probability of catastrophe falls at a slower pace than the scale of catastrophic damage increases. Weitzman considered the implications of this outcome "absurd": current generations cannot devote all of their resources to disaster risk prevention, and the conditions under which the Dismal Theorem holds are undoubtedly highly restrictive. However, the message of caution when implementing and interpreting cost-benefit assessments remains valid: the value of emission reductions should not only be measured by the damage prevented but also by the reduced probability of the occurrence of irreversible catastrophes.

In this context, the IPCC scientific community has been guarded about the use of cost-benefit approaches, preferring instead to keep to the definition of maximum temperature thresholds for preventing the risk of serious and irreversible damage. Overall, the main argument for more ambitious mitigation policies than those based on the cost-benefit model output lies in the finding that both GHG concentrations and damage are irreversible.

The irreversibility of GHG concentrations is linked to current levels of technological advancement. Negative emissions technology may reverse GHG inventories, but the prospect of such a development remains wholly speculative at this point, and the prudent approach would be to expect a dwindling and/or depleted carbon budget.

Even if one assumes that emissions become partially reversible in the future, some of the damage caused will be irreversible, meaning that the services currently offered by nature that will have disappeared will not be able to be replaced by technological substitutes. Front-loading and increasing efforts provides an option value against the risk of being without any room for manoeuvre in the future; if an unforeseen but favourable event occurs, it will still be possible to reduce the level of subsequent abatement when compared with forecasts; however, when faced with the carbon budget constraint, an unforeseen and unfavourable event will in all cases produce damage (Bureau, 2017).

Highlighting the limitations of existing cost-benefit approaches does not mean that the economic and social costs of mitigation to meet these thresholds should be ignored. A cost-effectiveness approach makes it possible, through a carbon value trajectory, to measure the economic effect of mitigation actions and their merit order, the required decarbonisation investment and the risk of stranded costs to meet a given climate target.

Translating Carbon Value into Public Policy

The value of carbon sets a baseline for calibrating climate policy: all actions that entail an abatement cost below the baseline must be undertaken as they are socially and economically viable.

The leading mitigation policy instrument is uniform pricing applied to all global emissions (Tirole, 2009): the broader the scope, the more opportunities exist for abatement at low cost. This efficiency rule does however pose difficult questions in terms of equity. Applying a single global price for carbon not only raises the issue of free-riding, but also of financial compensation: advanced countries carry a large share of the responsibility historically for global warming, yet the main actions to reduce emissions, in particular the elimination of coal, focus on emerging countries. Where financial compensation schemes are not in place between countries, the uniformity of the carbon price cannot ensure equitable outcomes (d'Autume *et al*., 2016). At present, the 2015 Paris Agreement relies on an accumulation of quantitative commitments by nation states, which is a more pragmatic method of achieving harmonisation of climate mitigation policies internationally, but without the decentralised coordination of efforts that a single global carbon price would allow.

Minimum pricing for carbon is necessary. The operational question is the correct level with respect to two considerations, the first of which is social: can carbon pricing be aligned with a high baseline value? The second consideration is economic: can carbon pricing be enough to realise substantial decarbonisation of human activity?

Questions regarding the correct price and the complementarity of instruments for reducing carbon emissions are the subject of a large body of research in climate economics. The terms of the debate are now clear: pricing aligned to the value of carbon would be relevant in a world where public policy is closely aligned on the carbon neutrality objective and where market imperfections are non-existent or already overcome. This would assume:

- Close coordination of land and urban planning policies and transport and mobility policies (that people are not forced to commute long distances due to excessive property costs, towns and cities are compact and have sustainable transport networks, etc.);

- Actors have zero-carbon alternatives (suitable infrastructure, technological solutions) and a means of funding profitable decarbonisation investment (access to credit, guarantees against certain types of risk, etc.);

- The State is able to address its distributive effects of a carbon tax or its impact on competitiveness.

A more refined analysis would view the transition to carbon neutrality as dependent on alignment of all public policies regarding "net-zero emissions" and a "smart" aggregation of additional measures. This has been argued by the OECD (2015) and in the Stern-Stiglitz report (2017); to remain on the right pathway towards carbon neutrality, there needs to be a minimum global price of carbon to ensure transparent pricing and the profitability of decarbonisation initiatives, and to encourage research into innovative solutions. However, the scope of action to achieve substantive carbon reductions from human activity is much broader, including in particular:

- Building a regulatory framework that facilitates optimal land use (increasing population density in towns and cities, and minimising commuter journeys);

- Subsidies for "green" R&D in addition to pollution charging to overcome instances of

market failure and the tendency of companies to limit innovation to their own field of expertise (Acemoglu *et al*., 2017) ;

- Investment in public infrastructure and low-carbon buildings; risk sharing where necessary with respect to zero-carbon technologies through guarantee schemes, and facilitating access to credit.

According to Stern & Stiglitz (2017), a minimum price of carbon should fall between $50 and $100 per ton of CO_{2e} by 2030. It should be noted that, in light of statistics published by the World Bank and the OECD, much progress remains to be made towards minimum pricing. A 2019 survey by the World Bank showed that 46 countries and 25 territorial authorities have introduced carbon pricing. However, such arrangements only cover 20% of global greenhouse gas emissions, with the remaining 80% outside the scope of any pricing mechanism. The OECD (2018) measures the Carbon Pricing Gap, i.e. the carbon price deficit of OECD countries and the G20 by comparison with a baseline of €30 per tonne of CO_2: in 2018, the deficit was 76.5%.

Without revisiting the discussion around the correct choice of climate policy instrument, it should also be noted that public policy-makers require key information over and above the baseline price of carbon, in order to develop a climate policy.

Adopting a high price of carbon requires a detailed appreciation of the potential winners and losers in order to design the most suitable carbon offset mechanisms. It does not however require a detailed understanding of the abatement costs across different economic sectors. It is the economic agents themselves who, through an intimate knowledge of their own abatement costs, decide to incur a tax or to reduce their emissions.

Where the government opts to use non-tariff instruments – typically regulations or subsidies – detailed knowledge of abatement costs becomes essential to efficiency: too low a level of subsidy or light-touch regulation is inefficient; too high a level of subsidy creates rent-seeking; overly stringent regulation may impose compliance costs in excess of the baseline value of carbon. Appropriate calibration of climate policy therefore depends on the capacity of the government to know and track in detail the actual abatement costs. This requirement is particularly important, given that available research indicates that the cost of decarbonisation actions are widely dispersed among economic actors within each sector, which is not surprising: one solar energy plant or one wind farm generates very different abatement costs depending on its location and the structure of the pre-existing energy system.

It is possible to make a generic classification of decarbonisation actions by each sector based on their abatement cost (Gillingham & Stock, 2018):

- Actions with zero or negative abatement costs, in particular because they do not involve significant investment or generate immediate savings. Such rare instances of a "free lunch" primarily entail restraint, e.g. purchasing a vehicle based on need rather than a larger, more powerful car when changing vehicle, adding a dose of ethanol into petrol, manual optimisation of a building's heating through the day, or carpooling;

- Actions with positive abatement costs that are lower than the baseline value of carbon. These are actions that are not financially viable but appropriate for communities, and should be encouraged;

- Actions whose abatement costs remain high, based on current knowledge, such as the use of carbon-free hydrogen for transport, industry or energy production, or carbon trapping and sequestration.

In the latter example, abatement costs should be assessed dynamically: an action might entail a high initial cost but also have the potential to reduce the cost over time through economies of scale and learning effects (Vogt-Schilb *et al*., 2014). This can be seen in the case of photovoltaic solar panels and in electric vehicle development. Some actions fall into intermediate scenarios and are thus the subject of discussion: the transition from coal to gas generates significant short-term GHG savings but involves installation of appliances that emit CO_{2e} in the long term; nuclear energy substantially reduces GHGs, but the associated abatement cost tends to increase over time.

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Amid uncertainty over the timing, scale and apportionment of damage, analysis of the economic literature suggests that it is undoubtedly too soon to use cost-benefit analysis to calibrate precautionary actions. The near-term challenge is "buying flexibility". Setting a

specific target today makes it possible to cover the risk of serious and irreversible damage, with the option to make subsequent adjustments to the mitigation path in the event of "good news" regarding climate or "backstop" technologies.

Under the 2015 Paris Agreement on climate, the parties have set a target of achieving carbon neutrality, i.e. GHG emissions and the absorption capacity of carbon sinks to be in balance – by the second half of the 21st century. In working collectively towards this target, France, like other European countries, has set this same target for 2050. This ambition must be reflected in behavioural changes, investment and, more generally, concerted action from the public and private sectors. In this regard, assigning a monetary value to carbon means assigning value to actions to protect the climate, emphasising that decarbonisation actions have a collective value. Once a carbon value trajectory is established, all public and private actors have a medium-to-long-term reference point for determining the appropriate actions to take and to implement them in order of merit. □

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Causal Inference and Impact Evaluation

Denis Fougère* and Nicolas Jacquemet**

Abstract – This paper describes, in a non-technical way, the main impact evaluation methods, both experimental and quasi-experimental, and the statistical model underlying them. In the first part, we provide a brief survey of the papers making use of those methods that have been published by the journal *Economie et Statistique / Economics and Statistics* over the past fifteen years. In the second part, some of the most important methodological advances to have recently been put forward in this field of research are presented. To finish, we focus not only on the need to pay particular attention to the accuracy of the estimated effects, but also on the requirement to replicate evaluations, carried out by experimentation or quasi-experimentation, in order to distinguish false positives from proven effects.

JEL Classification: C1, C2, C3, C54
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Over the past twenty years, the number of impact evaluation studies, whether experimental or quasi-experimental, has increased exponentially. These methods make it possible to identify, using individual survey data, relationships between variables that can be rigorously interpreted as cause-and-effect relationships. They are based on observation and research schemes that ensure that estimated differences in outcomes (e.g. in terms of earnings, employability, productivity or educational results) are mainly due to the intervention or policy implemented, and that selection and self-selection biases that tarnish many empirical studies are significantly reduced or even eliminated. In particular, these methods aim to statistically identify so-called "counterfactual" outcomes, i.e. those that would have occurred had the intervention in question not been implemented. The identification of the causal effect of the intervention on the outcome variable (its "impact") is then deduced by comparing the observed outcomes for the statistical units (unemployed people, employees, companies, students, etc.) benefiting from that policy.

A Short Review of the Standard Techniques

To achieve this goal, the simplest experimental method, which consists in randomly drawing units that benefit from the policy to be evaluated and comparing their post-intervention situation with that of the units (individuals or firms) that do not benefit from this policy, ensures that a causal relationship between the policy and the observed effect is demonstrated, without the analyst having to make overly restrictive assumptions. The other methods, known as quasi-experimental methods, seek to identify situations where, depending on a certain number of factors, the fact of benefiting from the intervention is independent of the characteristics, observable or not, of the units targeted by that intervention. These methods can be grouped into four categories, which are presented below in a non-technical manner.[1]

Instrumental Variables

Let us suppose that we observe the wages of two groups of workers, the first group having recently benefited from an active labour policy such as a training program, the other group having not benefited from it. Using the linear regression method, it is possible to estimate not only the effects of several variables characterizing the workers, such as age, gender, family situation, level of education, place of residence, etc., but also the effect of the participation in the training program on the post-program wage, i.e., the wage received at the time of the survey. However, this simple method may produce biased estimates. The problem is that participation in the training program is not exogenous: it can not only be correlated with the observed characteristics that we have just mentioned, but also with variables not observed by the analyst, such as a desire to change profession, a desire to learn new skills, the employee's productivity as assessed by his/her employer, etc. Consequently, the fact of having participated in the training program is likely to be correlated with the error term of the regression, the value of that error term generally being dependent on these unobserved characteristics. This correlation is the cause of the so-called "endogeneity" bias. To deal with this problem, econometricians have used the instrumental variable method for a long time. By definition, an instrumental variable must have a very significant impact on access to the program being evaluated – in this case, the training program – without directly affecting the wage level received after participating in that program. The estimation method used in this case is the so-called "two-stage-least-squares" technique. The first step consists in regressing participation in the training program on all exogenous variables (age, gender, etc.) but also on the value of the instrumental variable (which can be, for example, the date of a significant amendment made to the conditions governing access to this program). In a second step, individual wages must be regressed on the same exogenous variables and on participation in training program, not as actually observed, but as predicted by the first regression. The coefficient associated with this "instrumented" value can be interpreted, under certain very restrictive conditions, as "the causal effect" of the training program on trainees' wages.

Matching Methods

The main purpose here is to compare beneficiaries and non-beneficiaries by neutralising the differences due to the distribution of observable characteristics. These methods are based on two assumptions. The first stipulates that the

1. These methods are described in detail, for example, in Crépon & Jacquemet (2018), Chapter 9.

assignment to the group of beneficiaries depends exclusively on observable exogenous characteristics and not on the anticipated outcomes of the intervention: this assumption is called the "conditional independence assumption". The second assumption is that any individual or firm has a non-zero probability (comprised strictly between 0 and 1) of being *a priori* a beneficiary of the intervention, whatever the characteristics of that individual or firm, or whether or not that the individual or the firm is actually (i.e. *a posteriori)* a beneficiary of the intervention: this assumption is called the "overlap assumption". When these two assumptions are valid, the method consists in comparing the outcome for each beneficiary with the average of the outcomes for the non-beneficiaries who are "close" in terms of the observable characteristics (age, gender, level of education, etc.), and then averaging all these differences among the group of beneficiaries. Proximity to the beneficiary under consideration, i.e. the choice of his/her "closest neighbours", can be made using a distance (such as the Euclidean distance or the Mahalanobis distance), or even more simply using a propensity score, defined as the probability of being a beneficiary of the intervention given the observable variables characterising the individual; this probability can be estimated in a first step, using for example a logit or a probit model, independently of the value of the observed outcome variables.

Difference-in-Differences Methods

These methods are based on a simple assumption. Suppose that we observe the variations between two dates of an outcome variable such as the wage within two distinct groups. The first of these groups, called the "target group", "treated group" or "treatment group", benefits from a given intervention or an employment policy; the second, called the "control group",[2] does not. The employment policy is implemented between the two dates under consideration. The method relies on the following assumption: in the absence of this policy, the average wage change for individuals in the treated group would have been identical to that observed in the control group (the "parallel trends" assumption). The validity of this assumption, which cannot be verified, can be confirmed by the fact that, before the policy was implemented, wages evolved in the same way in both groups (that is the so-called "common pre-trends" assumption). Unlike the previous assumption, this second one can be tested on the basis of data observed prior to the implementation of the intervention, provided that repeated observations are available during this period. This method thus exploits the longitudinal (or pseudo-longitudinal[3]) dimension of the data.

The Regression Discontinuity Method

This method can be applied when the access to an intervention or a public policy is dependent on an exogenous threshold set by the authorities in charge of that policy. This threshold may be an age condition (for retirement, for example), an employment level threshold (for example, a tax reduction policy for firms with less than 20 employees), or a level of resources giving access to a scholarship or a tax credit. In its simplest form, regression discontinuity makes it possible to compare the average value of the outcome variable in the group of beneficiaries, for example those whose income or age is just below the eligibility threshold, with the average value of this variable in the comparable control group, composed of those whose income or age is just above that threshold. The underlying assumption is that, for people who otherwise have the same characteristics in terms of employment skills, level of education or gender, those just below and above the threshold are identical. Only sheer chance, for instance a date of birth, distinguishes them. Under these conditions, a simple difference between the means of the outcome variable (for example, the level of wage or education after the policy is implemented) makes it possible to estimate the causal effect of the intervention in question. However, this difference is only a local measure, close to the threshold, and its extrapolation to income levels or ages far from that threshold has no scientific validity. For this reason, it is said that regression discontinuity makes it possible to estimate a local average treatment effect (discussed in detail below).

Each type of method therefore corresponds to very specific assumptions. In practice, particularly when it is not possible to conduct a randomized experiment, it is important to recognise the information available to the analyst and to know which of these assumptions are most likely in order to choose the method which is best suited to the data available. Since the pioneering

2. These expressions are the same in each of the causal inference methods used.

3. The repeated observations may not be those concerning the same individuals but may be repetitions of random samples taken from the same population and form a "pseudo panel".

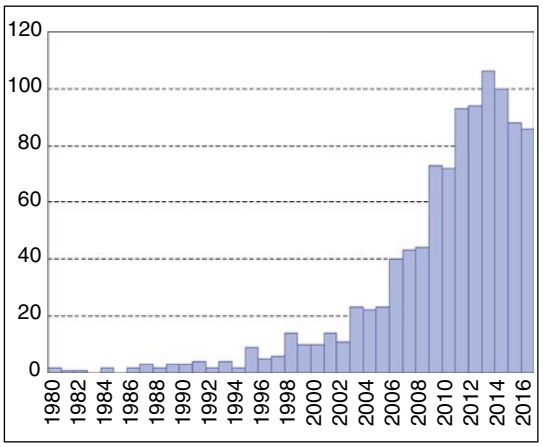
article published by LaLonde in 1986, several studies have been devoted to the comparison of evaluations carried out using experimental and quasi-experimental methods, and in particular to the estimation biases that may result from using quasi-experimental methods. Due to space constraints, it is not possible to summarize the results of those comparisons here. On this topic, the reader may consult, for example, papers written by Glazerman *et al*. (2003), Hill (2008), Chabé-Ferret (2015), Wong *et al.* (2017), and Chaplin *et al.* (2018).

A Flourishing International Scientific Literature

These methods have been applied in many research fields. For example, in the field of educational policy, the number of randomized controlled trials (RCTs) that have resulted in international publications has increased from just a few in 1980 to more than 80 per year since 2010 (Figure I). Quasi-experimental evaluations have followed a similar trend and nowadays, constitute together what some have called an "empirical revolution".[4] These studies and the quantitative assessments that they contain are resources of prime importance when it comes to choosing, designing and implementing public policies.

The recent publication of several reference articles and books also shows just how developed and diverse econometric evaluation methods have become. These include the books by Imbens & Rubin (2015), Lee (2016), and Frölich & Sperlich (2019), which follow on from the survey papers by Angrist & Krueger (1999), Heckman *et al.* (1999), Heckman & Vytlacil (2007a, 2007b), Abbring & Heckman (2007), and Imbens & Wooldrige (2009). The *Handbook of Field Experiments* published by Duflo & Banerjee in 2017 is the reference book on randomised field experiments. For laboratory experiments, Jacquemet & L'Haridon's book (2018) is the most recent reference. Finally, the list of papers on causal inference methods published in the best international economic or statistical journals over the past 30 years is too long to be included here. The interested reader will find it in the bibliographies of the above-mentioned works. Summaries in French (more or less formalised) are also available. These include papers by Brodaty *et al.* (2007), Givord (2014) and Chabé-Ferret *et al.* (2017).

Figure I
Number of randomised controlled trials conducted between 1980 and 2016 in the field of educational policy published in an international scientific journal, from Connolly *et al.* (2018)



Many Evaluations Studies Were Published in *Économie et Statistique*

The journal *Économie et Statistique* (not "/ *Economics and Statistics*" at the time) has accompanied this progress and these developments over the past twenty years, frequently publishing papers applying econometric evaluation methods to French data, mainly produced by public statistics departments and agencies. Some of these papers have found a real resonance in the public debate. It is admittedly risky to draw up an exhaustive list of them, since some of these publications may have escaped our attention. However, some of them may be cited by grouping them according to the methods used.

The instrumental variable technique was used by Crépon *et al.* (2004) to measure the effects of reduced working time on firms' productivity and employment. Leclair & Roux (2007) then used it to measure relative productivity and the use of short-term jobs in firms. Instrumental variables were also used by Beffy *et al.* (2009) to estimate the effects of students' paid work on their success in higher education, and by Fougère & Poulhès (2014) to study the influence of ownership on the household financial portfolio.

The reader will find applications of the difference-in-differences method in several papers published

4. *Angrist & Pischke (2010).*

in the journal. The first publications to use this method are the papers by Bénabou *et al.* (2004), devoted to the evaluation of priority education zones, and Behaghel *et al.* (2004), who sought to estimate the effects of the Delalande tax on employees' transitions between employment and unemployment. Fack & Landais (2009) used it to assess the effectiveness of tax incentives for donations. Carbonnier (2009) assessed the incentive-based and redistributive consequences of tax incentives for the employment of a home-based employee. The method made it possible for Bozio (2011) to measure the impact of the increase in insurance duration following the 1993 pension reform. Geniaux & Napoleone (2011) used a difference-in-differences method coupled with a matching method to assess the effects of environmental zoning on urban growth and agricultural activity. Again using the difference-in-differences method, Simonnet & Danzin (2014) assessed the effect of income support on the return to work of recipients, and Bérard & Trannoy (2018) measured the impact of the 2014 increase in real estate transfer taxes on the French housing market.

The papers that have applied matching methods include, in particular, those written by Crépon & Desplatz (2001) who used such a method to estimate the effects of payroll tax relief on low-wage workers' employment, by Even & Klein (2007) who estimated the medium-term effects of subsidized jobs on the employment of beneficiaries, by Rathelot & Sillard (2008) who assessed the effects of the urban tax-free zone policy on paid employment and the setting-up of new undertakings, and by Bunel *et al*. (2009) who focused their study on the effects of social security contribution reliefs on employment and wages.

The regression discontinuity method first appeared in *Économie et Statistique* by Lorenceau (2009), who estimates the effects of lower payroll charges granted in rural regeneration areas on the setting-up of new undertakings and employment level. It was also used by Baraton *et al.* (2011) to assess the effects of the 2003 reform on the retirement age of secondary-school teachers.

To our knowledge, *Economie et Statistique / Economics and Statistics* has, strictly speaking, not yet published any papers on randomized trials. This does not mean that French economists have not written high-quality research papers in this field. On the contrary, under the influence and sometimes with the collaboration of Esther Duflo, Professor of Economics at the MIT, French economists have published papers on randomized trials in the best international journals, particularly in the field of employment or education policies. The reader will find notable examples of such papers in the works of Crépon *et al.* (2013, 2015), Avvisati *et al.* (2014), Goux *et al.* (2017), or Barone *et al.* (2019). However, *Économie et Statistique* has published three papers on audit experiments, which, while being random experiments, cannot be considered as randomized field experiments. An audit study is a form of social experimentation in a real situation, mainly designed to detect a situation of discrimination. In the simplest case, the statistician compares the behaviour of a third party, usually an employer or a landlord, towards two people with exactly the same profile concerning all the relevant characteristics, except for the one suspected of giving rise to discrimination, for instance ethnic origin, disability, religion, age, gender, sexual orientation, etc. The paper by Petit *et al.* (2011) on the effects of an individual's place of residence on his/her access to employment, as well as those by Petit *et al.* (2013) and Edo & Jacquemet (2013) on the effects of gender and origin on discrimination in the workplace, are particularly representative of this type of approach, the limitations of which, both methodological and conceptual, were mentioned by Aeberhardt *et al.* (2011) in a comment published in the journal following the paper written by Petit *et al.* (2011).

The list of publications, particularly international publications, using statistical methods of causal inference is growing day by day. In addition to studies directly applying them with experimental or quasi-experimental data, much work has been devoted in the last ten years to refining these methods, or to coming up with solutions to overcome some of their limitations. The rest of this paper is devoted to presenting the developments that we believe are particularly promising in this area. Due to space constraints, we have not been able to address all the emerging themes here, including, in particular, social interactions and interference in randomised trials. This subject, which has unfortunately been relatively neglected to date, is addressed, for example, in the papers written by Hudgens & Halloran (2008), Aronow (2012), Manski (2013), Liu & Hudgens (2014), and Baird *et al.* (2018). An extensive review of recent developments and future research directions can be found in the papers written by Athey & Imbens (2017a, 2017b) and Abadie & Cattaneo (2018).

The Canonical Impact Evaluation Model

From its original formulation by Rubin (1974), the canonical impact evaluation model emphasises the heterogeneity of the response of economic agents following an intervention concerning them[5]. In this model, each observation unit is characterised by two "potential outcomes" specific thereto: y_{i0} is the outcome that would be observed for the unit i in the absence of the intervention, and y_{i1} is the outcome that would be observed as a result of the intervention. For each unit, only one of these two effects is observed. Rather than a "causal effect", the intervention is therefore associated with a distribution of situational changes $\Delta_i = y_{i1} - y_{i0}$, $i = 1,\ldots,N$, N here being the sample size. The evaluation process therefore requires choosing the parameter of this distribution that the analyst seeks to identify. Among the parameters summarising the distribution of the effect of the intervention (or treatment), the most common are the average treatment effect and the average treatment effect on the treated.

The average treatment effect (ATE) corresponds to the mathematical expectation of this distribution: it therefore measures the average change in outcome for an individual randomly selected from the population. The average treatment effect on the treated (ATT), for its part, is specific to the sub-population of individuals who actually benefit from the program (and formally corresponds to the conditional expectation to be actually treated). The two parameters are only equal under very restrictive assumptions. For example, they match each other trivially if the intervention concerns the whole population (for instance, an increase in the minimum age for leaving the school system, a measure that concerns all pupils), or if the treatment is supposed to act in the same way on all the individuals ($\Delta_i = \Delta,\ i = 1,\ldots,N$). In all other circumstances, these two parameters are distinct. They provide different information on the distribution of the causal effect: the average treatment effect on the treated measures the effectiveness of the program through the change in the beneficiaries' outcome, while the average treatment effect indicates how effective it would be if the program were to be applied to the entire population. The evaluation method chosen strongly influences the parameter that can be measured. Randomized experiments make it possible to estimate the ATE provided that the random assignment to experimental groups is made in the entire population and that all individuals selected to take part in the experiment actually do so. However, they can be used to estimate the ATT only when some of the selected individuals refuse to take part in the experiment or, more generally, when only a non-random sub-sample of the collected sample is observed (see Chabé-Ferret *et al.*, 2017, for an illustration). The difference-in-differences estimator or the matching estimators, for their part, measure the change in the situation specific to the beneficiaries, i.e. the ATT.

Beyond the importance of the choice of the parameter to be estimated (which must take precedence over the choice of the identification method), the heterogeneity of the treatment effect constitutes a significant limitation to the ability to generalise the estimated effects of an intervention in the context of a particular empirical study (see below).

The Local Average Treatment Effect (LATE)

Since the work of Imbens & Angrist (1994), who introduced the local average treatment effect (LATE) estimator, the interpretation of the instrumental variable estimator as the "average treatment effect on the treated" has been called into question. It is only valid if the effect of the program is the same for all individuals, regardless of their age, gender, experience, etc., which is obviously a very unrealistic assumption. Imbens & Angrist (1994), and many econometricians following them, show that if the effect of an intervention or public policy is likely to vary from one group of individuals to another, and more generally to be heterogeneous within a given population, only a local estimator can be produced for those individuals who decide to benefit from the program when it becomes available as a result of a variation of the instrument. Those individuals are called "compliers", i.e. people who comply or adhere to the programme when the value of the instrument changes. The group of compliers is probably best defined when confronted with people who systematically refuse the program ("never-takers") and those who are always willing to take participate in it ("always-takers"), regardless of the value of the instrument. The implementation

5. This model is different from the model introduced by Judea Pearl, which uses the formalism of directed acyclic graphs, which are often used in epidemiology or psychometry (see Peters et al., 2017, or Pearl & Mackenzie, 2018).

of the LATE estimator assumes that there are no individuals who would be willing to take part in the program when it is not offered, but who would refuse to do so once the program is rolled out. This group of people, who are called "defiers", is assumed not to exist: this assumption corresponds to what Imbens & Angrist (1994) call the "monotonicity assumption". The LATE estimator therefore measures the effect of the intervention only on the group of compliers, which unfortunately cannot always be identified. When it is, for instance when a lottery or a random procedure changes the assignment to the treatment (i.e., the proposed intervention or program), the LATE estimator can be obtained using the two-stage least squares procedure. Angrist & Imbens (1995) propose a more general method that takes into account the effect of other exogenous variables (such as age) in the implementation of the LATE. Angrist *et al.* (2000) apply this approach to the estimation of simultaneous equation models.

The External Validity of Impact Evaluation Methods

Several of the methods cited above are characterised by strong internal validity: they provide credible estimators of the average effects of interventions for the samples under consideration. However, the possibility of extrapolating their outcomes to a larger population, i.e., their external validity, is often called into question.

In the case of randomized trials, this criticism is based on the fact that the samples are generally quite small and concern particular groups, for example people living in some given environments or with specific characteristics; they are not representative of the population as a whole, or at the very least of all the potentially eligible people. The issue of external validity is fundamentally linked to the heterogeneity of the effects of interventions (see below). Suppose that a trial is conducted in a setting A, which may correspond to a given location, period, or sub-population of individuals. How do the estimates of the effects of this particular intervention conducted in this particular setting inform us of what the effects of the same intervention would be in another location, in a different period, for a different group of individuals, i.e., in a setting B that is different from setting A? The differences may result from observed and unobserved characteristics of those other locations, periods or individuals, and possibly from changes (no matter how slight they are) in the intervention procedures. To answer these questions, it is useful to have access to the results of multiple trials, carried out in different settings, and if possible, with fairly large samples representative of the eligible population (at least in terms of the main observable characteristics). Microfinance represents a particularly interesting example. For instance, Meager (2019) analyzed the results of seven trials conducted on this topic, and found that the estimated effects were remarkably consistent.

Another approach is to explicitly take account of the differences between the distributions of the characteristics specific to the groups or periods in question. Hotz *et al*. (2005) and Imbens (2010) propose a theoretical setting in which the differences in effects observed within a group of several locations stem from the fact that the units established in these locations have different characteristics. By means of an adjustment procedure that consists in reweighting individual units (persons, households, firms, etc.), they can compare the effects of the intervention in question in these different locations. This technique is close to the inverse probability weighting methods[6] recommended by Stuart and co-authors (Imai *et al.*, 2008; Stuart *et al.*, 2011; Stuart *et al.*, 2015).

It should be recalled that the instrumental variable estimator is often interpreted as a local estimator of the average treatment effect, i.e., as a LATE estimator that measures the average treatment effect for those members of the population (the compliers) whose assignment to the treatment is modified by a change in the value of the instrument. Under what conditions can this estimator be interpreted as the average treatment effect for the entire population? In other words, what are the conditions that ensure its external validity? Two groups are never affected by the instrumental variable: the always-takers who always receive the treatment, and the never-takers who never receive it. To answer the question, Angrist (2004) suggests testing whether the difference between the average outcomes of the always-takers and the never-takers is equal to the average treatment effect on the outcome of the compliers. Angrist & Fernandez-Val (2013) seek to exploit a conditional effect ignorability assumption stipulating that, conditional on certain exogenous variables, the average effect

6. Inverse probability weighting is a statistical technique for calculating standardized statistics for a pseudo-population that is different from the one from which the data were collected.

for compliers is identical to the average effect for always-takers and never-takers. Bertanha & Imbens (2019) suggest testing the combination of two equalities, namely the equality of the average outcomes of untreated compliers and never-takers, and the equality of the average outcomes of treated compliers and always-takers.

In the case of regression discontinuity, the lack of external validity is mainly due to the fact that this method produces local estimators, which are only valid around the considered eligibility threshold. If, for example, that threshold is an age condition, regression discontinuity does not make it possible to infer what the average effect of the intervention would be for people whose age differs significantly from the age defining the eligibility threshold. Under what conditions can the estimated effects obtained through regression discontinuity be generalized? Dong & Lewbel (2015) note that in many cases, the variable that defines the eligibility threshold (called the "forcing variable") is a continuous variable such as age or income level. These authors point out that in this case, beyond the extent of the discontinuity of the outcome variable in the vicinity of the threshold, it is also possible to estimate the variation of the first derivative of the regression function, and even of higher-order derivatives. This makes it possible to extrapolate the causal effects of the treatment to values of the forcing variable further away from the eligibility threshold. Angrist & Rokkanen (2015) propose to test whether, conditional on additional exogenous variables, the correlation between the forcing variable and the outcome variable disappears. Such a result would mean that the allocation to treatment could be considered independent of the potential outcomes (this is called the unconfoundedness property)[7] conditional on those additional exogenous variables, which would again allow the result to be extrapolated to values of the forcing variable further from the threshold. Bertanha & Imbens (2019) propose an approach based on the fuzzy regression discontinuity design.[8] They suggest testing the continuity of the conditional expectation of the outcome variable, for a given value of the treatment and of the forcing variable at the threshold level, adjusted by variations in exogenous characteristics.

Difference-In-Differences and Synthetic Control

As noted above, the implementation of the difference-in-differences method requires there to be a control group whose evolution over time reflects what the treatment group would have experienced in the absence of any intervention. This assumption cannot be tested over the period following the intervention, during which differences in outcome between groups also reflect the effect of the policy. A testable component of this assumption is that the past evolution of the outcome variable (before the policy being evaluated is implemented) is on average similar to that of the same variable in the treatment group. When it is rejected, it is possible to create an artificial control ("synthetic control") unit, based on the observations of the control group, using an appropriate weighting system. This synthetic control is constructed in such a way that the past evolution of the outcome variable within it is identical to that of this variable in the treatment group.

The method was introduced by Abadie & Gardeazabal (2003) in a study aimed at assessing the effect of ETA terrorist activity on the development of the Basque Country's GDP between 1975 and 2000, a period when the Basque separatist terrorist organisation was most active, frequently committing extreme acts of violence. The problem is that between 1960 and 1969, the decade preceding the beginning of the period of terrorist activity, the Basque Region's GDP evolved very differently from the average GDP of the other sixteen Spanish regions, leading to the assumption of a common pre-treatment trend being rejected. Abadie & Gardeazabal (2003) then proposed to construct a synthetic control region whose GDP evolution between 1960 and 1969 would be similar to that of the Basque Country's GDP. This can be achieved by minimizing the distance between the annual observations of the Basque Country's GDP between 1960 and 1969 and those of this synthetic region. More formally, the annual GDP values in the Basque Country between 1960 and 1969 are denoted $y_{1,t}$ (t = 1960,…,1969) and grouped together in a vector $\boldsymbol{Y}_{1,0} = [Y_{1,1960} \ldots Y_{1,1969}]$. Similarly, the annual observations concerning the GDP of each of the other sixteen Spanish regions are denoted $Y_{j,t}\left(j = 2,\ldots,17; t = 1960,\ldots,1969\right)$ and stored in a matrix denoted $\boldsymbol{Y}_{0,0}$ of dimension $\left(10 \times 16\right)$. The synthetic control region is constructed from a

7. "The unconfoundedness assumption states that assignment is free from dependence on the potential outcomes" (Imbens & Rubin, 2015, p. 257).
8. The sharp regression discontinuity design corresponds to the case where nobody can derogate from the constraint of the eligibility threshold. This case is opposite to that of the fuzzy regression discontinuity design, in which treated individuals, or untreated individuals, are observed on both sides of the threshold.

weighting vector $\boldsymbol{w} = [w_1, \ldots, w_{16}]'$ of dimension (16×1) which minimizes the following weighted Euclidean norm for a given matrix $\boldsymbol{V}$:

$$\left\| \boldsymbol{Y}_{1,0} - \boldsymbol{Y}_{0,0}\boldsymbol{w} \right\| = \sqrt{\left(\boldsymbol{Y}_{1,0} - \boldsymbol{Y}_{0,0}\boldsymbol{w}\right)' \boldsymbol{V} \left(\boldsymbol{Y}_{1,0} - \boldsymbol{Y}_{0,0}\boldsymbol{w}\right)}$$

In a first simple application, Abadie & Gardeazabal (2003) choose the identity matrix as the matrix $\boldsymbol{V}$. This allows them to easily find the weighting system $\boldsymbol{w}^*$ that minimizes this norm.[9] They verify that the ten annual GDPs of that synthetic region, which are calculated as $\boldsymbol{Y}^*_{0,0} = \boldsymbol{Y}_{0,0} \times \boldsymbol{w}^*$ during the 1960-1969 period, are similar to the yearly GDPs of the Basque region observed during the same period. This allows them to then calculate the counterfactual GDPs of the Basque region during the period of terrorist activity (1975-2000). These counterfactual GDPs are denoted $\boldsymbol{Y}^*_{0,1}$ and are calculated in the dimension vector (26×1) $\boldsymbol{Y}^*_{0,1} = \boldsymbol{Y}_{0,1} \times \boldsymbol{w}^*$, where $\boldsymbol{Y}_{0,1}$ is the dimension matrix (26×16) which groups together the observations concerning the 26 annual GDPs[10] of each of the sixteen Spanish regions other than the Basque Country. The causal effect of terrorism on the Basque GDP is then measured as $\boldsymbol{Y}_{1,1} - \boldsymbol{Y}^*_{0,1}$ where $\boldsymbol{Y}_{1,1}$ is the dimension matrix (26×1) which groups together the 26 annual observations of the Basque GDP from 1975 to 2000.

In general, $\boldsymbol{V}$ is a diagonal matrix with non-negative diagonal elements. In an extended version of this method, Abadie & Gardeazabal (2003) and Abadie *et al.* (2010, 2015) propose to choose matrices $\boldsymbol{V}$ whose elements are data driven. The number of units treated may be greater than one: in this case, a synthetic control must be calculated for each unit treated. However, when the number of units treated is very large, the synthetic control of a treated unit may not be unique. Abadie & L'Hour (2019) propose a variant that takes this difficulty into account. Their estimator is written:

$$\left\| \boldsymbol{Y}_{1,0} - \boldsymbol{Y}_{0,0}\boldsymbol{w} \right\|^2 + \lambda \sum_{j=2}^{J+1} w_j \left\| \boldsymbol{Y}_{j,0} - \boldsymbol{Y}_{1,0} \right\|^2, \text{ with } \lambda > 0$$

In this expression, $\boldsymbol{Y}_{j,0}$ is the vector whose elements are the observed values of the outcome variable for the control unit j $(j = 2, \ldots, J+1)$ during each of the periods preceding the implementation of the intervention. The estimator proposed by Abadie & L'Hour (2019) includes a penalty λ for differences between the values of the outcome variable of a treated unit and those of each control unit in the period before the intervention was implemented. Abadie & L'Hour (2019) show that, under these conditions, and except in a few specific cases, their estimator provides a single synthetic control.

Extended versions of the synthetic control estimator have also been proposed by Amjad *et al.* (2018) and Athey *et al.* (2018), who suggest the use of matrix completion techniques, but also by Hahn & Shi (2017), who base their approach on sampling-based inferential methods.

The Role and Choice of Explanatory Variables

Regardless of the type of intervention or evaluation method chosen by the researcher, the individuals, households, firms, etc. sampled, whether or not they are beneficiaries of the intervention, whether they are members of the target group (i.e. the treatment group) or the control group, may still differ in terms of some exogenous characteristics (such as age, gender, number of years of labour market experience, etc., for individuals, or number of employees, date of creation, short-term debt level, etc., for a firm). In the case of a non-stratified randomized controlled trial or a sharp regression discontinuity design, a simple regression of the observed outcome variable on a constant and a treatment group dummy variable is sufficient to obtain a convergent estimator of the average treatment effect in the sample. The addition of exogenous variables to this regression will mainly improve, in theory, the precision of the estimator of the average treatment effect.

However, in cases other than non-stratified randomization or sharp regression discontinuity design, it is necessary to add assumptions about the role of exogenous variables in order to obtain consistent estimators. The most commonly used assumption is that of conditional independence. This assumption states that the assignment to the treatment group, represented by a random variable T, and the potential outcomes of the intervention, denoted y_{1i} for a treated individual and y_{0i} for an untreated individual, are independent conditional on all relevant exogenous variables $\boldsymbol{x}$, i.e. all those affecting the probability of benefiting from the intervention. This assumption is crucial for implementing a technique such as matching. Once this hypothesis is accepted, if the sample is large enough

9. The only regions with weights well above zero are Madrid and Catalonia.
10. 2000 – 1974 = 26 years.

and/or the number of exogenous variables is not too high, it is possible to implement an exact matching method: this is based on comparing the outcome of each treated individual with that of an untreated individual having exactly the same observable characteristics. When this method cannot be implemented, particularly when the number of exogenous variables is too high, this exact matching is often replaced by a distance criterion making it possible to associate to each treated individual his/her "closest neighbour" in the sense of the chosen distance, or to implement the technique of the propensity score, as defined above: the outcome of each treated individual is compared with that of the untreated individual who has a propensity score whose value is very close to that of the treated individual's propensity score.[11] Exogenous variables that can be used to construct a valid propensity score should be conditionally independent of the assignment to the treatment group for a given value of this score.[12] The set of these exogenous variables is potentially extremely large. In addition to these variables, it is possible to include in this set some of their interactions, dichotomous indicators for those with multiple modalities (e.g. levels of education or socioprofessional categories), some transformations of these variables such as their powers or logarithms, etc.

Faced with the multiplicity of exogenous variables that can be mobilised, several recent studies have recommended the implementation of model and variable selection methods such as machine learning methods (McCaffrey *et al.*, 2004; Wyss *et al.*, 2014; Athey & Imbens, 2017a; Chernozhukov *et al.*, 2018), and LASSO[13] methods (Belloni *et al.*, 2014, 2017; Farrell, 2015). For example, McCaffrey *et al.* (2004), like Wyss *et al.* (2014), combine the method of random forests[14] with the LASSO technique in order to estimate the propensity score. It should be noted that these methods can be applied to evaluation methods other than matching. This is the case, in particular, of the method proposed by Belloni *et al.* (2017), which consists of a double variable selection procedure. The LASSO regression is used first to select the variables that are correlated with the outcome variable, and then again to select those that are correlated with the treatment dummy variable. After that, ordinary least squares can be applied by combining these two sets of variables, which improves the properties of the usual estimators of the average treatment effect, especially compared to simpler regularised regression techniques such as ridge regression.

The Heterogeneity of the Effects of an Intervention

Recent work has often focused on the heterogeneity of the effects of an intervention between groups of eligible individuals. Figure II illustrates this situation using a fictional example drawn from Leamer (1983). To make it easier to depict graphically, the heterogeneity of the treatment effect is assumed to be related to a variable x, the values of which differentiate individuals from each other. The left-hand side of Figure II describes the identification of the causal effect using a sample of individuals for whom the values of the exogenous variable, plotted on the x-axis, are dispersed only to a low extent. The variation in the outcome variable between individuals in the control group and those in the treatment group (i.e., the heterogeneity of the treatment effect) is measured by the slope of the regression line $\Delta(\mathbb{x})$, but it does not allow to disentangle between the many possible generalizations of the effect to other ranges of heterogeneity (of which two examples are drawn on Figure II). Looking also at the right-hand side of Figure II shows that having access to additional data, corresponding to greater heterogeneity among individuals ($x \in \mathbb{x} \cup \mathbb{x}'$), allows the analysis to be refined and pin down the distortion of the treatment effect in the population.

A wider range of observed situations therefore makes it possible to refine the estimation of the causal effect of the treatment, and to characterize its heterogeneity according to the observable characteristics of the individuals. As rich as the available data may be, however, the identification of the distribution of the treatment effect cannot be solved empirically. As an illustration, Figure III presents various measurements of the effect of a treatment, estimated for a wide range of values of the exogenous variable x. Nevertheless, these point values of the treatment effect are compatible with an infinite number of underlying distributions, of which Figure III presents three examples: $\Delta_a(x), \Delta_b(x)$, et $\Delta_c(x)$.

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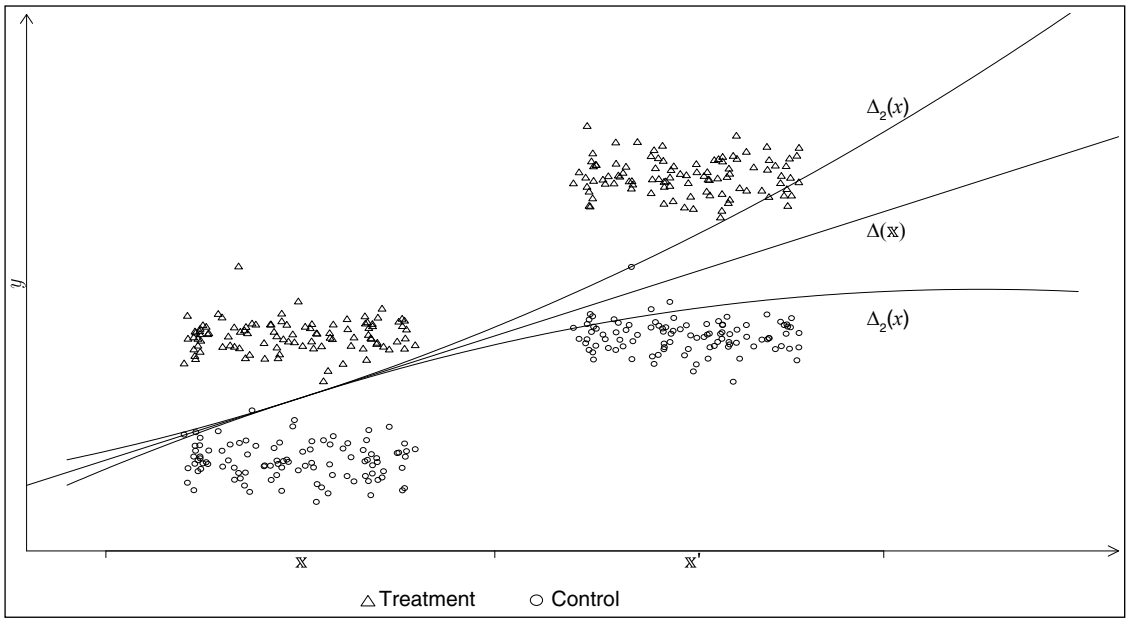
11. It is sometimes preferable to compare it with a weighted average of the outcomes of untreated individuals whose propensity scores have similar values. This is the principle that is implemented in the case of kernel matching.

12. This property is called the "balancing score property".

13. LASSO stands for Least Absolute Shrinkage and Selection Operator. This method, introduced by Tibshirani (1996), is a method for shrinking regression coefficients that essentially involves estimating the coefficient vector by minimizing the sum of the squared residuals under an additional regularisation constraint.

14. To implement this technique, the reader can in particular use the R package randomForest (https://cran.r-project.org/web/packages/randomForest/index.html).

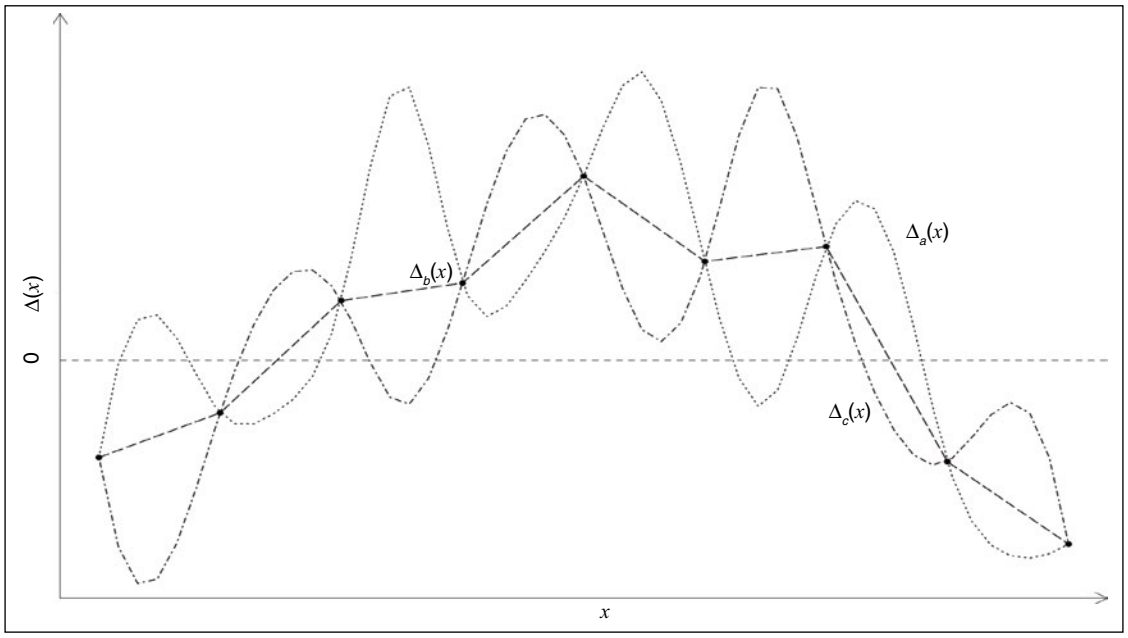
Figure II
Empirical identification of the effect of a treatment using an exogenous variable x with low ($x \in \mathbb{x}$) and high dispersion ($x \in \mathbb{x} \cup \mathbb{x}'$)



However fine the information provided by the data may be, and however heterogeneous the sample may be, the ability to describe the entire distribution of the treatment effect requires prior modelling to select the form of the relationship between the outcome variable and the treatment.

In the case where the sample is large and contains information on many variables, as it

Figure III
From the estimation to the identification of the distribution of the treatment effect



is the case with big data, it is possible to estimate heterogeneous treatment effects by combining quasi-experimental causal inference methods with LASSO methods and, more generally, with machine learning techniques (see, for example, Wager & Athey, 2018; Knaus *et al.*, 2017, 2018). This statistical approach can be generalised on a case-by-case basis with several treatments (Lechner, 2018).

Recent empirical work has focused on measuring the heterogeneity of effects, often in conjunction with the question of the external validity of the estimators used. Particularly compelling examples of this approach are given in the work of Dehejia *et al.* (2019) and Bisbee *et al.* (2017), who examine, using LATE-type estimators and data from more than a hundred international censuses, the causal link between fertility and female labour force participation. Their results are relatively convergent. Another example is provided by Allcott (2015), who assesses the variation in the effect of an energy reduction policy that has been gradually implemented at 111 sites in the United States: he finds that the effect of this policy has been stronger at the ten sites where the scheme was initially applied, suggesting that these first sites were selected because of their particular characteristics.

Precision of the Estimated Effects: The Quality of Identification beyond Unbiasedness

The attention paid to the estimation of causal effects in the policy evaluation literature has confined thoughts about identification to the unbiasedness of the estimated effects. In this context, the precision of the estimates is mainly addressed on the basis of the statistical significance of the estimated effects – an intervention being considered worthy of interest provided that its estimated effect is significantly different from 0.

A first limitation of statistical significance, which is well known but still largely overlooked in the empirical literature (see McCloskey & Ziliak, 1996; Ziliak & McCloskey, 2004), is that it does not make it possible to assess the quantitative importance of the measured effects. For each of these effects, statistical significance depends only on the precision of their estimation. A very small point estimate can thus be statistically very significant, while a very large effect can be insignificant due to its very low precision. In fact, hypothesis testing is nothing more than an alternative formulation of a confidence interval (provided the confidence level matches the level of the test). In this sense, statistical significance only provides information on whether the value zero belongs to the confidence interval built on the estimated parameter, i.e., to all the underlying effects compatible with the point estimate. Relying solely on statistical significance, whether to reject an intervention or to consider it beneficial, is tantamount to giving disproportionate weight to one of the many values within the confidence interval, many of which lead to a decision contrary to that indicated by statistical significance in the strict sense: in other words, a too wide confidence interval (i.e., a too imprecise estimation of an effect with a high point estimate) may lead to discard the intervention if this interval includes zero, or being considered beneficial if this interval, although gathering negligible values, is narrow enough to exclude zero (Amrhein *et al.*, 2019).

The attention paid to statistical precision must be just as close as the attention to the identification of causal effects. Improving precision requires in particular to minimize uncontrolled sources of variation. The control over the environment – i.e. blocking the sources of variation other than those of the variables of interest, such as the level of a "treatment" or the way it is administered – is an experimental approach that not only achieves identification but also increases the precision of the estimates (see the paper by Deaton & Cartwright, 2018, on this subject). Randomization, often presented in an excessive or even activist manner as the "golden rule" of policy evaluation, achieves identification of the causal effect based on the statistical similarity of the units belonging to the control and the treatment groups. It does not control, however, for all the unobserved factors that can add noise to the estimation.[15]

The importance given to the significance of the estimated effects may also lead to a certain number of deviations in the interpretation of the statistical tests. In particular, the limit value of the test statistic that leads to the rejection of the null hypothesis of no effect does not, in any way, measure the probability that the alternative hypothesis, stipulating the existence of an effect, is true. This probability is measured by the power of the test, the value of which is dependent on the distribution that

15. In a paper that is relatively critical of the mechanical applications of the randomized trial procedure, Deaton (2010) reviews the identification problems that remain despite random assignment to the treatment and control groups.

produces the test statistic when the alternative hypothesis is true, and therefore on the true (unknown) value from which the estimation results. An additional issue is that the *p*-value does not correspond either to the probability that the null hypothesis (i.e. the absence of effect) is true. This probability is indeed conditional on the null hypothesis: the distribution of the test statistic associated with the estimation is deduced from the value of the effect under the null hypothesis. If the calculated value of the test statistic is denoted $\hat{s}$ and the null hypothesis is denoted H_0, the *p*-value therefore formally measures the quantity $Pr(\hat{s} \mid H_0)$. The probability that the null hypothesis is true corresponds to the reverse conditioning, $Pr(H_0 \mid \hat{s})$. The confusion between these two probabilities can be illustrated by what the behavioural science literature calls the "prosecutor fallacy", introduced by Thompson & Schumann (1987): although, for example, the probability of winning at roulette without cheating is very low, it is obviously wrong to infer that a winner at roulette must be a cheater. Assessing the probability that the null hypothesis is true entails measuring the unconditional probability of this event, as illustrated in the next section.

The Increasing Risk of "False Positives" and the Need for Replication Work

Significance tests are subject to two types of risks of error: "false positives" are situations in which the estimation wrongly leads to thinking that a non-zero effect exists, and "false negatives" relate to the opposite situation, where the absence of an estimated relationship is only apparent. The respective probabilities of these cases correspond to the Type I error (also known as the "level" of the test), which is often denoted α and the most commonly chosen value of which is 5%, and the Type II error, β, which is the opposite of the power, $\mathcal{P} = 1 - \beta$. The power measures the probability of detecting the effect of the intervention and depends on the intensity of that effect: it does not correspond to a probability, but to a function that also depends crucially on the sample size.[16]

An estimated effect is "statistically significant at the 5% threshold" if the probability of getting this estimate while the effect is actually zero is less than 5%. This property implies a 5% probability of making a mistake when concluding that the estimated effect of an intervention is statistically significant. This probability is often interpreted as measuring the proportion of statistically significant results that are incorrect. This conclusion is only true in very specific circumstances, and the consequences of Type I errors on the credibility of empirical work are in fact often much more serious than its value suggests.

To illustrate this point, Wacholder *et al.* (2004) describe the components of the False-Positive Report Probability (hereinafter denoted "FPRP") as a function of the statistical properties of significance tests. The FPRP is the probability that the effect of an intervention is actually zero, even though the estimation produces a statistically significant effect. The calculation of this probability involves an unknown quantity (which is not usually discussed, even though it is fundamental) that corresponds to the proportion, denoted $\overline{y}$, of interventions that have a non-zero effect amongst all the interventions that are being evaluated. Table 1 describes the probability of occurrence of the four types of possible situations: the legitimate detection of an absence

16. *The benchmark power level in applied work is 80%, although Ioannidis* et al. *(2017) show that in more than half of applied economics work, the median power is 18% or even less.*

Table 1
Components of the probability of occurrence of a false positive

Veracity of the alternative hypothesis	Statistical significance test		Total
	Significant	Insignificant	
Non-zero effect of the intervention	$(1-\beta)\overline{y}$ [True positive]	$\beta\overline{y}$ [False negative]	$\overline{y}$
Zero effect of the intervention	$\alpha(1-\overline{y})$ [False positive]	$(1-\alpha)(1-\overline{y})$ [True negative]	$(1-\overline{y})$
Total	$(1-\beta)\overline{y} + \alpha(1-\overline{y})$	$\beta\overline{y} + (1-\alpha)(1-\overline{y})$	1

Notes: Subject to the existence or absence of an intervention effect, each of the cells describes the probability that the estimated effect is statistically significant (first column) or statistically insignificant (second column), taking account of the level α of the test, its power β, and the proportion $\overline{y}$ of interventions that have a non-zero effect amongst all those evaluated.
Sources: Wacholder *et al.* (2004, p. 440).

(true negative) or presence (true positive) of an intervention effect, as well as the occurrence of false positives, or false negatives.

Given the probabilities of Type I and Type II errors, the probability of a false positive occurring (the proportion of effects that are only apparent amongst all the interventions having a significant effect) is measured by:

$$FPRP = \frac{\alpha(1-\bar{y})}{\alpha(1-\bar{y})+(1-\beta)\bar{y}}$$

Most of the commonly used statistical tests are consistent, i.e. their power tends towards one as the sample size increases. In this very favourable situation (where $\beta = 0$), this probability is less than the level α of the test only if at least half of all the interventions that are evaluated have a non-zero effect. If this frequency is higher, the probability of occurrence of false positives is lower than the level of the test. It is higher than this level under the opposite (and certainly more credible) hypothesis that, of all the interventions evaluated, less than one in two has a non-zero effect, a situation that is all the more likely to occur as more evaluations are undertaken. It is of course impossible to quantify $\bar{y}$, and very difficult to collect objective information on this proportion. Still, the consequences of the variations of $\bar{y}$ on the credibility attributed to the results of evaluations are not without importance: under the extreme hypothesis that one intervention out of 1,000 has a non-zero effect ($\bar{y} = 0{,}001$), the probability of reporting false positives is greater than 98%.

This situation may be further aggravated by the conditions under which the results of the evaluation are made public.[17] Ioannidis (2005) focuses in particular on two types of bias that increase the probability of reporting false positives: publication bias and communication bias. Publication bias refers to the particular appeal of works highlighting a non-zero effect at all stages of the process – from project-funding decisions, to the results being communicated to the general public, after having been validated academically by being published in prestigious scientific journals. These publication biases lead to a distorted proportion of positive results. They are reinforced through communication biases, which consist in reporting on an evaluation only if it leads to significant effects, while at the same time not reporting evaluation results that conclude to no effect of other kinds of interventions. As stressed by Roth (1994), this risk is particularly high when an intervention is developed following a trial and error process, which leads to changes in the terms and conditions of a "pilot" intervention after it has been found to have no effect, until a final proposal is developed that gives rise to the expected significant effect on the outcome. This process is legitimate because it allows to design effective public policies; it does not affect the probability of reporting false positives if all trials are made public at the same time as the final evaluation. Conversely, this process leads to a communication bias as soon as only significant effects are made public, while previous unsuccessful attempts are ignored.

Publication biases, like communication biases, lead to an increase in the proportion of false positives. To illustrate this point, the proportion of positive results caused by one of these two types of bias is denoted B. Amongst the $\bar{y}$ interventions that actually have an effect, the analysis will make it possible to accurately conclude that there is a non-zero effect for a proportion $(1-\beta)$ of cases, while a certain number $(B \times \beta)$ will appear to have an effect due to one of the types of biases. Similarly, a proportion α of interventions amongst the $(1-\bar{y})$ actually having zero effect will appear as having no effect, while a certain number $B \times (1-\alpha)$ will appear as having a non-zero effect due to bias. In total, the FPRP becomes:

$$FPRP = \frac{(1-\bar{y})\left[\alpha + B(1-\alpha)\right]}{(1-\bar{y})\left[\alpha + B(1-\alpha)\right] + (1-\beta)\bar{y} + B\beta\bar{y}}$$

* *
*

For the "credibility revolution" announced by some authors (Angrist & Pischke, 2010) to be fully successful, public policy evaluation cannot be based solely on convincing identification strategies. The replication of policy evaluation results, making it possible to distinguish false positives from the proven effects of an intervention (Clemens, 2017), remains essential, as is the need to ensure the precision of the estimated effects. □

17. We have deliberately left out the issue of questionable practices that deliberately force the significance of results, for example by deliberately choosing the outcome variable from among all the variables on which the intervention may act, a practice that artificially increases the proportion of false positives (see, for example, List et al., *2001). Christensen & Miguel (2018) present an overview of practices that cause the credibility of empirical results in economics to be weakened, and list a certain number of possible solutions.*

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The Emergence and Consolidation of Microsimulation Methods in France

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Abstract – The purpose of this paper is to trace the gradual emergence of microsimulation models dedicated to the analysis of tax and social security policies in France since the mid-1960s, as well as their subsequent consolidation since the mid-2000s. A brief outline of these models is given using the static/dynamic distinction. A connection is made between the construction of the Mir model (standing for *Modèle de l'impôt sur le revenu*, an income tax model) and the development of the Household income survey *Revenus fiscaux*. Then we distinguish two periods: An initial period that saw a proliferation of such models and a second period, of standardisation, during which the Ines model has acquired a central position. Besides ongoing evaluations (of minimum income and pension schemes, insurance for long-term care), the most recent expectations in this area relate to the *ex ante* evaluation of measures designed to accelerate the ecological transition and of universal income-type schemes. Finally, we underline that the recent replacement of all the periodic declarations made by employers to various administrations by a unique declaration (the *Déclaration sociale nominative*, or DSN) significantly renews the range of administrative sources capable of feeding into these models.

JEL Classification: C53, D04, D1, D31, H2, H3, H55, J26
Keywords: microsimulation, public policy evaluation, economic analysis of social policies, social minima, family policies, pensions, ageing, long-term care

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The purpose of this paper is to trace how microsimulation models have been developed in France over the past fifty years and how they have come to play an important but overlooked role in tax and social policy analysis. On the one hand, microsimulation methods fulfil a strong demand for the effects of tax and social policies to be evaluated, including, in particular, reforms in the financing of social security, changes in family policies and the future of pensions. On the other hand, barriers to the implementation of these methods have now been completely removed since, on the one hand, individual data are available and, on the other hand, computers are powerful enough to simulate economic and social situations at the individual level.

The article starts with a brief introduction to microsimulation methods in order to provide the reader with a better understanding of the matter at hand. Then a first section, examines the phase of the development of microsimulation models, which resulted in them becoming a fixture in the landscape of social policy analysis. The second section provides a roadmap for microsimulation models to ensure these meet current demands in the *ex ante* assessment of public policies.

Microsimulation methods seek, as part of a bottom-up approach, to trace the behaviours of individual units (individuals, households, companies) at the most disaggregated level possible. The implementation of these methods requires the availability of individual data – that will constitute the starting point of the microsimulation – and computing capacities.

Static Models

The simplest microsimulation models are "accounting" models. Take the case of income tax, where the individual unit is the tax household. Based on a representative sample of tax returns, the amount of tax is calculated using the current schedule: all the factors that determine the amount of tax are included in the tax return and the tax schedule is coded in a computational program. A tax reform can thus be evaluated by calculating the tax using a new schedule and comparing, for each taxpayer, the old tax amount and the new tax amount. It is therefore possible to quantify the aggregate cost (or return) of the reform, but also to identify the winners and losers of the reform, i.e. their number, the distribution of gains and losses, etc. It is also possible to assess the redistributive effects of the reform: on the one hand, taxpayers can be broken down according to their standard of living and, on the other hand, the distribution of the average amounts of gains and losses by standard of living can be estimated. For example, we might say that "the last decile of living standards is the decile that stands to lose the most from the reform" and therefore assess the consequences of the reform in terms of reducing or increasing inequalities in living standards.

Microsimulation methods only began to emerge in the 1960s since they require a large amount of individual data (and therefore an information system capable of recording and accessing large volumes of data) and sufficiently powerful computing capabilities. In the case of income tax, it may be tempting to draw on all tax returns and to perform calculations for the 38 million returns currently available to France's revenue authority. Of course, a sample drawn with a good sampling design is sufficient, but we know that advances in computer science open up the possibility of developing a microsimulation model on a one-to-one scale.

"Accounting" models are also known as "static" models since, in these models, individuals do not respond to the new environment resulting from the reform being evaluated. Some reforms only have a financial goal, such as reducing the public or social security deficit, while others seek to limit inequalities or are implemented with the explicit aim of changing behaviours. In all cases, the responses of individuals should be taken into account since otherwise the assessment of the measure would be incomplete. Let us return to the case of income tax and assume, for example, that the ceiling on the tax discount for the employment of a home-based employee is raised. The primary purpose of the reform is not to "make a gift" to individual employers; rather, its objective is to promote employment in the personal services sector. It would therefore be absurd to quantify the cost of the measure as if it did not lead individuals to employ more home-based workers: in other words, the microsimulation model must incorporate behavioural responses. In this example, assumptions must be made about the "intensive margin" (the proportion in which an increase in the ceiling leads private individuals to employ an employee at home for a longer period of time) and the "extensive margin" (the proportion in which individuals will be able to employ an employee when they did not previously). However, to be

complete, it is also necessary to model the situation of employees by once again distinguishing between the intensive margin (i.e. the number of employees employed part-time who increase their working time) and the extensive margin (the number of unemployed or inactive people who will be able to find a salaried position as a home worker).

Dynamic Models

Models that incorporate behavioural responses in this way are referred to as "dynamic" models since, in many cases, they are built to make (more or less) long-term forecasts: the method thus seeks to reproduce dynamic sequences by generating the trajectories of all individuals in the sample over the entire period considered.

Perhaps the most suggestive way to understand dynamic microsimulation is to consider the situation of a pension fund seeking, on the one hand, to predict its situation in 20 years' time and, on the other, to assess the consequences, over the same time horizon, of a change in the rules for calculating pension entitlements. The fund can implement an aggregated method by estimating what could be, on the one hand, the growth rate of the mass of contributions available to it for the next 20 years and, on the other, the growth rate of the mass of pensions that it will have to pay over the same period. There are several possible scenarios, depending on macroeconomic assumptions relating to growth, unemployment, inflation, etc.

A distinction can be drawn between this aggregate projection method and a microsimulation method based, in this instance, on the following six steps:

1. Calculate the number of incomers, i.e. the number of (a) new contributors: individuals moving into work or out of unemployment; (b) new pensioners: individuals drawing their pension;

2. Within the data, identify the incomers;

3. For each incomer, estimate the amount: (a) In the case of a new contributor, of his or her contributions based on his or her starting salary using an econometric estimation; (b) In the case of a new pensioner, his or her pension based on the applicable regulations but also his or her employment history;

4. Calculate the number of leavers, i.e. the number of (a) outgoing contributors: individuals who change pension funds, become unemployed or even die; (b) retirees who disappear;

5. Within the data, identify the leavers;

6. Estimate changes for current contributors, i.e. (a) the variation of each contributor's salary, again based on a model; (b) the increase in the pension of each retiree, in accordance with the applicable regulations.

Thus, the aim is to project the information system of the pension fund – in other words, to ensure that in twenty years' time it has the same individual data that it currently has. In 20 years' time, it will therefore be possible to calculate the mass of contributions and the mass of pensions for the reference situation but also for the new rules for calculating entitlements.

In dynamic microsimulation, the calculations follow one another. Let us suppose that the time scale of the model is monthly, meaning that, for each individual, the calculations are made month by month. For example, the salary is updated each month based on the individual's characteristics but also based on his or her previous wages. The computer is thus tasked with manufacturing individual trajectories, fictitiously but realistically, for the entire period studied. It is possible to artificially generate trajectories that differ from one individual to another but which, on average, are aligned with macroeconomic developments: we thus arrive at a picture that shows both the diversity of individual situations and the (relative) regularity of aggregate dynamics. This is done using a pseudo-random number generator: the computer provides a sequence of numbers, each of which represents a realisation of the uniform distribution between 0 and 1. These pseudo-random numbers are used to simulate events. Let us suppose that, for a given category of employees, the probability of them losing their job from one month to the next is 1.5%. Let us also suppose that, in the model, the category includes 200 employees: it follows that the event must be simulated for 3 employees on average. Those employees for whom the pseudo-random number is less than 1.5%, i.e. 0.015, will be retained.

Pseudo-random number generators provide a means of generating individual trajectories that artificially reproduce the range of situations of the individual units. The artificial changes are also reproducible since the computer is able to replicate exactly the same sequence of numbers. This is one of the key attractions of the

method: two simulations conducted, for example, one week apart will yield exactly the same results while generating non-trivial individual changes.

The opposition between "static" and "dynamic" models also stems from the two different origins of microsimulation methods. The origins of the "dynamic" method can be traced back to Orcutt (1957). For each unit, Orcutt distinguishes between inputs (all the factors that determine the unit's decisions) and outputs, i.e. strictly economic outputs, but also events of "all kinds" – meaning demographic events such as the birth of a child, marriage, divorce, relocation, death, etc. The term "behaviour" is thus used in a very broad sense since it may refer either to a change of state triggered by comparing a pseudo-random draw with an exogenous probability or to a behavioural response within the meaning of standard economic theory, i.e. a decision resulting from the maximisation of a utility function under a set of constraints. Dynamic microsimulation models were thus developed as an alternative to aggregate population projection methods. As we have seen, static models are less ambitious, seeking simply to trace the regulation of compulsory taxes and social transfers by applying it to individual units.

Microsimulation methods will not be discussed further. Interested readers are referred, for example, to Chambaz & Le Minez (2003) and Legendre (2004) for an examination of what these methods can bring to the evaluation of a new measure in terms of estimating its budgetary cost, evaluating its redistributive consequences and estimating its incentive effects (among other things). The reader may also consult the following articles: Blanchet (1998), Legendre *et al*. (2003), Blanchet *et al.* (2015) and Blanchet *et al.* (2016). Another perspective can be found in Bessis (2019), who looks at the history of microsimulation models with an interpretation in terms of the construction of economic knowledge. Here, the aim is to trace how microsimulation models have become irreplaceable tools for *ex ante* evaluations of tax and social policies.

The Emergence and Establishment of Microsimulation Models

To the best of my knowledge, the first static microsimulation model in France, known as Mir (standing for *Modèle de l'impôt sur le revenu*, an income tax model), was developed at the Forecasting department of the Ministry for the Economy and Finance, with the aim of better understanding the redistributive effects of income tax. Three publications have traced the development of this model: Bégin *et al.* (1971), Bonacossa *et al.* (1975) and Coutière *et al.* (1981).

The Strong Link between Microsimulation and Data

One interest of this set of publications is to implicitly trace the history of the Household tax income survey (*enquête Revenus fiscaux*) the assumption being: no microsimulation model without a sufficiently reliable representative sample. The first surveys were conducted on the basis of the population census, based on a sample of dwellings: local tax centres were tasked with collecting the corresponding tax returns and transmitting them, while taking care to exclude personal information, to the National Institute of Statistics and Economic Studies (Insee) in order to ensure statistical and tax secrets remained separate. Because of the cost of collection, surveys were conducted on average every five years. It was only from 1996 onwards that the *Revenus fiscaux* surveys began to draw on the Labour Force surveys and became an annual occurrence: the focus now was on matching tax data, for each individual in the Labour Force surveys, to the data provided by the latter. Collection became automated and tax centres were no longer responsible for collecting the data.

However, the main purpose of these surveys is not to feed into microsimulation models dedicated to social policy analysis. Rather, they are designed to better understand household living standards and, in particular, to produce poverty statistics. The *Revenus fiscaux* survey thus became the *Revenus fiscaux et sociaux* (RFS) survey from 2005 onwards by incorporating, among other data, the social security benefits actually received by households, previously imputed.[1]

This shows that microsimulation methods are demanding in terms of the volume and quality of data they use as inputs and that data are obtained at a considerable cost.

1. This improvement had been recommended by the National Council for Statistical Information, which had noted that knowledge of social benefits was poor since they were often non-taxable, did not always appear in tax returns and were imputed in the survey.

The articles mentioned above also provide a basis for measuring the significant progress made in information processing over the past fifty years. In the 1960s, the data were recorded on punched cards and were therefore difficult to process. Bégin *et al*. (1971) explained that the data were initially transferred to a magnetic tape "in such a way as to render the whole thing more manageable". It should be noted that in terms of its design, microsimulation operates as a recursive system: the period is short enough that the decisions of one unit cannot be considered to influence immediately the decision-making of the other units. For example, Orcutt (1957) refers to periods of one week or one month to justify such a hypothesis. As a result, the microsimulation can be programmed by requiring only sequential access to the data of each unit. Two magnetic tape drives were enough for a dynamic microsimulation. One of the two drives was used to read the data in sequence while the other drive was used to write the data unit by unit; the drives were then made to swap roles and the output data from the previous period became the input data of the new period. Nowadays, magnetic tapes are no longer used, but the idea persists that even in order to describe interactions between units, a system of simultaneous equations is not necessary.

The Development of Static Models

These first static models provide a good illustration of the information that can be obtained with these tools. In the case of income tax, they provide a means of better characterising the tax, but also its properties, including, in particular, its progressiveness. For example, macroeconomic analysis indicates that the share of income tax in total compulsory taxation remains relatively low in France. For its part, microsimulation provides a basis for establishing the distribution of the tax based on a wide range of criteria (size of the tax household, nature of the main income, etc.), but also for showing that income tax is relatively concentrated and that its progressivity is irregular.

From the Tax System...

The Mir model was used to evaluate the effects of changes in tax law, whether *ex post*, for a measure adopted by the Finance Act; or *ex ante*, for a hypothetical measure whose cost (or return) and redistributive consequences are to be calculated. In Bégin *et al*. (1971), the family quotient system was the subject of an initial evaluation at the time, the benefit provided by the scheme was estimated on average at 20% of total tax revenue. In Coutière *et al*. (1981), the focus was on "the separate taxation of married women" (i.e. tax individualisation). We thus see how microsimulation is capable of contributing to the public debate on controversial aspects of the tax system.

The analysis of redistribution had yet to reach stable ground. The breakdowns presented relate to socio-professional categories, the household's income brackets, the household's tax brackets, and even the household's net income deciles. Socio-professional categories was the preferred option in representing social stratification. Presentation in terms of deciles of living standards in total population was not used. It was only later that it would gain currency, providing a better representation of individuals in the standard of living distribution.

Coutière (1983) provides an exemplary illustration of the use of the Mir 4 model, the version of the model based on the 1975 *Revenus fiscaux* survey, by considering different scenarios for increasing income tax so that the structure of the overall tax burden in France appears similar to that observed in comparable Western countries. The author made it clear that the point is not to assess the impact of taxation: "*The problem of tax incidence is, as economists have long known, one of the most formidable problems in economic theory*". The scenario that attracts the most attention is the one where employee social security contributions are reduced by 10 percentage points and income tax revenue is doubled both by removing a number of provisions specific to the French system and by taxing the income supplement following the reduction in contributions. While the total amount levied remains unchanged, taxation is more progressive and less concentrated and the new system is more redistributive. This scenario, which involves broadening income tax, would have provided an alternative to the developments seen at the time, which took the form of the creation of the General Social Contribution (CSG) in 1990.

... to the Tax-Benefit System

In the 1980s, the economic authorities thus had significant expertise in the field of static microsimulation. However, such expertise remained limited to compulsory levies and therefore did not allow for an analysis of the

tax and social security system as a whole; however, we know that the reduction of inequalities is achieved, for the most disadvantaged individuals, by means-tested social benefits and, for the most well-off individuals, by progressive contributions. An important impetus for the development of global microsimulation models (known as Tax Benefit Models) was provided in the late 1980s by a team led by François Bourguignon, at the *École des Hautes Études en Sciences Sociales*, in the form of a simple but pioneering and relatively complete model called Sysiff. This period also saw the spread of microcomputers: the rise of microsimulation models was no longer limited by the processing capacity of computers and it became easier for researchers to invest in these methods.

There have been several versions of the Sysiff model. The first, based on the 1975 *Revenus fiscaux* survey, provided a means of comparing the architecture of compulsory taxes in France and Britain (see Atkinson *et al*., 1988). The second version, based on a sample from the Household income and expenditure survey, represented the French part of the Euromod project (Bourguignon *et al*., 1988, and Sutherland, 1997). In other words, these initial studies form part of an international, and specifically European, comparative perspective aimed, on the one hand, at clarifying the link between the structure of compulsory taxes and the social security system, particularly the Bismarckian and Beveridgean systems, and, on the other hand, at better assessing the options for changing the way social security is financed in France.

The analysis of family policies is another area where there is a great demand for expertise. On behalf of the French Tax Board, a study on the family quotient of income tax developed simulations presenting different variants such as, for example, capping the benefit provided by the marital quotient (Glaude, 1991). The author then set about promoting the development of a microsimulation model at Insee, with a view, in particular, to obtaining a general overview of family policy.

The Rise of Questions on Social Protection and Employment

Finally, the *Revenu minimum d'insertion*, or RMI (a minimum income scheme) was introduced in late 1988; five years later, a first scheme to reduce employers' social security contributions on low wages was introduced. At the time, employment policies were characterised by both general and targeted measures, as noted by L'Horty (2006). The measures were general insofar as they were not aimed at a particular category of workers or businesses. However, they were also targeted since they depended either on the family configuration and the level of earned income for minimum benefit schemes or on the hourly wage rate for schemes involving reduced contributions. It is thus clear why the economic and social authorities might have been keen to equip themselves with microsimulation models as quickly as possible, thereby reviving the pioneering approach of the Mir model. In short, it had become apparent that such models were necessary for costing and evaluating this type of scheme. In particular, if unemployment results, in part, from labour market failures, is it because of insufficient demand due to excessively high labour costs relative to labour productivity or rather because of a shortage of supply resulting from an excessively low net wage relative to the minimum social benefits? Should companies be given financial incentives to hire low-skilled workers or should workers be encouraged to return to work?

The standard economic analysis posits that a differential mechanism such as the RMI (where one euro more earned at work translates into one euro less of benefits and, therefore, the same disposable income) leads to an "inactivity trap": in other words, this scheme generates marginal tax rates equal to 100%, operating as a disincentive to return to work. It thus became apparent that the advantage of microsimulation models in France was that they provided a basis for estimating distributions of financial work incentives.

A New Generation of Static Models

In addition, the new annual *enquête Revenus fiscaux* (from 1996 onwards) proved essential in providing an informational basis for microsimulation models dedicated to social policy analysis. In other words, the time was ripe for the emergence of a new generation of static models: data and at least three areas of interest – the financing of social security, the analysis of family policies and the evaluation of minimum benefit schemes.

At Insee, the INES model (standing initially for *Insee Études Sociales*) was developed from the mid-90s onwards (David *et al.*, 1999). The model was soon used as part of the report from Claude Thélot and Michel Villac, commissioned by the then Prime Minister, Lionel Jospin, to respond to the contestation caused by the means testing of family allowances. These then become universal once again in return for a new cap on the benefit provided by the family quotient: here the key role of microsimulation in public decision-making is clear to see.

At the *Caisse nationale des Allocations familiales* (CNAF, the French national family allowance fund), the MYRIADE model was developed in the early 2000s (Legendre *et al.*, 2001). This model is specifically dedicated to the analysis of family policies. It was used as part of the reform of childcare subsidies, which led to the introduction in 2004 of a childcare benefit designed specifically for infants (the *Prestation d'accueil du jeune enfant*, or PAJE). The model has also been used, together with INES, to assess *ex ante* different scenarios for the provision of support to young adults on behalf of the *Commission nationale pour l'autonomie des jeunes* (a dedicated Commission of experts – see Foucauld & Roth, 2002). It is particularly difficult to assess the standard of living of young people, especially students (not least because of their increasing numbers following the second "massification" of higher education). Insee's poverty statistics do not take households whose reference person is a student into account. By using the information on family relationships, microsimulation models provide a basis for going further and for assessing students' standard of living based on assumptions about the pooling of resources within an extended notion of family that reintegrates young adults who no longer share the parent's house.

In the mid-2000s, the *Observatoire français des conjonctures économiques* (OFCE), in collaboration with THEMA, a joint research unit that had acquired a degree of expertise in regulation based on standard cases (Hagneré & Trannoy, 2001), began work on the MISME microsimulation model in the mid-2000s. The book by Landais *et al* (2011b) helped to bring microsimulation methods to a wider audience. The model developed by the authors, as an extension of the SYSIFF model, was adopted by the Institute for Public Policy (*Institut des politiques publiques*, or IPP) when it was first introduced in 2011; (Landais *et al.*, 2011a; Bozio *et al.*, 2012). The IPP publishes the statutory schedules on its website; these are consistently classified and regularly updated – a considerable task. The tax income schedule has been made available since it was first introduced in 1914. In addition, the Treasury Directorate-General was keen to develop its own expertise, a move that resulted in the development of the SAPHIR model presented in Amoureux *et al.* (2018). This model is used in preparing the Finance Act and the Social Security Financing Act, which is its main originality.

The potential contributions of microsimulation models to public policy development are well illustrated by the reform of the RMI (the minimum income scheme introduced in the late 1980s), which led to the *Revenu de solidarité active* (RSA). A relatively strong aversion to inequalities, which can be justified, for example, by the difference principle put forward by John Rawls, argues for the introduction of high minimum social benefits to provide the most vulnerable in society with an adequate standard of living. Differential social benefits create a strong disincentive to work. The theory of optimal taxation, developed in the 1970s by Mirrlees (1971), explains the terms of the trade-off between social equity and economic efficiency.

In France, Piketty (1997) argued, based on a very sketchy evaluation conducted by assuming that each decile of the wage distribution constitutes a representative employee, that marginal rates, according to the standard of living, are U-shaped, meaning that they tend to be very high at both ends of the distribution of earned income because of the RMI and housing allowances for the bottom of the distribution and income tax for the top of the distribution. Is this U-shaped profile optimal? It is certainly easy to lend it theoretical substance. To reduce inequalities, average rates must increase with income. A high marginal rate provides a means of increasing the average rate and thus ensuring redistribution; on the other hand, it creates strong disincentives to work. It is therefore preferable to have high marginal rates at the bottom of the distribution since, on the one hand, the number of individuals who are disinclined to work is low and, on the other hand, the number of individuals bearing a higher tax burden is high. Somewhat surprisingly, it is less easy to justify high marginal rates at the top of the distribution: for example, this requires retaining a particular distribution tail for high incomes.

Therefore, can a system that organizes, in a way, the exclusion of low-skilled individuals by pitting them against dissuasive marginal rates of return to work be described as "optimal"? The optimality of the system can be challenged in two very different ways: first, by arguing that the financial benefits of returning to work are probably not the main argument in participation decisions, particularly in a context of job shortages; second, by explaining that the losses for society resulting from the exclusion of the least employable individuals are probably underestimated. The idea that returning to work "doesn't pay enough" gained ground in the 2000s, as shown, for example, by Bourguignon (2001). Moreover, a clearer distinction is made between an intensive margin (marginal effective tax rates) and an extensive margin (effective tax rates on return to work), as argued, in particular, by Saez (2002). Microsimulation models document this question by estimating the profile of marginal tax rates as a function of earned income; see Albouy *et al*. (2002) and Legendre *et al.* (2004).

The implementation of the RSA was largely driven by this vision, putting microsimulation models to use in a different way, this time to quantify *ex ante* the cost of the reform by examining several scenarios on the "slope" of the scheme. The RSA initially provided for a basic minimum income support (RSA-*socle*) and a permanent work incentive scheme, called RSA-*activité*, which allowed beneficiaries to retain 62% of their earned income: the "slope" of the scheme was therefore equal to 0.62. The marginal taxation rates were thus limited to 38% at the bottom of the income distribution. However, the effective marginal tax rates generally remain higher, notably because of housing benefits. The *Prime d'activité* (an in-work tax credit scheme) replaced the RSA-*activité* and the *Prime pour l'emploi* (or PPE, an employment premium) on 1st January 2016 by merging them, allowing beneficiaries to retain 61% of their earned income. The budgetary cost of the RSA-*activité* has been difficult to estimate: the (decreasing) amount is relatively sensitive to its determinants, the basis used to calculate the benefit, which is quarterly, does not appear in the survey on tax and social income (*enquête Revenus fiscaux et sociaux*, ERFS), family configurations are an important factor, etc. Its determination was the subject of a report based on the work carried out with the Ines, Myriade and Saphir models, the subject being all the more burning since a specific tax on financial income had been introduced to finance the replacement of the RMI by the RSA. It then became apparent that the cost had been overestimated, in particular because of a high rate of non take-up. The profile of marginal rates is no longer U-shaped but tilde-shaped, as established, for example, by Sicsic (2018) with the Ines model.

The recent history of low-income support policies is probably better known: the in-work (or "activity") bonus was increased in 2019 following the "yellow vests" (or *gilets jaunes*) movement and the *Revenu universel d'activité* (or RUA, a new scheme of income support) project. Over the last thirty years, static microsimulation models have become indispensable tools for public decision-making. At the same time, dynamic models have enjoyed a similar rise in use.

The Development of Dynamic Models

The distinction between static and dynamic models is not simply a matter of presentational convenience. In fact, the two categories of models focus on relatively different areas, with dynamic models concentrating for the most part on assessing the future of pension systems. In dynamic models, individuals grow older and generational renewal is explicitly addressed. In France, the earliest models were developed at the periphery of the social and economic authorities, with pioneering work conducted by Didier Blanchet at the French Institute for Demographic Studies (INED), then further developed at Insee, in the *Redistribution et politiques sociales* Unit, with the construction of the first comprehensive dynamic model dedicated to the study of pensions in France, the Destinie model. This model was gradually developed from the mid-1990s onwards (Chanut & Blanchet, 1998; Division Redistribution et politiques sociales, 1999).

Demographers soon came to realise the value of microsimulation methods for population projections as an alternative to the component method, which remains the method of choice today. Under the component method, a given population is broken down into groups (e.g. women and men by year group) and changes in group size are monitored over time. For example, the aim may be to predict the number of women aged 50 in t+1; this figure is calculated based on the number of women aged 49 in t by applying the survival rate of women aged 49 in t. Where individual data are available,

microsimulation methods are more effective than a projection method since individuals can be tracked over time, thereby generating all the information associated with each individual. The component method allows answering the question: How many women over 80 will there be in 30 years? Microsimulation methods also allow answering the following questions: How many women over 80 years of age will there be in 30 years who (i) are widows? (ii) have at least two children? (iii) own their own homes? And so on. In a dynamic microsimulation, family relationships are subject, like the other characteristics of individuals, to the ageing/renewal process, meaning that they are maintained and updated as necessary. Here we see the value, for social policies that are required to consider possible substitutions between family solidarity and national solidarity, of having at their disposal projections of a representative sample of the resident population incorporating family relationships. This point is explained very clearly in Chanut & Blanchet (1998).

Studies on Pensions

With regard to pensions, the first task was to measure all the effects of the 1993 reform relating to the general scheme, to an increase in the length of the contribution period, to the calculation of the average annual salary on which the pension is based over a longer period (from 10 to 25 years) and to the price-indexation of pensions: What were the savings on pension expenditure generated by the reform? Which measures resulted in the biggest savings? Did the reform lead to a reduction of inequalities in pension income? It is important to have an understanding of trends and changes in the lowest pensions in order to quantify the savings since it is necessary to take into account the minimum pension and the basic old-age pension. Thus, the first version of Destinie, based on the Household Wealth survey (*enquête Patrimoine*), adopted particularly simple assumptions by operating on the basis that the entire population was covered by the general scheme and benefited, in the case of supplementary pensions, from the ARRCO and AGIRC schemes (the two main pension regimes of the private sector).

The evaluation of the gradual transition, for the calculation of the average annual salary used in the computation of pensions, from the best 10 years to the best 25 years is not straightforward. At first sight, upward careers appear to be worst affected by the measure, thus leading to a reduction of inequalities in pension income. However, a review of the relevant regulations is sufficient to show that "multi-pensioners" were particularly affected since the extension of the calculation period was applied in each scheme (the 2003 reform amended this rule to limit the injustice to multi-pensioners). On the other hand, microsimulation highlights the anti-redistributive nature of the measure. In a retrospective microsimulation exercise on the generation born in 1938, Bridenne & Brossard (2008) show that it is the first deciles, depending on the level of the pension, that stand to lose the most from the measure, with the exception of the first decile, where the losses are limited by the minimum pension. In addition, the anti-redistributive impact is more pronounced for women than it is for men, with incomplete careers being a much more common phenomenon among women. This is a good illustration of the lessons provided by microsimulation: in this example, the results of microsimulation contradict the initial intuition.

The development of Destinie anticipated the demand for expertise: in the early 2000s, the modelling of retirement decisions was introduced into the model. The 2003 reform, which limited pension reductions (for people retiring early) and introduced the pension premium (for those going beyond the retirement age), gave more importance to the choice of retirement age, whereas in the previous system retirement at the full rate age was the best option. The second version of the Destinie model separates out the public service pension scheme and the model is thus designed to contribute to the evaluation of a universal pension plan. The model will not be discussed further here: Blanchet (2011) presents a detailed history of Destinie, while the second version of the model is examined in detail in Blanchet *et al*. (2011). Destinie was a pioneering model and remains central today since part of its information base[2] was incorporated into pensipp, a microsimulation model designed to project long-term pensions developed by the IPP (*Institut des Politiques Publiques*), and into Aphrodite (Cuvilliez & Laurent, 2018), a model built by the Treasury Directorate General to develop its own expertise, following the example of the static Saphir model. For its part, the department of the Ministry of Labour in

2. *The biographies of individuals in the Household Wealth survey based on a comparison with the inter-scheme sample of contributors.*

charge of statistics and studies (Drees) developed the Trajectory model (Duc *et al.*, 2016) by relying directly on the data from the all pension schemes sample in order to obtain detailed and reliable information on professional careers. This model was intensively used in 2018 and 2019 to feed the expertise of the High Commission for Pension Reform in charge of proposing a universal pay-as-you-go system. In addition, "sectoral" microsimulation models have been developed at the *Caisse nationale d'Assurance vieillesse* (CNAV, the National old age insurance fund) for the general scheme (Poubelle *et al*., 2006) and at the *Service des retraites de l'État* (the State pension authority) for the public service pension scheme.

Analyses of Ageing and Long-Term Care

One of the advantages of dynamic microsimulation models is to allow for disentangling age and generation effects. This is important, for example in health economics when studying ageing: when considering the use of health services, a distinction must be made between what relates to the state of health proper, which depends mainly on age but also on distance from death, and what relates to the behaviours involved in access to care, where the generation effect plays a key role. A similar capacity to dissociate temporal effects from generational effects is also found in the long-term analysis of pensions. In a defined benefit system (such as the French basic annuity scheme) that protects pensioners from economic and demographic risks, the pension scheme presents necessarily a "dependence on growth" identified by Blanchet *et al*. (2011), the 2008-2009 financial and economic crisis having created the prospect of sustainably weaker growth. Using the Pensipp model, Blanchet *et al*. (2016) discuss three scenarios for reducing this "growth dependence", including a point-based defined contribution pension system.

Finally, dynamic models are particularly used in research on dependency, a risk that could (and should) be covered by social security. Using the Destinie model, Marbot & Roy (2015) outlined the prospects for the *Allocation personnalisée d'autonomie* (APA, an allowance aimed at people aged 60 and in need of care). Comparative work by Bonnet *et al*. (2019) illustrate the use of microsimulation to discuss the prevalence of dependency among the elderly and the associated financing options in nine European countries.

The Consolidation Phase of Microsimulation Models

The somewhat rosy outline provided above requires some qualification. There is no doubt that microsimulation models have come to play a central role in the field of public policy evaluation, but it has also become apparent they are very costly to maintain. To inform the public debate, it is always possible to produce "series of variants", where the main components of the tax and social security system are assessed on the basis of a more or less marginal change to the parameters of their schedule. For example, income tax is assessed by increasing all schedule rates by 1%, before then increasing all tax bracket thresholds by 1%, etc.; each time, the results are presented as a deviation from the reference situation and broken down according to criteria of interest. By proceeding in this way, we are able to shed light on how our tax and transfer system actually operates.[3] However, in many cases, new measures under discussion do not fall within the scope of parametric reforms, instead taking the form of altogether new schemes which, in the microsimulation model, require both searching for the information necessary to determine eligibility for the scheme and programming a new module in the model from scratch. It seems difficult to propose a "push-button" instrument that would allow an imperfectly informed user to really benefit from the model.

After the 2000s, a period marked by a proliferation of models, the 2010s have been a period of consolidation during which Ines has become a central model, not least because of the high maintenance costs of these models, while Destinie has become a reference model.

The Institutionalisation of the Ines and Destinie Models

The institutionalisation of the Ines model occurred in several stages. In the early 2000s, Insee and the Drees (the Directorate of statistics and studies of the ministries of social affairs in charge), agreed to work in collaboration to develop the model, now referred to by the acronym Insee-Drees. The two institutions will pool the costs of developing and maintaining the model.

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*3. Since 2018, Insee has made available a series of variants (*cahiers de variantes*) of benefit and tax reforms, based on the Ines model (https://www.insee.fr/fr/statistiques/fichier/3604001/CAHIER_VARIANTES_tableaux.xls, the new versions are available on the Ines page https://www.insee.fr/fr/information/2021951). See Fontaine & Sicsic (2018) for the methodology and variants for 2016, Biotteau & Sicsic (2019) for 2017.*

The second stage saw the CNAF abandon the Myriade model and join the Ines consortium. There were many reasons for this, including, among others, the proximity of the teams that had collaborated on the evaluation of the implementation of the RSA, closer collaboration further upstream to develop the ERFS survey, difficulties in maintaining Myriade, which had been programmed in C++, the persistently high cost of maintaining the models and difficulties in recruiting and motivating data analysts on this type of project.

Finally, more recently, the opening of the Ines source code in 2016 has reconfigured the landscape. In 2018, the Treasury Directorate General made the Saphir model code available to the public under pressure from the *Commission d'accès aux documents administratifs* (CADA, a body that regulates access to administrative documents). On the other hand, Insee and the Drees, both part of the Official statistical service, had adopted a more open position by promoting the appropriation of the Ines model by third parties. As a result, the Ines model has come to play a central role, as illustrated, for example, by the OFCE's use of the model. Overall, despite the fact that key actors such as Parliament are struggling to develop expertise in the evaluation of public policies (Padirac, 2018), the situation has improved considerably: it is now possible to challenge, on the basis of an internal critique, the evaluations put forward by government and to develop independent expertise more easily than before by taking advantage of free access to the tools developed by the official statistical services. The last remaining obstacle concerns access to data. As things currently stand, "running" the Ines model requires an authorization of access to the data from the ERFS (*enquête Revenus fiscaux et sociaux*).

As noted above, Destinie came to play a particular role in the 2000s, with its information base being reused by others and its modular structure allowing it to be used on topics related to population ageing. The source code was made publicly available in 2018 and the model is very precisely documented for the benefit of both ordinary users and modellers.

The Call for Standardisation

The consequence of the homogenisation of the field was, it seems, a call for standardisation. National accounts have worked tirelessly, albeit at the cost of many conventions, to clarify the content of macroeconomic aggregates: thanks to the 2010 European system of accounts, we know precisely what public debt is "in the Maastricht sense". In other words, microsimulation models should be more aligned to describe the different components of the tax and social security system. For example, it is difficult to count all compulsory levies as taxes since some levies provide individualised benefits. In particular, because of the close link between contributions and benefits, old-age pension contributions should be seen as elements of remuneration.

On the other hand, indirect taxes are often excluded from the analysis of redistribution despite the fact that in the public debate they are often perceived as anti-redistributive. We can mention here a recent study that uses a microsimulation approach to examine the effects of an increase in VAT (André & Biotteau, 2019). Similarly, the degree to which public spending is individualised can vary: such is the case, for example, of education spending. It is thus clear that it is possible to standardise imputations that relate either to indirect taxes or to public expenditure in order to document the situation of social groups that would bear significant indirect taxes but would benefit relatively little from public services.

The issues of non take-up of social benefits and benefit fraud would merit being taken into account in microsimulation models. Non take-up was a key argument used as part of a largely negative evaluation of the RSA. In other words, microsimulation models could be refined to incorporate this particular dimension into the evaluation of social policies. Such models could help in the fight against non take-up by identifying the relevant causes. They would also provide some perspective on the matter by estimating the intensity of non take-up: however serious it may be for a family to be deprived of assistance that could enable it to escape poverty, it is also very easy to see why a family should not request what is effectively very limited assistance (with the minimum amount of the RSA currently standing at 6 euros). Finally, the National Accounts (Hagneré & Mahieu, 2017) seek to take into account illicit work. In social policy making, the possibility of fraud sometimes determines the architecture of the system. Microsimulation models could help to make this type of constraint explicit.

A Roadmap for Microsimulation Models

We now attempt in this last section to present a roadmap for microsimulation models for the coming years. Three important topics are already discussed above: the introduction of universal benefits and certain means-tested benefits with the RUA, work on a universal pension scheme and the insistent question of social insurance for long-term care risk. The use of microsimulation models has been structured around these three topics. These models could also be used to inform public debate on two other issues: climate transition and universal income. We will finish by the perspectives opened up with the consolidation into a single declaration (the *Déclaration sociale nominative*, DSN) of the mandatory declarations that employers must make.

Microsimulations to study policies of ecological transition

It seems to me that the ecological transition will undoubtedly require the expertise provided by microsimulation models. Alongside, of course, the education of individuals and the introduction of strict regulations, it is difficult for economists to disregard the need for a substantial increase in the price of the factors that cause environmental degradation (see also Quinet, this issue). On the one hand, the price of energy, for example, has not seen the increase that would have been required for global warming to be contained. I cannot resist reminding here that after the first oil shock in 1975, the price of a litre of petrol was approximately 2.20 French francs, compared to around 1.60 Euros in 2018. Between those two dates, the gross minimum wage rose from 7.30 French francs per hour to 9.90 Euros. Purchasing a litre of petrol in 1975 required 20 minutes of work, compared to around 10 minutes in 2018. On the other hand, the price of factors that harm the environment is too low to enable investments that could help avoid them to be financially profitable: simply put, what is the point of insulating your home if your annual heating bill only drops by a few hundred Euros? Aligning economic profitability with ecological profitability might involve investment aid. However, it is far more likely to involve a significant increase in the price of all the factors that cause negative externalities on our environment – an increase obtained through taxation.

However, a view such as this is socially unacceptable since it amounts to making the most disadvantaged in society pay for the ecological transition. There is, therefore, no "double dividend": the revenues from such taxation intended to charge a full price (i.e. including negative environmental externalities) must be used to help individuals adapt and change their habits. It is therefore necessary, first, to identify families in "fuel poverty" and, second, to assess different support systems. The range of existing schemes is extremely broad, from the *crédit d'impôt transition énergétique* (CITE, a tax credit aimed at energy transition) to the *chèque énergie* (granted on a means-tested basis). As the price of energy remains low, these schemes are targeted by being reserved for certain investments or families, with many attendant disadvantages, including a partially arbitrary list of investments, the stigma of means-testing, the weakening effect of non-universality on social cohesion and widespread non take-up. With the increase in taxes, aid could be massively increased and much less targeted. If we want to use taxation in this way in order to contribute to the ecological transition and if we want it to be socially acceptable (rather than being perceived as "punitive taxation"), it seems important to inform the public debate with the lessons provided by microsimulation models. Examples include work developed with the Prometheus model (Thao Khamsing *et al.* 2016), or with the Taxipp model (Douenne, 2018). These models may not be capable of predicting social movements, but they do have the potential to identify the anti-redistributive effects of indirect tax policies.

The Evaluation of Universal Income Schemes

A second issue that could come up in the public debate is the question of universal basic income. The weak version of universal basic income involves a simplification of the tax and social security system. The most striking illustration is perhaps to be found in family policies: currently, family allowances are no longer universal, the benefit provided by the family quotient is capped at a relatively low level, the first child does not grant the right to receive allowances but does confer the right to the family quotient so that only taxable families are supported, the back to school allowance is paid based on means testing, etc. Ultimately, it seems more legitimate to replace this set of provisions with a universal allowance granted from the first child, the amount of which would only

depend on the age of the child, with half of the allowance being paid to the first parent and the other half going to the other parent. This is the just the kind of proposal put forward, for example, by Régent (2018) on the basis of a careful examination of social legislation. It would be worthwhile applying a microsimulation model to the matter with a view to assessing all the associated consequences. Our tax and social security system could also be simplified by moving to an individualisation of income tax, meaning that married couples or partners in a Civil Solidarity Pact (PACS) would be taxed separately. The twin pressures of the RSA and income tax could be converted into a universal basic income corresponding to the RSA-*socle* and a universal income tax. The purpose of these reforms is not only simplification. They are also designed to reduce the sense of injustice. In other words, the principle is that no one is excluded from the right to universal basic income or from the duty of universal taxation.

The strong version of universal basic income is more a matter of stabilising the income of households in the face of anticipated upheavals in the labour market. It is not necessarily a question of imagining massive job losses as a result of the automation of the economy, which the creation of new jobs would do little to offset. We can at least predict that the content of jobs will change dramatically and that there will be significant pressure on employees to be adaptable. The result will be a strong social demand for a new form of security for individuals, such as a relatively high level of universal basic income. Therefore, static microsimulation models are not necessarily the most appropriate tools for examining the consequences of this kind of reform. Would a universal basic income lead to an increase in the number of people working part-time out of choice (rather than not finding a full-time job)? Would it create upward or downward pressure on the lowest hourly wage rates? Establishing this would require developing a model that gives sufficient consideration to the behaviour of workers and companies to inform the debate.

A New Landscape for Data

The final topic is the matter of data, a crucial factor for microsimulation models. With the *Déclaration sociale nominative* (DSN, replacing all the periodic declarations sent by employers to various administrations) fully in place for most employers since 2017, the landscape has changed profoundly in terms of the range of administrative sources that provide information on household income and serve as a basis for the input sample of a static microsimulation model. The DSN contains monthly data on earned income, which also include a volume/price split (i.e. data on hours worked and total remuneration and, therefore, on the hourly rate of remuneration). First, the new framework places the revenue authority in a special situation: since it also knows all of the occupants of a dwelling, it is able to build a highly representative sample for a microsimulation model. Second, in its current form, the *enquête Revenus fiscaux et sociaux* (ERFS) is clearly becoming secondary: the value of matching it with the Labor Force survey, which provides information on individuals'economic activity, is lessened and its disadvantages are more obvious (such as the scope being limited to ordinary households and the areolar structure of the sample design not allowing for detailed regional statistics). Third, access to the history of the DSN for each individual considerably increases the accuracy of the schedule-based imputations. One of the difficulties encountered by microsimulation models concerns the means-testing used to determine eligibility for most social security benefits. Means can be estimated over a period of one year or one quarter; they are also estimated with a variable time lag. For example, housing benefits are calculated based on a family's annual means but with a two-year lag. In the case of the RSA, the quarterly means of the previous quarter are taken into account. However, it remains very difficult to assess individuals' entitlement to unemployment benefits, calculated on a daily basis based on a history of employment of varying length.

We are thus beginning to see the outline of a major survey made available to researchers that would provide a basis for cooperation and competition in the development of microsimulation models: specifically, cooperation to build a common information base (individual data but also schedule parameters) and competition to ensure a range of expertise in the field of economic and social policy evaluation. The data generated by the DSN would provide the information on working conditions but also on mobility between home and work; tax returns and the information available to the revenue authority would provide the information on other income, including sickness and unemployment benefits, but also on various characteristics

relating to housing and the local authority of residence. It would, of course, be necessary to impute a large amount of missing data, but researchers would have a very complete picture of individual situations and circumstances, including, in particular, local benefits (Anne & L'Horty, 2002) and indirect taxes.

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One of the strengths of microsimulation methods is that they allow for a contribution to economic policy debates in a straightforward manner by countering *ad hoc* examples, which are highly unrepresentative, with examples that are truly relevant because they are sufficiently widespread. Despite this potential, microsimulation methods remain somewhat overlooked. Macroeconomic modelling, in conjunction with the improvement of national accounts, has developed a common space for macroeconomists. New-Keynesian models have provided a framework in which controversies have flourished: we need only think of the Phillips curve, the Lucas critique or the Taylor rule. Stochastic dynamic general equilibrium models with nominal or real rigidities have even been seen as a continuation of New-Keynesian models.

However, microsimulation models have not provided a comparable space in which social policy controversies would have developped. The academic world continues to make too little use of these methods. But there is good reason to believe that given the very strong social demand for evaluating social policies, microsimulation methods will come to play a more central role in the toolbox of statisticians and economists. □

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