Aggregate Employment, Job Polarization and Inequalities: A Transatlantic Perspective

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1. Introduction :

1.a. Accounting for changes in level of employment rates and structure of employment

This paper aims at assessing the short-run and long-term effects of *structural reforms* in economies that need to undertake significant amounts of employment reallocation across industries, firms and occupations when technology changes. It locates at the intersection of two strands of literature:

- The first one tires to identify the reasons behind the low employment level in Europe compared to the US (the so-called "European employment problem", Ljungqvist and Sargent, 1998; 2008). This literature lays stress on the role of labor market institutions (hereafter LMI) in shaping transatlantic differences in employment rates and on the role of structural reforms in improving European *employment levels*.

- The second strand of literature deals with the *employment structure*, and the dynamic of wages across skill groups. Starting with Katz and Murphy (1992) several works focused on how technological progress may induce shifts in labor demand in favor of skilled

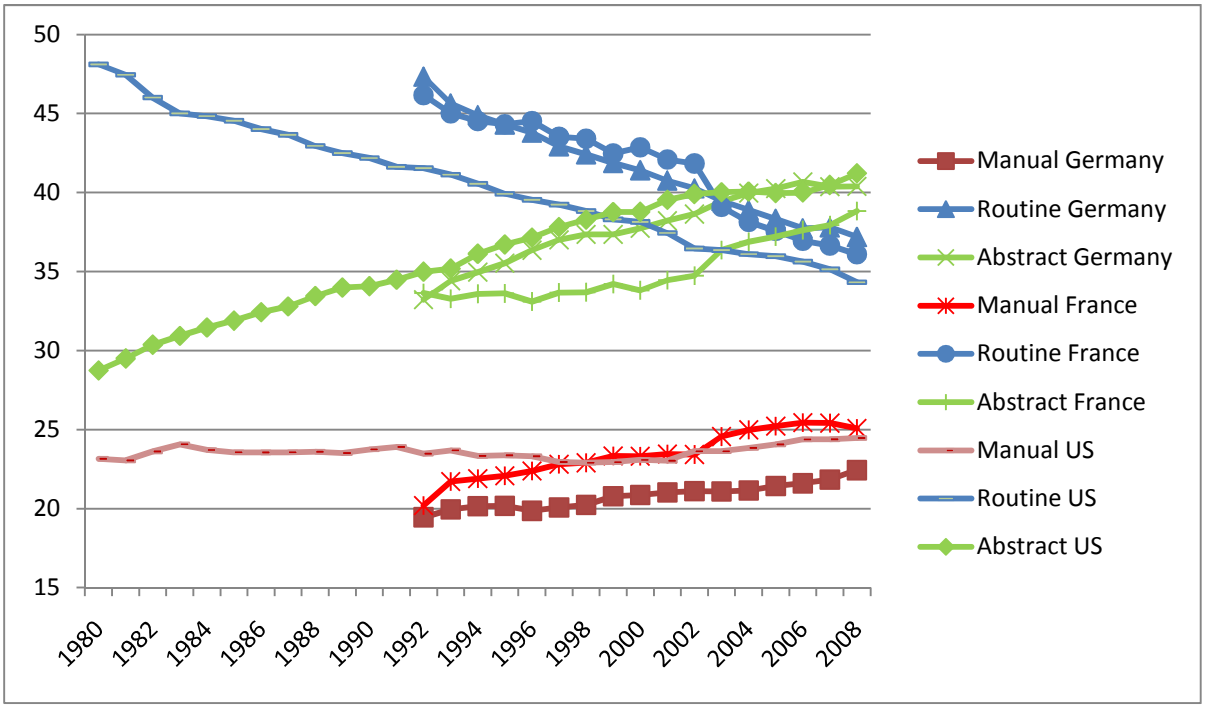
workers. This “Skilled-biaised technological change” (SBTC) has proved quite successful in accounting for the evolution of skill premia in the United States throughout the twentieth century, as well as in capturing the differences in employment rates among advanced nations characterized by real wage rigidities. However, this literature has failed to account for another relevant stylized fact characterizing the evolution of the employment structure, and suggesting that recent technological changes might rather lead to “Job Polarization” (JP). Over the last 30 years in the US (and the last 20 years in Europe) employment growth has been fast not only in both high-paid (*abstract)* jobs but also in low-paid (*manual*) jobs; employment levels significantly fall among middling (*routine*) jobs, those involving tasks that can be replaced by machines (Autor and Dorn, 2013; Goos et al, 2009). Unlike in the case of the SBTC theory, JP implies that within the group of unskilled workers there are winners (workers in service jobs, which require non-routine manual task and mainly involve assisting for others –e.g. janitors, cleaners, child care) and losers (middle-skilled, routine workers – e.g. production and craft, operative and assembler, and transportation, construction, mechanical).

The fact that the adoption of new technologies requires significant amounts of reallocation from routine to manual workers implies that models aiming at capturing the short and long term consequences of structural policies require a much higher degree of complexity than previously understood. Papers focusing on the European employment problem focus on the *level* of employment but discard the study of the employment and wage dynamics *across skill groups*. And yet, the extent employment reallocation is significantly affected by labor market institutions, with excess rigidities potentially able to prevent firms and workers to seize opportunities created by technological changes. These interactions might be crucial to our understanding of the “European employment problem”. At the other end of the spectrum, recent papers focusing on changes in the structure of employment are developed under the assumption of constant aggregate employment.
The present project aims bridging the gaps between these two strands of literature by studying the strong interaction between the level and the structure of employment (in terms of opportunities for skilled vs. unskilled workers), and by assessing the consequences of structural reforms in this context. This study mainly focuses on the long-run consequences of labor market reforms. A systematic analysis of the short-run effects, and the extension to product market reforms is left for the second phase of this project.

A glance at the data (Figures 1 and 2) suggests that the interaction between the level and the structure of employment can be complex.

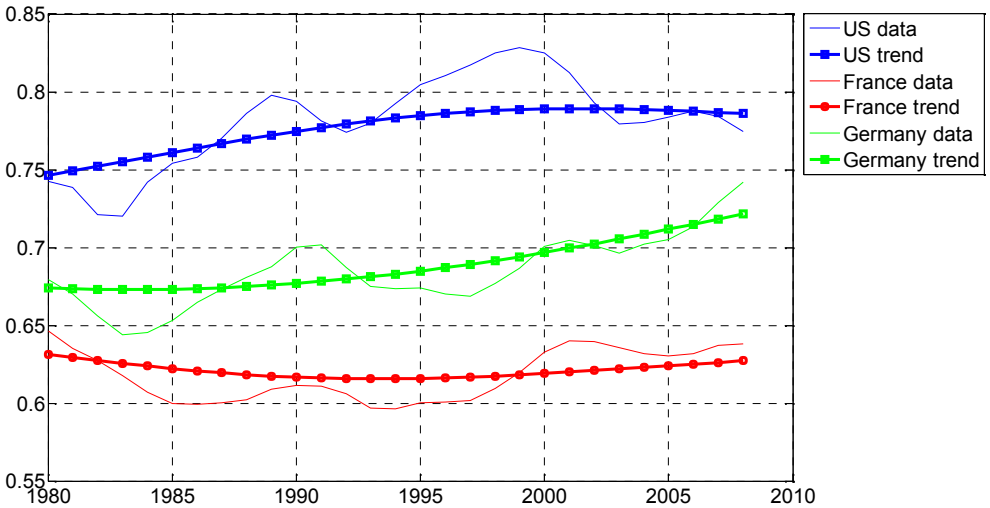
The data suggest that job polarization is prevalent in the US, France and Germany, with a rising employment share of service manual jobs and abstract jobs along with a pervasive fall in routine jobs (Figure 1). Notice also that, although job polarization is at work in the US as well as in 2 core countries of continental Europe, aggregate employment has evolved very differently with a striking rise in aggregate employment in the US between 1980 and 2000, a rise that begin after 1990 in Germany and a downward trend in aggregate employment in France until the end of 90s (Figure 2).

Figure 1 : Employment shares of abstract, routine and manual occupation in France, Germany and the US.



Source: OECD computations based on CPS for US data, EULFS for Germany and French Labor Force Survey for France[1].

Figure 2 : Employment rates in France, Germany and the US.



Source: OECD data. Employment to working age population (15-64 years old).

[1] In the paper, we consider data prior to the 2008 crisis. Indeed, the Great Recession induced sizable breaks in employment levels and LMI. Matching these breaks lies beyond the focus of this paper.

Figures 1 and 2 suggest that job polarization must be understood in relation with the evolution of the level of aggregate employment. Indeed, in Figure 1, the US employment share of service occupation jobs has increased by only 6% over the last 30 years. Given the rapid rise in the US aggregate employment level in the 1980s and 1990s, the apparent limited increase in manual-task employment share actually involves large labor reallocations from routine to manual jobs. The evolution of the labor supply, where the supply of skilled workers increases, makes this increase in the share of manual tasks even more remarkable: for the current structure of the labor supply, a share of 15% of manual worker would be necessary to maintain the employment structure of the 1980s. This contrasts with the European experiences. First, given that the technological change occurs 10 year later in Europe, the observed fall in employment rates can be explained by the increase in the generosity of LMI: between the unskilled workers, the more affected by this change in the labor costs are those whom are substitutable by an input having a constant price: the routine jobs. After the 90s, the task-biased technological change is at work, but the experiences of the two European countries are different. It seems that France does not transform the structural change allowed by new technologies, into a rise in the employment rate, unlike Germany or to the US, 10 years before. With the technological change, the substitution between routine jobs and computers is accelerated, leading to a decline in the share of routine jobs, and, in an extreme case where all new fired workers from the routine become permanently non-employed, constants numbers of jobs in abstract and manual tasks are enough to lead to a rise in the share of employment in these two occupations. This point is missed in the current literature on skilled/unskilled workers.

This paper therefore provides a tool for assessing the impact of structural reforms on the aggregate level of employment as well as wage and employment dynamics across skill groups. We will also be able to contrast short-run and long-term effects by looking at the transition path induced by technological changes.

1.b. Mechanisms at work in the model

The mechanisms at work in our model are the following:

- The falling price of new technologies induces firm to substitute routine workers for computers. Computers complement abstract tasks. The least productive routine workers switch to manual non-routine occupations. Labor reallocations take place at the bottom of the skill distribution.
- Abstract workers (with higher wage and more numerous) ask for more services provided by manual workers. This rise in labor demand for manual non routine tasks drives the increase in wage at the very bottom of the skill distribution, which induces more routine workers to switch occupation.
- We extend the existing literature by modelling the labor market using search and matching frictions and workers' occupational choice. Such a modelling capture (i) the endogenous level of jobs by tasks, (ii) the costly delays of reallocation though unemployment episodes, and (iii) the impacts of policies with a arbitration between the short-term gains of preserving current jobs and long-term gains linked to reallocations.
- We are able to study how technological change has the potential to generate job polarization, thereby affecting the level of aggregate employment through job destructions (in routine jobs), job creations (in abstract and manual jobs) as well as

workers' occupational choices. We will show that LMI reforms can alter the speed and depth of job re-allocations, depending on the segment of the labor market affected by the reform. In particular, assistance programs and unemployment benefits can reduce the incentives for firms to open new jobs at the bottom of the occupations, thus hampering the reallocations of unskilled worker. Alternative wage setting rules can also have very different impacts on reallocation. The crucial point is the magnitude of the real wage rigidity and its asymmetric impact on occupations. In sectors characterized by expanding labor demand (in which real wages shall go up), real wage rigidities ("wage norms" coming from past negotiations) introduce a wage moderation, encouraging firms to create jobs. At the opposite, in sectors with declining labor demand (hence downward pressure on real wages), real wage rigidities ("social norms" inherited from previous contracts) raise the fragility of the existing jobs. But while these "social norms" comes from past bargainings, the real wage rigidities cannot stop the reallocation process. At the opposite, if "social norms" come from a external actor, the State for example in the case of the minimum wage, it is possible that their levels and their increases over time will be no longer compatible with the profitability of firms. In this case, the reallocation process can be stopped. In this case, only high skilled workers can benefit from the new technology. LMI reforms hence have the potential to affect the level of employment as well as its structure across tasks.

- The model allows for a quite comprehensive assessment of the distributional effects of policy reforms, focusing on both wages and on incomes (which include wages and non-employment revenues, i.e. unemployment benefits and social assistance programs). Importantly, we exploit the model dynamics to compute a measure of inequality based on *permanent incomes* (accounting for current and expected discounted incomes). Comparing static and dynamic inequality indexes allows a better understanding of the distributional impact of LMI. It can also give a more realistic measure of the "perceived" inequalities because it account for the current incomes and from opportunities. For example, lower generosity in assistance programs and unemployment benefits makes the economy more unequal based on current incomes (the static measure of inequalities). However, if reforms increase the chances to find a job, accounting for the monetary values of future employment opportunities can compensate the initial increase in inequality.

  This suggests that the static inequality measure (based on current income) could be used to infer for the short-term distributional consequences of reforms, while dynamic inequality (based on permanent income and therefore accounting for future employment opportunities) better captures the long-term consequences.

1.c. Institutional settings

We consider the cases of three large OECD economies representative of alternative institutional settings, having the potential to induce divergent time-paths in the evolution of labor market outcomes during the process of technological transition:

- The US, where flexible wages and institutions ease technology-induced job reallocation.
- France, the polar case with a rigid labor market, a minimum wage that increases over time in real terms, and an evolution of LMI that can potentially stall aggregate unemployment and job reallocation

- Germany, an intermediate case. The German labor market is rather rigid, but does not feature a "national" minimum wage (but with sector-specific wage "norms"). The evolution of LMI first stalled job reallocation, but then reversed in the second period of the technological transition

The 3 countries were chosen to illustrate divergent time-path of LMI along the technological transition. In addition, these countries are all characterized by job polarization but also by contrasting evolutions of the aggregate employment level. This provides the opportunity to illustrate the interaction between the level of employment and its structure across task groups.

Table 1 : LMI dynamics during the technological transition

	Replacement rates		Social assistance		Bargaining power	
	1980	2008	1980/1990	2008	1980	2008
US	0.15	0.08	220($/per recipient)	150	0.2	0.12
France	0.3	0.35	52 (€/per inhabitant)	206	0.45	0.5
Germany	0.3	0.225	23 (58 in 1995)	41	0.6	0.4

1. The bargaining power indicator is an average of the union density and the union coverage
2. Social assistance statistics are available only from 1990 onwards for European countries

1.d. Caveats

The findings shall be interpreted with caution as the model is developed under the assumptions of rational expectations. Since we report deterministic simulations, all forward-looking agents are perfectly aware of the technological trend as well as the changes in economic policy. As a result, short-term costs can be under-estimated as workers and firms, who anticipate any change in LMI, can modify their behavior before the actual implementation of reforms.[2] Secondly, the current version of the model does not consider cost to firm entry. The introduction of such a cost could make the model relevant in assessing the impact of PMR reforms on employment and job re-allocation.[3]

2. Main features of the model

The model is a dynamic general equilibrium model with search and matching frictions, featuring workers' endogenous occupational choice and job polarization induced by a deterministic task-biased technological change. The model equations and calibration are provided in Appendix 1.

The building blocks of the model are:

- The economy consists of 2 sectors: the good-producing sector and manual non-routine services. The good producing sector uses 3 inputs: i) high-skilled workers in abstract non-routine cognitive jobs, ii) unskilled workers employed in routine, repetitive tasks and iii)

[2] Future extensions will include unanticipated changes in labor market reforms such that workers and firms will be surprised in the short – run by the policy reform. This could increase the short-term cost of reforms.
[3] This extension is also on the agenda and could provide interesting tools to discuss reform packages including a combination of PMR and LMI reforms.

technology (equipment, computers, machine), a good that can also perform repetitive tasks. Unskilled routine workers can be easily replaced by machines while abstract workers complement repetitive tasks (whether performed by machines or unskilled workers). Technological change is captured by a downward trend in the price of computers, which creates a strong incentive for good-producing firms to substitute unskilled labor for capital.

The service sector employs only unskilled labor in non-routine manual tasks (such as janitors, cleaners … occupations involving assisting others).

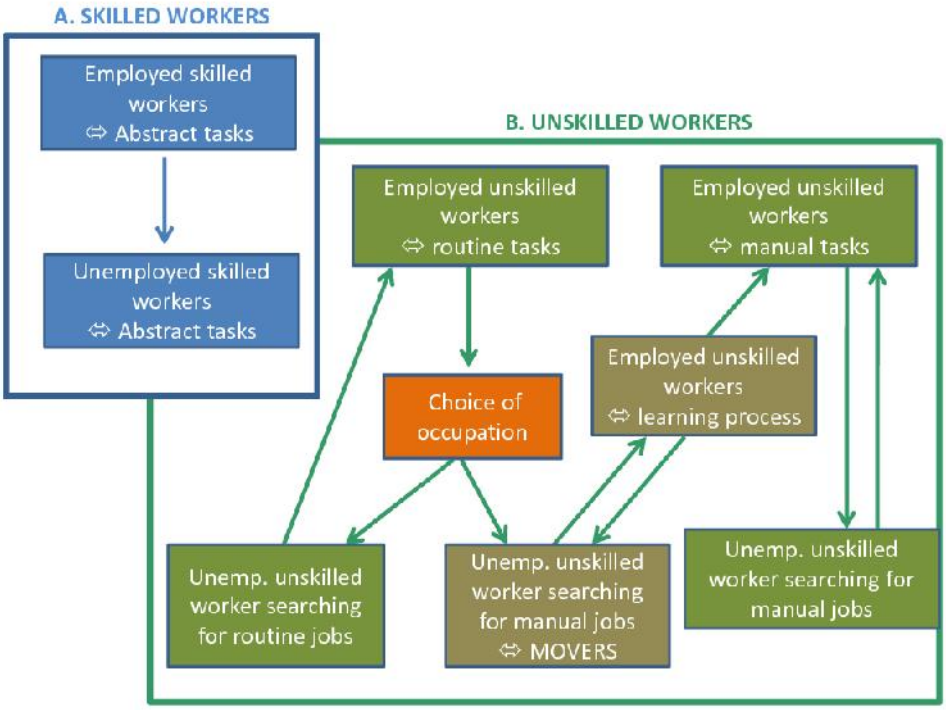
- Labor supply consists of skilled and unskilled workers. Skilled workers are homogeneous and all perform abstract tasks (non-routine, cognitive jobs) in the good-producing firm. There is a continuum of unskilled workers who differ with respect to their abilities. The model endogenously determines which unskilled workers occupy routine occupations versus service occupations. Low- skill workers have homogeneous (heterogeneous) skills at performing manual (routine) tasks. This is consistent with the view that blue-collar workers in the factory differ in performing their tasks on the assembly line while jobs such as janitors can hardly differ in terms of productivity in providing non-routine manual services.
- Labor market flows are summarized by Figure 3.
  Panel A: skilled workers are employed in abstract tasks. When fired, they join the pool of unemployed skilled workers and look for an abstract job.
  Panel B: unskilled workers can be employed either in routine tasks in the good producing firm or in manual tasks in the service sector. When fired from the good-producing firms, routine workers can choose to switch occupation (we call them "movers") and join the pool of unemployed workers looking for manual jobs. Movers differ from other unemployed workers looking for a manual jobs because i) their unemployment benefit depends on their past occupation as routine workers, ii) they just arrived on the market for manual jobs and lack proper information about the tasks and firms on the market. Movers gradually learn about the tasks and the market: they job finding probability and their productivity as manual workers is lower than their counterparts.[4]
- Due to search and matching frictions on the labor market, hiring takes time. There is directed search on the labor market for unskilled routine labor, for each ability level. Job finding probabilities as well as probabilities of filling a vacancy are endogenously determined by the number of firms and workers in each segment of the labor market. Occupational choices, by affecting the number of workers in each unemployment pool, directly alter unemployment rates in each sector of the economy as well as job finding probabilities. A job can be destroyed for exogenous reasons. Endogenous separation occurs in case of real wage rigidity, in which case, a firing cost is incurred. [5]

[4] The model proposes a stylized mapping of skilled and jobs. The data might suggest that the real world involves more complex mobility. However, we argue that our stylized model captures the salient mobility involved in job polarization and changes in aggregate employment.

[5] Two remarks must be made at this stage. First, firing costs are not severance payment but rather administrative costs of lay-off procedures. They are pure losses. Secondly, endogenous separations occur in our model because some firms incur negative profits, especially in the routine segment of the labor market. Recall that, in a world of continuous technological change, we can expect routine wages to fall (more on wage determination in the main text), in which case, the firm would not be likely to incur negative profits, even in a world with falling routine labor productivity. In contrast, it is only when wages are completely rigid that firms can be trapped between production costs and falling labor productivity. This situation leads to negative profits.

- Wages are the result of 3 possible institutional arrangements:
  - A Nash bargaining, where wages respond to changes in labor productivity and tensions on the labor market. This modelling is the line with the US labor market features.
  - A sector- or occupation-specific wage rigidity. More specifically, we consider that each industry has a specific reference wage (a "social norm"), leading the real wage to the weighted average of the Nash wage and this "social norm" (a as in Hall, 2005). This modelling aims at capturing the institutional features prevailing in Germany.
  - In the model calibrated on French data, a real minimum wage homogenous for all occupation is introduced, whose evolution mimics the data. Specifically, the wage defined as the maximum between the minimum wage and the Nash-bargaining age. For the purposes of the benchmark calibration, the minimum wage is assumed to be binding for all manual jobs and the lowest-ability fraction of routine jobs.
- The demand for good and service stems from the skilled and unskilled households. They consume goods and services. Both are complements. This is a crucial element. The adoption of new technologies by good-producing firms allows them to expand their production. The resulting fall in the price of good increases the demand for goods. As goods and services are complements, the demand for services also expands. The relative price of services goes up, which also drives the increase in real wages in the service sector, thereby inducing workers to switch occupations from routine to service jobs.

Figure 3 : Labor market flows in the model



The firm then closes down, therefore incurs firing costs. In the model, for each ability level in routine jobs, in case of rigid wages only, we can endogenously define a scrapping-time after which the firm shuts down.

Regarding the model calibration, some parameter values are set based on existing empirical evidence and others calibrated to match selected moments in the data. Since the paper is focused on trends in employment, the selected moments in the data include employment shares at 2 different times, the beginning and the end on the sample and the average over the sample of these employment shares (9 moments per country).

Labor market institutions and wage-setting are country-specific while we consider that consumer preferences, technology and distribution of abilities within unskilled labor are the same cross countries. In addition, given that the model predicts the complete path of employment composition and level following a technological change, we need to set values for the *path* of labor market institutions, technological change and increase in skilled labor.

In particular, we assume that

- Technological change (the fall in the price of computers) starts in 1980 in the US while it starts in 1990 in European countries but, due to a catching-up effect, technological change is twice faster than in the US.
- We take into account the improvement in the population educational attainment: the share of skilled workers increases at the same pace in all countries, even if the levels in 1980 are not the same.
- The evolution of LMI is country-specific and fits general trends found in LMI data
    - US : a continuous decline in assistance programs (unconditional income, not linked to labor market activities), replacement ratios and workers' bargaining power
    - France: since the mid-1980s, an upward trend in generosity of assistance programs, replacement ratios and minimum wage
    - Germany: is characterized by 2 sub-periods, with, first, as in France, an upward trend in generosity, then, starting in the early 1990s, a reversal on workers' bargaining power (1990) and generosity of assistance programs as well as unemployment replacement ratios (1995).

Full details on the calibration are available in Appendix 1.

3. The model fit

3.a. Aggregate employment

Figure 4 summarizes the model's predictions regarding aggregate employment levels and employment rates across skill groups. As for employment rates (top panels of Figure 4), the model matches the upward trend found in the US until 2000, that is 20 years after the start of the "technological transition".[6] The graph below shows the theoretical and observed employment rates for skilled and unskilled workers. In the model as well as in the data, skilled and unskilled workers benefit from the technological change: the balance between

[6] The model misses the fall in the employment rate since 2000, however. Yet, this contraction is essentially explained by the reduction in labour force participation of youth (staying longer in education) and the increase in disability rates among adults (see e.g. OECD, 2014): OECD Employment Outlook 2014, Box 1.1 and Annex Table B. Neither factor is modeled in the analysis, though.

falling routine and rising manual positive, showing that the reallocation process does not discourage workers.

The model is also able to capture the fall in the French unemployment rate. The rebound in 2000 is missed in the model. In our view, this employment hike is related to the French extensive program of cuts on payroll taxes for low-wage workers starting in 1998. This resulted in an increase in the employment rate of unskilled workers. This policy change is missed in the model.[7]

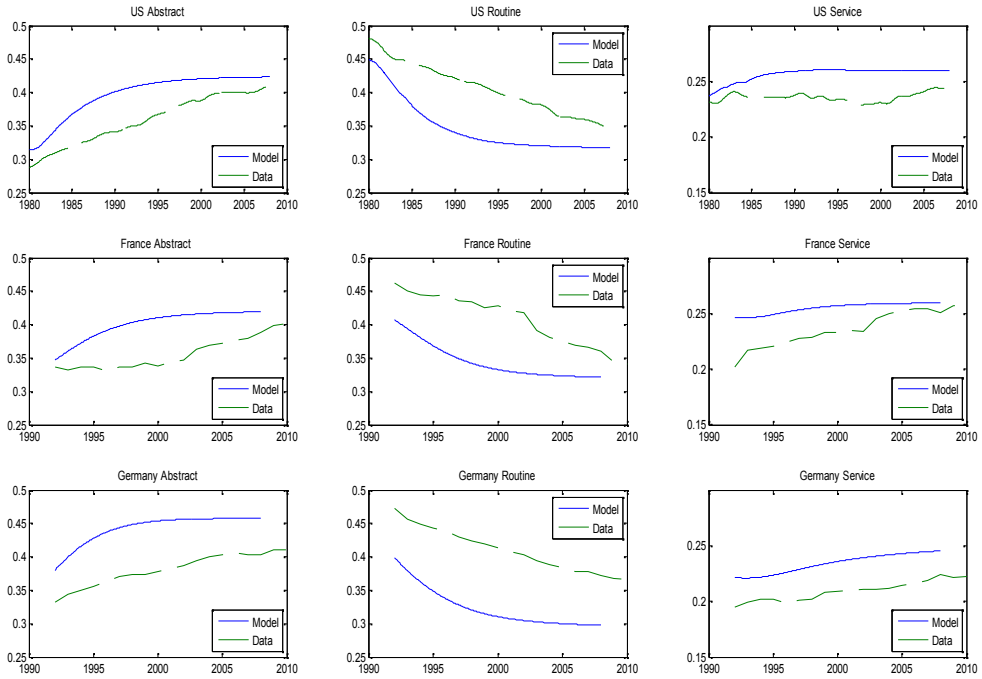
Figure 4 : Model's prediction on aggregate employment in the US, France and Germany.

3.b. Job polarization

The model captures the job polarization in all countries (Figure 5). The theoretical predictions are consistent with the levels of employment shares as well as their evolution, especially the starting and ending points (with the exception of the French routine and service share at the start of the sample). The model's predictions are slightly different from the data for Germany but the trend is consistent with the data.

[7] We present in the appendix a variant of the French case where payroll tax subsidies are introduced. In this case, we re-calibrate the model in order to match the same set of moments. The main results are similar. We choose to present the case without payroll tax subsidies reform in the main text in order to compare countries more easily.

Figure 5 : Model's prediction on employment shares by task in the US, France and Germany.



3.c. Inequalities

Job polarization induces shifts in labor demand and supply across tasks, which generates divergent wage dynamics in the pool of employed workers; wage and income inequalities are further affected by the prevailing labor market institutions. In the model, the patterns of inequality can be captured in two complementary ways. First, by simply looking at the relative growth of wages paid for different groups (tasks); second, exploiting the simple heterogeneous agent structure of the model to look at changes in earnings or income inequality through more standard indicators as the Gini index.

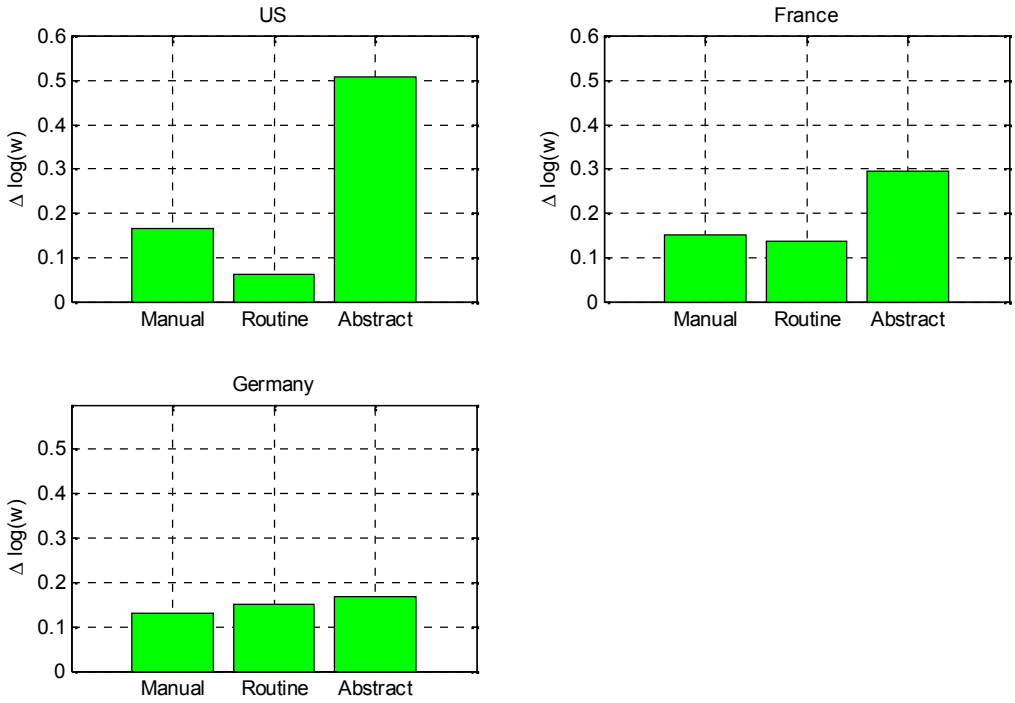
3. c. 1. Wage growth by task

Figure 6 reports the impact of job polarization on wage dynamics across tasks. We compute the predicted increase in wage for each task group between the beginning and the end of the technological transition.[8] Our model is able to capture the polarization of US wages found in Autor and Dorn (2013): wage growth is largest at the top and bottom of the wage than in the middle.[9]

[8] In order to make the graph comparable to Autor and Dorn (2013)'s, we take into account the general increase in total factor productivity that is common to all wages. This increase is computed on country-specific TFP using GDP, labor and capital data.

[9] In Autor and Dorn (2013) paper, US real hourly wage goes up by 17% at the bottom of the skill distribution (respectively 11% and 25% in the middle and top of the skill distribution. Source : US Census data, 1980-2005)The model over-estimates the wage gain for abstract workers as their wage in the model responds to the rise in labor demand.

Figure 6 : Change in real wage by task in the US, France and Germany.



The cases of France and Germany illustrate the impact of wage-setting rules on wage polarization, which suggests that wage polarization has no the same characterization in all countries.

- In Germany, the wage is set with respect to a sector-specific reference wage whose value is based on past wages (the "social norm"). For abstract workers whose labor demand is rising, the reference wage tends to dampen the rise in the wage as shown in Figure 6. In contrast, for routine workers whose labor demand is falling, the reference wage contributes to containing downward pressures on the wage: the wage declines for these occupations are lower than in the US.
- In France, in contrast to Germany, the growth of wages, for abstract workers, captures changes in labor demands: the abstract workers benefit from rise in productivity. For the routine and the manual workers wage growth comes from the increases in the real minimum wage.

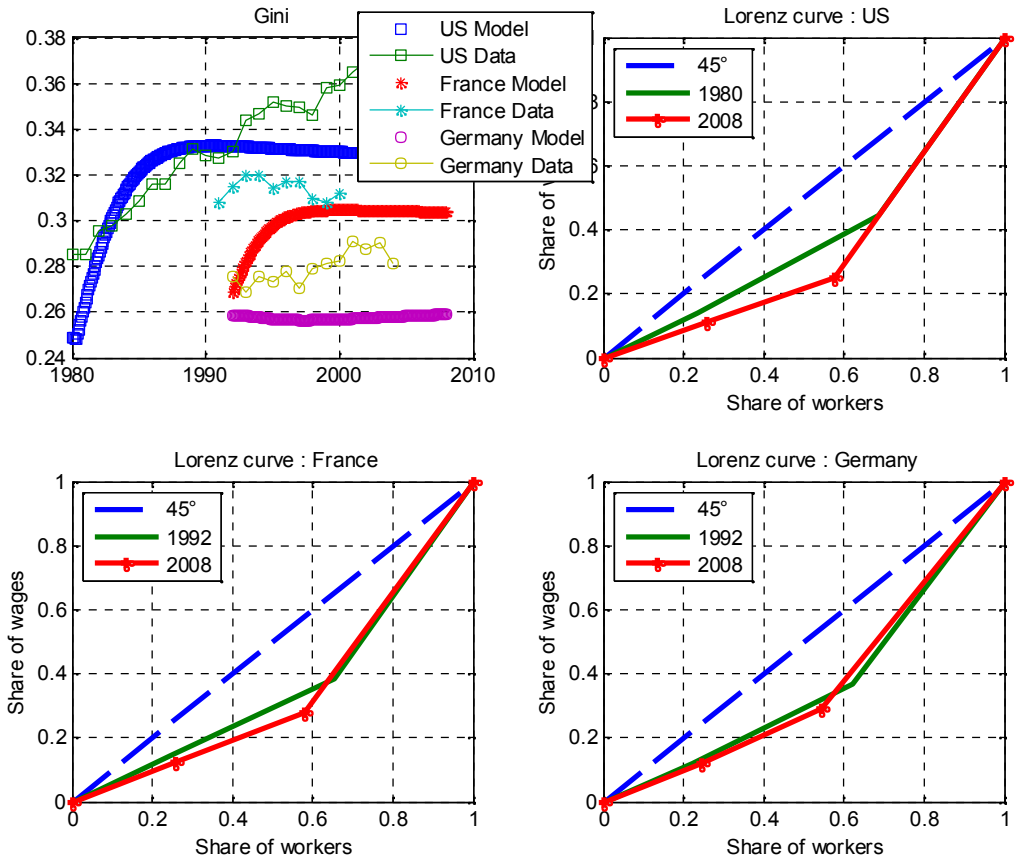
Figure 6 reports growth rates across task groups. In order to fully grasp the evolution of inequalities, one must take into account the evolution of the number of workers in each group. Next section fills this gap.

3. c. 2. Gini on wages, labor income and permanent income

The model features a simple heterogeneous agent framework, including abstract workers, a continuum of routine workers and manual workers. In this section, we assess to which extent job polarization can capture changes in earnings inequality (as summarized by the Gini indicator) in this context. With shifts in labor demand and occupational choices, the mass of workers in each employment pool evolves over time. The Gini coefficient then

reflects both the changing shares of workers in each group as well as the wage growth differentials reported in Figure 6. Figure 7 displays Lorenz curves for each country at the beginning and the end of the technological transition.[10] At both points in time, we can compute a Gini coefficient on wages and compare the model's predictions to the data.

Figure 7 : Wage inequality along the transition path. Lorenz curves at the beginning and the end of the technological transition for each country. Evolution of Gini coefficients



Source: Gini coefficients (US: Heathcote, Perri, Violante, 2010; Germany: Fuchs-Schündeln,Krueger and Sommer, 2010; France : Atkinson, Glaude, Olier and Piketty, 1997)

- The model is consistent with the increase in wage inequality found in US data until the early 1990s (see fourth panel). After the early 1990s, wage inequality continues to rise in the US data, an upward trend which could be matched in the model considering another wave of technological change.
- The model also predicts a stable Gini along the transition in Germany, which matches the findings on German wages. The data suggest a rebound in wage inequality in 2003, which could be related to "mini-jobs", which we do not have in the model.
- Finally, the model slightly under-predicts the level of the French Gini coefficient. France is characterized in the model by an increase in Gini along the transition path, which echoes the hump-shape found in the French data in the early 1990s.

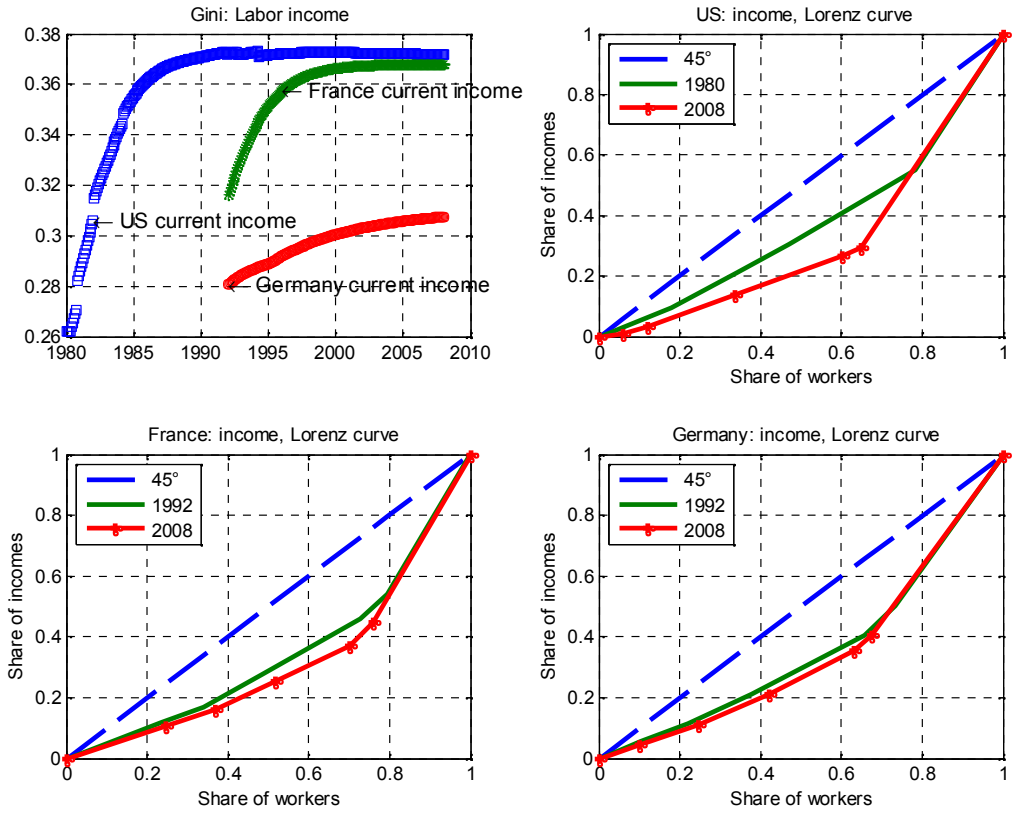
[10] Curves are actually piece-wise linear because of the limited heterogeneity in the model.

Differences in the existing wage-setting mechanisms account for the divergent evolutions of inequalities in France and Germany. In Germany, as shown in Figure 6, the reference wage limits the increase in abstract wages and the fall in routine wages, which tends to narrow the range of wages in the economy. In France, even if the increasing real minimum wage dampens the inequalities with respect to the middle of the distribution, the larger wage inequalities than in Germany come from the larger increase of the high wages.

3. c. 3. Inequalities in current income versus Inequalities permanent incomes

We now report predicted Gini coefficients on income rather than earnings (Figure 8[11]). Because agents do not save in the model, income includes only wages and income when non-employed (social assistance and unemployment benefits).

Figure 8 : Inequality in current income



Notice that all Gini curves in Figure 8 shift upward compared with Figure 7: the population now includes the lowest-income groups of non-employed individuals. In the US, the rise in inequality now takes into account the decline in the generosity of income when non-employed. It is also the case in Germany after 1995. Germany now displays a steady rise in current income inequalities. The initial differential in Gini inequality between France and

[11] In this Figure, we do not report any observed Gini coefficients for want of data. Indeed, available Gini are measured either on earnings or on total income (including capital income, which we do not have in the model)

Germany comes from the highest social assistance and unemployment benefits in Germany in 1990.

In France, the shape of the Gini evolution remains the same. As can be seen from the evolution of the Lorenz curves, workers in middling positions tend to lose during the transition process: they leave routine jobs, their wage increase less than in other segments of the labor market (Figure 6) while abstract workers keep gaining from the technological change. This change in employment opportunities dominates the rising generosity of the minimum wage as well as income when non-employed through assistance programs and rising unemployment benefits. In a nutshell, in France, the generous assistance programs and unemployment benefits do not succeed in dampening the rise in inequalities driven by the wage growth at the top of the skill distribution (as shown in Figure 6). Nevertheless, France is the country where the poorest worker is less poor than in another country: this could be a foundation of this income distribution. Its cost is that the number of non-employed workers is larger than in the other countries.

The previous Gini captures inequalities in *current* income (static perspective). As such, it provides a picture of dispersion of instantaneous income. However, we argue that inequalities in future employment opportunities shall also be taken into account when assessing the impact of technological changes on inequalities (a dynamic perspective).

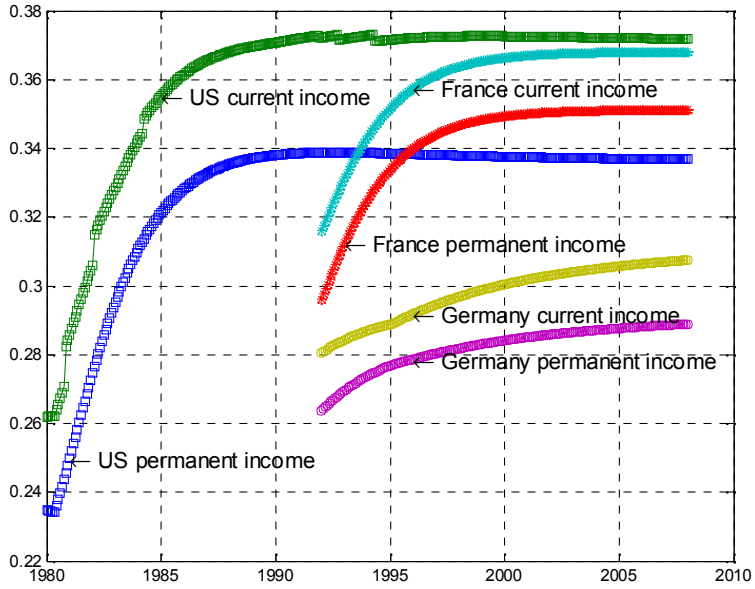
In order to do so, we compute a measure of inequalities based on "permanent income", which accounts for future employment opportunities for each group of workers.[12] So, if there is no mobility from employment to employment (or to an occupation to another) in the economy, this measure is the same as the inequality on current incomes, whereas if mobility is large, the current state does not provide any information about the income status tomorrow and thus all workers can incorporate in his current income the actualized value of these future incomes (a gain if the worker is at the bottom of the distribution, a loss if he is at the top). The results are reported in Figure 9.

- Since the aggregate employment rate increases in the US and in Germany after 1995, the chances to become employed rise. Then, the Gini curves on permanent income shifts downward with respect to its counterparts on current income. In France, labor mobility exists, leading the Gini curve on permanent incomes to shift downward with respect to its counterpart on current incomes. However, at the beginning of the technological transition, this shift is small (a gap of 0.01 between the Gini curves on permanent and current income) relative to what can be seen in the US and Germany (Gini gap of 0.02). This slight difference in the French case suggests that France does not perform as well as Germany and the US in terms of improvement in employment opportunities.
- Interestingly, when considering permanent income France appears more unequal than the US. This is because the relatively weaker contribution of future employment opportunities outweighs the rising generosity of the minimum wage as well as of the income granted by existing assistance programs and unemployment benefits.[13]

[12] We rely on value functions as they capture the discounted value of income given future employment opportunities for each agent in the economy. We compute the monetary income flow that is equivalent to value functions.

[13] This result echoes findings by Flinn (2002).

Figure 9 : Gini coefficients on current income versus permanent income



4. The short-term and long-term effects of labor market reforms

4.a. Evaluation strategy

In evaluating country-specific institutional arrangements, 2 options are possible.

- The first one involves *out-of-sample predictions*, which is the natural way of using a DGE model. This implies forecasting macroeconomic effects of a given policy reform. We chose not to pursue this route because this exercise also implies strong assumptions about technological changes and educational attainment. Thus the evaluation of a change in the evolution of LMI is conditional to a scenario about a lot of exogenous variables.

- The change in LMI presented below rely on *in-sample evaluation*s: given the observed dynamics of technological change and educational attainment, we compute what would have happened if one country had adopted an alternative institutional arrangement. The impact of the policy change is measured as the gap with respect to the benchmark evolution.

- In this paper, the change in LMI is assumed to be decided well before the start of the technological transition and is therefore anticipated by all agents. The extension to non-anticipated reforms at one point in time during the technological transition is left for the next phase of the project.

  For example, in the case of France, in all policy experiments, we compare France (in the benchmark French calibration) to a hypothetical French economy in which some LMI values are set at the US level. As mentioned above, this change in LMI is decided well before the start of the technological transition. As a result, since we consider reforms

that make the French market more flexible, the hypothetical French economy starts with a higher employment rate than observed in the French data.

4.b. Preview of results and intuitions

The model's predictions depend on the wage-setting institutions. In this respect, France differs from Germany. We present in Table 2 the main characteristics of the model: they are presented by distinguishing in two types of adjustment conditional to the existence or not of a minimum wage. We also present synthetically the impact of the labor market institutions in these "two regimes".

Table 2: How does wage-setting affect the model's predictions on the impact of institutional arrangements?

	Centralized Minimum wage (France)	No centralized minimum wage (Germany or US)
Wage setting	-Low-skilled jobs are at the minimum wage ⇔ No wage flexibility -Other jobs (higher skill jobs in particular) bargain their wage ⇔ High wage flexibility	Wage is a weighted average of -a sectoral reference wage and -a time-varying wage (labor productivity in the sector and outside opportunities based on social assistance and unemployment benefits).
Lower EPL	-Effect on aggregate employment -EPL matters when firms are struggling with labor costs. It is the case since the MW increases even in declining sectors	No effect on aggregate employment because wages fall in declining occupations
Lower assistance program (targeted at unskilled workers only) or lower unemployment benefit (for all workers)	-Affects only the employment of workers who bargain their wage through a decline in the reservation wage. -Does not affect employment at the bottom of wage distribution (workers are paid at the minimum wage ⇔ no impact of the reservation wage)	-Boosts employment through a fall in the time-varying part of the wage (which increases the value of employment): the reservation wage declines.

The wage-setting schedule in Germany is an intermediate case between the US flexible wage-setting and the French wage rigidity. Germany combines wage rigidity through the reference sectoral wage and wage flexibility through the responsiveness of the reservation wage to productivity and outside opportunities. The former allows to keep a lid on wage inequality while the latter make the reservation wage responsive to changes in productivity and reforms, which is crucial in easing labor adjustment for unskilled workers.

Table 3 presents a synthetic view of the model's predictions on structural reforms.

Table 3: Model's predictions on structural reforms

Policy	Centralized Minimum wage (France)	No centralized minimum wage (Germany)
Change in wage – setting: towards more flexible wages	**Removal of the MW** • Employment rate goes up by 10 percentage points • The structure of the employment is largely modified: 10 years after the beginning of technological changes, the share of abstract tasks falls from 42% to 36%, whereas the share of the manual tasks rises from 25 to 32% (the chances to be employed are more equally shared between skilled and unskilled workers, they are also higher). • Gini on wage rises from 0.293 to 0.322, 10 years after the beginning of technological changes • Inequalities on permanent income fall (from 0.342 to 0.338) due to the improvement in employment prospects. A switch to a German wage-setting also yields a 10 percentage point increase in aggregate employment. Nevertheless, these employment gains have not the cost of a large increase in inequalities because of the sectoral reference wage which maintains the wage gaps during the technological transition.	**Switch to US wage-setting** • The aggregate employment rate rises by 5 percentage points. • These gains come from the increase of the employment rate of unskilled workers. • Inequality increases, even in terms of permanent income: the income gaps are not compensated by a larger social mobility
Removal of EPL	• Increase the employment level: the EPL is an expected tax that reduces the incentive to hire. • When firms become obsolete, the absence of EPL lead to endogenous destructions: non-employment increases. Limited impact so far (less than 1 percentage point)	• When wage in declining occupations cannot increase, there is no endogenous job destruction • The removal of EPL does not change the equilibrium employment

Lower unemployment benefit • France: a decline in the replacement rate from 0.35 to 0.15 (the UB in the US), whereas in the benchmark scenario, it increases from 0.35 to 0.45 (the observed values in France) • Germany: UB is constant at 0.4 (its level at the beginning of the 80s) compared to a decline after 1995 (benchmark).	• Aggregate employment rate increases by 2 percentage points • Employment rate of skilled workers rises by 4 percentage points, • Employment rate of unskilled rise by only 0.5 percentage points • Fall in wage inequalities (the highest wages are lower) • Fall in permanent income inequalities because employment prospects are improved	• Employment rate increases by 2 percentage points • Unskilled unemployment is more responsive than skilled employment because this is the segment where reallocation takes place • There are more manual and routines jobs than in the benchmark (0.1 percentage point in employment share) • Wage inequalities increase because the lowest wage are the most sensitive to the reform • By taking into account the employment gains, the inequalities of perspective dampens the rise in wage inequalities, but inequalities rises even with this measure
Lower assistance program • France: a decline of the social assistance from 50%. • Germany: constant assistance program at their levels in the 80s, compared with benchmark (assistance program fall after 1995 from 50%)	• Negligible effect on aggregate employment • Unskilled workers would accept lower wages, but it is not possible because of the MW. • This reform, when the economy is constrained by a MW, leads to a large increase in inequality on current and permanent income	• Aggregate employment goes up by 3 percentage points in the short run • Unskilled workers accept lower wages: their employment rate rises. • Wage inequality increases because the bottom of the distribution is lower • Permanent income inequalities fall because employment perspectives rise.

First of all, the table 3 shows that the effect of each policy reform depends on the targeted segment of the labor market. In particular, policy reforms can target only unskilled workers through changes in social assistance programs (since skilled workers are not eligible to these programs) or in minimum wages in France. By altering the segment of the labor market when labor reallocation is intensive due to the technological change, these policies mainly affect unskilled workers' employment. It is also important to notice that the Minimum wage and the social assistance programs affect income inequality through 2 channels: a direct channel and an indirect channel through their impact on aggregate employment. Minimum wage plays a direct role in limiting inequality among employed workers only (insiders). Outsiders (non employed individuals) are, by definition, not eligible to the minimum wage. Secondly, any increase in the minimum wage, by lowering the employment rate reduces the size of insiders in the population. With the creation of non-employment trap at the bottom of the income distribution, the whole economy can be characterized by increased income

inequality even if the minimum wage goes up. At the opposite, social assistance programs affect income inequality through a direct impact on the income of the poorest population (outsiders, non employed individuals). Even if they can also reduce employment via their impact on the reservation wage, they do not create an opposition between insiders and outsiders.

- If we start with the extremity of the spectrum in terms of real wage rigidities, the French case, we are interested in the switch to a more flexible wage-setting. This yields large employment gains, whether through the complete removal of the minimum wage or the switch to a German wage-setting.
    - The effect of the change in minimum wage is large compared to other policy reforms in table 2. This calls for several comments:
        - This sizable effect corresponds to a sizable policy reform: we consider a complete removal of the minimum wage. In the case of a less drastic reform, 1% decline in the minimum wage leads to a rise in the aggregate employment rate of 1.5% and in rise the employment rate of unskilled workers of 3.6% .
        - The large effect is also consistent with the view[14] that the effect of minimum wage on employment depends on its initial level. When it is relatively low and decreasing in real terms as it the case in the US, it is slightly binding, and even for these firms, the constraint disappears over time because the real minimum wage declines. In this case, subsequent decreases might not lead to favorable changes in employment. In contrast, with a high level and a growing real value (which is the case in France according to OECD earnings database), the minimum wage is likely to hamper hiring.[15]
        -
    - The switch to a German wage-setting has also sizable effects on aggregate employment. In contrast to the removal of MW, predicted inequalities are kept under control through the strong impact of reference wage in wage –setting Indeed, the German wage-setting avoids the imperfect treatment of inequalities via social programs. For low-paid workers, the real wage cannot grow at a faster rate than the productivity: the chances to be employed are higher than in an economy with a minimum wage. For inequalities, even if more wage flexibility leads to higher wage inequalities, a smaller fraction of people excluded from employment must be satisfied with the UB or social assistance programs, which are lower current incomes than a low wage.
- On inequalities: The comparison between inequalities based on current income versus permanent income allows to grasp the trade-off between potential short-run costs (worsening of inequalities based on current income) and long-term gains (moving to a more equal economy with larger employment opportunities). Thus if the change in LMI leads to significant improvements in the employment rate, lead by an increase in the job

[14] See Cahuc, Carcillo and Zylberberg (2014)

[15] Unlike the minimum wage in the US which has declined in real terms since the early 1980s, the real minimum wage has been increasing in France since the early 1970s. Thus, the complete removal of the minimum wage removes not only its level effect but also the effects linked to its expected growth along the technological transition.

finding rate (a decline in the unemployment duration). The probability of the upward mobility rises in the expectations of the agents at the bottom of the current distribution, leading them to increase their permanent incomes, whereas, at the top of the distribution, the risk to lose a job did not change. Given that more wage flexibility, lower UB and/or lower assistance programs largely increase the chance to be employed, the inequalities based on permanent income declines. Remark that the impact of a change in UB or in assistance program can have an impact only if there is no minimum wage.

- Indeed, reforms can complement each other. Without minimum wage, the wage-setting rule is more flexible: reforms that change the reservation wage can then be efficient to improve employment rates.
    - When flexible wages and a decline in UB and SP are introduced simultaneously, the flexibility is used to bargain a lower wage, leading firm to hire more workers
    - When reforms on UB and SP are introduced in an economy with MW, they have no impact. Such reforms can boost employment (in particular the employment rate of the low skilled workers) *after* a reform imposing more flexible wages.
    - Reforms reducing the labor cost attenuate the downward trend of the number of routine jobs, leading to damp the decline of the employment share of routine jobs: labor market rigidities increase the fragility of this declining sector by preventing the wage from declining
    - EPL matters only when firms are struggling with production costs, which is the case with rigid wages. Reforming EPL in an economy with responsive wages does not yield sizable effect. Notice that this paper analyzes the impact of EPL in a context of long-run technological changes. This contrasts with the literature studying EPL reforms in a business cycle perspective (as in Cacciatore, Duval and Fiori, 2012) in which firms keep unprofitable jobs in expectations of better times. In this paper, with the fall in the price of computers, firms using routine labor cannot wait for better times.

In the rest of this section, we will present the model's prediction on selected policy reforms in Table 2 in order to illustrate the mechanisms at work in the model. The other policy reforms are available in the Appendix.

We will look at the following cases:

- Towards more flexible wage-setting :
    - Removal of MW in France versus switch to German wage-setting
    - Removal of sectoral reference wage in Germany, with or without the reforms in social assistance in the mid-1990s
- Removal of EPL in France, Removal of EPL in France if the French wage-setting were like Germany

4.c. Towards more flexible wage setting

4.c.1. In France, removing the MW or switching to the German wage-setting

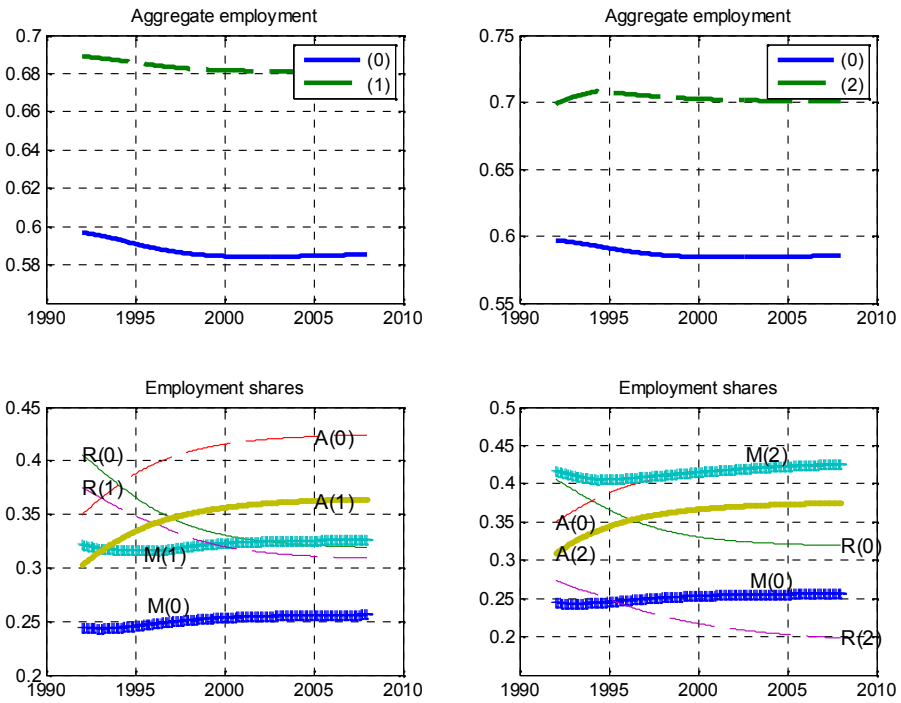
In both cases, there is no longer any centralized minimum wage in France.

The removal of MW (reform (1)) drastically lowers labor costs at the bottom of the wage distribution (which affects all manual workers as well as the lowest ability workers in routine jobs). This tends to boost employment in manual jobs. More routine workers switch occupation to manual jobs. The employment shares evolve accordingly. The share of abstract workers mechanically falls as aggregate unemployment goes up (driven by the hike in employment of unskilled workers).

With a switch to the German wage-setting (reform (2)), the sectoral reference wage introduces wage rigidity. In labor markets with rising demand (abstract and manual jobs), this moderates the wage increase, which increases the value of jobs for firms and favors employment growth for these tasks, while in labor market with falling labor demand (routine jobs), this puts brake on the wage contraction, to the detriment of routine employment. Aggregate employment still increases because of rising employment at the top and bottom of the skill distribution.

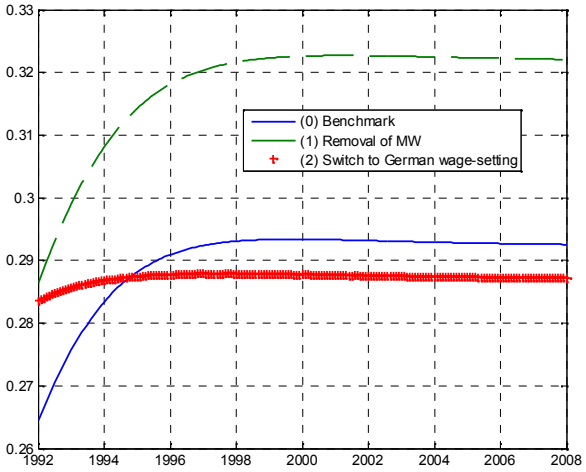
Figure 10 : Towards more wage flexibility in France.

(0)=benchmark. (1): removal of MW in France. (2): switch to German wage-setting in France.



The 2 reforms affect aggregate employment in a similar way. However, interestingly, the impact on inequality is different. Looking at wage inequality (Figure 11), the removal of minimum wage mechanically lowers wages at the bottom of the skill distribution. Wage inequality increases. In the case of the German wage-setting, the presence of the reference-wage in the Nash bargaining results in a stable Gini coefficient along the transitional path.

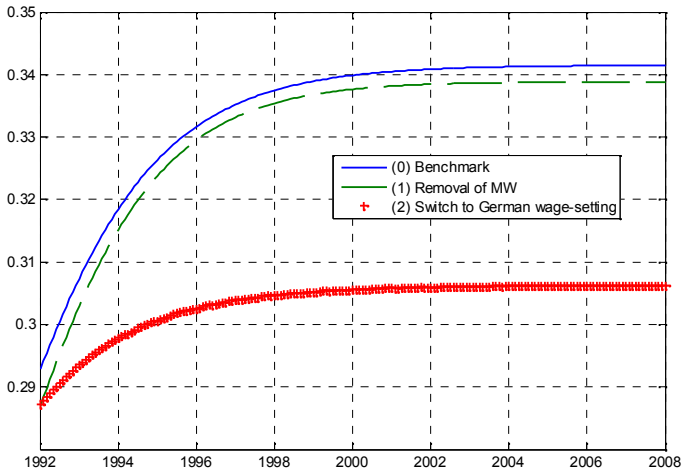
Figure 11 : Towards more wage flexibility in France. Wage inequality.



Because we now considering unemployed workers, the index of inequality based on current income (not reported here in order to save space) increases. Since social assistance programs and unemployment benefits are the same under both reforms, the gap between Gini curves still remain due to the difference in wage dynamics.

More interestingly is assessing the impact of the reforms on permanent income inequalities (Figure 12). The removal of MW improves employment perspectives, which result in lower Gini coefficients than in the benchmark calibration. However, abstract workers keep on benefiting from the technological change through a significant wage growth. This drives the rise in inequalities along the transitional path. Based on the current wage inequality (Figure 11), one might conclude that the MW is an effective tool for reducing inequality. However, a look at Figure 12 suggests that, after taking into account employment prospects, inequalities are not actually drastically reduced by MW. The economy with MW (Gini (0) on Figure 12) is actually slightly more unequal than the one without MW (Gini (1) on Figure 12).

Figure 12 : Towards more wage flexibility in France. Permanent income inequality.

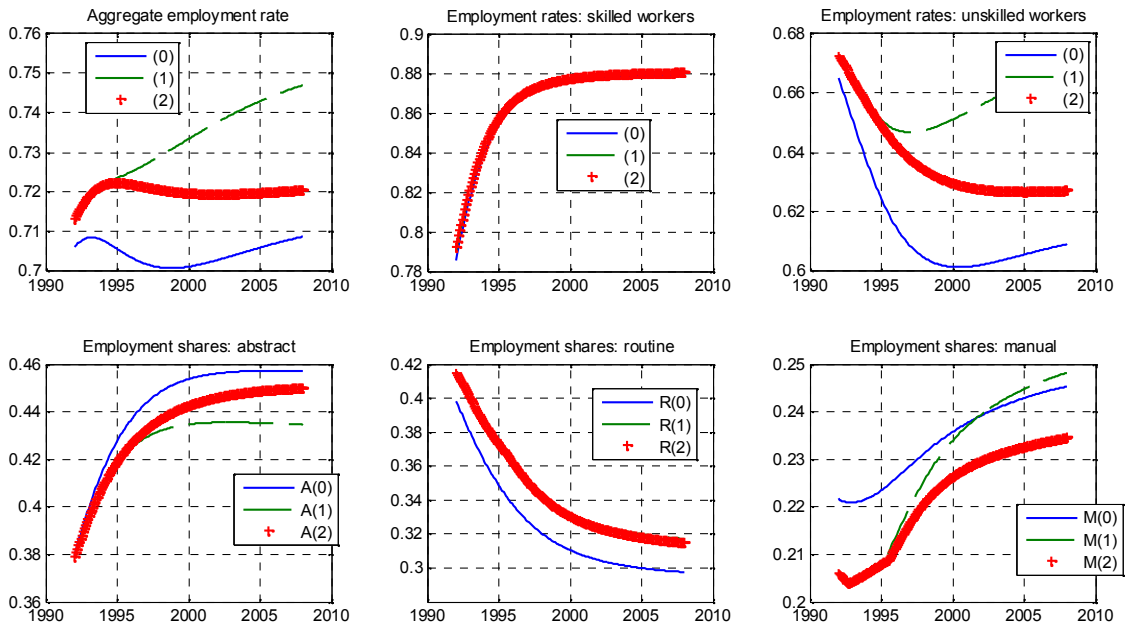


4.c.2. Removal of sectoral reference wage in Germany, with and without the fall in social assistance (SA) and unemployment benefits (UB) after the mid-1990s

The reforms illustrate the different impact on employment and inequalities of wage flexibility per se, and wage flexibility combined with a fall in assistance and unemployment benefits. In both cases, greater flexibility leads to large employment gains, which are stronger for manual workers. These are amplified by reforms in social assistance and unemployment benefits. Indeed, these reforms take advantage of the responsiveness of flexible wages to SA and UB. This conclusion is drawn from Figure 13. With flexible wage and fall in SA and UB, aggregate employment goes up by 5 percentage point at the end of the transition while the employment gains are divided by two (2 percentage point increase) in the case of Germany if the LMI reforms had not taken place.

Figure 13 : Switch to US wage-setting in Germany.

(0)=benchmark. (1): Switch to US wage-setting. Reform (2): Switch to US wage-setting without the fall in social assistance and unemployment benefits after the mid-1990s



The switch to wage flexibility increases current income inequality (Figure 14, Gini coefficient (1)). The increase in current income inequality can be dampened if SA and UB do not fall along the transition path (Figure 14, Gini coefficient (2)). However, whatever the scenario of wage flexibility, both Gini curves lie above the benchmark calibration (0). The switch to a more flexible wage rule unambiguously leads to more unequal current income distribution.

Do improved unemployment prospects compensate for the widening wage inequality? Based on Figure 15, the answer depends on the scenario for SA and UB. If SA and UB fall (Gini (1)), improved employment prospects cannot compensate for the widening wage dispersion (Gini (1) lies above Gini (0)). In contrast, in the case of maintained UB and SA (Gini (2)), then inequality based on permanent income fall with respect to the benchmark (Gini (2) lies below Gini (0)).

Figure 14 : Switch to US wage-setting in Germany. Current income inequality

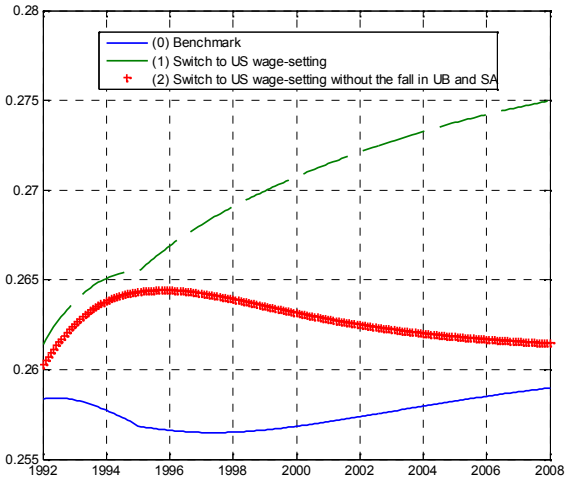
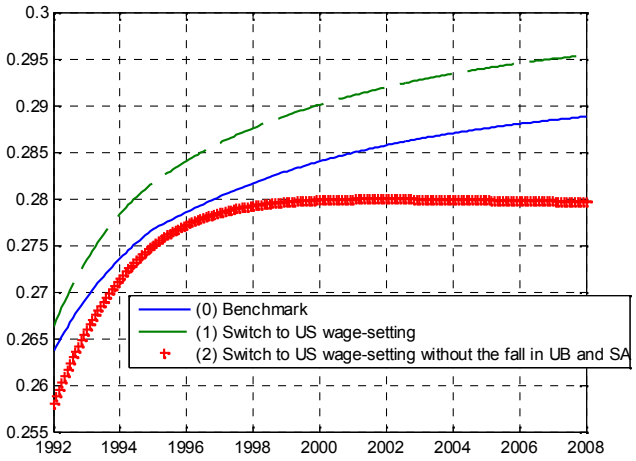


Figure 15 : Switch to US wage-setting in Germany. Permanent income inequality.



4.d. Removal of EPL in France

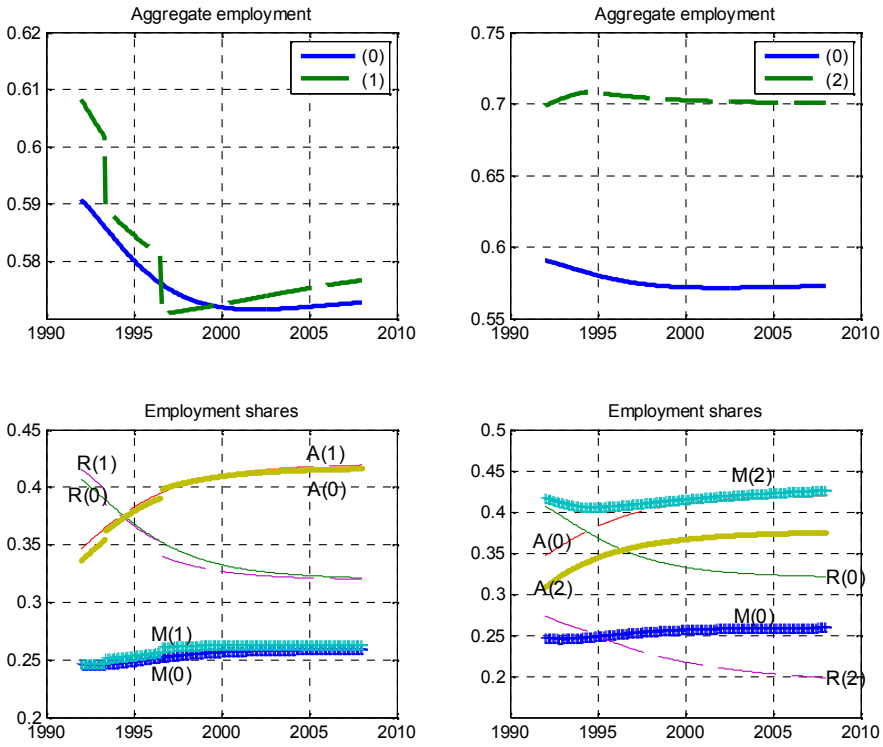
We present the following cases

- Removal of EPL in France
- Removal of EPL in France with ALMP
- Removal of EPL in France with switch to German wage setting

We show that removal of EPL generates short term costs that disappear if ALMP is implemented at the same time. We also show that removal of EPL has little impact if the wage-setting rule is flexible.

Figure 16 displays the evolution of aggregate employment in France in the benchmark calibration versus a hypothetical French economy with no firing costs.

Figure 16 : Removal of EPL in France. (0) benchmark, (1) Removal of firing costs, (2) Removal of firing costs and switch to German wage-setting

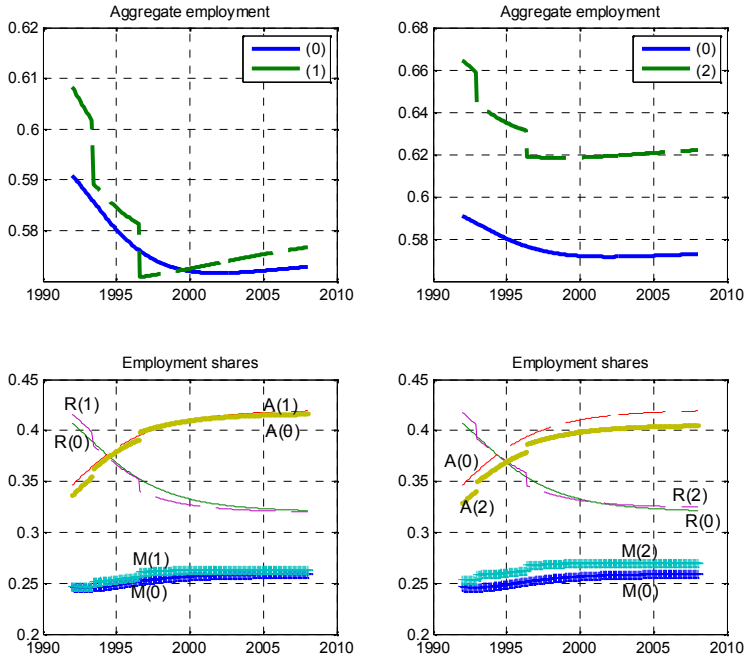


France is characterized by a high and increasing real minimum wage. This puts pressure on the profitability of routine jobs (which are penalized by technological progress), thereby pushing some firms to shut down when profit becomes negative. If firing costs are high, firms maintain non-profitable jobs, waiting the job destruction though the exogenous separation process (not costly) and thus avoid paying the firing costs. At the opposite, in the case without firing cost, firms destroy the jobs generating negative profits. Given that the institutional change is anticipated, a low EPL leads firms to be less selective during the hiring process: given that low productive jobs can be destroyed freely, they are created when it exists positive profit. Finally, remark that EPL, by maintaining employment in declining sectors, slowdowns the reallocation process: 3 years after the last wave of firings, the economy without EPL has a higher employment rate, the worker having earlier the opportunity to reallocate their work effort. The fall in EPL hence induces two waves of firings in the hypothetical French economy, as can be seen from the sudden drops in aggregate employment on Figure 16. These successive falls in employment constitute the short-term losses associated with a relaxation of job protection laws. The model predicts that firings occur in routine jobs, which is the segment of the labor market with falling labor demand (as can be seen on Figure 16 with the 2 sudden drops in routine employment shares). The short-term losses remain quantitatively small. The extension to non-anticipated reforms might yield larger short-term losses.

Since the disappearance of EPL generates larger outflows from routine jobs, more workers are faced with the choice of occupational changes. More workers switch occupations, hence employment in manual jobs as well as the share of manual employment go up.

Using a combination of ALMP [16] and lower EPL (Figure 17), the model predicts that, even if the 2 waves of firings occur, policy makers can actually avoid short-term losses.

Figure 17 : Removal of EPL in France. (0) benchmark, (1) Removal of firing costs, (2) Removal of firing costs and ALMP

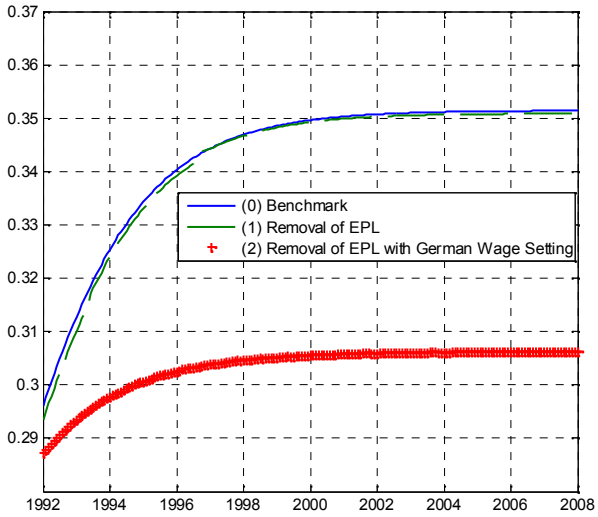


With the switch to German wage setting rule and removal of EPL, the quantitative effects look like the switch to the German wage setting alone (Figure 16 (2) looks like Figure 10 (2)). The fall in EPL does not add additional gains with respect to the switch to German wage setting. No firm actually struggles with production costs in the case of the German wage setting rule. In spite of the downward wage ridigity introduced with the sectoral reference wage, the time-varying part of the wage is enough to avoid shutting down factories. This illustrates the difference between the German wage setting and the minimum wage that increases in real terms, even for jobs in declining segments of the labor market.

The fall in EPL per se has little impact on inequalities on permanent income (Figure 18) while the switch to the German wage-setting combined with EPL leads French inequalities to look like what would have happened with the switch to the German wage – setting along (Gini (2) on Figure 12).

[16] As in Cacciatore, Duval and Fiori (2012), a strengthening of ALMPs is modelled in a stylized way as an increase in the efficiency of the job matching process. This captures 'threat effects' from institutional mechanisms such as compulsory participation in active labour market programs or referral to ALMPs under threat of benefit sanctions.

Figure 18 : Removal of EPL in France. Gini coefficients on permanent income



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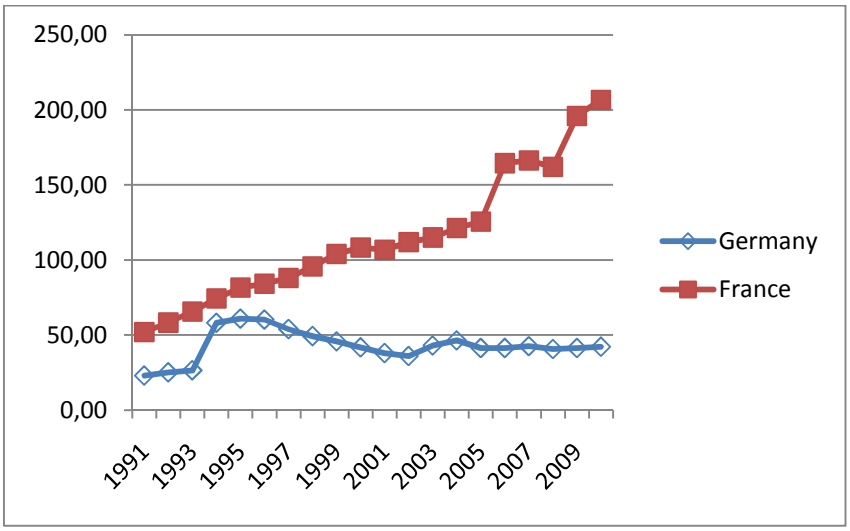
Appendix 1 : the model

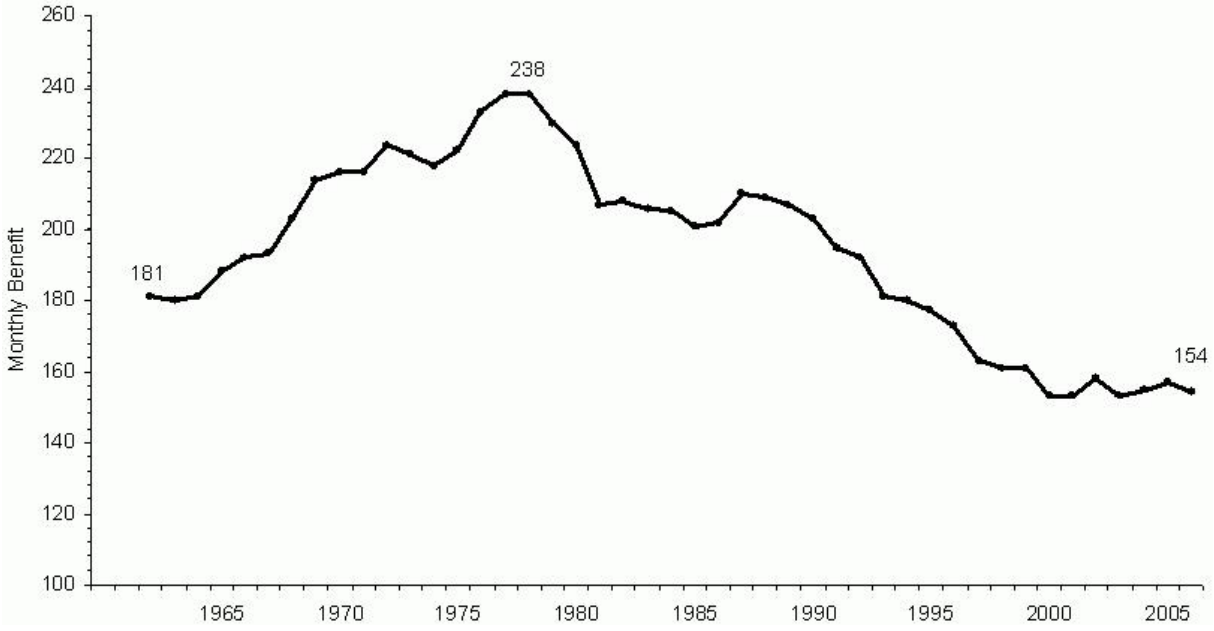
Empirical evidence to support our calibration of assistance programs, unemployment benefits and bargaining power

Social protection benefits – Social Exclusion, Euro per inhabitant (at constant 2005 prices)



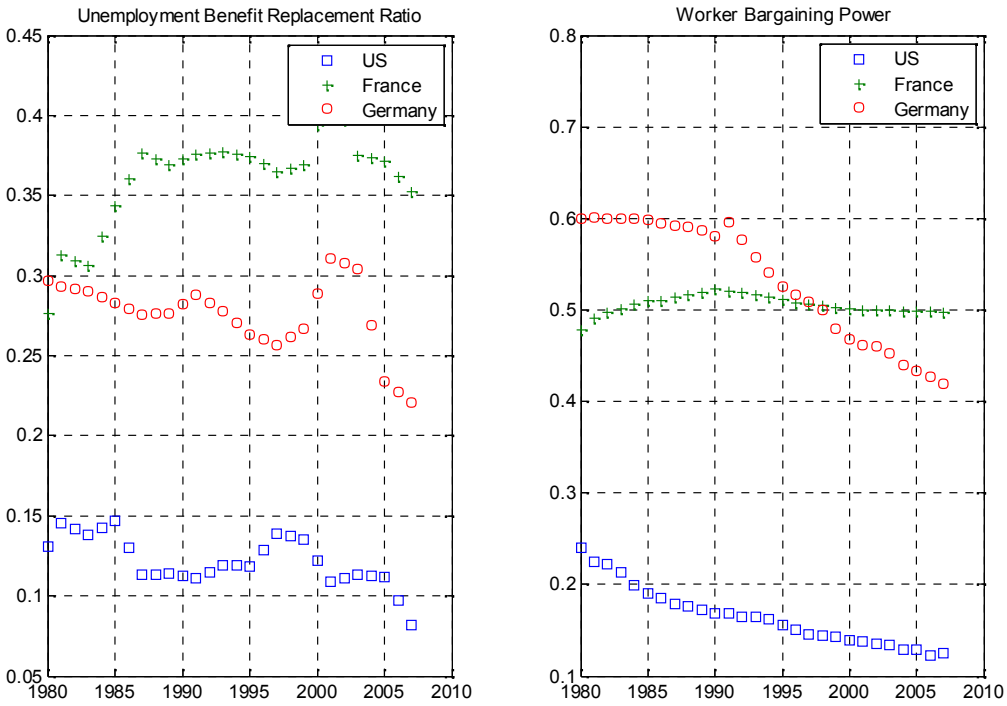
Source: Eurostat

Temporary Assistance for Needy Families (TANF) and Aid to Families with Dependent Children (AFDC) in the US. Average Monthly AFDC/TANF Benefit per Recipient in Constant 2006 Dollars



Source: U.S. Department of Health and Human Services, Administration for Children and Families, Office of Family Assistance, Quarterly Public Assistance Statistics, 1993

Unemployment Benefit and Workers' Bargaining Power



Source : OECD data on UB replacement rate. The bargaining power is the average the union density and the union coverage from the Database on Institutional Characteristics of Trade Unions, Wage Settings, State Intervention and Social Pact (ICTWSS)

Appendix 2 : the French case with a payroll tax subsidies (PTS) introduced in 1997

From the view point of the firm, the PTS is equivalent to a reduction in the minimum wage. Thus, in a labour market equilibrium binding by a minimum wage, the introduction of the PTS reduces the increase of the real minimum wage: this policy then promotes the employment (see Figures A2.1). For the workers, the level of the minimum wage is preserved: this insure the same gap between the lowest and the highest wage. But there the PTS generate some employment gains which reduce the permanent income inequality. Nevertheless, the Figure A2.2 shows that the impacts of the PTS on inequalities are small. Thus, to omit this policy in the results presented in the main text can be considered as a good approximation of the main forces at work in the long run trend of the labour market.

Figure A2.1 : Employment dynamics with and without payroll tax subsidies (France)

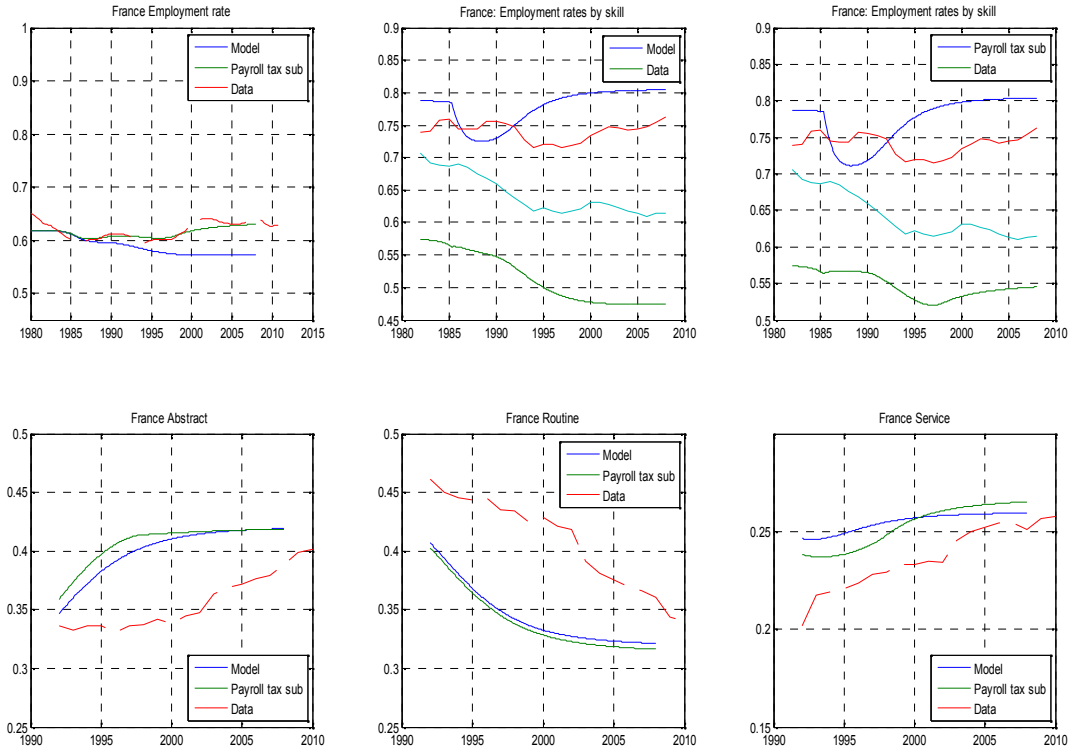


Figure A2.2 : Inequalities with and without payroll tax subsidies (France)