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Accounting for labor gaps

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ABSTRACT

This study explains the impact of taxes and labor market institutions on the total hours observed in France, Germany, the United Kingdom, and the United States. We develop a balanced growth model with matching frictions in the labor market distinguishing between the extensive margin and intensive margin of labor supply. We show that (i) hours are more sensitive to changes in taxes, whereas employment reacts more to shifts in labor market institutions and (ii) a substitution effect exists between employment and hours. Counterfactual experiments show that if France had experienced the same trend in labor market institutions as the United States, its employment rate would have increased by 25 percentage points, whereas its number of hours worked per employee would have reduced by 1 percentage point. If France had chosen the US' paths of both taxes and labor market institutions, then its employment rate would have been larger by 20 percentage points and the number of hours worked by employees would have been larger by 3 percentage points than the current one, a situation observed before the 1970s.

1. Introduction

The total hours worked (total hours hereafter) during the post-WWII period have been characterized by (i) a sharp decline in France and Germany, (ii) a less significant decline in the United Kingdom, and (iii) an increase in the United States (see Fig. 1, left panel). Whereas in the 1960s, total hours were 15% higher in Europe than in the United States, today they are 20% lower. The works by Layard and Nickell (1999) and Blanchard and Wolfers (2000) show that shifts in tax rates and labor market institutions (LMIs) have significantly influenced labor market aggregates. Nevertheless, owing to the lack of a structural approach, little is known about the labor market outcomes that would have been realized if countries had not experienced the changes in policy variables observed during the past 50 years. In this article, we aim to bridge this gap by explaining the trends in total hours using a dynamic general equilibrium model compatible with a balanced growth path, and performing some counterfactual experiments in order to study the effects of different policy frameworks. In our model, the structural changes that can drive these trends are long-run shifts in taxes, LMIs, and technological progress. We provide an original quantitative investigation by paying attention to the difference in the trends of the two margins that compose total hours: hours per worker (the intensive margin) and the number of employees (the extensive margin). Indeed, the second and third panels of Fig. 1 show that these two margins have specific dynamics within countries. While the decline in

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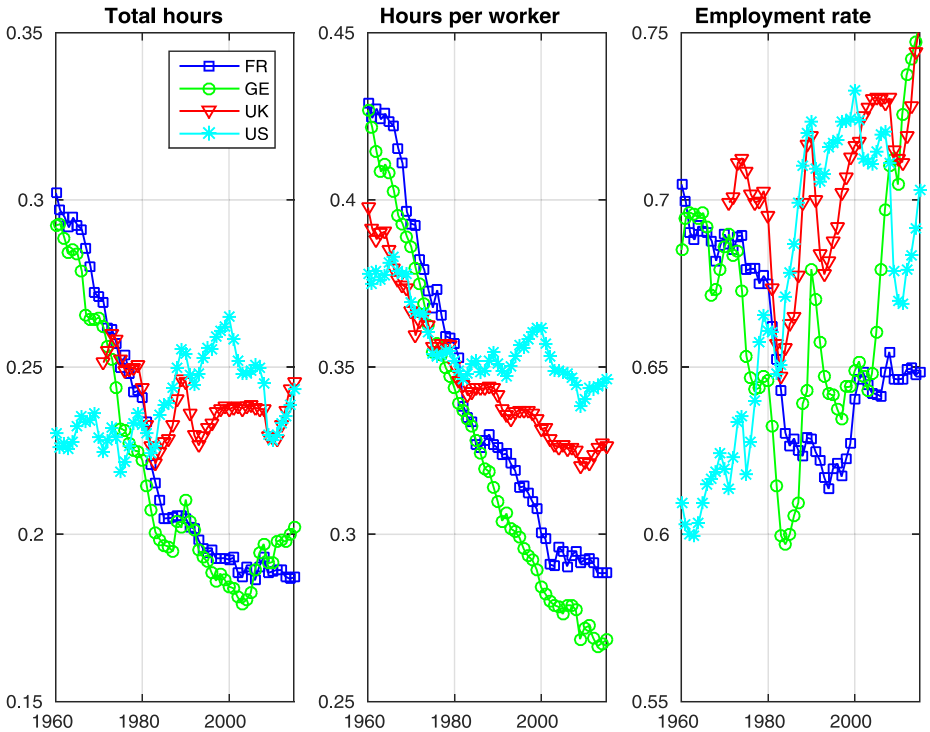

Fig. 1. *Total hours 1960–2015: trend and decomposition.* Total hours are given by the number of hours per year per worker multiplied by the number of employed. We normalize total hours by dividing them by the working age population and a measure of total workable hours. Hence, the measure we report is ($\frac{N \cdot h}{14 \cdot 365}$).

total hours in Germany is driven by a fall in hours per worker, in France both the employment rate and hours per worker have decreased; in the United Kingdom, both margins have experienced a similar trend to that in the United States.

In the first part of the paper, we measure the differences in trends for the two margins composing total hours. We also provide measures of the significant heterogeneity in the trend of tax rates and LMIs. By contrast, we show that the European process of catching up with US total factor productivity (TFP) is shared by the three European countries.

In the second part of the paper, we develop a dynamic general equilibrium model in which the employment allocation is governed by a matching process and hours worked per employee are efficiently bargained.[3] This class of macroeconomic model provides a way to analyze labor market adjustments on both margins. In our model, employment wedges are directly generated by taxes and LMIs, whereas efficient bargaining on the number of hours worked per employee implies that only tax distortions can have a direct impact on hour wedges. Beyond these direct effects, indirect channels through wealth effects explain the interactions between the two margins and thus the dynamics of the two wedges. Indeed, in a general equilibrium framework, the impacts of policy changes (taxation and LMIs) depend crucially on the adjustments of both margins of total hours. These two margins can be considered as substitutes because policies increasing the cost of job creation reduce the employment rate but can lead to an increase in hours worked per employee through the negative wealth effect induced by the scarcity of jobs. Solving under the perfect foresight assumption, we ensure the consistency of the paths of the endogenous variables (the equilibrium paths of the labor market aggregates) with the structural changes of these country-specific exogenous variables (tax rates, LMIs, and productivity series).[4] We then show a non-trivial interaction between the two labor margins, leading to a substitution between hours per worker and employment. Moreover, taxes and LMIs do not have the same impact on these substitutions. A change in LMIs has a direct impact solely on the extensive margin: lowering wage pressures (by reducing the bargaining power of workers or their unemployment benefits) increases the level of hiring. In our dynamic framework, this is perceived as a positive wealth effect, leading households to reduce their hours worked as employees. By contrast, a reduction in tax affects both the extensive and the intensive margins. This provides incentives to increase efforts at work (intensive margin), with the side effect of raising disutility at work and thus the reservation wage. Therefore, this last effect counteracts the positive (direct) impact of the tax decrease on labor costs. Thus, the employment rate is less sensitive to tax reforms, whereas the hours per worker rate is highly sensitive to them.

[3] The model is close to the early contributions of Langot (1995) and Andolfatto (1996) in the context of business cycle analysis.

[4] Accounting for intertemporal choices is not negligible when the drift in the tax rate is time-increasing, thereby leading individuals to work more today and postpone their leisure time. This is not the case in a static framework in which an increase in tax can only reduce the successive equilibrium hours worked.

The responses of the two margins interact, supporting the idea that the changes in the extensive and intensive margins are not independent.[5]

From a quantitative point of view, we show that our model predicts both the slope of the continuous decline in hours per worker in all European countries and the considerable changes in employment rates. This result is obtained under the assumption of identical preferences for leisure across countries[6] and using a calibration strategy under which the structural parameters are identified by targeting the average hours per worker and employment over the sample. This suggests that without taking into account any business shocks, the trends in both margins composing total hours are mainly driven by long-run shifts in taxes and LMIs. Since the United States did not experience the same shifts in taxes and LMIs as the European countries, the large structural gaps in terms of the total hours of continental European countries with respect to the United States can be viewed as the result of their market designs. Our chronological analysis also allows us to detect the country-specific changes that explain these structural gaps and their trends: the experience of Thatcher in the United Kingdom, the one of Mitterrand in France, and those of Kohl–Schröder in Germany. We show that these policy experiences have high persistence (akin to a structural change) and thus produce long-run shifts in total hours.

Finally, taking advantage of our structural approach, we show that a hypothetical French economy experiencing the paths of taxes and LMIs of the United States would have seen its employment rate increase continuously, from 70% to 87%, and would have reduced the decline in its hours worked per employee by 4 percentage points. If only US LMIs were "imported" in the French economy, the employment increase would be the same, whereas hours worked per employee would be lower than that currently observed over the sample. These substitution effects between the two margins underline the complementarity of a simultaneous change in tax and LMIs that affects both components of total hours. Our general equilibrium approach also allows us to measure the output losses induced by French labor market distortions. Since 1981, these losses have grown steadily to reach 7 percentage points of the level of potential output each year after 2010.

In terms of the related literature, Fang and Rogerson (2009) have already shown that the two margins of total hours can be considered as substitutes. However, they only perform a steady-state analysis in a partial equilibrium framework. We thus go beyond their work by taking into account the intertemporal substitution effects as well as the wealth effects generated by saving. Our quantitative analysis follows the method developed by McDaniel (2011), who considers a neoclassical growth model of labor supply, extended to include home production and subsistence consumption, and analyzes the trend in total hours for 15 OECD countries. According to the author, 80% of the change in total hours can be explained by the trend in tax rates and 20% by labor productivity. Ohanian et al. (2008) compute the wedges of the first-order conditions (FOCs) governing labor supply in a neoclassical growth model with annual frequency data for a large set of OECD countries, while Prescott (2004) computes this static wedge at two points (the early 1970s and the mid-1990s).[7] Quintero Rojas and Langot (2016) measure the static wedges of the FOCs of a matching model. We thus depart from these papers, since we account for the whole time path of the endogenous variables. This is not a negligible contribution because it is the only way to measure the labor gaps as the paths generated by structural changes. Indeed, the measures resulting from the static wedges of FOCs use the observed endogenous variables at each time point, which can be affected by changes other than those related to taxes, LMIs, and TFP. The experience is then not completely isolated, contrary to our case where only exogenous variables are used.

The remainder of this paper is organized as follows. Section 2 documents the data used. In Section 3, the search and matching model is outlined. Section 4 calibrates the model's key parameters and applies it to the data. In Section 5, we present the results of our counterfactual experiments. Section 6 concludes.

2. The basic facts

In this section, we describe the data we use for the United States, France, Germany, and the United Kingdom. We consider the United Kingdom as an "intermediate" case, lying somewhere in between the United States and the continental European cases. With respect to Germany, most of the data (e.g., GDP, hours) have been reconstructed to correspond to the reunified country after 1989. However, the variables that measure labor market arrangements are not typically comparable between the two economies of West and East Germany.[8] We therefore decided to consider the simulations for Germany for the past 20 years (i.e., from 1990). Our choice of countries is interesting from the perspective of testing the theory. Since the exogenous variables (taxes, LMIs, and TFP) do not have the same dynamics over this time period, we expect that the same will apply for the endogenous variables, namely hours per worker and employment rates.

[5] This point is also underlined by Chang et al. (2012). These authors, however, use a model without labor market frictions in which the shift in LMIs cannot be analyzed.

[6] Hence, we abstain from using a "cultural" interpretation to explain the differences in hours worked across countries. See, for example, Alesina et al. (2006), where externalities in the utility from leisure at a society level can generate a "social multiplier".

[7] Ljungqvist and Sargent (2007) underline that the standard neoclassical growth model used by Prescott (2004) cannot account for the observed impact of both taxes and LMIs. The neoclassical growth model, as adopted by Prescott (2004) and McDaniel (2011), can therefore be considered as a parsimonious approach to evaluate the impact of the observed tax changes on aggregate worked hours. However, in this model, the labor wedge is reduced to the tax wedge. Ohanian et al. (2008) show that the labor wedge computed with a model that merges hours worked per employee and the employment rate is not independent of LMIs such as the unemployment benefit system or the type of wage bargaining arrangement.

[8] For the years before reunification, data on LMIs (i.e., the generosity of unemployment benefits and workers' bargaining power in our case) refer only to West Germany.

Table 1
Ratios.

Ratios in 2015 relative to 1960	US	FR	UK	GE
Total hours ($\frac{Nh}{Pop \cdot 365 \cdot 14}$)	1.06	0.62	0.98	0.69
Employment rate ($\frac{N}{Pop}$)	1.15	0.92	1.08	1.10
Hours per worker ($\frac{h}{365 \cdot 14}$)	0.92	0.67	0.91	0.63

For the United Kingdom, we report the ratios in 2015 relative to 1971.

2.1. Hours per worker and employment rates

In this section, we present the basic facts taken into account in our model.[9] Fig. 1 describes the dynamics of hours worked and employment in the selected countries. Table 1 summarizes these data.

The trend in total hours differs widely over the past 50 years in the selected countries. While total hours slightly increased in the United States, they declined considerably in France and Germany, with their trend in the United Kingdom being somewhere in between. This trend is caused, as we have seen, by the path of the two margins that compose total labor input: the intensive and extensive margins.

The American "jobs miracle" that began in the 1960s was characterized by an increase in the employment rate and a small decline in hours worked per employee. Germany and the United Kingdom show comparable employment rate trends, but only after the 1980s; in the United Kingdom, the employment rate recovered after the crisis of the early 1980s, while the break in Germany seems to correspond to the reforms implemented by Schröder and Hartz[10] in the early 2000s. As shown in the right panel of Fig. 1, the United Kingdom and Germany closed the "employment gap" with respect to the United States just before the Great Recession and then suffered a lower decrease during the crisis, so that today they show a higher employment rate than the United States. By contrast, France performed particularly poorly. Its employment rate fell from 70% to 65%, as shown in the right panel of Fig. 1, following the presidential election of Mitterrand in 1981. Because the last part of the paper compares the United States with France, we retain 1981 as a break date in the following.

If we look at the intensive margin, in the central panel of Fig. 1, we observe a sharp decline in France and Germany, while hours per worker declined only marginally in the United States. The United Kingdom seems to share the trend of its continental neighbors, but only until the beginning of the 1980s when the decline slowed. Since then, hours worked per employee has been stable and only slightly lower than those of an American worker.

We can measure the gap in total hours worked between country i and the United States, namely $Gap_{i,t} = N_{i,t}h_{i,t} - N_{US,t}h_{US,t}$, as well as the contribution of employment rates and hours per worker to this gap. To measure these two contributions, we follow Rogerson (2006). We consider two hypothetical cases. In the first scenario, the relative employment changes in country $i \neq$ US did not happen and the employment rate evolves as in the United States; in the second case, the relative changes in hours worked by employees in country $i \neq$ US did not happen and effort at work evolves as in the United States. Hence, the series "*N contribution*" are the number of additional hours that economy i would have worked at time t if its employment rate were the same as in the United States. The comparison of these series with the observed differential in relative total hours ($Gap_{i,t}$) provides us with a measure of the employment rate contribution. If the contribution of employment to the total hours gap is significant, we expect a series of hypothetical total hours close to the gaps in actual hours. We replicate the same computation for the contribution of hours worked by employees ("*h contribution*").[11]

Fig. 2 reports the results for France, Germany, and the United Kingdom, where the reference year is $t_0 = 1981$. As expected, the size of the gap is smaller in the United Kingdom than in France and Germany. From the beginning of the 1980s, the three European countries exhibit differing experiences. In Germany, the contribution of the employment rate is small and even positive at the end of the period, showing that this country provides the same employment rate as the United States. This dynamic, in terms of the relative influence of the employment rate on the hours gap, is shared by the United Kingdom. Thus, for these two countries, the gap with the United States is the result of a smaller number of hours worked per employee: the losses in Germany and the United Kingdom are 270 h and 75 h per year, respectively. In France, the experience is different: from 1985 to 2000, the most significant contribution to the hours gap is the low employment rate in the French economy. During this period, the losses due to this "underemployment" are equal to 150 h per year per participant. At the same time, hours per French worker make a strong contribution to the hours gap (approximately 150 h per worker on average since 1980). Thus, both gaps in France are significant and of a similar magnitude.

2.2. Taxes, LMIs, and technological progress

To account for these country-specific patterns in total hours, we introduce three groups of time-varying exogenous variables into our model: a set of tax rates that defines the tax wedge (tax on labor income and consumption), a set of variables

[9] Appendix A describes the data sources.

[10] These new laws regulating the labor market raised access to part-time work and reduced labor costs. Thus, hours per worker do not increase, whereas by the end of the sample, the employment rate has surpassed that observed in the United States for the first time since the end of WWII.

[11] See Appendix B for more details on this decomposition.

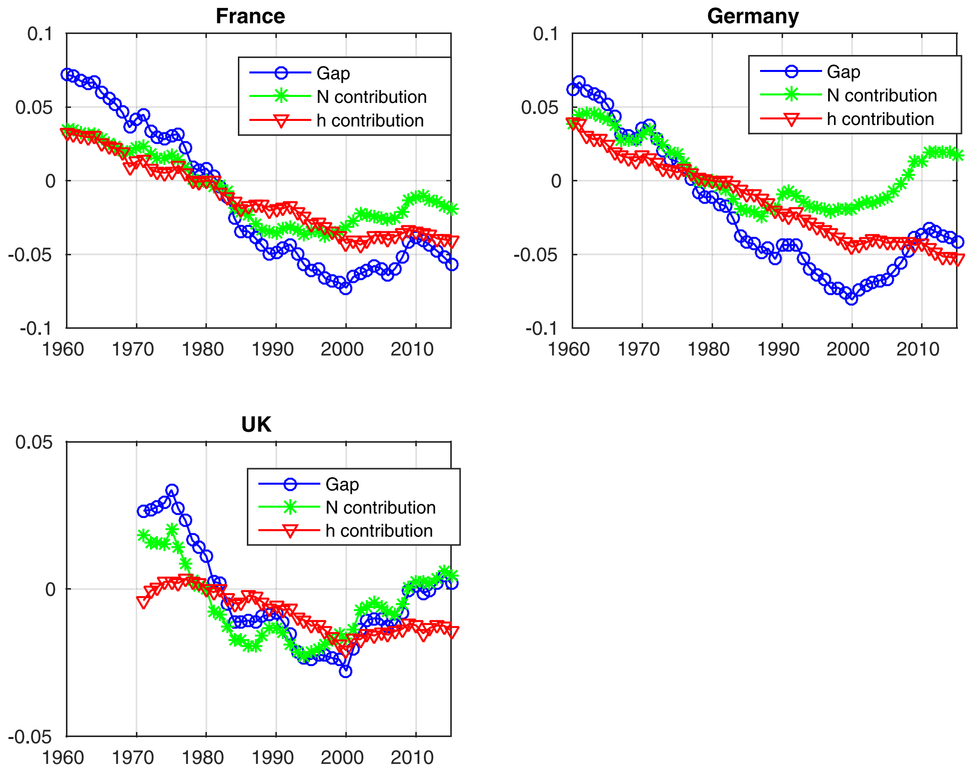

Fig. 2. *Decomposition of the total hours gaps.* In each panel of Fig. 2, for each country, the reference year (t_0) is 1981. Total hours Nh are multiplied by 365*14. In 1960, a French worker worked 7% more than an American worker in comparison with 1981, the reference year for this gap. At this time, the contributions of the employment rate and hours worked by employees to this gap were equal (3.5%), meaning that a French worker had more chance of being employed and worked longer than an American worker.

summing the LMIs (the replacement rate and an indicator of the level of unionization, representing the bargaining power of the worker), and the Solow residual of the production function, representing TFP.[12]

We also consider the tax rates on capital revenues and investment[13] and categorize government expenditure into collective and individual. According to the OECD,[14] government expenditure on collective consumption refers to expenditure that benefits society as a whole, or large parts of it, through the provision of public goods or services (e.g., defense, justice), whereas expenditure for individual consumption is typically that spent on health care, housing, education, and so on.[15] The rationale for this distinction lies in the fact that the part of consumption that the government uses for individual services can be considered as a perfect substitute for private consumption, while collective services cannot be bought in the private market by households. As shown in the following section, we consider expenditure on collective services as entering into the utility function of the household in a separate way.

We can use these data in two ways. We can extract their trends and only use the smoothed components as the inputs of the model or we can use the raw data. The problem with the first strategy is that it suppresses (by a smoothing effect) the possibility of a chronological discussion of the output of the model and its interpretation based on historical events. If we consider the raw data, we can use their breaks to detect periods of country-specific policy changes. The problem with this last strategy is that transitory policy changes are also kept in the data and used as inputs of the model.[16] We favor this last strategy, which is more constraining for the model but also allows easier interpretations of the historical trends.

2.2.1. *Taxes on labor and consumption*

Fig. 3 reports the trends in consumption and income taxes. The tax wedge was stable throughout the period in the United States: to consume \$1, it was necessary to produce \$1.27 in 1960 and \$1.37 in 2015. By contrast, in France, the tax wedge

[12] Appendix A describes the data and data sources in detail.

[13] See Appendix E.1.

[14] See https://data.oecd.org/gga/general-government-spending-by-destination.htm.

[15] See Appendix E.2 for more details.

[16] For example, this is the case for the increase in unemployment benefits decided by the Obama administration during the last recession. These benefits strongly increase and return to their initial level seven years after the beginning of the crisis. A criticism of our strategy is how to keep the policy change without explaining the cause of the recession motivating this policy. Therefore, we can only explain the decline in the US employment rate during the last

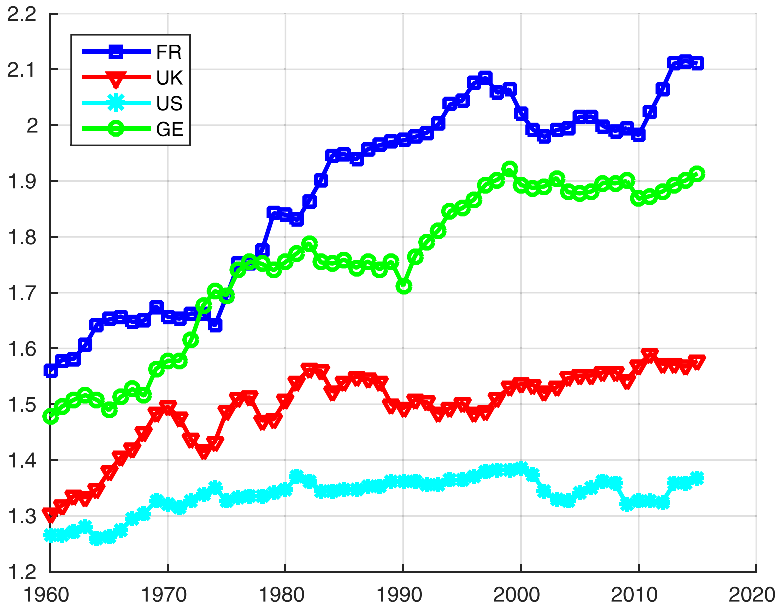

Fig. 3. Tax wedge $\frac{1+\tau_c}{1-\tau_w}$.

increased rapidly between 1960 and 1985 and continued to grow afterward at a lower rate: to consume $1 it was necessary to earn $1.56 in 1960 and $2.11 in 2015. In Germany, the tax wedge increased through the 1970s and 1990s, reaching a level today similar to that observed in France. In the United Kingdom, the tax wedge increased until 1980 and then remained stable at a level closer to that observed in the United States than in the continental European countries.

These data suggest two things in a world in which all employees have a job ($N = 1$). Firstly, the "static" effect of the taxes can reduce the number of hours worked by employees. Secondly, the "dynamic" effect induced by the intertemporal substitution can lead to an increase in labor supply at the beginning of the sample, when the taxes on labor are low, which is then compensated by a continuous decline.

2.2.2. LMIs

We consider two LMIs: a measure of the bargaining power of the worker and the unemployment benefit replacement rate. The data on bargaining power are taken from the Institutional Characteristics of Trade Unions, Wage Settings, State Intervention and Social Pact (ICTWSS) database.[17] Two statistical indicators provide an indirect measure of the bargaining power of the employee during the wage bargaining process: union coverage (UC) and union density (UD). These two indicators are closely linked to bargaining power: wide UC or high UD enable the worker to make counteroffers during the bargaining process. We choose to evaluate the worker's bargaining power by averaging UC and UD.[18]

The left panel of Fig. 4 reports the trend of the bargaining power of workers, suggesting that the influence of these institutions is different across our selected countries. We observe a continuous decline in the United States, while the United Kingdom and Germany showed a significant decline in the 1980s and 1990s, respectively (recall that for Germany, the data before reunification correspond only to West Germany). At the opposite end of the spectrum, France is characterized by a continuous small increase over the sample.

These trajectories are mainly explained by the fact that unions declined in density across all countries, but France overcompensated for these losses by increasing UC, promoted by the French governments during the 1980s. The break in the data for the United Kingdom is due to the labor market reforms promoted by the first Thatcher government. In Germany, after a brief surge in union membership after reunification, unions lost force during the 1990s.[19] The additional decline in

recession using the rise in unemployment benefits. As we will see after, given that agents know that this policy is transitory, our dynamic model predicts that its negative impact on the employment rate is negligible.

[17] J. Visser, ICTWSS database version 5.1. Amsterdam: Amsterdam Institute for Advanced Labour Studies, University of Amsterdam. September 2016.

[18] See Appendix D for a discussion of this measure.

[19] According to the European Foundation for the Improvement of Living and Working Conditions (https://www.eurofound.europa.eu/observatories/eurwork/articles/industrial-relations/trade-union-membership-and-density-in-the-1990s), "After German unification, West German trade unions expanded into East Germany, taking over East German trade unions and most of their members. As a consequence, total union membership rose to more than 13.7 million in 1991. Since then, however, total membership has fallen every year [...]. From 1991 to 1998, German trade unions lost almost 3.5 million members. A large share of these losses seem to stem from eastern German workers leaving the unions because of unemployment and disillusion with the western-

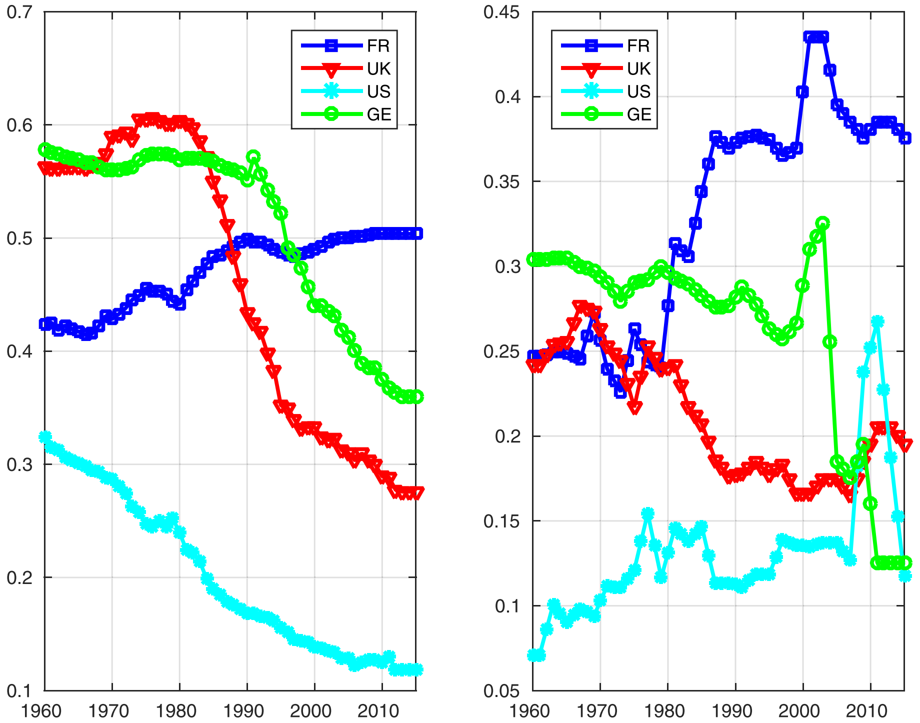

Fig. 4. LMIs: bargaining power of workers (left) and replacement rate (right).

the 2000s is linked to the impact of the Schröder governments, which limited the role of unions to achieve more flexibility in hiring and firing rules.

The indicator of the replacement rate is provided by the OECD. This is a measure of gross non-employment income over an unemployment period of five years. Since it is available only for uneven years, we linearly interpolated the missing values.

Concerning unemployment benefits, the dynamics of the replacement rate also different markedly across countries, as shown in the right panel of Fig. 4.

After a slight increase before the mid-1970s, the replacement rate in the United States remained constant. The spike in recent years was due to an increase in the length of the period in which workers can collect unemployment benefits, a measure adopted after the 2008 crisis.[20] While the replacement rate in the United Kingdom at the beginning of the sample was similar to that in France, it reduced during the Thatcher government. At the beginning of the 1990s, with the Kohl government, Germany experienced a decline in the replacement rate. Between 1993 and 1997, three laws led to a reduction in the number of people eligible for unemployment insurance and a reduction in the replacement rate. The first Schröder government chose to backtrack on these labor market reforms; however, the labor market outcomes led the second Schröder government to reintroduce more flexibility. After 2002 and the implementation of the Hartz reforms, the decline in the replacement rate was greater. The French experience has been different. The first socialist government (at the beginning of the 1980s) increased unemployment benefits by more than 50% and the second (the end of the 1990s) rose them by 13%.[21]

The basic DMP model, with constant hours worked by employees, suggests that large bargaining power or a high replacement rate reduces the employment rate (i.e., the “static” effect obtained at the steady state). Future increases in bargaining power or replacement rates reduce the incentive to hire today by decreasing the capitalization effect; therefore, the continuous rise in bargaining power or replacement rates decreases the employment rate over time.

2.2.3. Technological progress

We recover the Solow residuals, which measure the labor-augmenting technological process, from the production function as $A = (\frac{Y}{K^{1-\alpha}})^{1/\alpha}\frac{1}{Nh}$.

type unionism, but since not all unions provide separate figures for eastern and western Germany, it is hard to draw definite conclusions. Membership is also falling because unions have severe problems in recruiting younger workers and employees in the growing private service sector”.

[20] From March 2009, President Obama extended unemployment benefits from the original 26 weeks to a maximum of 99 weeks as part of the American Recovery and Reinvestment Act. From 2013, these extensions were phased out.

[21] See Appendix C for a discussion on the measure of unemployment incomes.

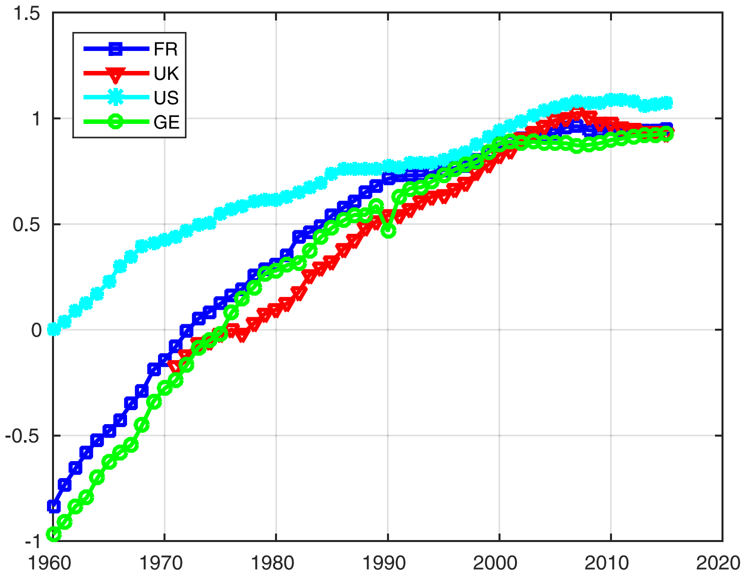

Fig. 5. Solow residuals in log.

Fig. 5 shows the logarithm of the technological process time series, suggesting that “breaks” occur in these time series.

As far as the European economies are concerned, there was a period of technological catching up after the material destruction of the WWII period. We suppose a break in the linear trend for TFP in the mid-1980s for France and the United Kingdom and in 1981 for Germany; for the United States, we suppose a break in the mid-1990s when TFP growth decreases. In all four cases, the Chow test confirms our hypothesis (for the details, see Appendix F).

We consider that the rate of growth on the balanced growth path is that of TFP estimated in the second half of the sample. Therefore, the higher rates of growth experienced in the first half of the sample correspond to a transitory period of the catching up for European countries and exceptionally high growth in the United States.

3. Employment rates and hours per worker: A theoretical model

The model we use is a neoclassical growth model with search and matching frictions in the labor market. We present the equilibrium under the assumption of dynamic perfect foresight. The model has an asymptotic balanced growth path because we need to take into account the transitional effects of the TFP catching up for European countries.[22]

3.1. Labor market

In the labor market, the trend of the stock of employment is given by the new matches M_t, which add to the “non-destroyed” jobs $(1-s)N_t$: $N_{t+1}=(1-s)N_t+M_t$, where the matching function has a standard Cobb–Douglas form $M_t=\Upsilon V_t^{\psi}(1-N_t)^{1-\psi}$ and V_t indicates the number of vacancies. We highlight here that the separation rate s is fixed over time and differs from country to country.[23] Labor market tightness is given by $\theta_t=\frac{V_t}{1-N_t}$, while $f_t=\Upsilon\theta_t^{\psi}$ and $q_t=\Upsilon\theta_t^{\psi-1}$ indicate the job finding and job filling probabilities, respectively.

3.2. Households

The economy is populated by representative households consisting of a continuum of identical infinite lived agents. Each agent can be either employed or non-employed (and thus free to occupy a job). Agents pool their incomes inside the household to fully insure them against non-employment idiosyncratic risk. The income of an unemployed agent is indicated by $\widetilde{b}_t$, which consists of the proportion ρ_t of the wage income. Agents consume and save by accumulating physical capital,

[22] The model has an asymptotic balanced growth path: consumption, the two types of public spending, investment and capital grow at a constant rate in the long run, as well as wage and the unit costs of a vacancy. This property is ensured by our choices of preferences and technology (see King et al. (1988)). Appendix H presents the stationary model.

[23] We have not found data on employment-to-unemployment transitions since 1960 for European countries. However, since the 1990s, Hobijn and Sahin (2009) show that the standard deviations of the means of these employment-to-unemployment transitions are 0.05, 0.03, 0.04 for France, Germany, and the United Kingdom, respectively. These small standard deviations suggest no significant trend over 1992–2004. This leads us to assume that the separation rate is constant. Therefore, the model cannot reproduce business cycle episodes such as the last recession in which job separations rose largely. However, our objective is to explain trends in total hours, not business cycle adjustments.

which they rent to firms. Agents pay taxes on their wage income, capital income, investment, and consumption spending. Government expenditure (G_t) provides utility to households. A distinction is made between collective services expenditure (G_t^{col}) and individual services expenditure (G_t^{ind}). We consider the part of consumption used by the government for individual services as a perfect substitute for private consumption, while the part offered to collective services enters the utility function of a household, but in a separate way. The program of a household is given by

$$W^h(N_t, K_t) = \max_{c_t, K_{t+1}} \left\{ \begin{array}{l} \log(c_t + G_t^{ind} - \bar{c}) + \chi \log(G_t^{col}) + N_t(-\sigma_l \frac{h^{1+\eta}}{1+\eta}) + (1-N_t)\Gamma^u \\ +\beta W^h(N_{t+1}, K_{t+1}) \end{array} \right\}$$

$$\begin{aligned} \text{s.t.} \quad I_t(1+\tau_{i,t}) + c_t(1+\tau_{c,t}) &= (1-\tau_{w,t})\left[w_t h_t N_t + (1-N_t)\widetilde{b}_t\right] + \pi_t + (1-\tau_{k,t})r_t K_t \\ K_{t+1} &= K_t(1-\delta) + I_t \\ N_{t+1} &= (1-s)N_t + f_t(1-N_t) \end{aligned}$$

where, at the symmetric equilibrium, we have $\widetilde{b}_t = \rho_t w_t h_t$. The term $\bar{c}$ indicates the presence of a “subsistence” term in consumption. This changes the individual choices by reducing the wealth effect mostly when, at the beginning of the period, the European economies are off the balanced growth path. Indeed, with exogenous growth, this component disappears because $C_t \to \infty$ when $t \to \infty$, whereas $\bar{c}$ is constant. By reducing the wealth effect at the beginning of the sample, this term is important to account for the catching up of European countries compared with the development levels of the United States in the aftermath of WWII.[24]

3.3. Firms

The representative firm produces using a Cobb–Douglas technology combining capital K_t and labor input $N_t h_t$: $Y_t = K_t^{1-\alpha}(A_t N_t h_t)^\alpha$. Technological progress A_t is labor augmenting, according to a balanced growth path. To hire workers, the firm posts vacancies V_t, and the unit cost of keeping a vacancy open is given by ω_t.[25] Hence, the total costs paid by the firm comprise the wage bill, rental cost of capital, and vacancy posting costs. Since the firm is owned by the household, the discount factor used to evaluate the future flow of profits includes the marginal value of wealth λ_t. The firm's program is given by

$$\begin{aligned} V^f(N_t) &= \max_{V_t, K_t} \left\{ K_t^{1-\alpha}(A_t N_t h_t)^\alpha - w_t h_t N_t - r_t K_t - \omega_t V_t + \beta \frac{\lambda_{t+1}}{\lambda_t} V^f(N_{t+1}) \right\} \\ &\text{s.t.} \quad N_{t+1} = N_t(1-s) + q_t V_t \end{aligned}$$

3.4. Wage bargaining

Wages and hours are set by the firm and worker simultaneously, according to a Nash bargaining scheme: $\max_{w_t, h_t} (\frac{\partial W^h}{\partial N_t})^{1-\epsilon_t} (\frac{\partial V^f}{\partial N_t}\lambda_t)^{\epsilon_t}$.

In contrast to most models, we allow for time-varying bargaining power of the firm (ϵ_t). The result of the bargaining process is given by the wage and hour equations:

$$\begin{aligned} w_t h_t = & (1-\epsilon_t) \underbrace{\left[\alpha \frac{Y_t}{N_t} + \omega_t \left\{ \frac{(1-s)}{q_t} \left(1 - \frac{\phi_{t+1}}{\phi_t} \frac{(1-\tau_{w,t+1})}{(1-\tau_{w,t})} \right) + \frac{\phi_{t+1}}{\phi_t} \frac{(1-\tau_{w,t+1})}{(1-\tau_{w,t})} \theta_t \right\} \right]}_{BS} \\ & + \epsilon_t \underbrace{\left[\frac{(1+\tau_{c,t})}{(1-\tau_{w,t})} (C_t - \bar{c}) \left(\Gamma^u + \sigma_l \frac{h_t^{1+\eta}}{1+\eta} \right) + \rho_t w_t h_t \right]}_{RW} \end{aligned} \tag{1}$$

$$\sigma_l h_t^\eta \frac{(1+\tau_{c,t})}{(1-\tau_{w,t})} = \alpha \frac{Y_t}{N_t h_t} \frac{1}{C_t - \bar{c}} \tag{2}$$

where $\phi_t = \frac{1-\epsilon_t}{\epsilon_t}$. The marginal labor cost per employee ($w_t h_t$) expresses the opportunity cost of working as the sum of the bargained surplus (BS) and the reservation wage (RW). BS is made up of two components: the marginal productivity of the employee and cost of the search activity.[26] During the bargaining process, the firm–worker pair shares the returns on the search process. For the worker, this is equal to the discounted time necessary to find a job offer, while for the firm, returns are instead equivalent to the discounted time necessary to find a worker. These relative time spans cannot be

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[24] See Rogerson (2006) for an analysis of the “subsistence” term in consumption on labor supply.

[25] The vacancy posting cost is time dependent to ensure the existence of a balanced growth path.

[26] In the case in which bargaining power and taxes are constant over time, we simply have $BS = \alpha \frac{Y_t}{N_t} + \omega\theta_t$.

proxied by the ratio of the average duration for these two search processes ($\theta_t = \frac{f_t}{q_t}$), as would be the case if bargaining power and taxes were constant.[27] Indeed, if workers expect that tomorrow their bargaining power will be close to zero ($\phi_{t+1} \approx 0$), the evaluation of the current match surplus is only driven by the search costs saved by the firm if the job is not destroyed: $(1-s)\frac{\omega_t}{q_t}$. On the contrary, when the bargaining power of the worker increases ($\phi_{t+1} > \phi_t$), the match value is depreciated by the firm (it expects a decrease in its bargaining power), whereas the relative time span is over-evaluated by the worker because his or her bargaining power increases. The dynamics of the tax rate on wages also modify the evaluation of the surplus by the bargaining partners. This fact explains why BS is a function of the dynamics of ϵ and τ. RW is given by the sum of the marginal rate of substitution of consumption for employment $(C_t - \bar{c})(\Gamma^u + \sigma_l \frac{h_t^{1+\eta}}{1+\eta})$ and unemployment benefits $\rho_t w_t h_t$. In the basic case, where the bargaining power of workers is nil ($\epsilon_t = 1,\ \forall t$), a gap remains, equal to $\frac{1}{1-\rho_t}$, between the real wage and marginal rate of substitution of consumption for employment because unemployment benefits are proportional to the average wage. By raising labor costs, this gap reduces the equilibrium employment rate.

The equilibrium number of hours (the intensive labor supply) is determined jointly with wages. Equation (2) shows that at the symmetric equilibrium, the solution is such that the marginal rate of substitution of consumption for an hour worked, net of the tax wedge, is equal to the marginal product of an hour worked. This expression does not introduce any LMIs because we assume an efficient bargaining process over hours worked; hence, the hours contracted are only directly affected by the taxes.

3.5. Equilibrium and balanced growth path

To complete the model, the market-clearing conditions in the goods market must be satisfied:

$$Y_t = C_t + G_t^{col} + I_t + \omega_t V_t \quad \text{with } C_t = c_t + G_t^{ind}$$

whereas the government budget constraint is balanced at each time point through the lump-sum transfers given to agents:

$$TR_t = \tau_{c,t} c_t + \tau_{w,t}[w_t h_t N_t + \rho_t w_t h_t (1-N_t)] + \tau_{i,t} I_t + \tau_{k,t} r_t K_t - \rho_t w_t h_t (1-N_t) - G_t^{col} - G_t^{ind}$$

We use a neoclassical growth model that allows for a balanced growth path. There are two sources of growth in the economy: population, which is growing at rate g_n, and technological progress, which is growing at rate g_A. Each of the four countries we analyze is characterized by a different total growth rate $g = g_A + g_n$.

In order for the balanced growth path to exist, we need the following assumptions:

(i) Preferences and technology have to be consistent with a balanced growth path (separable preferences, logarithmic in consumption, and labor-augmenting technological progress);
(ii) asymptotically, all parameters such as tax rates and labor market institutions are constant; during the first fifty-five years of the simulation (from 1960 to 2015), they evolve according to their historical series.

The period from 1960 to 2015 is therefore a "transition" period, when taxes as well labor market institutions, technology and vacancy posting costs differ from their long run values. Asymptotically, taxes and labor market institutions remain stable, while technology grows at its rate of growth g_A. Consumption, capital, investment, the two types of Government expenditures, as well the vacancy posting costs and wages all grow at the total rate of growth of the economy (g).

All the equilibrium equations are in Appendix H, with details on stationarized equations. Steady state can be found in Appendix L.

4. Quantitative results

The model is solved with perfect foresight using the software Dynare (see Adjemian et al., 2011). The path of all exogenous variables is known to agents from the beginning.[28]

The model, expressed in terms of the stationarized variables, is simulated for a finite number of periods ($T = 1000$), starting from 1960. The exogenous time series fed into the model are the policy variables (taxes and LMIs) as well as technological progress and the vacancy posting costs. For all series, we consider their trend according to the data until 2015. Our hypothesis about the long-run steady-state values is that there is no change after 2015 (i.e., all exogenous time series keep their values at the end of the sample until the end of the simulation).

First, we present our calibration strategy. Second, once the model is simulated with the identified parameters and the country-specific exogenous variables, we plot the simulated series and actual series for the four countries.[29] We then focus on the two countries at the ends of the spectrum, the United States and France and perform some counterfactual experiments. We provide an intuition of the functioning of the model by considering a steady-state version to study the impact

[27] See Burda and Weder (2016) for a discussion on the implications for business cycle fluctuations in the presence of a time-varying tax wedge in the wage equation.

[28] In Appendix I, we show that the paths are not greatly modified when the policy changes are unexpected. Given this robustness check, we prefer to present the results based on perfect forecasts because they avoid introducing the arbitrary timing of the market participants' "knowledge" of the reforms.

[29] As noted earlier, for Germany, we use our model to simulate only the period from 1990.

Table 2
Calibrated parameters Θ_c.

Common	β	δ	η	α	ψ		
	0.98	0.05	2	0.3	0.5		
Country	s_i	$g_{A,i}$	$g_{n,i}$	$g_{\omega,i}$	$\frac{\omega_{i,1960}}{(Y/Nh)_{i,1960}}$	$\frac{G_i}{Y_i}$	$\frac{G^{col}}{Y} \to \chi_i$
US	0.12	0.013	0.0104	-0.0125	0.17	0.15	0.098
FR	0.15	0.013	0.0056	0.0135	0.17	0.23	0.085
UK	0.17	0.024	0.0033	0.0025	0.17	0.19	0.090
GE	0.12	0.017	0.0017	0.0143	0.17	0.19	0.069

of a permanent change in the policy variable on both the intensive margin (hours per worker) and the extensive margin (in this case, represented by labor market tightness).

4.1. Identification of the parameters

To solve the model for each country numerically, we need to identify some of the parameters. The main identifying restriction is to assume that the preferences and production as well as the matching technology are the same across countries: the shared parameters are thus $\{\beta, \delta, \alpha, \eta, \psi, \sigma_l, \Gamma^u\}$. This restriction allows us to isolate the impacts of shifts in TFP, taxes, and LMIs. Nevertheless, we introduce country-specific parameters to account for the differences across countries $i \in \{US, FR, UK, GER\}$ on

- The labor market structures, $\{s_i, \Upsilon_i, \omega_{i,1960}, g_{\omega,i}\}$, where s_i is the separation rate, Υ_i is the matching function efficiency, $\omega_{i,1960}$ is the vacancy cost in 1960, and $g_{\omega,i}$ is the growth supplement of this cost relative to its growth on the balanced growth path;
- The size of the state, specifically the total ratio of Government expenditures over production $((G_i^{col} + G_i^{ind})/Y_i)$ and the ratio G_i^{col}/Y_i that gives us the parameter χ_i in the preferences;
- The level of development $\{g_{A,i}, g_{n,i}, \bar{c}_i/C_i\}$, where $g_{A,i}$ is the rate of growth in technological progress, $g_{n,i}$ is the rate of population growth, and $\bar{c}_i/C_i$ is the proportion of subsistence consumption.

Some of these parameters are calibrated using external information:

$$\Theta_c = \left\{\beta, \delta, \alpha, \eta, \psi, \{s_i, \omega_{i,1960}, \chi_i, g_{A,i}, g_{n,i}\}_{i\in\{US,FR,UK,GER\}}\right\}$$

whereas others are deduced from the model restrictions:

$$\Theta_m = \left\{\sigma_l, \Gamma^u, \{\Upsilon_i, \bar{c}_i/C_i\}_{i\in\{US,FR,UK,GER\}}\right\}$$

Calibrated parameters using external information. Table 2 shows all the numerical parameter values. We set the discount factor $\beta = 0.98$, the depreciation rate $\delta = 0.05$, and the elasticity of production with respect to capital $\alpha = 0.3$, according to standard values in the literature, when the period of reference is one year. In particular, to find evidence of the depreciation rate, we follow Gomme and Rupert (2007).

In the long run, we have the following restrictions: *(i)* $1 = \frac{\beta}{1+g}[1 - \delta + \frac{1-\tau_k}{1+\tau_{inv}} r]$, *(ii)* $r = (1-\alpha)\frac{Y}{K}$, and *(iii)* $I = (\delta + g)K$, where the values of g, τ_k, τ_{inv} are country-specific. For the United States, for example, the model implies an average investment/output ratio over the whole simulation period of $\approx$0.18. Hence, we obtain a gross interest rate $r \approx 13.39\%$ and thus $r - \delta \approx 8.39\%$, using *(ii)* and *(iii)*. Our value of α is such that the first equation is also satisfied for the average tax rates on capital and investment. Nevertheless, this standard calibration leads, as usual, to an overestimation of the interest rate.[30] We therefore choose to reduce the interest rate by an amount that corresponds to the risk premium ($\kappa = 20\%$), which is paid by the firm when the uncertainty on its investment projects is taken into account by the financing contract. This leads us to $r(1-\kappa) - \delta \approx 5.7\%$, which is closer to the long-run value of the asset returns.

Our parameter η is set to a value of 2, which implies a Frisch labor supply elasticity of 0.5, a widely adopted value in the literature, within the range of the estimates derived from micro-data reported by, for example, Chetty et al. (2011). The parameter ψ, which represents the elasticity of the matching function with respect to vacancies, is set to 0.5, which is an average of the range of possible values identified by Pissarides and Petrongolo (2001) and is widely adopted in the literature. For the separation rate s_i, we use the estimation results in Elsby et al. (2013).

For each country i we calibrated total government expenditures over GDP (G_i/Y_i) using historical data (we considered the averages over the time period). Then we focused on the expenditure on collective goods. As shown in Section E.2, the ratio of government expenditure on collective goods to GDP differs by country. This leads us to calibrate χ_i as a parameter, al-

[30] See Gomme and Rupert (2007) for more discussion on this point.

Table 3
Identified parameters Θ_m.

Parameter	US	FR	UK	GE
σ_l	31.1	31.1	31.1	31.1
Γ^u	0.03	0.03	0.03	0.03
Υ_i	0.29	0.49	0.52	0.39
$\bar{c}_i/C_i$	0.00	0.58	0.03	0.54

We report the value of $\bar{c}$ in terms of consumption per capita in 1960 for the United States, France, and Germany and in terms of consumption per capita in 1980 (our starting year for the simulations) for the United Kingdom.

lowing the model to match these collective goods as if they were chosen by the government in accordance with households' preferences.[31]

We then use information from our data to provide values to g_A and g_n. Using our computation of the Solow residual for each country (see Section 2.2.3), we fit a linear trend, which is our g_A. Similarly, we fit a linear trend to the population aged 15–64 and call it g_n. The total rate of growth of all the non-stationary variables is therefore $g = g_A + g_n$.

We have no time series for the unit costs of a vacancy, allowing us to easily calibrate the (stationarized) vacancy posting costs. We can rebuild ω_t using the information provided by Barron et al. (1997), according to whom the unit cost of a vacancy amounts to 17% of average labor productivity, and the model assumptions. If the restrictions provided by Barron et al. (1997) were satisfied each period, and given that the exogenous trend of our model implies that productivity grows at the rate g, then the stationarized vacancy cost would be $\widetilde{\omega}_t = \omega_t/(1+g)^t$, where $\omega_t \equiv 0.17 \times Y_t/(N_t h_t)$. However, this does not provide a stationarized value for $\widetilde{\omega}_t$ (see Appendix G), suggesting that the restrictions in Barron et al. (1997) cannot be applied in each period. Therefore, to extract the drift in $\widetilde{\omega}_t$, which is not strictly proportional to the exogenous growth, we assume that only the terminal and final values of the stationarized vacancy costs are 17%. Using these two boundary conditions, we compute the growth rate (g_ω) of the exogenous drift in the vacancy posting costs deflated by the exogenous growth rate. The stationarized vacancy posting costs thus change between 1960 and 2015 (the transition period) and then remain stable at their long-run level.[32] The results in Table 2 show relatively low values for the rate of growth $g_{\omega,i}$ for the Anglo-Saxons countries, and relatively higher values for the European Continental ones. In the UK and US, in fact, labor productivity remained stable or decreased across the sample (total labor increased during the period), while in France and Germany labor productivity actually increased. To keep the ratio of vacancy posting costs over labor productivity constant, therefore, vacancy posting costs had to decrease in Anglo-Saxon countries, and increase in the Continental European ones.[33]

Identified parameters from the model restrictions. The vector of parameters is the solution of $\min||\Psi^{theo}(\Theta_m) - \Psi||$. The targeted moments are $\Psi = \{\overline{N}_i, \overline{h}_i, \overline{\Delta h}_j\}$, for $i = US, FR, UK, GER$ and $j = FR, UK, GER$, where $\overline{X} = \frac{\Phi_m}{T-t_0}\sum_{t=t_0}^{T} X_t$, with $T = 2015$ $\forall X = N, h$ and $\overline{\Delta h} = h_{1975} - h_{1960}$. Given that $dim(\Psi) = 11$, there are overidentifying restrictions because $dim(\Theta_m) = 9$, given that that we restrict $c_{US} = 0$. Table 3 reports the values of the identified parameters.

Our restrictions are that the asymptotic preferences (represented by σ_l and Γ^u) are common to all countries. We use the scale parameter Υ_i of the matching function of each country as a free parameter. In our framework, since the equilibrium employment rate is influenced by the policy variables (directly from LMIs and indirectly from taxes), we can interpret the fact that the matching efficiency is higher in France, for example, than in the United States as follows. Considering the policy variables that *per se* discourage the employment outcomes, according to the functioning of the model, to explain the employment rates that we actually observe, our model implies that the matching process has to be relatively highly efficient.

As in Rogerson (2006); Ohanian et al. (2008), and McDaniel (2011), we introduce a consumption subsistence term to capture the fact that the number of hours worked were higher at the beginning of the sample in the countries poorer than the United States.[34]

4.2. Model fit

With these restrictions, any differences in the behavior of the economic variables predicted by the model are therefore guided by differences in the policy variables (i.e., taxes and LMIs) or "technological" conditions (i.e., Solow' residuals,

[31] In the optimal case, the marginal utility of a unit of private consumption is equal to that of a collective public consumption good, namely $1/C = \chi/G^{col}$. Since we have data for all these series for each country, under the assumption that actual collective good expenditure is optimal, we can recover the value of the parameter χ using the historical average values.

[32] The overall vacancy posting costs, as with all the other non-stationary variables in the model, in the long run grow at the rate of growth g.

[33] See Appendix G for the details.

[34] The presence of the term $\bar{c}$ is important from a quantitative perspective. McDaniel (2011) obtains values of $\bar{c}$, in terms of consumption in 1960, equal to 27%, 40%, 52%, and 54% for the United States, the United Kingdom, France, and Germany, respectively. In countries poorer than the United States, hours worked were much higher at the beginning of the sample period and decreased strongly in the catching up period. See Appendix J for a more detailed discussion.

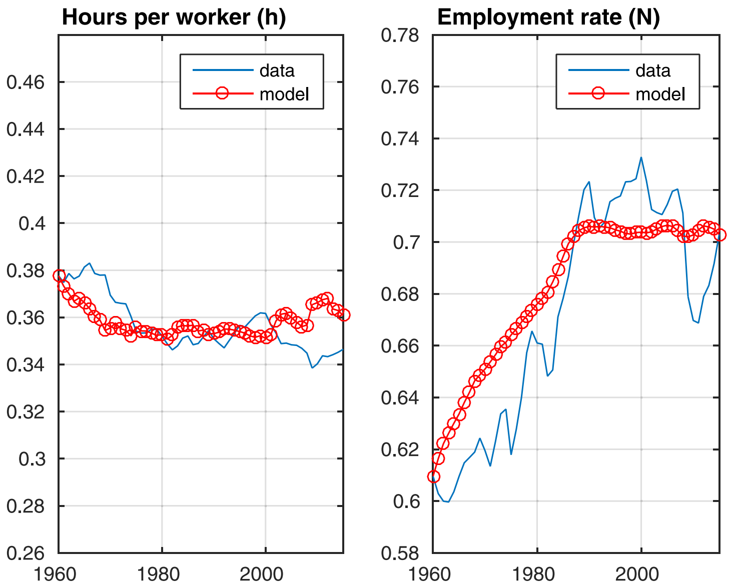


Fig. 6. The US economy.

matching technology efficiency, and vacancy posting costs). Our objective is to match the long-run trend of the intensive and extensive margins of total hours with our model simulations. We then report a graphical analysis as well as the mean square error (MSE) of each time series as a statistical measure of the model fit.[35]

Initially, for the United States, taxes remain stable, whereas LMIs shift slowly in favor of firms. The model then predicts an increase in the employment rate and a small decline in hours per worker. The composition of these adjustments of the two labor market margins leads to a marginal increase in predicted total hours during this period. Fig. 6 compares these results for the US economy with the observed data. Given that there is no break point in the time series of the taxes and LMIs in the United States, the model reproduces the small and continuous changes observed simultaneously in hours per worker and the employment rate. The substitution effect between employment and hours should have led to a decline in the intensive margin given the decrease in the employment wedge (see Fig. 4). However, this effect is dampened by the small decrease in the tax rate observed in the United States after 2000 (see Fig. 3). The MSEs for hours worked and the employment rate are $1.3997 \cdot 10^{-4}$ and $4.9191 \cdot 10^{-4}$, respectively. The ratio of the vacancy posting costs to labor productivity ($\frac{\omega}{Y/Nh}$) averages 17.4% over the period.

In France, the tax wedge experiences at least three regimes. From the beginning of the sample until 1985, it increases rapidly; between 1985 and 2000, its increase is less marked; and after 2000, we observe a significant decline (see Fig. 3). In response to these tax rates, the model predicts that each French employee works fewer hours, with a small recovery after 2000. This prediction is not contradicted by the data (see Fig. 7). In the French labor market, while bargaining power increases continuously until 2003, there are large upward breaks in the replacement rate, the first one being between 1981 and 1985 and the second one between 1999 and 2001 (see Fig. 4). In response to these substantial changes in LMIs, the employment rate predicted by the model largely declines at the beginning of the 1980s as well as between 1999 and 2001. These trends of LMIs interact with the significant decrease in the tax on labor paid by firms after 1997 (payroll tax subsidies, see Cheron et al., 2008). It seems that this last policy explains the rise in hours per employee, whereas the decline in the replacement rate after 2002 explains the increase in the employment rate. These predictions are consistent with the data (see Fig. 7), even if the elasticity of the model slightly overestimates the changes in the employment rate in France. The MSEs for hours worked and the employment rate are $1.9508 \cdot 10^{-4}$ and $4.1724 \cdot 10^{-4}$, respectively. The ratio of the vacancy posting costs to labor productivity ($\frac{\omega}{Y/Nh}$) averages 10.8% over the period.

For the United Kingdom, the large swings in the data on the tax wedge and replacement rate in the 1970s prevent us from finding an equilibrium path throughout the sample. A solution is found when we choose to start the simulation when Thatcher implemented her first reforms. The fit for the employment rate in the United Kingdom is slightly worse than that for the previous two economies: the MSEs for hours worked and the employment rate are $4.4621 \cdot 10^{-05}$ and 0.0010, respectively. The ratio of the vacancy posting costs to labor productivity ($\frac{\omega}{Y/Nh}$) averages 12.3% over the period. The model does a relatively good job of reproducing the dynamics for hours. It predicts the 5 percentage point decline in the employment rate at the beginning of the 1980s, followed by its continuous increase afterward. Indeed, after 1981, bargaining

[35] In Section K.1 of Appendix K, we show the individual contribution of each of the two groups of policy variables to the overall outcome of the model. Here, we "shut down" taxes or LMIs and simulate the model. Section K.2 reports the simulated values of the additional variables such as total hours.

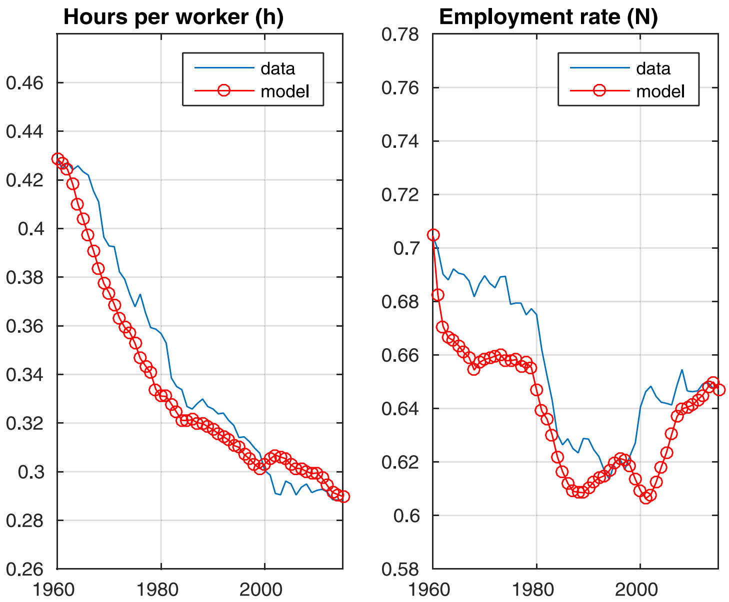


Fig. 7. The French economy.

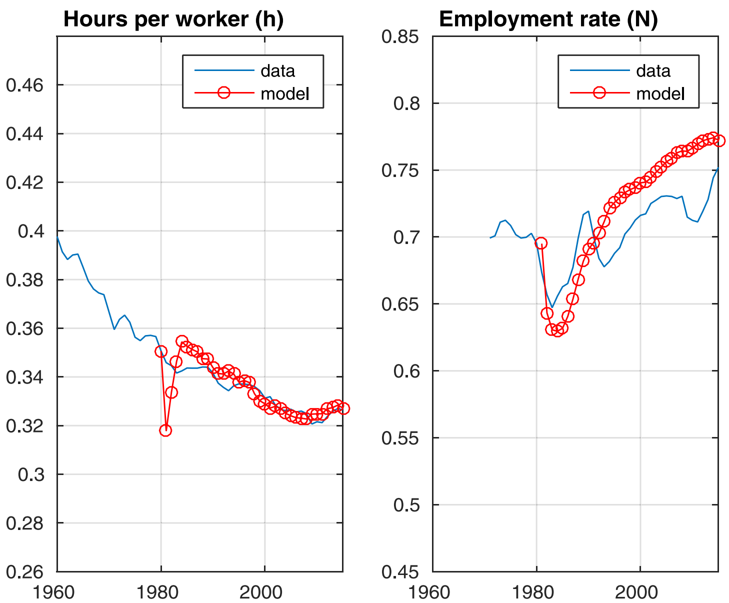


Fig. 8. The UK economy.

power and the replacement rate largely decline in the United Kingdom (see Fig. 4). In interaction with the higher TFP growth rate than in the other countries (see Fig. 5), the reforms launched by Thatcher and continued by Major explain the UK job miracle. Nevertheless, the model seems to slightly overestimate the elasticity of the employment rate to these changes. The substitution between the intensive and extensive margins explains the small decline in hours worked per employee given that the tax wedge remains stable from 1980 (see Fig. 3).

With respect to Germany, the simulation captures the decrease in the intensive margin that continues during the 1990s as well as the positive trend in the employment rate. Indeed, since the beginning of the 1990s, successive German governments have reduced the bargaining power of workers and the generosity of the unemployment benefits system (see Fig. 4). The increase in employment owing to the substitution effect leads to a decline in hours worked per employee. This reduction in effort at work is magnified by the rise in the tax wedge (see Fig. 3). The MSEs of hours worked and the employment rate are $3.6842 \cdot 10^{-4}$ and 0.0018, respectively. The ratio of the vacancy posting costs to labor productivity ($\frac{\omega}{Y/Nh}$) averages 10.0% over the period.

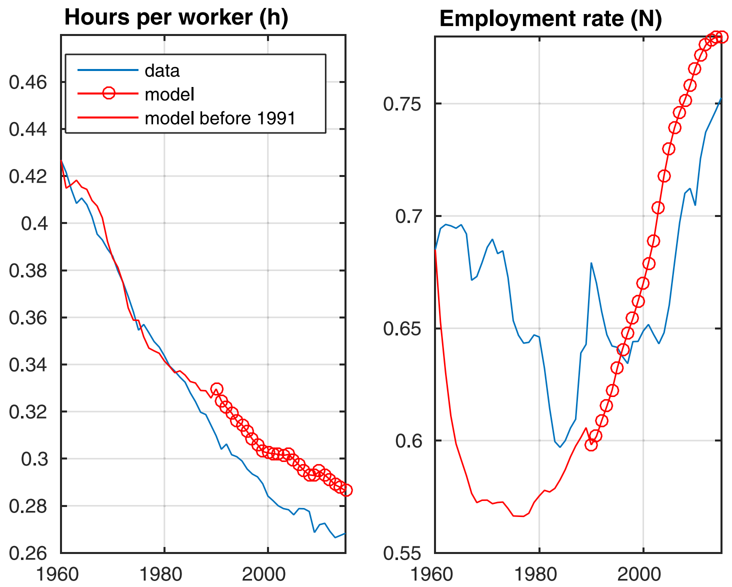


Fig. 9. The German economy.

4.3. *Analyzing the mechanisms of the model*

In this subsection, we analyze the mechanisms of the model by focusing on a steady-state analysis.

4.3.1. *Steady-state analysis*

Before considering the counterfactual experiments in the fully dynamic model, we look at the final steady state and study the comparative static effects of a change in a policy variable (tax rates, replacement rate, or bargaining power). To do this, we extend the analysis provided by Fang and Rogerson (2009) by including the replacement rate of the unemployment benefits and capital accumulation. This last extension implies that additional restrictions are taken into account: the Euler equation and a resource constraint including investment. Hence, our general equilibrium approach implies that labor supply (intensive and extensive margins) depends on equilibrium consumption through both the MRS and the resource constraint. To capture this, we add the resource constraint to provide the link between consumption and the labor market variable through the net output (consumption $C(\theta,\, h)$ is a function of θ and h),[36] and thus integrate this general equilibrium restriction into our labor market analysis. At the steady state, we can thus reduce the system equations for two unknowns $\{h,\, \theta\}$:[37]

$$\sigma_l h^{1+\eta} C(\theta,h) = \alpha A h \frac{(1-\tau_w)}{(1+\tau_c)} \left(\frac{r}{1-\alpha}\right)^{-\frac{(1-\alpha)}{\alpha}} \qquad (Ls)$$

$$\left(\frac{\epsilon}{1-\rho\epsilon}\right)\left[(1-\rho)\alpha A h\left(\frac{r}{1-\alpha}\right)^{\frac{(\alpha-1)}{\alpha}} - \left(\Gamma^u + \sigma_l \frac{h^{1+\eta}}{1+\eta}\right)\frac{(1+\tau_c)}{(1-\tau_w)} C(\theta,h)\right]$$
$$= \frac{\omega\theta^{1-\psi}}{\Upsilon}\left[\frac{1}{\beta} - (1-s)\right] + \left(\frac{1-\epsilon}{1-\rho\epsilon}\right)\omega\theta \qquad (JC) + (WC)$$

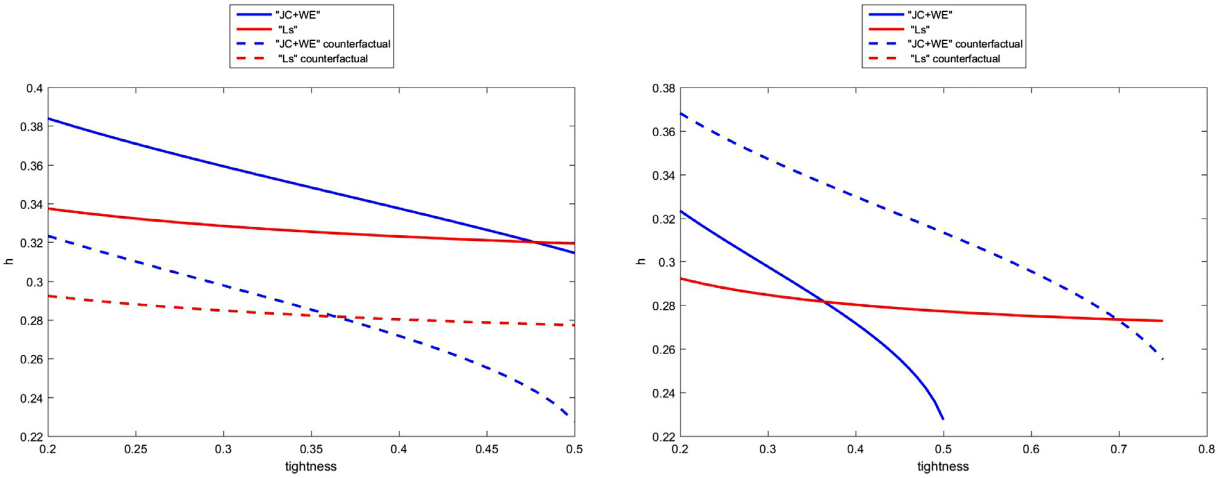
The (Ls) equation can be interpreted as the locus where the intensive margin is at equilibrium, whereas the second is the locus where the extensive margin is at equilibrium. As usual, this last locus merges the job creation curve (JC) and the wage curve (WC). These two relationships can be interpreted as showing a trade-off between the two margins of labor input for households as well as firms at the general equilibrium.

Proposition 1. *For an equilibrium employment rate greater than one-third, the resource constraint defining $C(h,\theta)$ always implies that $\epsilon_{C|h} > 0$ and $\epsilon_{C|\theta} > 0$.*

Proof. See Appendix M.1. □

[36] See Appendix L for a description of the system equations.

[37] When we consider the steady state of the model, we refer to an "asymptotic" steady state obtained when the subsistence consumption term is null. Hence, in the following, $\bar{c} = 0$.



Change in the tax wedge

Change in the replacement rate

Fig. 10. Steady-state comparative statics: France.

Given that an employment rate equal to one-third is largely below that observed for all countries along the total time span, we can confidently say that an increase in tightness or in hours per worker in our model implies an increase in consumption.

Proposition 2. *If $C(h, \theta)$ leads to $\epsilon_{C|h} > 0$ and $\epsilon_{C|\theta} > 0$, then the equilibrium intensive margin (equation (Ls)) defines the negative relationship between hours worked h and labor market tightness θ.*

Proof. See Appendix M.2. □

The optimal choice of the intensive margin shows that labor market tightness acts as a wealth effect on agents' decisions: a high θ implies a high employment rate and therefore a lower incentive for each individual in the household to work.

Proposition 3. *For $\frac{\eta}{1+\eta} > \rho$, there exists a value for $\Gamma^u < 0$ such that the equilibrium extensive margin (equation (JC) + (WC)) defines the negative relationship between hours worked h and labor market tightness θ.*

Proof. See Appendix M.3. □

The optimal choice of the extensive margin shows that a high h implies a higher gap between disutility at work and at home, leading to lower incentives for an additional worker in the household to work. This can be viewed as an increase in the wage reservation due to the scarcity of leisure when h increases.

Comparative statics: Counterfactual experiments. We now present the results of a comparative static analysis carried out to examine how a reduction in tax rates would impact the final steady state. We can, for example, apply US tax rates on consumption and labor income to France and check the functioning of the model. We expect both the labor supply and the labor market equilibrium curves to shift upward. The overall effect on hours per worker is unequivocally positive, while the effect on the extensive margin depends on the relative movements of the curves, as shown in the left panel of Fig. 10. Indeed, for our calibration, the tax reduction gives workers an incentive to work longer, while at the same time reducing labor costs (this effect overcompensates for the increase in the reservation wage of the worker, who now wants to work longer), inducing a rise in labor market tightness.

What if we simulate the French economy with the unemployment benefits system of the United States? The right panel of Fig. 10 shows that a change in the replacement rate does not affect the labor supply curve, but does affect the labor market equilibrium curve: the latter shifts toward the right, meaning that the effect on tightness is strongly positive. When workers are more in number, the generated wealth effect leads them to reduce their individual effort at work. Thus, the reservation wage is reduced, which amplifies the impact of the reduction in the replacement rate. Considering that the intensive margin curve is flat, the effect on hours per worker (which decreases overall) is quantitatively less significant.

5. Counterfactual experiments: Alternative policies

Once we have understood the forces at work at the steady state, we can perform a counterfactual experiment with the fully fledged dynamic version to evaluate the impacts of two types of experiences: that of American-style flexibility in an economy with the opposite experience such as France and that of French-style rigidity in the United Kingdom and Germany having implemented reforms toward more flexibility. These two opposite scenarios allow us to understand the contrasting rises or falls in labor market aggregates between countries.

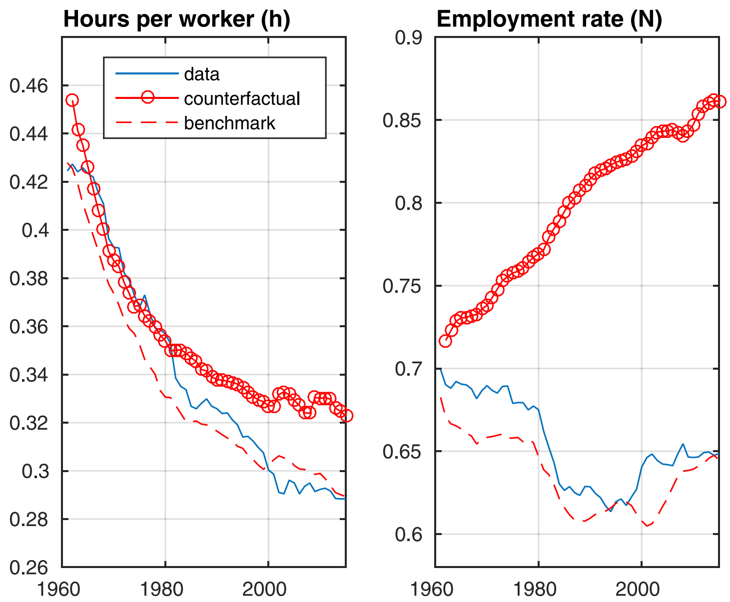


Fig. 11. Counterfactual: France with the US tax wedge and LMIs.

5.1. Impact of labor market flexibilization on the two margins

We start by looking at how the simulated variables for France would evolve if the policy variables were those that characterized the United States. In particular, we suppose that the tax wedge and LMIs (bargaining power of workers and the replacement rate) in France are in fact given by what we observed in the United States. The two economies differ therefore in the tax rates applied on capital and investment. In addition, the two countries are characterized by their specific technological and population trends as well their own matching technology (in terms of matching efficiency and vacancy posting costs) and separation rates. Fig. 11 shows the results of the simulations of the French economy with US taxes and LMIs.

On average, the fictive French employee works longer hours and has a much higher chance of being employed (the employment rate being the number of people employed over the total working age population). If we look at the trend of the employment rate, with the LMI arrangements that characterize wage negotiations in the United States, France would have observed a spectacularly high employment rate. At the end of the simulation, employment is 86% in this fictive France, whereas it is 65% in the actual economy.

Let us now consider a situation in which we have the US tax wedge trend in France, while keeping the labor market arrangements as they are. Fig. 12 shows that the number of hours worked would be higher. The important point here is that a simple reduction in consumption and labor income tax rates does not significantly affect employment because the decline in the labor cost they induce is compensated by the rise in the reservation wage of workers, who now work longer hours. These results are the counterparts, in a dynamic model, of the comparative static results summarized in Propositions 2 and 3.

Fig. 12 also shows the hypothetical case of France characterized by US LMIs but its own taxation system, showing a very high employment level with a contemporaneous decrease in hours worked. Agents in France, when strongly taxed, choose to work less than an American worker. The general equilibrium effects magnify these two direct effects. First, the large probability of being employed is perceived by the agent as a wealth effect that reduces his or her incentive to work longer. Second, when a worker reduces his or her hours, his or her reservation wage decreases, leading to a magnification of the rise in the employment rate. This also echoes the results obtained with the comparative static analysis in Propositions 2 and 3.

5.2. Impact of reform rigidifying the labor market

In Germany, the series of reforms initiated since reunification first reduced the bargaining power of employees and then lowered unemployment benefits (with a break in the late 1990s when the Greens were in government). We observe the reverse in France during this period (see Fig. 4). Finally, the tax wedge increased in Germany, but slightly less than it did in France (see Fig. 3). Therefore, if we implement in Germany, as a counterfactual experience, the taxes and LMIs of France, the losses in the employment rate continuously rise to reach a deficit of 10 percentage points in 2015 (see Fig. 13). Concerning hours worked per employee, this counterfactual scenario does not change the observed German path because the incentive

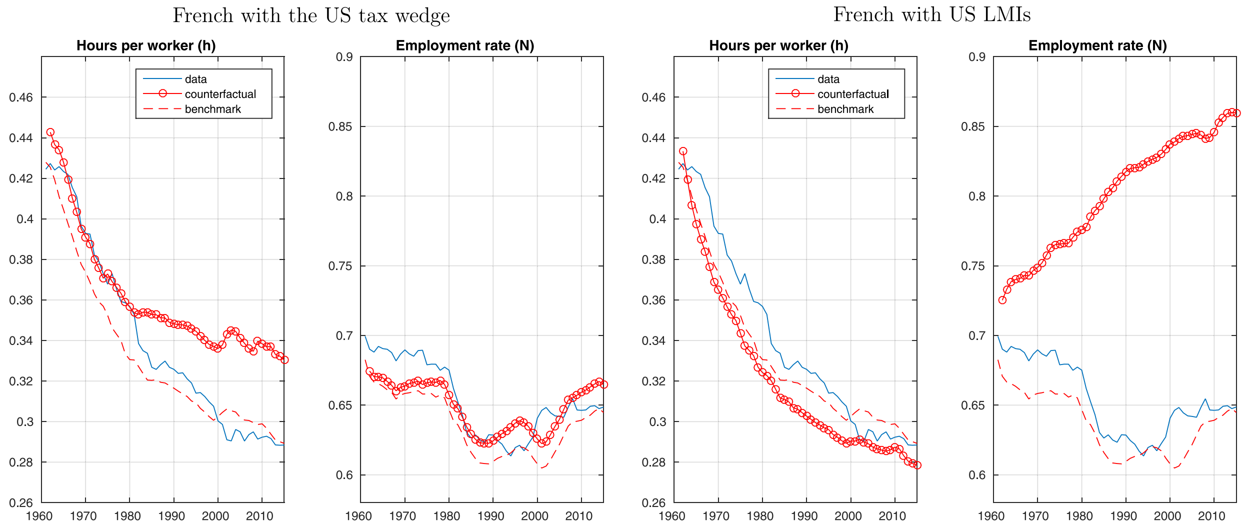


Fig. 12. Counterfactual: France with the US tax wedge or LMIs.

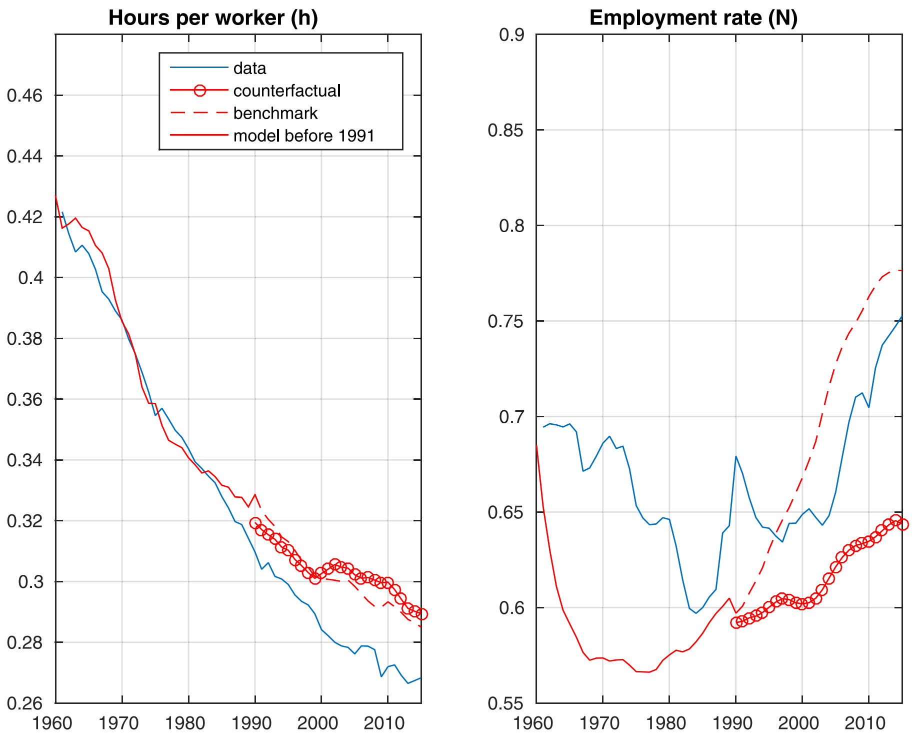


Fig. 13. Counterfactual: Germany with the French tax wedge and LMIs.

to work more induced by the negative wealth effect linked to the decline in employment is killed by the rise in taxes, specific to the French policy (see Fig. 13). Indeed, as shown in Fig. 14, the pure impact of the tax rise has not real impact on hours worked per employee (Germany with the French tax wedge in Fig. 14), whereas it is sufficient to overcompensate the incentive to work more that comes from counteracting the employment reduction induced by French-style LMIs (Germany with French LMIs in Fig. 14).

Concerning the United Kingdom, the counterfactual experiments lead us to draw the same conclusions: French-style LMIs would induce large employment losses. These losses would be larger than in the case of Germany because the liberalization of the UK labor market was decided early (at the beginning of the 1980s) and was more substantial: the employment losses induced by the French tax wedge and LMIs are around 20 percentage points in 2015 with the large collapse between 1982 and 1985, the most different periods between France and the United Kingdom (Thatcher vs. Mitterrand, see Figs. 4 and 3).

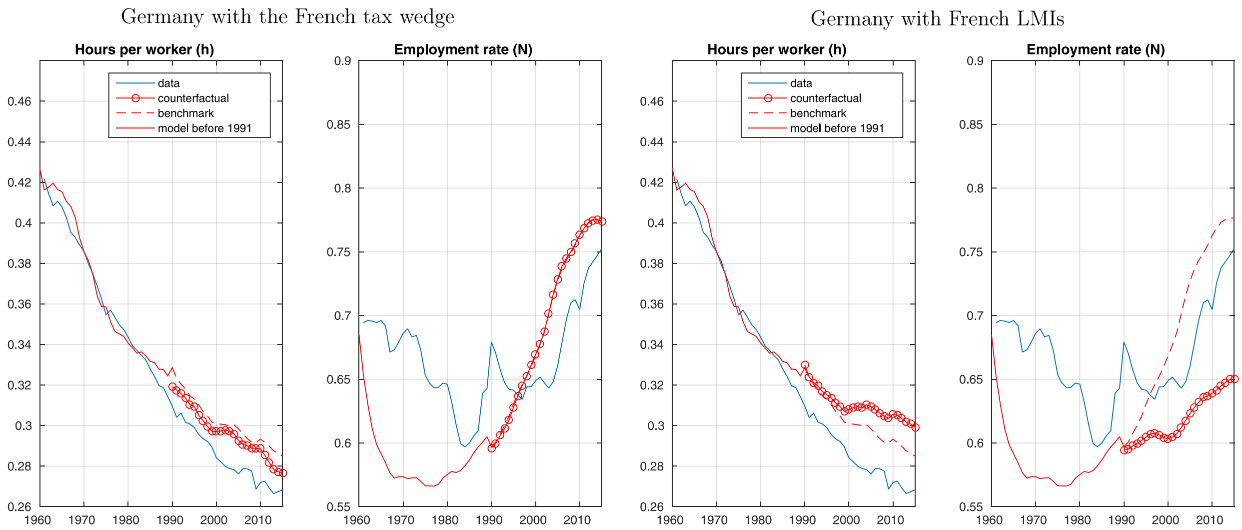


Fig. 14. Counterfactual: Germany with the French tax wedge or LMIs.

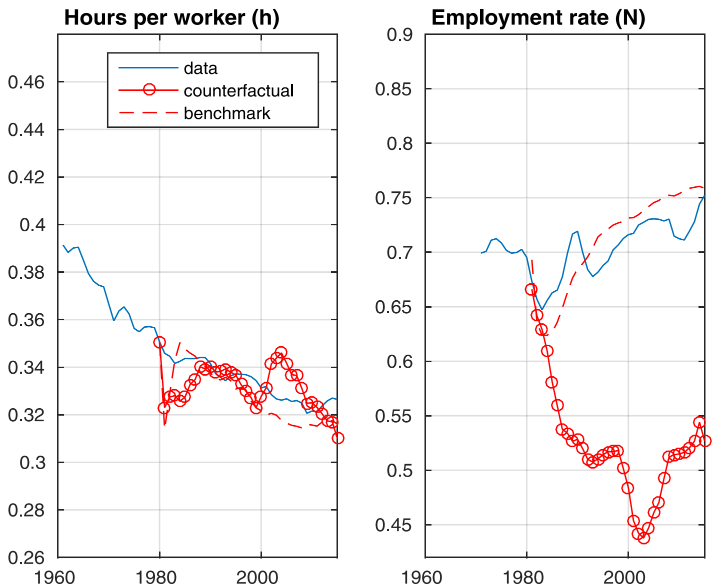


Fig. 15. Counterfactual: United Kingdom with the French tax wedge and LMIs.

The interesting feature of the United Kingdom is its lower tax wedge than in Germany, allowing us to better differentiate the path of hours worked per employee. With only taxes evolving as in France, UK employees would have worked fewer hours, converging to those of a French employee (see Fig. 16). While this tax wedge seems to affect employment little, this is not the case for LMIs. When they alone have a trend based on that observed in France, employment falls sharply, whereas hours worked by employees increase sharply driven by the wealth effect. This finding clearly shows that this substitution effect (i.e., the compensation of the low job opportunities by an increase in effort at work) cannot occur when all French-style distortions are at work because the high French tax then disincentivizes effort at work (see Fig. 16).

5.3. Structural output losses implied by low labor supply in France

To evaluate the impact of these policies on output, we compute the output losses induced by the tax wedge and LMIs in France with respect to a reference output value that would be chosen by a benevolent social planner. In a representative agent model with no heterogeneity, the government's consumption expenditure on collective goods would be financed in a non-distortive way through lump-sum taxes. In the labor market, the bargaining power of workers would be constant and equal to the elasticity of the matching function with respect to unemployment, while the unemployment benefit would be null (Hosios condition). The planner observes the same dynamics of technological process as private agents do.

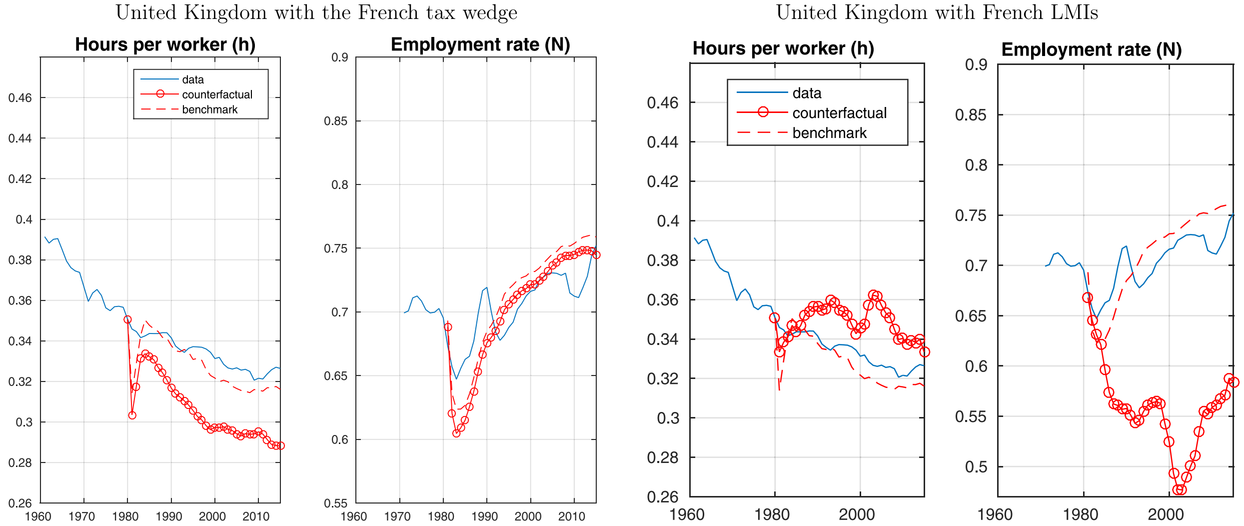


Fig. 16. Counterfactual: United Kingdom with the French tax wedge or LMIs.

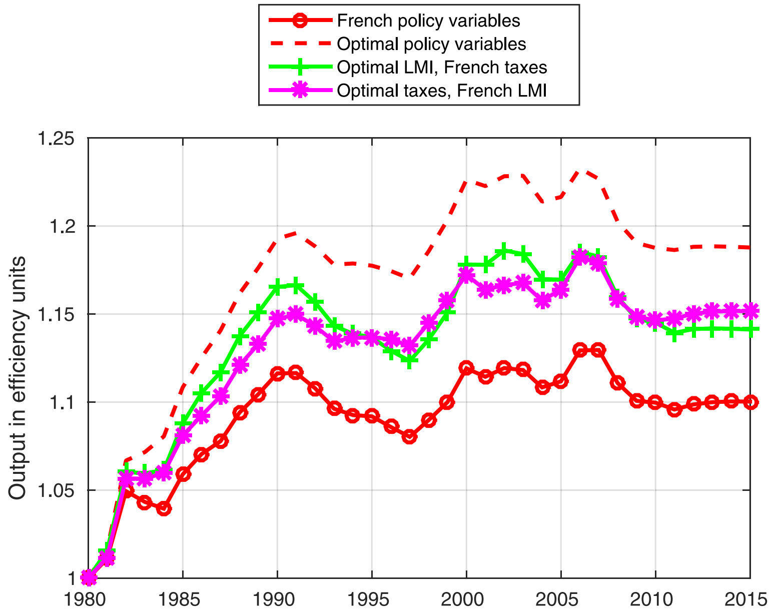


Fig. 17. Output losses: France.

Fig. 17 illustrates the percentage points of output (in efficiency units) that have been “lost” in France compared with what could have happened with a set of policy variables such as those chosen by the planner. All GDP data are normalized at their respective level in 1980. To evaluate the relative contributions of taxes and LMIs to these losses, two counterfactual experiments can be used: the case with only optimal taxes and the case with only optimal LMIs. Fig. 17 shows that output in France could have been 17% higher than its 1980 level; this growth comes from the TFP rise, inducing capital and employment accumulation processes. However, with the trends in the French policy variables, output today is only 10% higher than its 1980 level. Hence, the structural output losses are 7%. The contributions of tax and LMI distortions to these losses have the same order of magnitude.

6. Conclusion

In this paper, we presented a dynamic perfect foresight model of neoclassical growth with labor market frictions that can account for the long-run trends in both the extensive and the intensive margins of labor. Driven by the country-specific trend of both tax wedges and LMIs, its calibrated version reproduces the dynamics of these two margins for the United States, France, the United Kingdom, and Germany. We highlighted the non-trivial interactions between the two margins.

The counterfactual simulations showed that rigidifying the labor market through LMIs, as has been done in France since the beginning of the 1980s, has strongly reduced the employment rate, not compensated by the rise in hours worked by employees because taxes have also increased. Thus, we showed that making LMIs more flexible without lowering the tax wedge would lead to an even larger decrease in hours per worker.

Acknowledgment

We thank the editor and two anonymous referees for their helpful comments as well as R. Barnichon, F. Bilbiie, G. Cette, F. Fontaine, J-O. Hairault, A. Janiak, X. Ragot, and E. Wasmer. We also thank the seminar participants at the Banque de France, Paris School of Economics, Banco Central de Chile, University of Chile, and T2M (Berlin) seminars. Any omissions and mistakes are our own.

Appendix A. Data sources and definitions

The data used can be distinguished into two categories: policy variables and economic variables. The policy variables are the average tax rates, replacement rates, and bargaining power of workers.

The average tax rates are computed by McDaniel (2007) and are available on her website at http://www.caramcdaniel.com/researchpapers.

The replacement rates for unemployment benefits are computed by the OECD. To be consistent with our model, we need the gross replacement rate, which is available from 1963 until 2005; from 2005 onward, we use information on the net replacement rate to reconstruct the gross one. Both measures refer to the average replacement rate of income during unemployment over a five-year period (for details, see http://www.oecd.org/els/benefits-and-wages-statistics.htm).

Bargaining power is computed as the average between UC and UD. Both measures are contained in the ICTWSS database provided by the Amsterdam Institute for Advanced Labour Studies[38] available at http://www.uva-aias.net/en/ictwss.

Regarding the economic variables, we use hours worked per worker, the employment rate, and some GDP components (private consumption, investment, and government expenditure).

Hours are taken from the Total Economy Database of the Conference Board, available at https://www.conference-board.org/data/economydatabase/index.cfm?id=27762.

All other macroeconomic series are taken from the OECD Economic Outlook editions. In particular, we consider private final consumption expenditure (c), government final consumption (G), and private non-residential and government fixed capital formation, I). Our GDP is then reconstructed as the sum of these demand components ($Y = c + I + G$). All series are expressed in real terms (in 2010 USD at PPP).

Appendix B. Total hours decomposition

The procedure used is as follows:

1. Consider a reference year t_0, say 1981.
2. Consider a different year t. For each country $i = \{\text{France}, \text{Germany}, \text{UK}, \text{US}\}$, compute the change in the employment rate between t_0 and t: $\Delta^N_{i,t} = N_{i,t} - N_{i,t_0}$.
3. Compute the change for country $i \neq$ US minus the change for the United States: $r\Delta^N_{i,t} = \Delta^N_{i,t} - \Delta^N_{US,t}$. $r\Delta^N_{i,t}$ denotes the differential in country $i \neq$ US's employment rate relative to the United States (and to the reference year t_0).
4. Consider the hypothetical case in which the change in country $i \neq$ US's relative employment did not happen, and the chance of being employed evolves as in the United States. Instead, assume that $r\Delta^N_{i \neq US,t}$ (%) individuals were employed in t and worked the same number of hours as an individual in country $i \neq$ US, that is $h_{i,t}$. This would raise total hours in country $i \neq$ US by an amount equal to $\Delta^{Nh,N}_{i,t} = -r\Delta^N_{i,t} \times h_{i,t}$. The series $\Delta^{Nh,N}_{i,t}$ are the number of additional hours worked that economy i would have at time t if its employment rate were the same as in the United States.
5. The comparison of $\Delta^{Nh,N}_{i,t}$ with the observed differential in relative total hours provides us with a measure of the employment rate contribution. The observed differential is computed as $\Delta^{obs}_{i,t} = N_{i,t}h_{i,t} - N_{US,t}h_{US,t}$. If the contribution of employment to the total hours gap is significant, we expect a series of hypothetical hours ($\Delta^{Nh,N}_{i,t}$) close to the actual hours ($\Delta^{obs}_{i,t}$).

We also assess how much of the gap in total hours between each country and the United States is due to the intensive margin. To this end, we compare the contribution of the additional hours that European countries would have if all employed workers were working as much as American workers ($\Delta^{Nh,h}_{i,t}$). Given that $\Delta^{Nh,N}_{i,t}$ measures the additional hours that European countries would have if the employment rates were the same as in the United States, we have $\Delta^{Nh,N}_{i,t} + \Delta^{Nh,h}_{i,t} = \Delta^{obs}_{i,t}$, where $\Delta^{Nh,N}_{i,t}$ and $\Delta^{Nh,h}_{i,t}$ are the relative contributions of the extensive and intensive margins in the observed gap ($\Delta^{obs}_{i,t}$).

[38] J. Visser, ICTWSS database version 5.1. Amsterdam: Amsterdam Institute for Advanced Labour Studies, University of Amsterdam. September 2016.

Appendix C. Measure of non-employment incomes

In accordance with the idea that our model includes only two possible states (employed or non-employed for each member of the representative household), non-employment incomes must be in accordance with all the programs available for agents aged from 16–65 years. Hence, the measure of the replacement rate must represent the ratio of all alternative incomes over the wage.[39] If we restrict ourselves to unemployment benefits, this measure corresponds to the average gains during an unemployment spell, given the rules of the insurance scheme. Hence, we consider that a representative group of unemployed workers in each household gains the "average" amount of unemployment benefits. The degression and loss of eligibility explain the low replacement rate of a "representative" unemployed worker. However, beyond the heterogeneity between unemployed workers, the insurance possibilities also differ contingent on workers' ages. In particular, this is the case for pension schemes or early retirement benefits if they exist for those under 65 years; concerning older workers (55–64 years), our modeling assumption is the equivalent of saying that the revenue of a retiree (until 65 years) is equivalent to that of an unemployed person *stricto sensu*. Is this hypothesis acceptable? The largest bias can come from the country more generous to older workers, namely France. The trend of the replacement rate in France (left panel of Fig. 4) shows that the largest change occurred between the end of the 1970s and 1982/1983: the synthetic measure of the replacement rate rose from 0.25 to around 0.35. We find that behind this change were both the increase in the generosity of the support to the unemployed and the generosity of the compensation of the old. Let us consider the data provided by Blöndal and Scarpetta (1999) in their study. In 1975, the official retirement age was 65 years, whereas the average age at leaving the labor market was 63 years.[40] For the remaining years until 65, the authors report an "expected old-age pension gross replacement rate" of 62.5%.[41] In 1995, the normal retirement age was 60 years, the estimated age of transition to inactivity was 59.2 years, and the gross old-age pension replacement rate was 64.8%. The overall pension replacement rates in 1975 and in 1995 can therefore be computed as $p_{1975} = 0.625 \times (2/10) = 0.13$ and $p_{1995} = 0.65 \times (5/10) = 0.33$, where two-tenths and five-tenths represent the average number of years between 55 and 65 during which the worker receives a pension ((65–63)/(65–55) and (65–60)/(65–55), respectively). The measures are thus not far from the overall replacement rate. This finding suggests that the simplifying assumption of one representative non-employed worker in each household, paid at the replacement rate, is acceptable. Another interesting point is that the labor market reforms such as the change in the replacement ratios were implemented at the same time as the changes in the generosity of the pension system. This is particularly true for the large changes in France at the beginning of the 1980s and in Germany with the Schröder governments. Hence, in addition to a level that can be applied to all non-employed people, the changes in the replacement ratio of the UB corresponds approximately to the same changes in the specific programs for which only older workers are eligible.

Appendix D. Measure of bargaining power

In a Nash-bargaining problem, there are no institutions and the wage contract is signed by two parties; hence, bargaining power can be interpreted as a measure of relative impatience. One can link this theoretical framework to wage bargaining by assuming that the relative impatience of workers is dampened when they can share information in a union. Therefore, a natural way to measure the bargaining power of workers is to use an indicator of union size. The ICTWSS database provides a measure of UD. Alternatively, even if the union is small, information on the other contracts can be large (thus reducing the worker's impatience) if certain state rules imply a large coverage of the decisions of this small number of union members. The ICTWSS database also provides a measure of UC.

In the United States, UD is similar to the collective bargaining coverage (see Fig. 18). Therefore, in this country, there is no problem relating UC and/or UD to the bargaining power of workers.

This is not the case in the European countries, except for the United Kingdom after the 1980s. For example, only 7.7% of French workers are union members, while 98% are covered by collective bargaining agreements (see Fig. 18). The coverage rates are thus substantially higher than union membership. That is, in European countries, a large share of workers take advantage that their compensation is affected by collective agreements, even though they are not a union member (see Fig. 18).

If the UD and UC trends are the same, one could arbitrarily choose one of these two indicators to account for the power provided by the union to the worker during the wage bargaining process. This is the case for the United Kingdom and Germany, but not for France (see Fig. 18), where there was a decline in union membership in the 1980s (as in all other countries) accompanied by a significant rise in UC that did not occur in other countries.

Therefore, given that the trends of UD and of UC differ in France, we choose to keep the two pieces of information on unions (i.e., UD and UC) and build an indicator of the bargaining power of workers as their average. This is neutral for

[39] If we follow the definition provided by the OECD, the "replacement rate" for non-employment income is a comprehensive measure, referring to a person that is 40 years on average. This definition can be found at http://www.oecd.org/els/benefits-and-wages-statistics.htm.

[40] Blöndal and Scarpetta (1999), Table II.1.

[41] Blöndal and Scarpetta (1999), Table III.3.

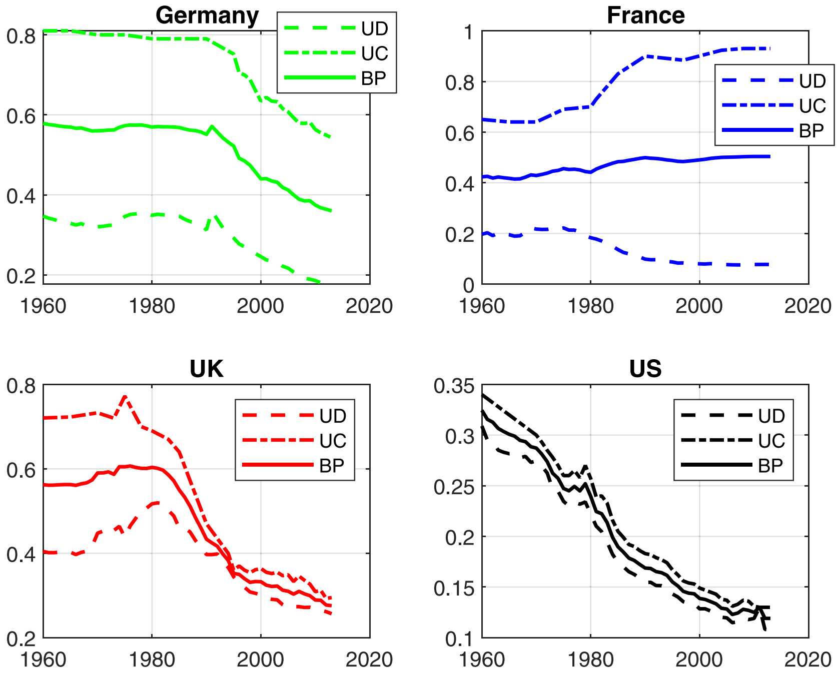


Fig. 18. UD, UC, and bargaining power.

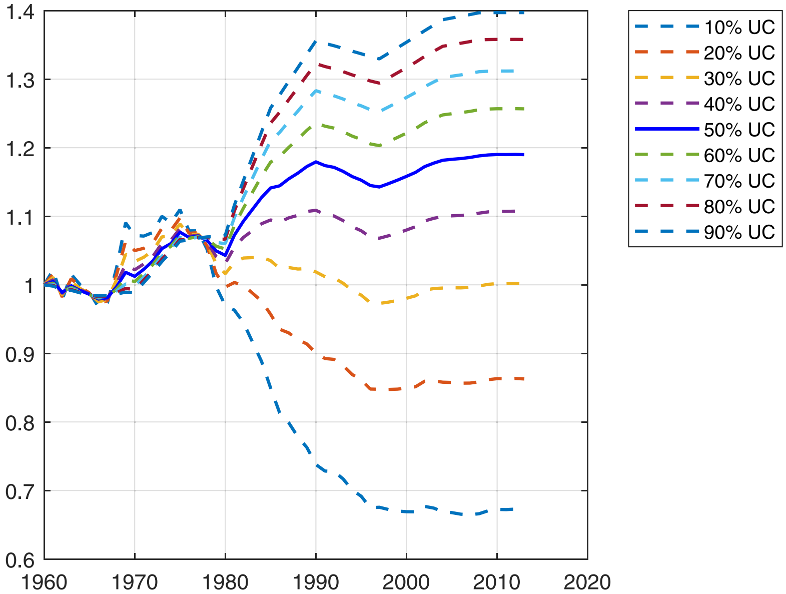


Fig. 19. Bargaining power in France.

Germany, the United Kingdom, and the United States (i.e., an alternative choice only implies a change in a scale parameter during the calibration procedure), but not for France. Fig. 19 shows that the weighted average of UD and UC in France implies a significant increase in bargaining power after 1981 for a weight of UC above 40%. Therefore, our measure of bargaining power can be viewed as conservative.

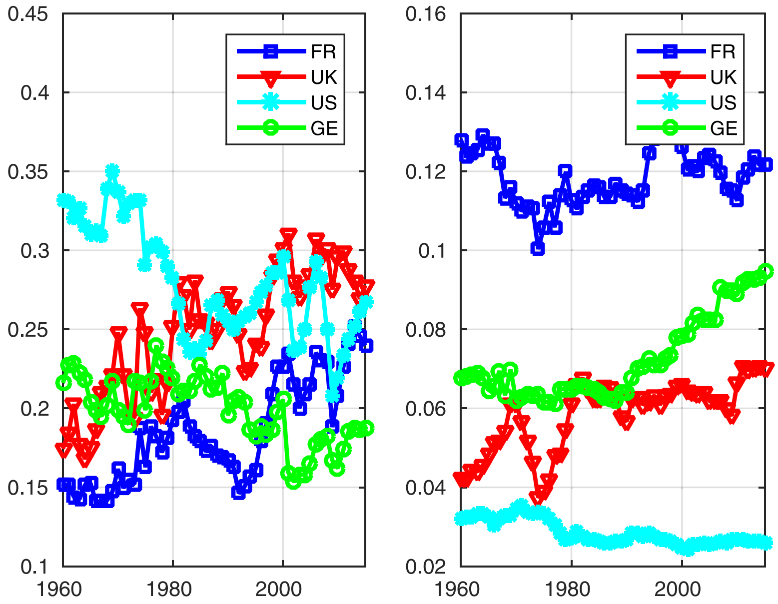


Fig. 20. Taxes on capital (left) and investment (right).

Appendix E. Taxes on capital and government expenditure

E.1. Taxes on capital and investment

Given that ours is a general equilibrium model, it is important not to omit taxes on capital that modify the relative demand between capital and employment. There are two types of taxes: those on the revenues of existing capital and those on investment goods.

Fig. 20 reports the trend of this set of exogenous variables. The policy choices differ on the two sides of the Atlantic. In the United States, taxes are largely based on capital income, whereas France and Germany, and to a lesser degree the United Kingdom, also have a tax on investment. The gaps in capital income taxes decline throughout the sample, whereas the gaps in investment taxes are persistent.

E.2. Government expenditure on collective goods

Data for the ratio of government expenditure on collective goods to GDP are taken from the OECD.[42] According to the definition adopted by the OECD[43], consumption expenditure on collective goods “covers all government final consumption expenditure on general public services, defence, public order and safety, economic affairs, environment protection, and housing and community amenities”. As shown in Fig. 21, France, Germany, and the United Kingdom have a rate of collective public spending in proportion to GDP comparable with other OECD countries,[44] while the United States is characterized by a higher share of collective public spending in which defense is included.

By contrast, individual government spending in France, Germany, and the United Kingdom is much larger than the average of OECD countries, while the share of individual government expenditure in the United States is minimal.

[42] Table COFOG, government expenditure by function.

[43] See OECD/Eurostat (2012), “Component expenditures of GDP” in Eurostat-OECD Methodological Manual on Purchasing Power Parities, OECD Publishing. https://doi.org/10.1787/9789264189232-7-en.

[44] Data come from Langot et al. (2014).

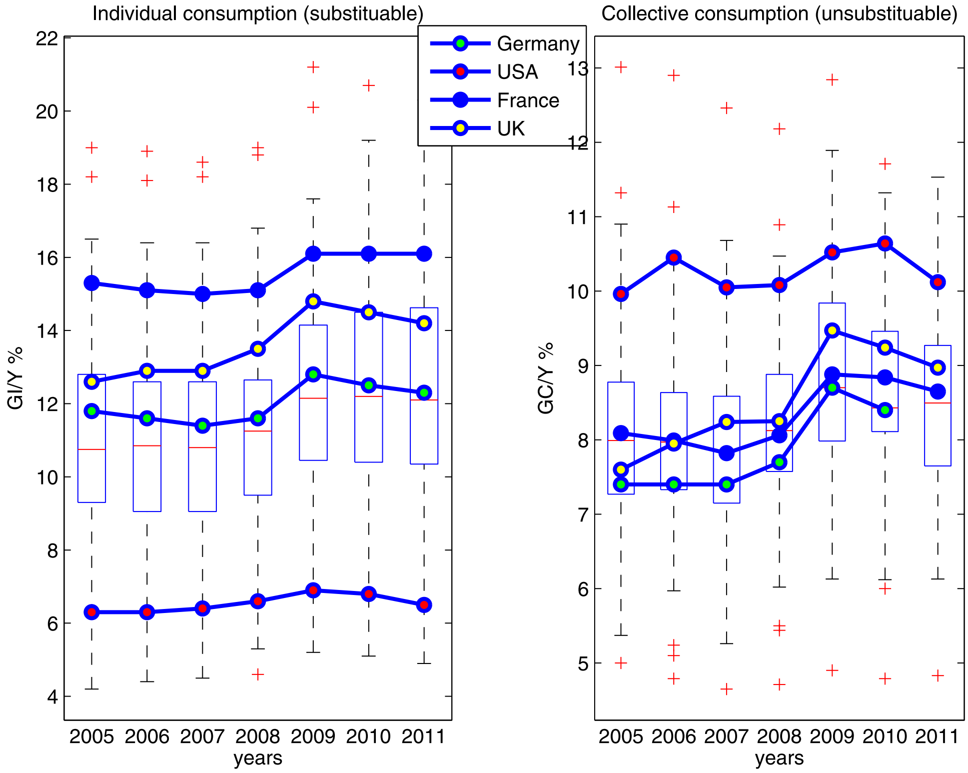


Fig. 21. *Decomposition of government expenditure (OECD data).* In both the individual and the collective panels of Fig. 21, for each year, the central mark is the median value over a sample of 32 OECD countries. The edges of the box are the 25*th* and 75*th* percentiles, the whiskers extend to the most extreme data points not considered as outliers, and the outliers are plotted individually.

Appendix F. Solow residuals

Fig. 22 shows the presence of a break in the linear trend of the Solow residuals. For the European economies, the presence of a break in productivity is linked with the catching up period of reconstruction after WWII. In particular, we identify a break in 1985 for France and the United Kingdom and in 1982 for Germany. For each country, the Chow test tells us to reject the null hypothesis of a unique time trend. For the United States, we consider a break in the mid-1990s, when we can observe a small decline in the growth rate of productivity. Our hypothesis is confirmed by the Chow test, which tells us to reject the null hypothesis of a unique linear trend.

Appendix G. Vacancy posting costs

To identify the stationarized series of vacancy posting costs, we start from the information in Barron et al. (1997), according to whom the costs of posting a vacancy amount to 17% of labor productivity. We assume that this restriction is satisfied only at the beginning (t_0) and at the end (T) of the sample **if** we use the stationarized measure of labor productivity and the gap between these two first evaluations of the stationarized vacancy posting costs estimates the growth rate of this shift:

$$\left.\begin{array}{l}\widehat{\omega}_{t_0} = 0.17 \times (Y_{t_0}/N_{t_0}h_{t_0})\\ \widehat{\omega}_T = 0.17 \times (Y_T/N_T h_T)/(1+g)^{T-t_0}\end{array}\right\} \Rightarrow g_\omega = \left(\frac{\widehat{\omega}_T}{\widehat{\omega}_{t_0}}\right)^{T-t_0} - 1$$

Using this estimation of g_ω, we can construct the component of ω_t that shifts over time. This shift is not linked to the exogenous rate of growth ($g = g_A + g_n$):

$$\widehat{\omega}_t = \widehat{\omega}_{t_0} \times (1+g_\omega)^t$$

This is the series in red in Fig. 23. Therefore, we can deduce the level of the vacancy posting costs (including the population growth that comes from the demographic shift of the number of vacancies, see Appendix H) consistent with the model restrictions:

$$\omega_t = \widehat{\omega}_t \times (1+g)^t$$

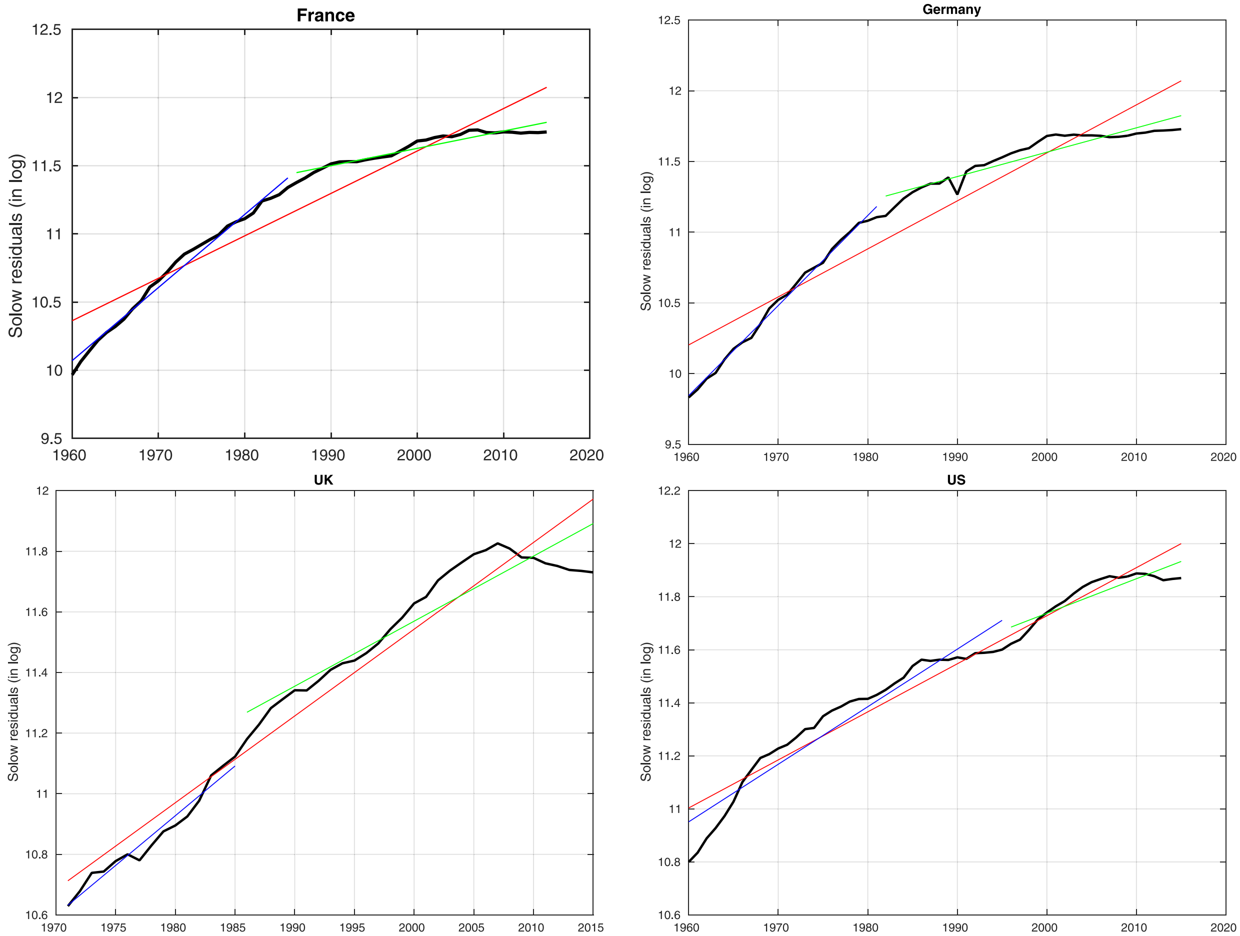


Fig. 22. Linear trends in productivity.

This time series is different from $\widetilde{\omega}_t = 0.17 \times \widehat{Y}_t/(N_t h_t)$, where $\widehat{Y}_t = Y_t/(1+g)^t$. This last series is shown in black in Fig. 23.

Appendix H. The balanced growth path

In our model, population and labor market aggregates are growing at the rate g_n, technological progress grows at the rate g_A. Therefore, the total growth rate is $g = g_A + g_n$, where we adopt the approximation $(1+g_A)(1+g_n) \approx (1+g)$. Let us define the total flows in the labor market as $\widetilde{N}_t + \widetilde{U}_t = \widetilde{Pop}_t$, where $\widetilde{X}_t = X_t(1+g_n)^t$. The labor market variables can be stationarized as follows:[45]

$$N_{t+1}(1+g_n)^{t+1} = (1-s)N_t(1+g_n)^t + M_t(1+g_n)^t \Rightarrow (1+g_n)N_{t+1} = (1-s)N_t + M_t$$

$$\widetilde{M}_t = \min\left[\min(\widetilde{V}_t, \widetilde{U}_t), \Upsilon \widetilde{V}_t^{\psi} \widetilde{U}_t^{1-\psi}\right] \Rightarrow M_t = \min\left[\min(V_t, U_t), \Upsilon V_t^{\psi} U_t^{1-\psi}\right]$$

$$f_t = \min\left(\frac{\Upsilon \widetilde{V}_t^{\psi} \widetilde{U}_t^{1-\psi}}{\widetilde{U}_t}, 1\right) \Rightarrow f_t = \min\left(\frac{\Upsilon V_t^{\psi} U_t^{1-\psi}}{U_t}, 1\right)$$

$$q_t = \min\left(\frac{\Upsilon \widetilde{V}_t^{\psi} \widetilde{U}_t^{1-\psi}}{\widetilde{V}_t}, 1\right) \Rightarrow q_t = \min\left(\frac{\Upsilon V_t^{\psi} U_t^{1-\psi}}{V_t}, 1\right)$$

$$\theta_t = \frac{\widetilde{V}_t}{\widetilde{U}_t} \Rightarrow \theta_t = \frac{V_t}{U_t}$$

The variables that grow at the total rate of growth g are: production (Y), capital (K), investment (I), consumption (c), vacancy posting costs (ω), wages (w) and Government expenditures (G^{col} and G^{ind}). The convention adopted is to indicate with $\widehat{X}$ a

45 To ensure that the job finding rate and job filling rate are in the range [0; 1], we take the minimum between the unconstrained definition of these rates and 1. In accordance with these constraints, the matching function is also redefined.

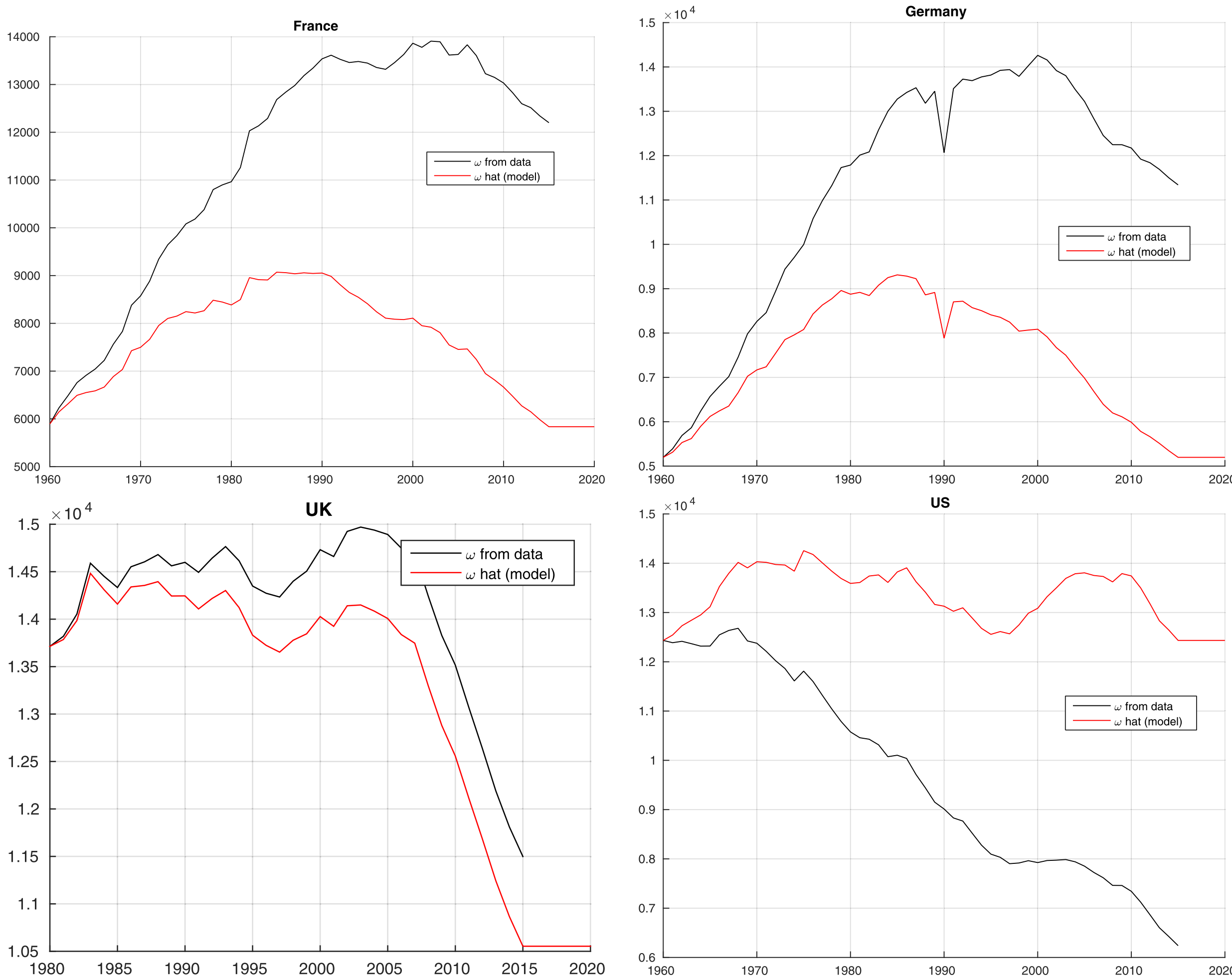


Fig. 23. Stationarized vacancy posting costs.

variable X, for $X \in \{A;\ c;\ Y;\ K;\ I;\ G^{col};\ G^{ind};\ w;\ \omega\}$, which is deflated by the rate its growth g_X, i.e. $\widehat{X}_t = X_t/(1+g_X)^t$, with $g_z \in \{g,\ g_A\}$. The first block represents the production function, the dynamics of capital and the FOC for capital:

$$\widehat{Y}_t(1+g)^t = (\widehat{K}_t(1+g)^t)^{1-\alpha}(\widehat{A}_t(1+g_A)^t N_t(1+g_n)^t h_t)^\alpha \Rightarrow \widehat{Y}_t = \widehat{K}_t^{1-\alpha}(\widehat{A}_t N_t h_t)^\alpha$$
$$\widehat{K}_{t+1}(1+g)^{t+1} = (1-\delta)\widehat{K}_t(1+g)^t + \widehat{I}_t(1+g)^t \Rightarrow (1+g)\widehat{K}_{t+1} = (1-\delta)\widehat{K}_t + \widehat{I}_t$$
$$r_t = (1-\alpha)(\widehat{K}_t(1+g)^t)^{-\alpha}(\widehat{A}_t(1+g_A)^t N_t(1+g_n)^t h_t)^\alpha \Rightarrow r_t = (1-\alpha)\widehat{K}_t^{-\alpha}(\widehat{A}_t N_t h_t)^\alpha$$

The second block represents the balanced Government budget and the resource constraint:

$$\begin{aligned}
\widehat{TR}_t(1+g)^t &= \tau_{c,t}\widehat{c}_t(1+g)^t + \tau_{w,t}[\widehat{w}_t(1+g)^t h_t N_t + \rho_t \widehat{w}_t(1+g)^t h_t U_t] + \tau_{i,t}\widehat{I}_t(1+g)^t \\
&\quad + \tau_{k,t} r_t \widehat{K}_t(1+g)^t - \rho_t \widehat{w}_t(1+g)^t h_t U_t - \widehat{G}_t^{\,col}(1+g)^t - \widehat{G}_t^{\,ind}(1+g)^t \\
\Rightarrow \widehat{TR}_t &= \tau_{c,t}\widehat{c}_t + \tau_{w,t}[\widehat{w}_t h_t N_t + \rho_t \widehat{w}_t h_t U_t] + \tau_{i,t}\widehat{I}_t + \tau_{k,t} r_t \widehat{K}_t - \rho_t \widehat{w}_t h_t U_t - \widehat{G}_t^{col} - \widehat{G}_t^{ind} \\
\widehat{Y}_t(1+g)^t &= \widehat{C}_t(1+g)^t + \widehat{I}_t(1+g)^t + \widehat{G}_t^{col}(1+g)^t + \widehat{\omega}_t V_t(1+g)^t \\
\Rightarrow \widehat{Y}_t &= \widehat{C}_t + \widehat{I}_t + \widehat{G}_t^{col} + \widehat{\omega}_t V_t
\end{aligned}$$

where the unit cost of a vacancy grows at the rate of the technological progress ($\omega_t = (1+g_A)^t\widehat{\omega}_t$), given that the number of vacancies grows at the rate of the population ($\widetilde{V}_t = (1+g_n)^t V_t$), and thus implying that $\omega_t\widetilde{V}_t = (1+g_A)^t\widehat{\omega}_t(1+g_n)^t V_t = \widehat{\omega}_t V_t(1+g)^t$. Lets us remark that $\widehat{\omega}_t$ can change over time as it is explain in Section Appendix G.

The third block describes the Euler equations (consumption and vacancies):

$$\frac{(\widehat{C}_{t+1}-\bar{c})(1+g)^{t+1}}{(\widehat{C}_t-\bar{c})(1+g)^t} = \frac{\beta(1+\tau_{c,t})[r_{t+1}(1-\tau_{k,t+1}) + (1-\delta)(1+\tau_{i,t+1})]}{(1+\tau_{c,t+1})(1+\tau_{i,t+1})}$$

$$\Rightarrow \frac{\widehat{C}_{t+1}-\bar{c}}{\widehat{C}_t-\bar{c}} = \frac{\beta}{1+g}\frac{(1+\tau_{c,t})[r_{t+1}(1-\tau_{k,t+1})+(1-\delta)(1+\tau_{i,t+1})]}{(1+\tau_{c,t+1})(1+\tau_{i,t+1})}$$

$$\frac{\widehat{\omega}_t(1+g)^t(1+\tau_{c,t+1})}{q_t(1+\tau_{c,t})} = \beta\frac{(\widehat{C}_t-\bar{c})(1+g)^t}{(\widehat{C}_{t+1}-\bar{c})(1+g)^{t+1}}\Big[\alpha(\widehat{K}_{t+1}(1+g)^{t+1})^{1-\alpha}(\widehat{A}_{t+1}N_{t+1}(1+g)^{t+1}h_{t+1})^{\alpha}$$
$$-\widehat{w}_{t+1}(1+g)^{t+1}h_{t+1}+(1-s)\frac{\widehat{\omega}_{t+1}(1+g)^{t+1}}{q_{t+1}}\Big]$$

$$\Rightarrow \frac{\widehat{\omega}_t(1+\tau_{c,t+1})}{q_t(1+\tau_{c,t})} = \frac{\beta}{1+g}\frac{\widehat{C}_t-\bar{c}}{\widehat{C}_{t+1}-\bar{c}}\Big[\alpha\widehat{K}_{t+1}^{1-\alpha}(\widehat{A}_{t+1}N_{t+1}h_{t+1})^{\alpha}-\widehat{w}_{t+1}h_{t+1}+(1-s)\frac{\widehat{\omega}_{t+1}}{q_{t+1}}\Big]$$

The last block describes the wage and hours equations, which are obtained from the Nash bargaining problem:

$$N_t(1+n)^t\sigma_L h_t^{\eta} = \frac{(1-\tau_{w,t})}{(1+\tau_{c,t})}\frac{\alpha(\widehat{K}_t(1+g)^t)^{1-\alpha}(\widehat{A}_tN_t(1+g)^th_t)^{\alpha}}{(\widehat{C}_t-\bar{c})(1+g)^th_t}$$

$$\Rightarrow N_t\sigma_L h_t^{\eta} = \frac{(1-\tau_{w,t})}{(1+\tau_{c,t})}\frac{\alpha\widehat{K}_t^{1-\alpha}(\widehat{A}_tN_th_t)^{\alpha}}{(\widehat{C}_t-\bar{c})h_t}$$

$$\widehat{w}_t(1+g)^th_t = \frac{(1-\epsilon_t)}{(1-\rho_t\epsilon_t)}\Big[\alpha(\widehat{K}_t(1+g)^t)^{1-\alpha}(\widehat{A}_tN_t(1+g)^th_t)^{\alpha}$$
$$+\widehat{\omega}_t(1+g)^t\left(\frac{1-s}{q_t}\left(1-\left(\frac{\phi_{t+1}}{\phi_t}\frac{(1-\tau_{w,t+1})}{(1-\tau_{w,t})}\right)+\frac{\phi_{t+1}}{\phi_t}\frac{(1-\tau_{w,t+1})}{(1-\tau_{w,t})}\theta_t\right)\right)\Big]$$
$$+\frac{\epsilon_t}{1-\rho_t\epsilon_t}\frac{(1+\tau_{c,t})}{(1-\tau_{w,t})}(\widehat{C}_t-\bar{c})(1+g)^t\left(\Gamma^u+\sigma_l\frac{h_t^{(1+\eta)}}{(1+\eta)}\right)$$

$$\Rightarrow \widehat{w}_th_t = \frac{(1-\epsilon_t)}{(1-\rho_t\epsilon_t)}\Big[\alpha\widehat{K}_t^{1-\alpha}(\widehat{A}_tN_th_t)^{\alpha}$$
$$+\widehat{\omega}_t\left(\frac{1-s}{q_t}\left(1-\left(\frac{\phi_{t+1}}{\phi_t}\frac{(1-\tau_{w,t+1})}{(1-\tau_{w,t})}\right)+\frac{\phi_{t+1}}{\phi_t}\frac{(1-\tau_{w,t+1})}{(1-\tau_{w,t})}\theta_t\right)\right)\Big]$$
$$+\frac{\epsilon_t}{1-\rho_t\epsilon_t}\frac{(1+\tau_{c,t})}{(1-\tau_{w,t})}(\widehat{C}_t-\bar{c})\left(\Gamma^u+\sigma_l\frac{h_t^{(1+\eta)}}{(1+\eta)}\right)$$

where $\phi_t = \frac{1-\epsilon_t}{\epsilon_t}$. The set of stationarized equations are used to solve the dynamic paths of the model.

Appendix I. Unexpected policy change

To check the impact of the perfect foresight hypothesis, we perform the following experiment. We suppose that at the beginning of the sample (in 1960), agents in France correctly anticipated the path of all the exogenous variables except for the replacement rate (we choose this policy change because the break in its trend is the largest among all changes in the exogenous variables). The agents consider that the replacement rate evolves until 1980 and then remains constant at its 1981 level. When the government changes in 1981 and the new one changes the replacement rate policy, agents are surprised. At this point, the new path of the replacement rate is revealed. Fig. 24 shows the results of this experiment.

Until 1978, under the hypothesis of perfect forecast (black line with triangles) or unexpected change (green line with stars), both scenarios produce the same results. After 1979, firms begin to reduce their vacancies if the policy change is correctly anticipated. Thus, the reduction in the employment rate is slightly smoothed until 1985, after which the employment rate again becomes the same, as we can see by looking at the lines that represent the perfect foresight case (black line with triangles) and reaction of agents when they are surprised (red line with circles). Nevertheless, the gap between the two scenarios never exceeds 1.5 percentage points, which is small given the size of the policy change.

Appendix J. Role of the subsistence term of consumption $\bar{c}$

In this section, we discuss the role of the term $\bar{c}$. As already highlighted in the main text, $\bar{c}$ captures the “exceptionality” of the period between the 1960s and 1970s for the economies reconstructed after WWII. To check the importance of this hypothesis, we consider an alternative version of the model in which $\bar{c}$ is zero, while all the other parameters are equal to the benchmark version (i.e., the two versions of the model share the same final steady state).

We show the performance of the model in replicating the variables of interest for France. As illustrated in Fig. 25, without the subsistence term $\bar{c}$, the model underestimates the level of hours; the important point is that it predicts a decrease in hours worked, even with a lower “speed.” We can also compute a simple measure of the “loss” in the model fit by considering the MSEs for hours for the two models: the MSEs for hours and the employment rate with the alternative model are 0.0027 and $4.1051 \cdot 10^{-4}$, respectively.

Fig. 24. Surprise in the replacement rate in 1981.

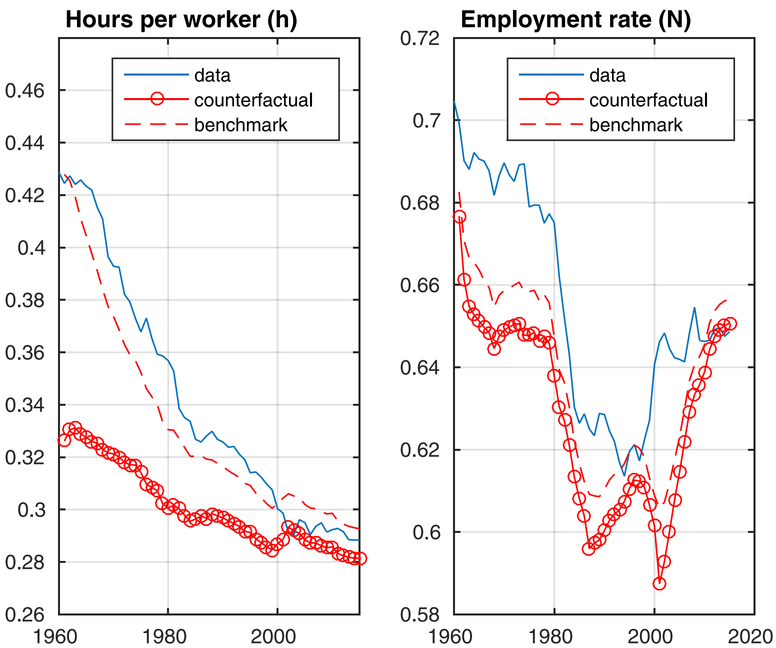


Fig. 25. The French economy.

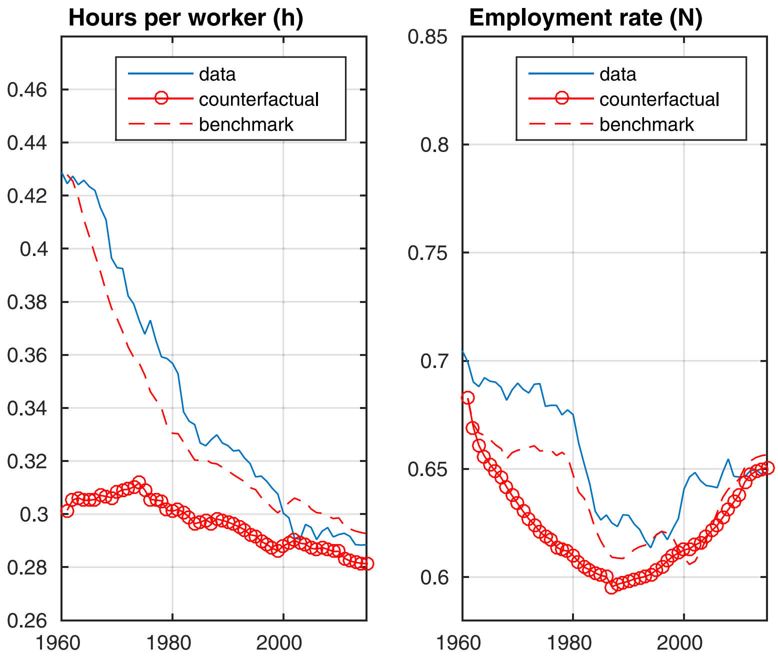


Fig. 26. Contribution of the exogenous variables (France): taxes.

Appendix K. Model fit

K.1. Driving forces of the model

In this section, we analyze the impact of the different driving forces of the model. To disentangle the effect of the trend of the exogenous variables, we proceed as in McDaniel (2011) by "switching off" the effects caused by the different variables. We compare the outcome of the "full" benchmark model with that of two counterfactuals:

(i) A model in which only taxes vary, whereas LMIs and labor productivity do not;
(ii) A model in which only LMIs evolve, whereas taxes and labor productivity do not.

In particular, we fix the level of the constant exogenous variables to that attained in 2010 so that all the versions of the model share the same final steady state.

The trend of hours for France in the top left panel of Fig. 26 shows the explanatory power of the tax wedge: hours remain flat until 1975 and then start to decrease, reflecting the tax wedge trend in Fig. 3. On the contrary, the employment trend is not at all explained in this case.

If we look at LMIs as the driving force of the model, we confirm the insight gained from the steady-state analysis. They explain the trend of the employment rate, while the overall effect of hours worked is limited because of the low elasticity of the labor supply locus (see the right panel of Fig. 10).

K.2. Additional model predictions

We report the complete set of information about the model fit: Figs. 28–31 show for each country not only hours per worker and the employment rate, as in the main text, but also total hours.

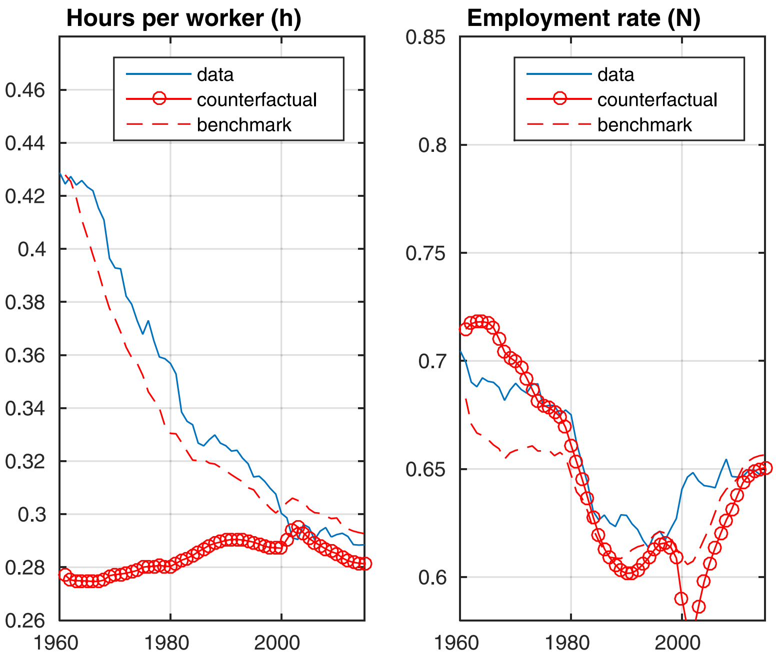


Fig. 27. Contribution of the exogenous variables (France): LMIs.

Fig. 28. The US economy.

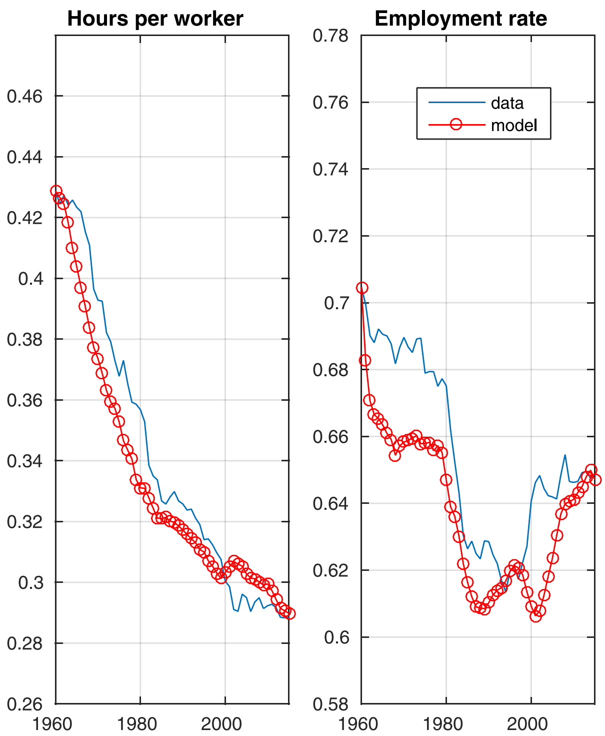


Fig. 29. The French economy.

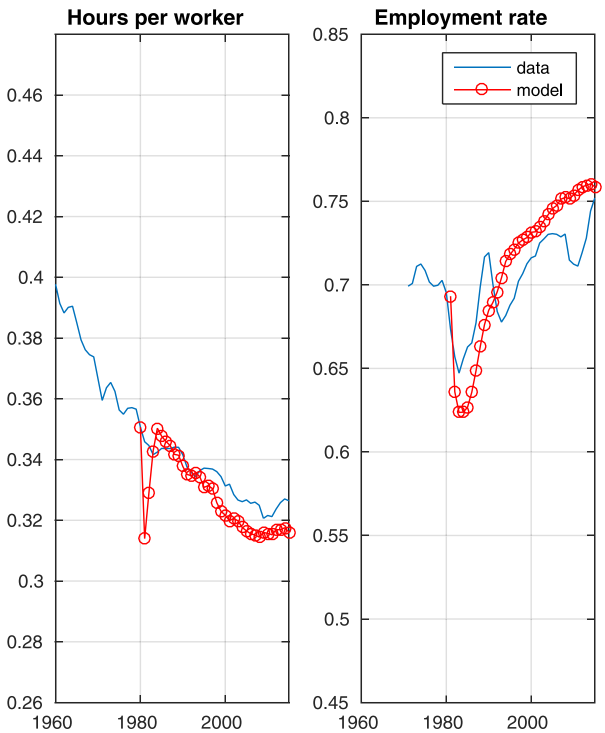


Fig. 30. The UK economy.

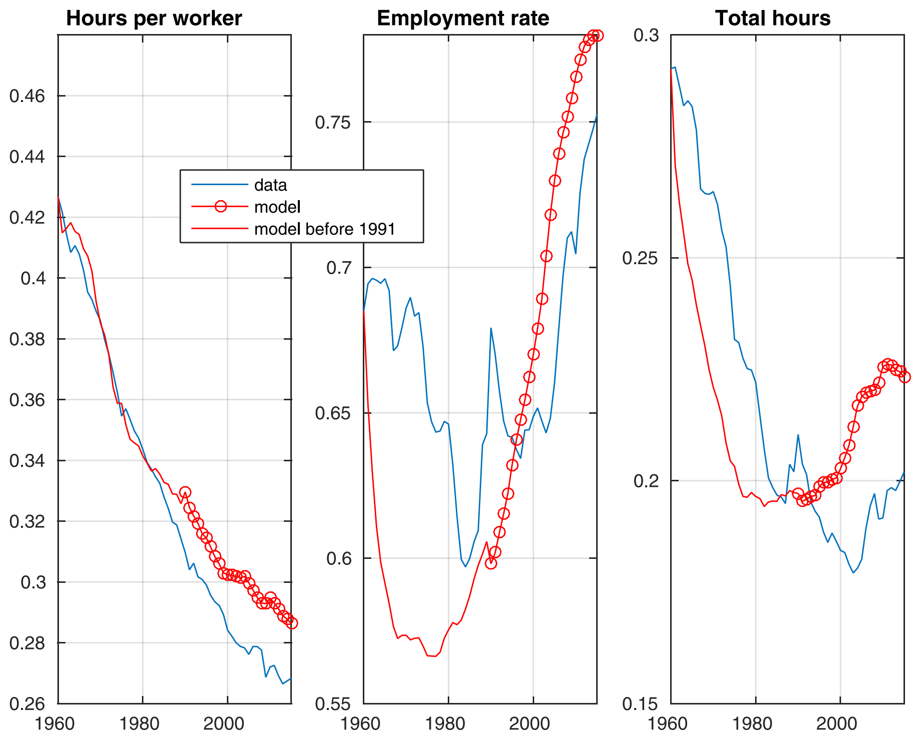


Fig. 31. The German economy.

Appendix L. Steady-state analysis

We first report all the equations that compose the model:

$$(n+s)N = q(\theta)V$$

$$(g+\delta)K = I$$

$$Y = K^{1-\alpha}(ANh)^{\alpha}$$

$$Y = C + I + G^{col} + \omega V$$

$$1 = \frac{\beta}{1+g}\left[r\frac{(1-\tau_k)}{(1+\tau_i)} + 1 - \delta\right]$$

$$r = (1-\alpha)\left(\frac{K}{ANh}\right)^{-\alpha}$$

$$\frac{\omega\theta}{f(\theta)} = \beta\left[\alpha\frac{Y}{N} - wh + (1-s)\frac{\omega\theta}{f(\theta)}\right]$$

$$wh = \frac{1-\epsilon}{1-\rho\epsilon}\left(\alpha\frac{Y}{N} + \omega\theta\right) + \frac{\epsilon}{1-\rho\epsilon}\frac{1+\tau_c}{1-\tau_w}(C-\bar{c})\left(\Gamma^u + \sigma_l\frac{h^{1+\eta}}{1+\eta}\right)$$

$$\theta = \frac{V}{U}$$

$$f(\theta) = \Upsilon\theta^{\psi}$$

$$q(\theta) = \frac{\Upsilon}{\theta^{1-\psi}}$$

$$\sigma_l h^{1+\eta} = \alpha\frac{Y}{N}\frac{1-\tau_w}{1+\tau_c}\frac{1}{C-\bar{c}}$$

We next report for clarity an intermediate step in the substitution. Let us define the following two values:

$$r = \left[\frac{1+g}{\beta} - (1-\delta)\right]\frac{1+\tau_{inv}}{1-\tau_k}$$

$$K = \left(\frac{r}{1-\alpha}\right)^{-\frac{1}{\alpha}} ANh$$

We can therefore reduce the system of steady-state equations to the following one:[46]

$$N(\theta) = \left(\frac{n+s}{\Upsilon\theta^{\psi}}+1\right)^{-1}$$
$$Y(\theta,h) = \left(\frac{r}{1-\alpha}\right)^{-\frac{(1-\alpha)}{\alpha}} AN(\theta)h$$
$$K(\theta,h) = \left(\frac{r}{1-\alpha}\right)^{-\frac{1}{\alpha}} AN(\theta)h$$
$$I(\theta,h) = (g+\delta)K(\theta,h)$$
$$C(\theta,h) = \frac{Y(\theta,h)}{N(\theta)}\frac{\alpha}{\sigma_l}\frac{(1-\tau_w)}{(1+\tau_c)}\frac{1}{h^{1+\eta}}$$
$$\frac{\omega\theta}{\Upsilon\theta^{\psi}}\left[\frac{1}{\beta}-(1-s)\right]+\frac{1-\epsilon}{1-\rho\epsilon}\omega\theta = \frac{\epsilon}{1-\rho\epsilon}\left[\begin{array}{l}(1-\rho)\alpha\frac{Y(\theta,h)}{N(\theta,h)}\\ -\left(\frac{1+\tau_c}{1-\tau_w}\right)C(\theta,h)\left(\Gamma^u+\sigma_l\frac{h^{1+\eta}}{1+\eta}\right)\end{array}\right]$$
$$Y(\theta,h) = C(\theta,h)+I(\theta,h)+\omega\theta(1-N(\theta))$$

By continuing with the substitutions, we arrive at the following three equations, which represent the labor supply equation, combination of the wage equation and job opening condition, and aggregate market clearing, respectively:

$$Ch^{1+\eta} = \frac{\alpha}{\sigma_l}\frac{(1-\tau_w)}{(1+\tau_c)}\left(\frac{r}{1-\alpha}\right)^{-\frac{(1-\alpha)}{\alpha}} Ah$$
$$\frac{\omega\theta^{1-\psi}}{\Upsilon}\left[\frac{1}{\beta}-(1-s)\right]+\left(\frac{1-\epsilon}{1-\rho\epsilon}\right)\omega\theta = \frac{\epsilon}{1-\rho\epsilon}\left[\begin{array}{l}(1-\rho)\alpha Ah\left(\frac{r}{1-\alpha}\right)^{-\frac{(1-\alpha)}{\alpha}}\\ -C\left(\frac{1+\tau_c}{1-\tau_w}\right)\left(\Gamma^u+\sigma_l\frac{h^{1+\eta}}{1+\eta}\right)\end{array}\right]$$
$$C+\omega\theta\left(1-\left(\frac{n+s}{\Upsilon\theta^{\psi}}+1\right)^{-1}\right) = Ah\left(\frac{r}{1-\alpha}\right)^{-\frac{(1-\alpha)}{\alpha}}\left(\frac{n+s}{\Upsilon\theta^{\psi}}+1\right)^{-1}\left(\left(\frac{r}{1-\alpha}\right)-(g+\delta)\right)$$

Appendix M. Proofs of the propositions

Equation (5) implicitly defines consumption $C(\theta, h)$ as a function of θ and h, which can be integrated into the two other relationships:

$$Ch^{1+\eta} = \frac{\alpha}{\sigma_l}\frac{(1-\tau_w)}{(1+\tau_c)}\left(\frac{r}{1-\alpha}\right)^{-\frac{(1-\alpha)}{\alpha}} Ah \tag{3}$$

$$\frac{\omega\theta^{1-\psi}}{\Upsilon}\left[\frac{1}{\beta}-(1-s)\right]+\left(\frac{1-\epsilon}{1-\rho\epsilon}\right)\omega\theta = \frac{\epsilon}{1-\rho\epsilon}\left[\begin{array}{l}(1-\rho)\alpha Ah\left(\frac{r}{1-\alpha}\right)^{-\frac{(1-\alpha)}{\alpha}}\\ -C\left(\frac{1+\tau_c}{1-\tau_w}\right)\left(\Gamma^u+\sigma_l\frac{h^{1+\eta}}{1+\eta}\right)\end{array}\right] \tag{4}$$

$$C+\omega\theta\left(1-\frac{1}{1+\frac{n+s}{\Upsilon\theta^{\psi}}}\right) = Ah\left(\frac{r}{1-\alpha}\right)^{-\frac{(1-\alpha)}{\alpha}}\left(\frac{\left(\frac{r}{1-\alpha}\right)-(g+\delta)}{1+\frac{n+s}{\Upsilon\theta^{\psi}}}\right) \tag{5}$$

We therefore obtain the system $(Ls)-(JC)+(WC)$, which is presented in the text.

M.1. Proof of Proposition 1

Let $\epsilon_{C|h} = C'_h\frac{h}{C(\theta,h)}$ and $\epsilon_{C|\theta} = C'_\theta\frac{\theta}{C(\theta,h)}$, where $C(\theta, h)$ is the consumption compatible with the resource constraint. Differentiating equation (5) with respect to h, we obtain $dC = \frac{-A(\delta+g-\frac{r}{1-\alpha})}{(\frac{n+s}{\Upsilon\theta^{\psi}}+1)(\frac{r}{1-\alpha})^{\frac{1}{\alpha}}}dh$. Let us substitute the expression of the equilibrium real interest rate, which is given by $r = (\frac{1+\tau_{inv}}{1-\tau_k})(\frac{1+g}{\beta}-(1-\delta))$. We find that

$$C'_h\frac{h}{C(\theta,h)} = \frac{-A\left[\delta+g-\left(\frac{1+\tau_{inv}}{1-\tau_k}\right)\left(\frac{1+g}{\beta}-(1-\delta)\right)\left(\frac{1}{1-\alpha}\right)\right]}{\left(\frac{n+s}{\Upsilon\theta^{\psi}}+1\right)\left(\frac{r}{1-\alpha}\right)^{\frac{1}{\alpha}}}\frac{h}{C(\theta,h)} > 0$$

[46] When we consider the steady state of the model, we refer to the "asymptotic" steady state obtained when the subsistence consumption term is null. Hence, in the following, $\bar{c}=0$.

because the term inside the parentheses in the numerator is always negative.[47] If we now check the derivative with respect to tightness, we find the following expression:

$$\frac{\partial C}{\partial \theta}=\omega\left[\frac{\Upsilon\theta^{\psi}}{n+s}(1+\psi)-1\right]+\left[\frac{-Ah\psi(n+s)(\delta+g-\frac{r}{1-\alpha})}{\Upsilon\theta^{1+\psi}\left(\frac{n+s}{\Upsilon\theta^{\psi}}+1\right)^{2}\left(\frac{r}{1-\alpha}\right)^{\frac{1}{\alpha}}}\right]$$

The second term in square brackets is always positive, so that the overall sign depends on the conditions of the first term in square brackets; we find that if the first term in square brackets is positive, too, there will be an overall positive sign in the numerator, which is satisfied if $\frac{\Upsilon\theta^{\psi}}{n+s}(1+\psi)>1$. Since we know that in steady state $\frac{f}{n+s}=\frac{N}{1-N}$, the previous condition reduces to $\frac{N}{1-N}(1+\psi)>1$ (i.e. $N>\frac{1}{2+\psi}$). In the most "restrictive" case ($\psi=1$), the condition would be satisfied by an employment rate equal to at least one-third.

M.2. Proof of Proposition 2

Differentiating Eqs. (3) and (5) leads to $\left(\eta+\epsilon_{C|h}\right)\frac{dh}{h}=-\epsilon_{C|\theta}\frac{d\theta}{\theta}$, where $\epsilon_{C|h}=C'_h\frac{h}{C(\theta,h)}$ and $\epsilon_{C|\theta}=C'_\theta\frac{\theta}{C(\theta,h)}$, where $C(\theta,h)$ is the consumption compatible with the resource constraint.

M.3. Proof of Proposition 3

Differentiating equation (4) leads to

$$\left\{\begin{array}{l}(1-\psi)\frac{\omega\theta^{1-\psi}}{\Upsilon}\left[\frac{1}{\beta}-(1-s)\right]\\+\left(\frac{1-\epsilon}{1-\rho\epsilon}\right)\omega\theta+\left(\frac{\epsilon}{1-\rho\epsilon}\right)\Gamma^{u}\frac{(1+\tau_c)}{(1-\tau_w)}C\epsilon_{C|\theta}\end{array}\right\}\frac{d\theta}{\theta}=\left(\frac{\epsilon}{1-\rho\epsilon}\right)\left\{\begin{array}{c}\frac{\eta-\rho(1+\eta)}{1+\eta}\alpha Ah\left(\frac{r}{1-\alpha}\right)^{-\frac{(1-\alpha)}{\alpha}}\\-\Gamma^{u}\frac{(1+\tau_c)}{(1-\tau_w)}C\epsilon_{C|h}\end{array}\right\}\frac{dh}{h}$$

With $\Gamma_u<0$ and $\eta-\rho(1+\eta)>0$, the right-hand side is positive, whereas the sign of the left-hand side is undetermined. Its sign is negative if and only if

$$(1-\psi)\frac{\omega\theta^{1-\psi}}{\Upsilon}\left[\frac{1}{\beta}-(1-s)\right]+\left(\frac{1-\epsilon}{1-\rho\epsilon}\right)\omega\theta+\left(\frac{\epsilon}{1-\rho\epsilon}\right)\Gamma^{u}\frac{(1+\tau_c)}{(1-\tau_w)}C\epsilon_{C|\theta}<0$$

If we assume that $\Gamma_u=-\sigma_l\frac{e^{1+\eta}}{1+\eta}$ with $e<h$, we then have $\Gamma_u=-\mu\sigma_l\frac{h^{1+\eta}}{1+\eta}$ with $\mu<1$. Using (3), we deduce that $\Gamma^{u}\frac{(1+\tau_c)}{(1-\tau_w)}C=-\mu\frac{\alpha}{1+\eta}\frac{Y}{N}$. Hence, the previous restriction can be rewritten as follows:

$$(1-\psi)\frac{\omega\theta^{1-\psi}}{\Upsilon}\left[\frac{1}{\beta}-(1-s)\right]+\left(\frac{1-\epsilon}{1-\rho\epsilon}\right)\omega\theta<\left(\frac{\epsilon}{1-\rho\epsilon}\right)\mu\frac{\alpha}{1+\eta}\frac{Y}{N}\epsilon_{C|\theta}$$

which is, when we assume for simplicity that $n\to 0$ and $\beta\to 1$,

$$\frac{\omega\theta(1-N)}{Y}\left[1-\psi+\frac{1-\epsilon}{1-\rho\epsilon}\frac{N}{1-N}\right]<\left(\frac{\epsilon}{1-\rho\epsilon}\right)\mu\frac{\alpha}{1+\eta}\frac{\frac{\alpha}{1-\alpha}(g+\delta)}{\frac{\alpha}{1-\alpha}(g+\delta)-\frac{\omega\theta(1-N)}{Y}}$$

given that

$$\begin{aligned}\frac{dC}{dh}\frac{h}{C}&=Ah\left(\frac{r}{1-\alpha}\right)^{-\frac{(1-\alpha)}{\alpha}}\frac{1}{C}\left(\frac{\left(\frac{r}{1-\alpha}\right)-(g+\delta)}{1+\frac{n+s}{\Upsilon\theta^{\psi}}}\right)\\ \Leftrightarrow \epsilon_{C|h}&=\frac{Y}{C}\left[\frac{r}{1-\alpha}-(g+\delta)\right]\\ &=\frac{Y\left[\frac{r}{1-\alpha}-(g+\delta)\right]}{Y\left[\frac{r}{1-\alpha}-(g+\delta)\right]-\omega\theta(1-N)}\end{aligned}$$

Assume that $x=\frac{\omega\theta(1-N)}{Y}<1$ is given. Therefore, we have

$$x\left[1-\psi+\frac{1-\epsilon}{1-\rho\epsilon}\frac{N}{1-N}\right]<\left(\frac{\epsilon}{1-\rho\epsilon}\right)\mu\frac{\alpha}{1+\eta}\frac{\frac{\alpha}{1-\alpha}(g+\delta)}{\frac{\alpha}{1-\alpha}(g+\delta)-x}$$

where the largest value on the left-hand side is obtained for $N=1/2$. Hence, a sufficient condition is

$$x\left[1-\psi+\frac{1-\epsilon}{1-\rho\epsilon}\right]\left(\frac{1-\rho\epsilon}{\epsilon}\right)\frac{1+\eta}{\alpha}\frac{\frac{\alpha}{1-\alpha}(g+\delta)-x}{\frac{\alpha}{1-\alpha}(g+\delta)}<\mu$$

[47] This can be seen more easily if we rearrange it as follows:

$$\delta\left(1-\frac{1}{1-\alpha}\left(\frac{1+\tau_{inv}}{1-\tau_k}\right)\right)+\frac{1}{1-\alpha}\left(\frac{1+\tau_{inv}}{1-\tau_k}\right)\left(1-\frac{1}{\beta}\right)+g\left(1-\frac{1}{\beta(1-\alpha)\left(\frac{1+\tau_{inv}}{1-\tau_k}\right)}\right)<0$$

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.euroecorev.2019.05.018.

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