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How do Product and Labor Market Regulations affect Aggregate Employment, Inequalities and Job Polarization? A General Equilibrium Approach

Julien Albertini

Jean-Olivier Hairault

François Langot

Thepthida Sopraseuth

How do Product and Labor Market Regulations affect Aggregate Employment, Inequalities and Job Polarization? A General Equilibrium Approach[1]

Julien Albertini[2], Jean-Olivier Hairault[3], François Langot[4], Thepthida Sopraseuth[5]

Abstract: This paper assesses the impact of structural reforms in the short and long-term on the markets for goods and labor. The novelty is to account for these policy changes in countries where large-scale reallocations are necessary following the adoption of new technologies. As this technological change has different effects on the levels and the composition of the employment across countries, three types of countries are considered: Anglo-saxon, continental Europe and nordic Europe. The impact of institutional reforms on the markets for goods and labor are then evaluated in terms of employment and changes in inequality. We show that it is possible to increase employment and reduce inequality to make the most of these new technological opportunities.

Keywords: technological change, job polarization, employment, structural reforms.

Comment les institutions sur les marchés des biens et du travail affectent l'emploi agrégé, les inégalités et la polarisation des emplois ? Un modèle d'équilibre général

Abstract : Cet article évalue les effets à court terme et à long terme de réformes structurelles des marchés des biens et du travail dans des pays où des réallocations de grande ampleur sont nécessaires suite à l'adoption des nouvelles technologies. Comme les nouvelles technologies ont eu des effets différenciés sur l'emploi et sa composition suivant les pays, trois types de pays sont envisagées. Les impacts des réformes des institutions sur les marchés des biens et du travail sont alors évalués, en terme d'emploi et d'évolution des inégalités. Nous montrons qu'il est alors possible d'accroître l'emploi tout en réduisant les inégalités pour profiter au mieux de ces nouvelles opportunités technologiques.

Mots-clefs : changement technologique, polarisation, emploi, réformes structurelles.

[2]Humboldt University (Berlin)
[3]Paris School of Economics (PSE), University of Paris I and IZA
[4]University of Le Mans (GAINS-TEPP and IRA), PSE and IZA
[5]University of Cergy-Pontoise (THEMA) and IUF

1 Introduction

"Further work tractably integrating various forms of labor market imperfections within a framework that incorporates the endogenous allocation of skills to tasks appears to be another fruitful area for research." Acemoglu & Autor (2011), p.1160.

For more than 30 years, developed countries have undergone dramatic structural changes driven by rapid technological progress. These technological changes affect the employment of skilled and low-skilled workers in a non-trivial way, generating task-biased demand shifts in favor of skilled and lowest-skilled workers, to the detriment of middle-skilled workers. These changes (sometimes referred to as "Task Biased Technological Change", TBTC) thus lead to job polarization, namely the disappearance of mid-level jobs (requiring a moderate level of skills, such as autoworkers' jobs) relative to both those at the bottom (requiring few skills such as cleaners and salespeople) and those at the top (requiring greater skill levels such as managers and professionals). Empirical evidence of pervasive ongoing job polarization has been provided for the US (Autor & Dorn, 2013)[1] and for European countries (Goos & Salomons, 2014). However, in European countries, the persistence of a high unemployment as well as the low employment rate compared to the US suggests that transitional reallocation process matters in the long-run: this echoes the so-called "European employment problem" (Ljungqvist & Sargent (2008), Ljungqvist & Sargent (1998)). Since the empirical works by Blanchard & Wolfers (1999), this literature lays stress on the role of the interaction between Labor Market Institutions (LMI) and aggregate shocks in shaping transatlantic differences in employment rates and on the role of structural reforms in improving European employment levels (see e.g. Hornstein et al. (2007)). Hence, as suggested by Acemoglu & Autor (2011), this paper aims at bridging the gaps between micro and macro analysis of the labor market by analyzing endogenous allocation of skills to tasks in a general equilibrium model with labor and good market imperfections, as well as evolving institutional environments.

In a previous work (Albertini, Hairault, Langot and Sopraseuth (2015)), we developed a multi-sectorial search and matching model with endogenous occupational choice to shed light on the way structural changes affect aggregate employment and job polarization. The originality of our approach is to analyze the dynamic path of employment reallocations. Indeed, the transformations of the production process have been progressive, driven by an incremental implementation of new technologies. The process can be long, because occupational changes result from search and learning activities from new tasks. Hence, we have proposed a non-stationary model that allows understanding these employment movements during a structural change. By identifying the direction of the structural change that suppresses jobs in the middle of the wage distribution, our previous model (Albertini, Hairault, Langot and Sopraseuth (2015)) also explains the job polarization and inequalities observed in the US and in European countries.[2]

Moreover, our previous work showed that some labor market institutions can stall the reallocation process because they do not allow the labor market to open some jobs for inexperienced workers on potential new jobs. This was obtained contrasting 3 types of country that differ with respect to their labor market institutions. Type I economies

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[1] Jaimovich & Siu (2015) show that this phenomenon is magnified in recession.

[2] Albertini, Hairault, Langot and Sopraseuth (2015) provide a model that matches the evolution of aggregate employment and employment shares by task. The model also captures the evolution of wage and income inequalities across countries and over time.

(reminiscent of the United States) have flexible labor market arrangements: there is no Minimum wage (MW) and low unemployment benefits. Type II are characterized by rigid labor market, mimicking that of France: a relatively high minimum wage, unemployment benefits and firing costs. Economies of Type III constitute an intermediate case (reminiscent of that in Germany): wage-setting displays sluggishness but there is no MW.

In this paper, we extend our previous analysis (Albertini, Hairault, Langot and Sopraseuth (2015)) along two dimensions. Firstly, we introduce an endogenous number of firms à la Melitz (2003) in order to account for interactions between good and labor markets, and their respective institutions. Secondly, rather than focusing on the historical path of our prototypical economies as in the previous paper we now want to forecast their future dynamics as spurred by large changes in technology. Hence, for each economy we analyze the transitional dynamics from today to a new world, i.e. the path along which structural technological changes remove the competitive advantages of workers in the middle of the wage distribution, leading them to move to new opportunities at the bottom of the wage distribution. By nature, this phenomenon takes time (searching for a job in a new occupation is time consuming), and it can be blocked if redistributive policies, by increasing the outside option of the poorest, cancel the potential profits of new jobs in the service sector.[3] Beyond the comparison of the initial and final steady states, we also solve the transitional dynamics. Further, our paper goes beyond the traditional analysis of PMR and LMIs' effects on labor market outcomes by focusing on their effects on the reallocation from routine to manual tasks.

Our main findings can be summarized as follows:

- In the benchmark simulations, Task Biased Technological Change creates more jobs. In these benchmark scenarii, we assume that LMI and PMR are stable and given by their current level in the 3 types of countries. The magnitude of job creations and thus the extent of employment reallocation depend on LMI and PMR: flexibility fosters employment gains. However, flexibility also generates increasing wage and income inequalities.
- LMI or PMR reforms have little effect on employment, except if they are targeted on segments of the expanding economy. Any policy that aims at protecting the declining tasks is inefficient in the medium and the long run. By contrast, the most efficient reforms are those that favor reallocation towards the expanding activities. These include targeting active labor market policy (ALMP) and payroll taxes reductions to low skilled workers, and liberalizing the service sector. The impact of these reforms depends on the wage-setting rule. In the Type III country, where the bargaining rules lead to wage moderation, the employment gains are the largest.
- LMI or PMR reforms have little effect on inequality. Whatever the reform, inequalities increase, driven by the polarization of the jobs.
- Nevertheless, employment gains in all types of country generate a government surplus in the long run. These new fiscal revenues can be used to reduce inequalities through a redistributive policy. The use of the government transfers as an additional income for all unskilled workers show how the efficiency gains can be used to reduce inequalities. We then show that the larger the employment gains, the more effective the redistributive policy.

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[3] This approach contrasts with the stylized model proposed by Autor & Dorn (2013) who stress only the long-term effects of the job polarization phenomenon in a frictionless economy. Workers move from the routine sector to the manual sector without search frictions.

2 Overview of the model

We develop a general equilibrium model that allows us to account for the transitional dynamics of the reallocation process induced by a "task biased technological change" (TBTC). This model is characterized by two features: first, there are search and matching frictions on the labor market, which helps us capture the speed of reallocation, and secondly, the number of firms in both good and service markets is endogenous, which will connect technological progress to competition through endogenous responses of markups to technological changes. From a methodological point of view, we introduce heterogeneity across countries only through their LMI: as preferences and technology are identical, heterogenous economic performances come only from country specific institutions. The idea is then to identify LMI that can alter the reallocation process towards new activities. Our 3 types of economies also differ with respect to their wage-setting arrangements. In Type I economies, wages are subject to bargaining between firms and workers, and hence are responsive to changes in productivity and workers' outside options (unemployment benefits, social programs). In type II economies, wage-setting is bounded by a minimum wage, which is uniform for all sectors while, in Type III economies, wage evolves with a reference to a sector-specific social norm which leads to an endogenous wage moderation specific to each sector. By introducing imperfect competition and an endogenous number of firms in the products markets this paper extends the previous work of Albertini, Hairault, Langot and Sopraseuth (2015) assessing the role of "Product Market Regulation" (PMR) policies on the labor market outcomes during this period of structural change.

Regarding the model calibration, some parameter values are set based on existing empirical evidence and others calibrated to match selected moments in the data. Since the paper is focused on trends in employment, the selected moments in the data include employment rates (Figure 1) and employment shares (Figure 2): the beginning and the end on the sample as well as the average over the sample. Labor market institutions and wage-setting are country- specific while we consider that consumer preferences, technology and distribution of abilities within unskilled labor are the same cross countries. In addition, given that the model predicts the complete path of employment composition and level following a technological change, we need to set values for the path of labor market institutions, technological change and increase in skilled labor.

Figure 1: Employment rates in countries that exemplify types I, II and III
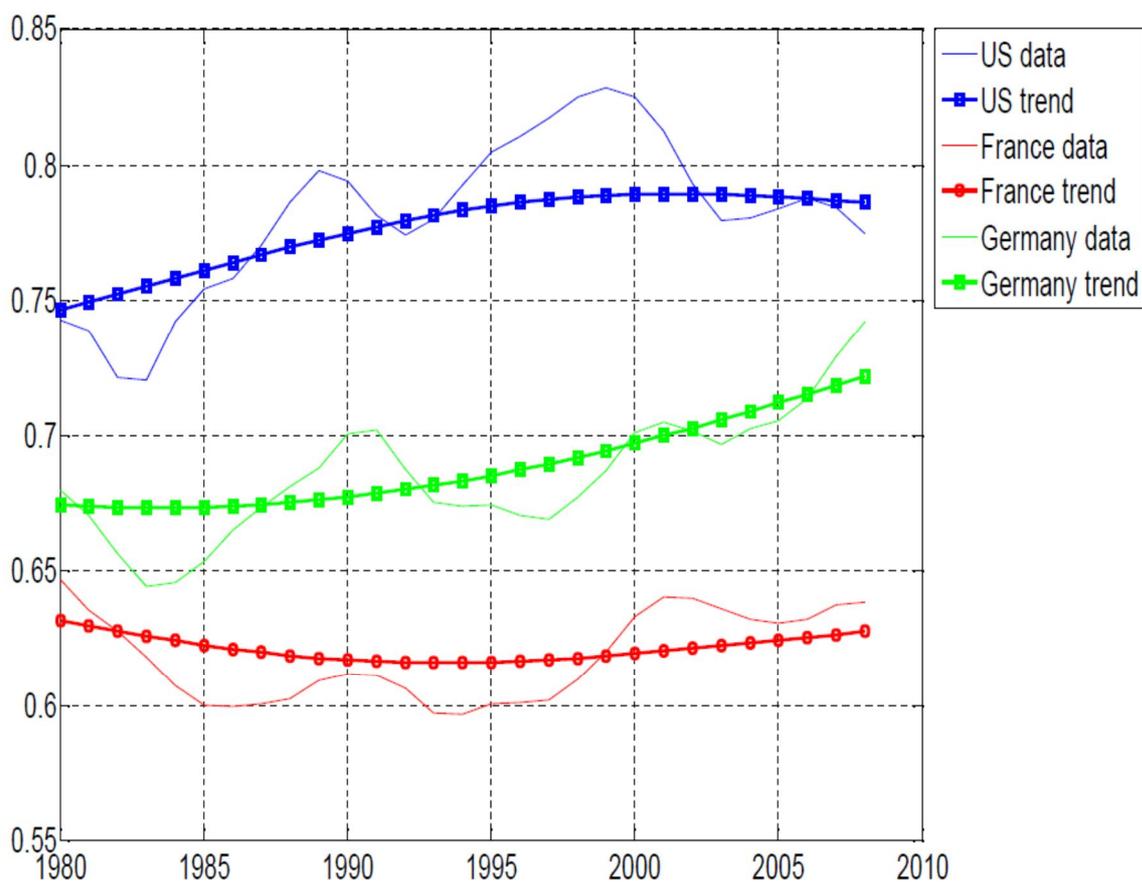
Source: OECD computations based on CPS US data, French and German labor surveys.

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Figure 2: Job polarization: Changes in employment share in abstract, routine, and manual tasks in countries that exemplify types I, II and III

Source: OECD computations based on CPS US data, French and German labor surveys.
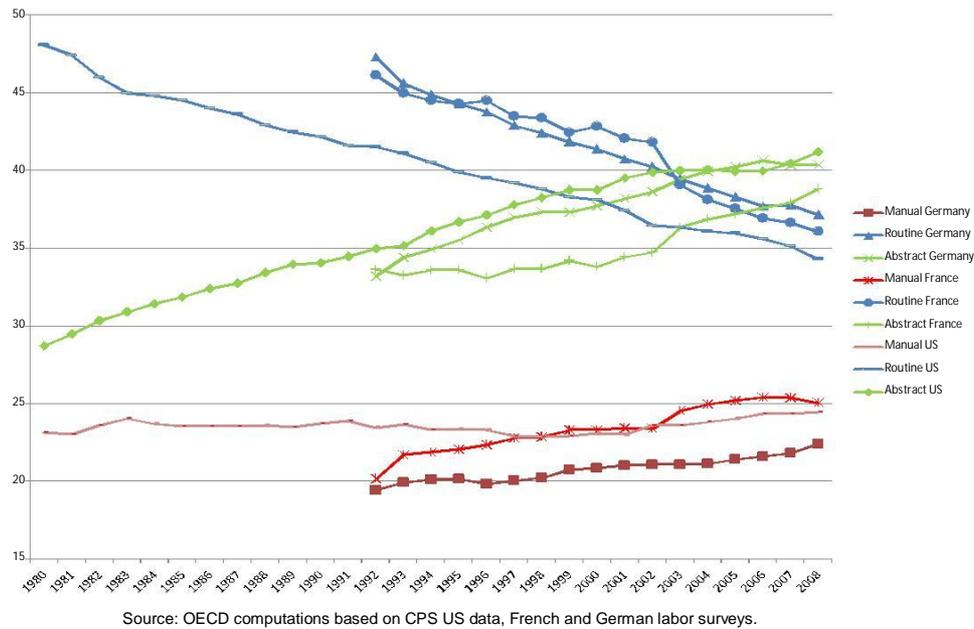
2.1 Building blocks of the model

The model is summarized in Figure 3, whereas the complete model is presented in Appendix A. It is a dynamic general equilibrium model with search and matching frictions, featuring workers' endogenous occupational choice and job polarization induced by a deterministic task-biased technological change. We also account for an endogenous number of firms, specific to each type of goods. In order to make the model tractable, we abstract from financial markets. There are no savings.

Figure 3: The model with labor market frictions and firm entry
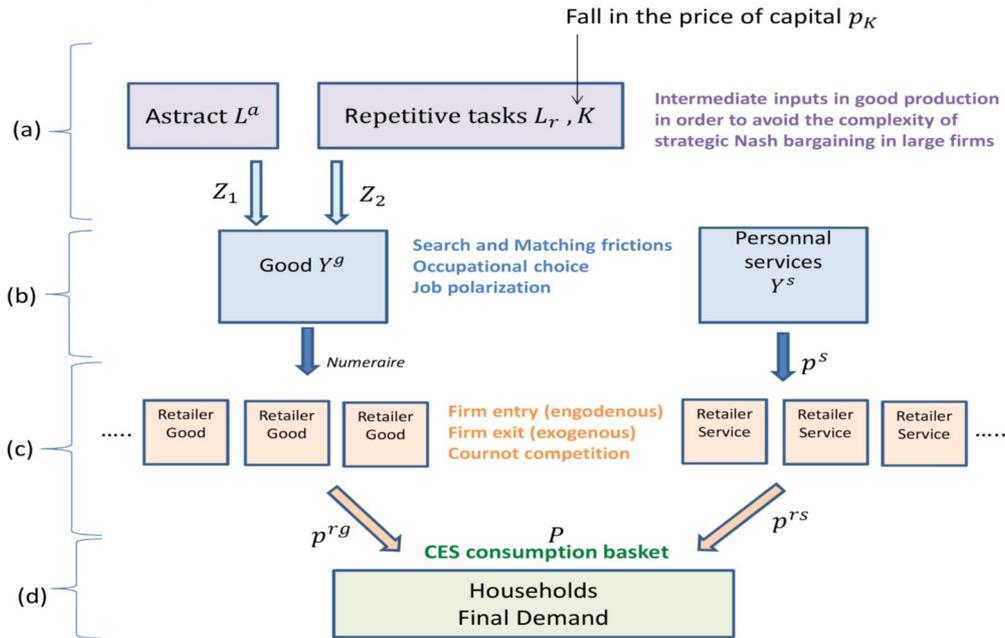
The building blocks of the model are
- (a) and (b) (section 2.3) :
    - Block (a) (section A.4): The good producing sector uses 2 intermediate goods: a high-tech good Z_1 and a low-tech good Z_2. This decomposition of inputs (Z_1 and Z_2) is made in order to avoid the useless complexity of the strategic wage bargaining in large firms.
        - The high-tech good is produced by high-skilled workers in abstract non-routine cognitive jobs L_a.
        - The low-tech goods are produced by a CRS production function that uses i) un-skilled workers employed in routine L_r, and ii) technology (equipment, computers, machine), a good that can also perform repetitive tasks K.

      In the production of low-tech goods, unskilled routine workers can be easily replaced by machines while high-tech goods, and thus abstract workers, complement repetitive tasks (whether performed by machines and/or unskilled workers). Technological change is captured by a downward trend in the price of technology p_K, which creates a strong incentive for low-tech good producing firms to substitute unskilled labor for capital.

    - Block (b): Search and matching frictions in both sectors, occupational choice and job polarization occurring because of the task-biased technological change.
      The service sector employs only unskilled labor L_m in non-routine manual tasks (occupations involving assisting others such as janitors, cleaners ...).

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- (c) : Firm dynamics (section A.8 of the appendix)

    - Retailers in each sector buy inputs from producing firms and sell it to consumers. We have retailers in good and retailers in services in order to allow the policy maker to possibly lower PMR only in one-sector rather than the two sectors.
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    - In each retailing sector, there is Cournot competition. The price and quantity therefore depend on the endogenous number of firms. The larger the number of firms, the keener the competition, the lower the retail price, the higher the

quantity produced by retailers. Firm entry is endogenous and subject to entry costs[4]. Firm exit occurs exogenously at a fixed rate, as in Melitz (2003).

- (d) : Final demand (section A.9.1 of the appendix): households buy goods and services from retailers. General equilibrium effects now include the price dynamics in all sectors of the economy. The government budget is balanced each period by a lump-sum transfer to households (section A.9.3 of the appendix). In the benchmark scenario, transfers are similar across households. This will no longer be the case in section 6, with redistributive policies.

The model is thus well designed to address economic policy concerns and particularly to assess structural reforms on product and labor market allowing to transform this new technological opportunity into an employment opportunity for all workers. In Table 1, we report the policy tools available in each block of the model (b) and (c) by distinguishing the policy instruments.

Table 1: Policy tools in each block of the model

	Policies	tools
(b)	ALMP	a subsidy to hiring costs
	unemployment benefits	a change in the replacement rate
	employment subsidies	2 payroll tax rates (unskilled, skilled)
(c)	PMR	entry costs (one in each sector)

2.2 Interaction between firm entry and employment dynamics

Several simplifying assumptions were made to make to keep the model tractable
- Labor market frictions affect only the production of good and personal services (block (b)) and product market frictions affect only retailers (block (c)).
- All firms in the retailing sector (block (c)) have the same productivity. Entry or exit will not affect the average productivity in the retailing sector.

In spite of this simplification, the model can capture large gains from lowering PMR as well as the strong interaction between PMR and LMI:
- Lower entry costs in block (c) will increase firm entry, thereby lowering the retailing price. All households will benefit from the fall in retailing price.
- In addition, higher firm entry in block (c) increases the demand for inputs from good and service producing firms in block (b), which could increase labor demand and aggregate employment, if labor market institutions are flexible enough. This last mechanism underlines the strong interaction between LMI and PMR.

2.3 Search and matching frictions with endogenous occupational choices

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[4] Entry costs are paid in terms of goods (rather than labor as in Melitz (2003)). The entry cost is also affected by congestion effects: the larger the number of new entrants, the higher the entry cost. In Melitz (2003), entry costs are paid in terms of labor. Firm entry is then bounded by the households' ability to supply labor. In our model, entry costs are paid in terms of goods. Firm entry is then bounded by adjustment costs to entry. We provide in section A.8 of the appendix a rationale for this assumption.

Even if the endogenous number of firms, and thus the endogeneity of the markup, can magnify the impact of technological change, the main originality of our model is to account for workers' mobility across labor markets . We describe this part of the model in this section. Labor supply consists of skilled and unskilled workers (Figure 4)

- Skilled workers are homogeneous and all perform abstract tasks (non-routine, cognitive jobs) in the good-producing firm.

- There is a continuum of unskilled workers who differ with respect to their abilities. The model endogenously determines which unskilled workers occupy routine occupations versus service occupations (through the endogenous determination of the threshold [?] below which workers choose to work in manual jobs). Low- skill workers have homogeneous (heterogeneous) skills at performing manual (routine) tasks. This is consistent with the view that blue-collar workers in the factory differ in performing their tasks on the assembly line while jobs such as janitors can hardly differ in terms of productivity in providing non-routine manual services.

Figure 4: Workers
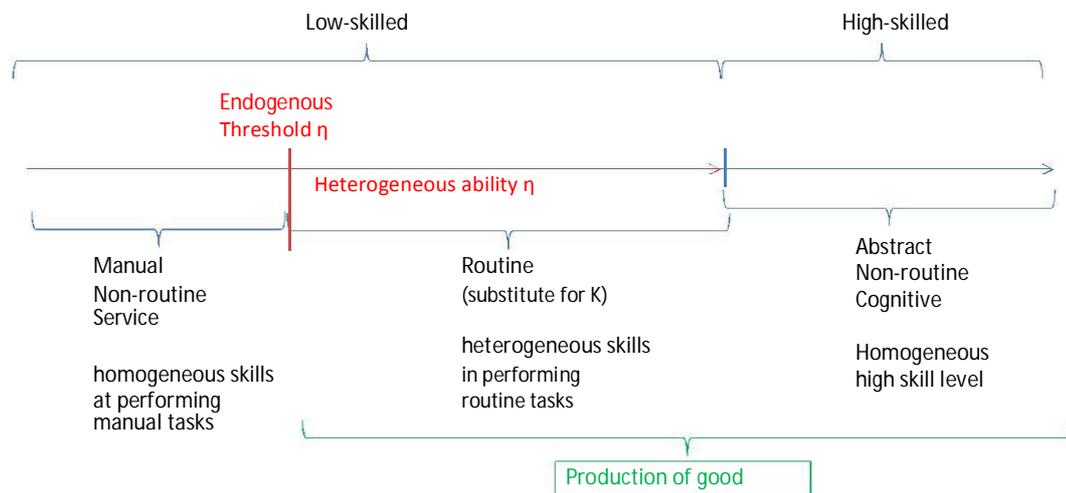
Figure 5: Labor market flows
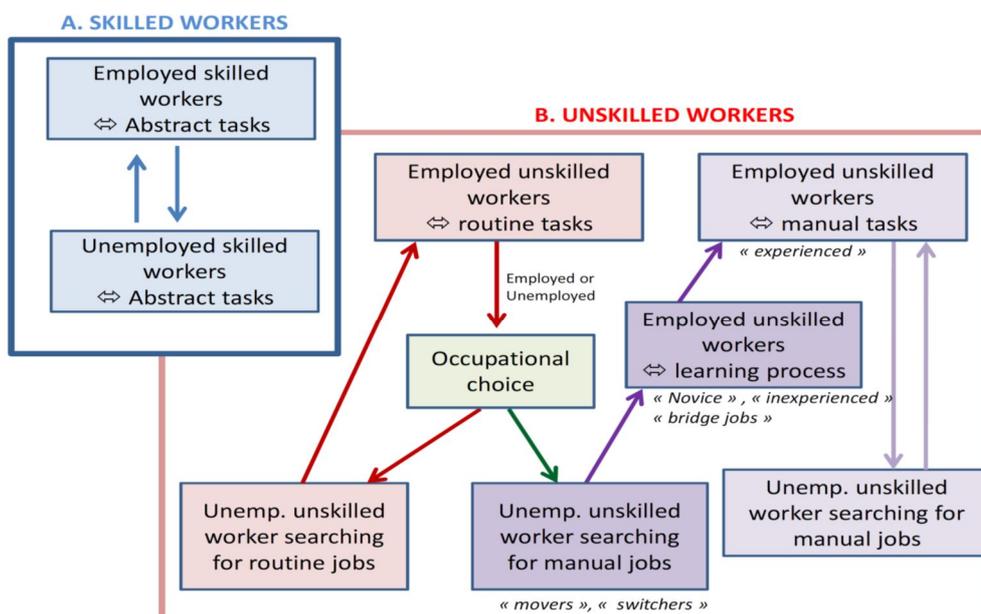
Labor market flows and occupational choices are (Figure 5)

- Skilled workers are employed in abstract tasks. When fired, they join the pool of unemployed skilled workers and look for an abstract job.
- Unskilled workers can be employed either in routine tasks in the good producing firm or in manual tasks in the service sector. When fired from the good-producing firms, routine unemployed workers can choose to switch occupation (we call them "new movers" L^n_m) and join the pool of unemployed workers looking for manual jobs. New movers differ from other unemployed workers looking for a manual job because i) their unemployment benefit depends on their past occupation as routine workers, ii) they just arrived on the market for manual jobs and lack proper information about the tasks and firms on the market. New movers gradually learn about the tasks and the market: they job finding probability and their productivity as manual workers is lower than their counterparts. The reallocation process from routine to manual jobs can then take time as manual jobs are slowly created and routine jobs are gradually destroyed.

Labor markets are characterized by search and matching frictions à la Mortensen & Pissarides (1994). Search is directed as there is a labor sub-market for each occupation and for each ability level in routine jobs. Within each pool, the meeting process between workers and firms is random. There is no on-the-job search (Appendix A.2).

3 Benchmark scenario: Job polarization in a context of long-term technological change

3.1 Model Mechanisms

The long run conditions of different economies depend on their technological opportunities and their market arrangements. Technology changes over time putting pressure on some type of existing jobs but also creating new opportunities. It therefore involves intensive reallocation of resources and a change in the productive structure. While the increased production possibilities induce a "wealth effect", this is not shared by all agents. For some workers the technological progress is "labor augmenting"; but, by reducing the need for repetitive tasks, for others it is "labor saving". The final impact depends on the ability of the economy to reallocate the "saved" labor in "new" market activities. This story is at the heart of Autor & Dorn (2013) model: job polarization is the outcome of a technological change that destroys labor previously paid at wages in the middle of the distribution. These workers are occupied in "routine" tasks easily computerized and then replaced by capital. The other tasks are not directly substitutable by the technological change: "abstract" and "manual" tasks cannot be replaced by a computer. Even if "manual" tasks do not benefit from the technological change via an increase in their productivity, the more efficient production process ("wealth effect") allows the demand for these manual-producing jobs to grow.

if the reallocation from routine towards manual task is not stalled, the technology-induced structural change can be shared by all workers. But reallocation takes time, by itself, adding some delays in the convergence towards the "new long run" equilibrium. Beyond the persistence of the adjustment, this process can be costly in the short run: indeed, when jobs are destroyed, for workers that have no future in declining sectors of the economy, it is optimal to switch occupation. However, all workers switching at the same time creates a

congestion effect in labor market of manual tasks. Notice also that, while the time of reallocation is largely induced by the absence of opportunities on the labor market of routine tasks, opportunities on the labor market of manual tasks may be low at this reallocation time: in the short run, job polarization can induce a fall in the employment rate. One of the main contributions of our dynamic model is to provide a general equilibrium analysis of these adjustments. The originality of our approach is to account for market imperfections in both labor and good markets: in the labor markets, there are search-matching frictions and real wage rigidities, whereas in the good market there is an endogenous number of firms in both good and service markets determined by costly entry in imperfect competition markets. Hence, labor reallocation through unemployment and learning episodes is costly, whereas the entry of new firms magnifies the impact of the technological change via an increase in competition in the long run.

Hence, 3 main features distinguish our work from Autor & Dorn (2013)'s. First, we do not focus only on the asymptotic allocation after a "task biased technological change" (TBTC): we also analyze the reallocation dynamics during a gradual technological change, with their potential costs in the short run (employment losses). Secondly, in Autor & Dorn's (2013) work, there are no frictions either on the labor market or the product market. We will show that such frictions slow down the reallocation process. Finally, Autor & Dorn (2013) show that employment gains are also associated with an increase in wage inequality. From the policy marker's point of view, TBTC can not only generate employment gains but can also have negative redistributive effects. We quantify the employment gains and the expected deterioration in Gini coefficients.

3.2 The long-run effects of technological change in a frictionless economy (Author and Dorn, 2013)

Autor & Dorn (2013)'s model is general equilibrium setting describing polarization without labor market frictions and perfect competition on product markets. Their model is based on several assumptions.

- There is full employment on both skilled and unskilled labor market, and the labor supplies are exogenous and constant. Hence, by assumption, the technological change has no impact on the aggregate employment level. Only the repartition of unskilled workers between "routine" and "manual" tasks is endogenous.

- There are two representative firms: the first one produces goods Y_g with capital K, "abstract" tasks L_a and "routine" tasks L_r, whereas the second produces services Y_s with "manual" tasks L_m. The number of firms is fixed.

- There is one representative household. She consumes goods C_g and services C_s. The price of the capital is an exogenous process.

For Autor & Dorn (2013), the story behind polarization is the following.

The diffusion of the supply shock on inputs choices. The price of capital declines with the introduction of TBTC (supply shock), leading good-producing firms to intensify their production processes in capital. Capital is highly substitutable to "routine" tasks, because repetitive tasks can be replaced by machines, whereas it is weakly substitutable to "abstract" tasks. These technological possibilities then lead firms to increase the capital ratio over "routine" tasks when the price of capital declines (panel (a) in Figure 6). Even if it would be profitable for firm to hire more skilled workers on "abstract" tasks, the assumptions of (i) full-employment and (ii) constant population, imply that this tightness is completely reported on wages. Hence, new technologies allow the good sector to increase its production by a large

increase in capital, a relative decline in its number of "routine" jobs and a rise in the wage of workers on "abstract" tasks. Notice that the decline in "routine" jobs results from separations of the least productive workers on these tasks. Indeed, the real wage per unit of human capital declines for a routine task: hence, at the bottom of abilities distribution, it becomes more profitable to work in the service sector, where ability does not matter for the individual wage (panel (b) in Figure 6). These separations are immediately compensated by hirings on a "manual" task (no frictions on the labor market). This reallocation process is driven by frictionless individual choices: with the fall in routine wages, incentives are thus given to move towards new opportunities.

Figure 6: Autor & Dorn (2013) model : size of employment and number of firms are fixed, only relative wages change
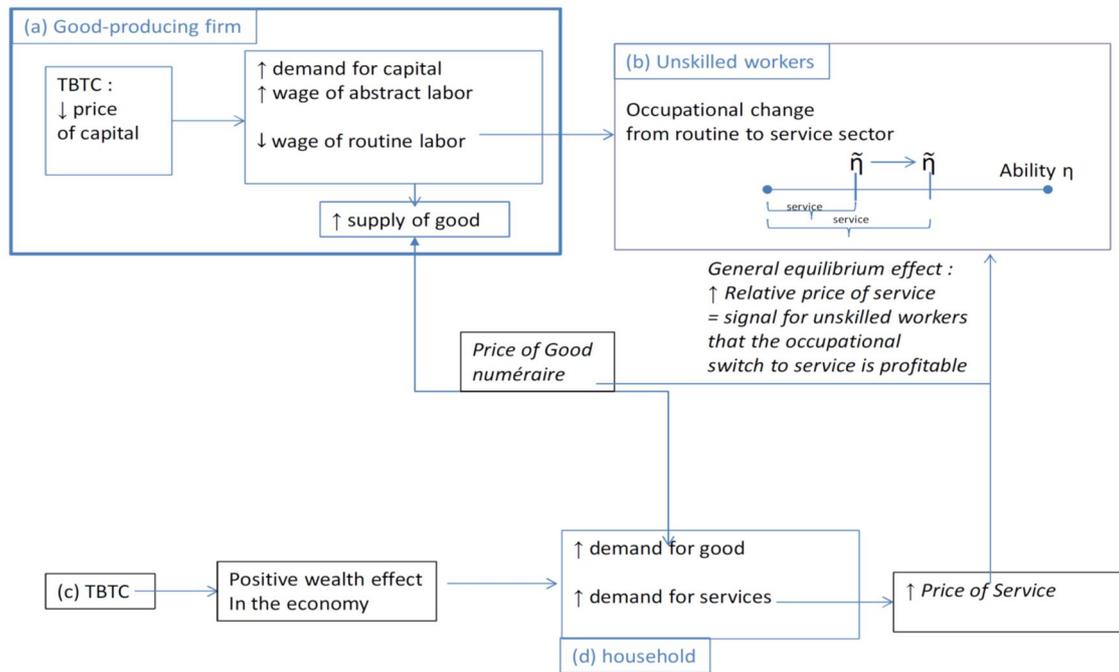
In italics : General Equilibrium effects. LMI: Labor Market Institution. PMR : Product Market Regulations

Inequalities. Notice that the labor reallocation process requires that wages adjust downward in the routine sector while relative wages in abstract and service jobs increase. TBTC generates wage polarization.

The general equilibrium effect. The permanent increase in technological progress is a source of the large "wealth effect" that increases consumers' aggregate income (panel (c) in Figure 6). This generates a "new" demand for both good and the service sectors (panel (d) in Figure 6). This can induce price increases. However, the two markets are not symmetrical:
- in the good market, the supply shock coming from the decline in the capital price, generates a large rise in the supply. Hence, if these movements driven by the supply are larger than the ones driven by the demand, the price in the good market declines.
- At the opposite, for the services, the impact of the demand shock is not compensated by the higher labor supply which comes from the reallocation from routine to manual labor markets (panel (6) in Figure 6). Hence, the relative price of services increases, which raises the wage in manual tasks, thereby providing a strong signal that the occupational

switch to service is profitable. This general equilibrium magnifies the reallocation process from routine to manual tasks.

## 3.3 Introducing labor market frictions: consequences for employment reallocation

Autor & Dorn's (2013) analysis focus on long-run impact of TBTC: their model discards transitional dynamics, there is full-employment in all labor market, and the conditions to obtain job polarization are derived from the asymptotic properties of the model.

The first contribution of our analysis is to account for the levels of aggregate employment because we do not assume full employment and exogenous labor supply. Our second contribution is to account for the transitional (short and the medium run) dynamics in an economy where the length of reallocation is not negligible: there are movements in unemployment due to the search process when workers switch from one occupation to another. We also explain why the transitional dynamics specific to the matching model, is also important to explain the sluggishness in employment rates. By including unemployment dynamics along the transitional path, we are also able to analyze income inequalities, in addition to wage inequalities.

3.3.1 Frictional labor market and the long run impact of TBTC

Figure 7 shows that, with respect to Autor & Dorn (2013), this study takes into account labor market institutions (LMI) and product market regulations (PMR). LMI affects labor market adjustments, while PMR modifies price adjustments. Given the general equilibrium effect of relative prices on occupational choices, LMI strongly interacts with PMR. The endogenous dynamics of these inefficiency wedges on product and labor markets explain the employment levels for each tasks, and thus the dynamics of aggregate employment.

Figure 7: TBTC in a model with labor market frictions, product market regulations and and occupational choice: size of employment and number of firms adjust to TBTC
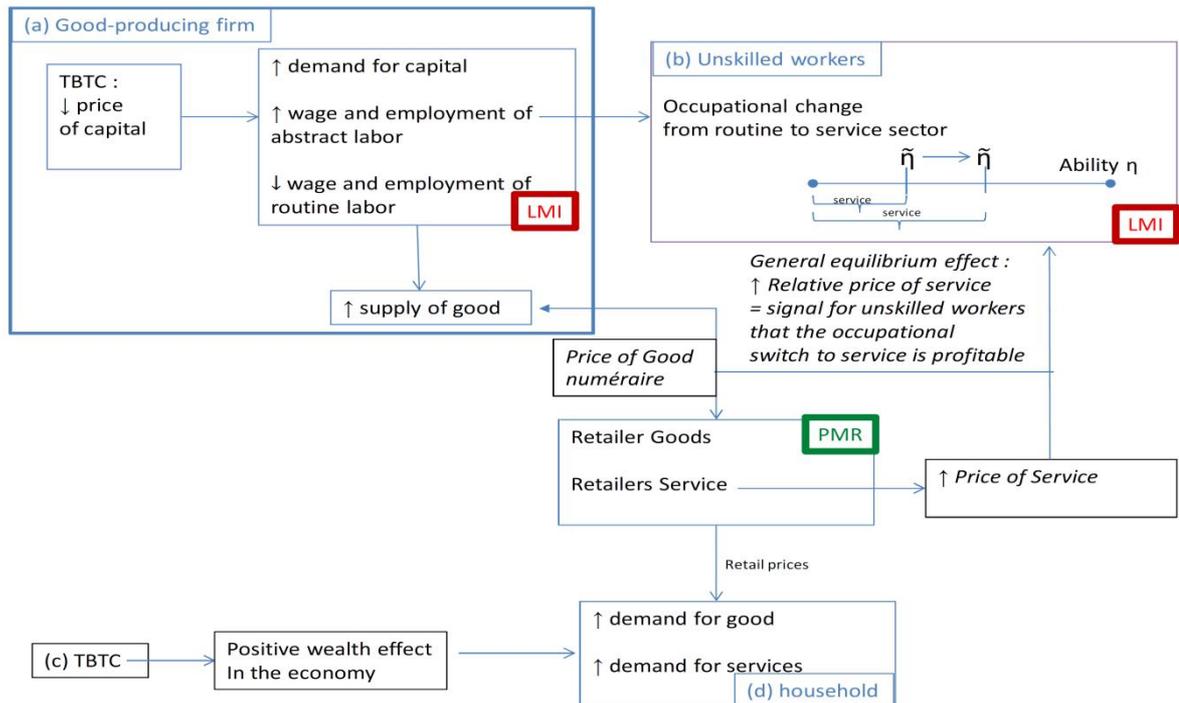
In italics : *General Equilibrium effects.* LMI: Labor Market Institution. PMR : Product Market Regulations

With labor market frictions, hiring takes time as firms (and job seekers) have incomplete information on the pool of potential employees (and job openings). Job finding is also subject to congestion effects as the endogenous probability of finding a job depends on the number of vacancies relative to the number of job seekers. This ratio is the labor market tightness.

A very simple way to understand the complete mechanism of our model, is to capture the equilibrium in each labor market (routine, manual and abstract tasks) as the intersection of the job creation condition (JC) and the wage curve (WC). The first one is a decreasing relation between the ratio "vacancies over unemployment", labor market tightness (θ), and the wage (w): it indicates that hiring intensity declines with the wage (the labor cost). The second locus is an increasing relation between θ and w, showing that workers ask for a higher wage when their relative scarcity is large. The general equilibrium effects are captured by the standard AD=AS model, in each market, goods and services. Finally, the last relationship equates tightness in the routine and manual labor markets. Because individual ability (η) matters for productivity in routine tasks, the incentive to hire (and thus tightness) rises with ability in the market for routine workers. Hence, the equilibrium with tightness for the manual tasks, which is a function independent from ability η, determines the ability threshold η at which it is optimal for workers to switch from routine to manual tasks ("occupational choice). Figure 8 depicts these relationships.

Figure 8: TBTC in a model with labor market frictions and occupational choice

(1) routine tasks — θr(η), wr(η), WC, JC, E_0, E_1

(2) manual tasks — θs, ws, WC, JC, E_0, E_2

(3) abstract tasks — θa, wa, WC, JC, E_0, E_1

(4) good market — pg, yg, AS, AD, E_0, E_1, E_2

(5) occupational choice — θ s, η̃, θ r(η|0), θ r(η|1), E_0, E_1, E_2

(6) service market — ps, ys, AS, AD, E_0, E_2
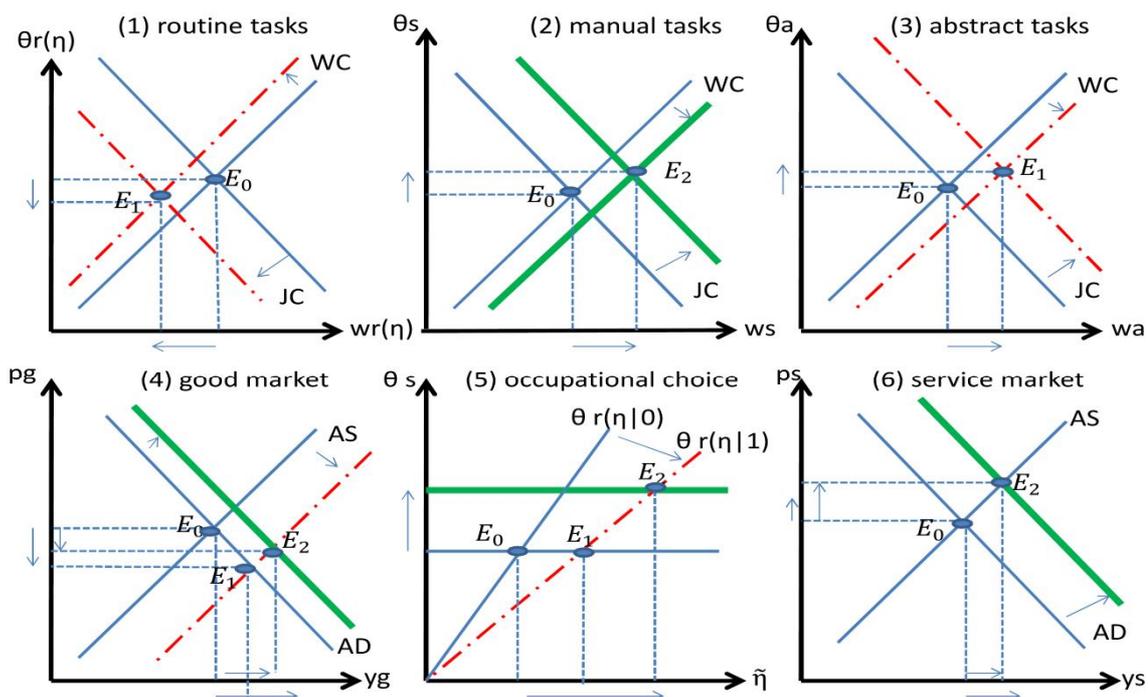
Solid lines (E_0) = before the technological change; Dash-dot lines (E_1) = after the technological change without General Equilibrium feedback; Bold lines (E_2) = after the technological change with General Equilibrium feedback

The impact of the Task Bias Technological Change (TBTC) can be decomposed as follows:

- The decline in the computer price reduces the marginal productivity of routine task (they are replaced by computers). This shifts the JC curve downward (panel 1 of Figure 8). Part of this lost competitiveness is absorbed by a wage cut (the WC curve shifts upward, because TBTC results in lower productivity on routine jobs). The total effect is a decline in both tightness and wages for these workers.

- TBTC increases productivity on abstract tasks (JC curve shifts upward, panel 3 of Figure 8). Despite a crowding out effect induced by wage bargaining (the WC curve shifts downward in panel 3 of Figure 8), the total effect is an increase in both tightness and wages for these workers.

- This supply shock shifts AS downward in the good market (panel 4 of Figure 8), and for a given level of ability η, the profitability of routine task declines, leading the curve θr(η) to rotate to the right (panel 5 of Figure 8).

- This supply shock also generates additional incomes. Their allocations between goods and services drive the demand expansion. Given that the good market is also affected by the supply shock (which tends to lower good prices), the increase in the price of service is necessarily larger than the one observed in the good market (the green lines in panels (4) and (6) of Figure 8). Hence, the relative price of services goes up, and so does the marginal gain of each produced services.

- The feedback effect on the labor market magnifies the initial impact of the supply shock. Indeed, the marginal return of services goes up: this leads to a shift upward (downward) of the JC (WC) curve in the labor market of manual tasks (the bold lines in panel (3) of Figure 8). Higher returns on service also lead more workers to move towards manual jobs (the horizontal line representing the value of θs shifts up in panel (5) of Figure 8).

Figure 9: Employment rates (levels)
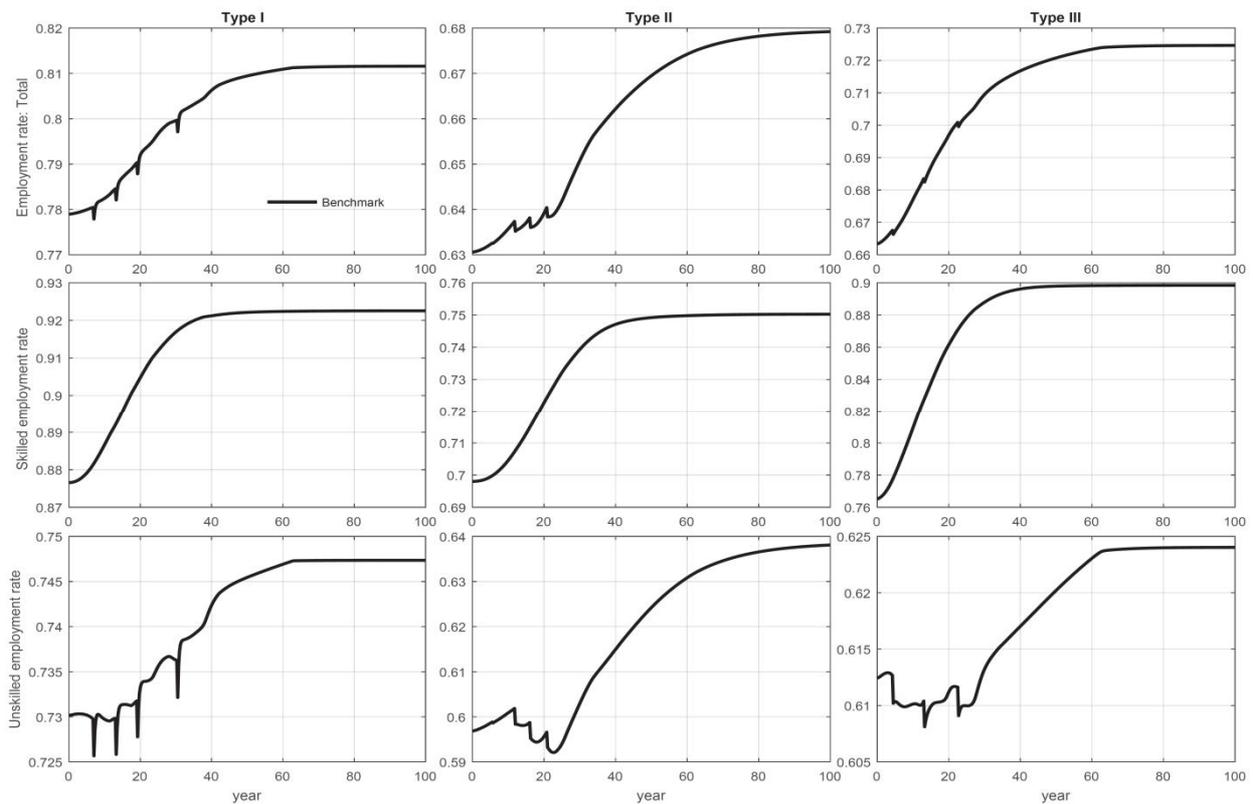
These adjustments show that job polarization is worth being analyzed in a matching model. The first value added of a matching model lies in its ability to provide employment levels that depend on the good and labor market institutions. Its second value added is to provide elasticities of these employment rates to exogenous changes (technology or policies), which depend on the level of the employment and hence on the good and labor market institutions. Finally, this model being dynamic, its third value added lies in its ability to account for persistence in the adjustment dynamics, and this labor market flexibility also depends on the institutions. Figure 9 accounts for these 3 dimensions: the initial level of the employment rate, its final level (the long term multiplier of the shocks) and the persistence of the adjustment. Type I economies begin with a high initial employment rate for skilled and unskilled workers. Hence, it is more difficult to improve this initial "good" situation. The adjustment of unskilled employment also suggests large and rapid reallocations, as employment losses are absorbed rapidly. In contrast, Type II economy has an initial low employment rate: the margins to improve this poor situation are large. Adjustment paths of unskilled dynamics shows that the creative process allowing to absorb the destructions of routine job takes time, leading to persistent adjustments. Type III economy is an intermediate case.

3.3.2 Why does time for labor reallocation matter?

Given that the employment state is always preferred to unemployment, occupational choices, (ie. to search for a "routine" or a "manual" job), are governed by unemployment values.[5]

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[5] We study only situations where employment value is larger than unemployment value in "routine" or "manual" labor markets for a worker. Employed workers always prefer their "insider" positions.

These unemployment values depend on two main components: the expected gains (wages and benefits) and the time duration of an unemployment episode.

At the time of the technological change, workers, whether employed or unemployed, learn that their contemporaneous and future labor incomes will be modified. For some unemployed workers searching for a "routine" task, the unemployment duration can become infinite (firms stop opening vacancies on -type labor market segment). Thus, they decide to start searching for a manual job. At this time, the intensity of "computerization" of the production process is at its beginning. Thus, the increase in the demand for service, and thus the rise in the relative price of the service is moderate. This implies that the creation of new jobs in the service sector is also moderate: a labor market with "reasonable" unemployment duration disappears, workers move to a labor market where the unemployment duration is higher. The occupational switch still makes sense as the prospects of finding a job in the future improve. Hence, the search frictions allow us to account for transitional "technological unemployment", which is an unemployment "excess" generated by the instantaneous closure of opportunities in the labor market of routine jobs, replaced by opportunities lower than the ones before the shock. Moreover, when some unemployed workers decide to move towards manual jobs, the stock of unemployment worker is transitionally beyond its long-run value. Hence, non-employment is larger than its "natural" rate even if workers have instantaneously a higher probability to be hired than in their previous unemployment spells. This last point underlines the importance to develop a dynamic model to account for a reallocation process.

Given that the computerization process takes time, and that the re-organization of the production process extends the length of the transition, one can observe a decline in employment rates of unskilled workers, despite their occupational choices, leading them to search on markets where opportunities are better and improving (Figure 10).

Notice that these opportunities are better because the previous ones, on the labor market of routine tasks, disappear. Hence, this additional "technological unemployment" can be resorbed only after a meeting with a firm, and this search process can take time. These adjustment processes are quantitatively large because non-employment adjusts to its long-run level with some sluggishness.

Figure 10: Employment rates (base=100)
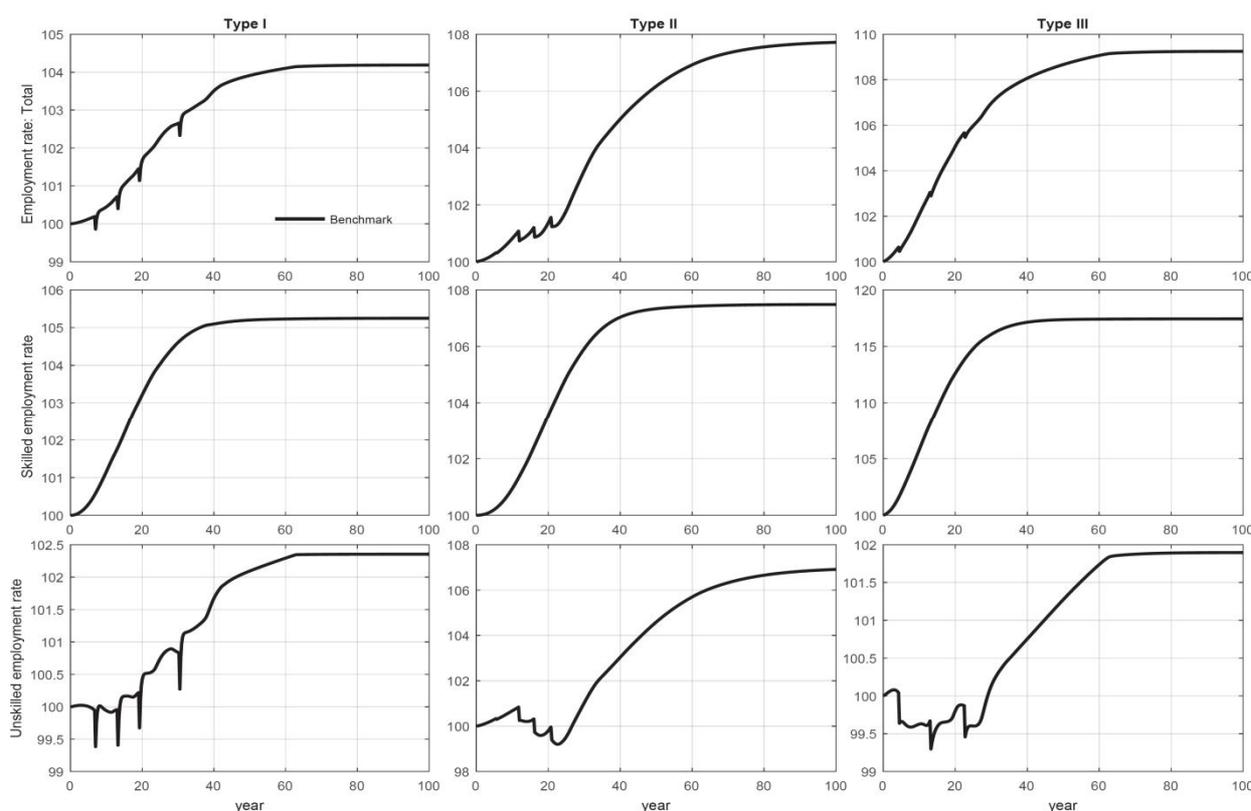
Figure 11 shows that the service labor market gradually absorbs new arrivals from the routine labor market. This search process is not the same across countries. In type I economies, Figure 11 shows that, when workers have no opportunities in the labor market of the routine jobs, they move towards the manual labor market: instantaneously, the non-employment in the manual labor market jumps, but rapidly, the high job finding rate allows worker to find a job. In contrast, in type II economies, after the same type of reallocation, given that the job finding rate is low, the persistence in non-employment is larger. Type III economies, with a finding rate lower than the one in type I economies but larger than the one for type II, constitute an intermediate case. [6]

When we evaluate policy reforms, we will account for these differences between transitional costs across countries (short-term costs). Indeed, if the job polarization is accompanied by large movement of the workforce into unemployment, and if unemployment spells are long, then the social costs will be large even if this phenomenon is transitory. These social costs are measured by the rise in government expenditures along the transition path. We will also give a dynamic measure of the employment gains over time.

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[6] In type-II economy, TBTC leads to a decreasing in the non-employment rate in the long run, unlike what it is predicted for the other types of economy. This "positive" effect of TBTC in the type-II economy is explained by the fact the TBCT leads the MW to become non-binding in the long run: the economy quits the trap of the MW equilibrium at the bottom of the wage distribution. Hence, in the long run, the marginal product of a job increases more rapidly than the labor cost. This result comes from the absence of an indexation of the MW on the technological progress, and hence its decreasing relatively to productivity.

Figure 11: Non-employment by task (base=100)
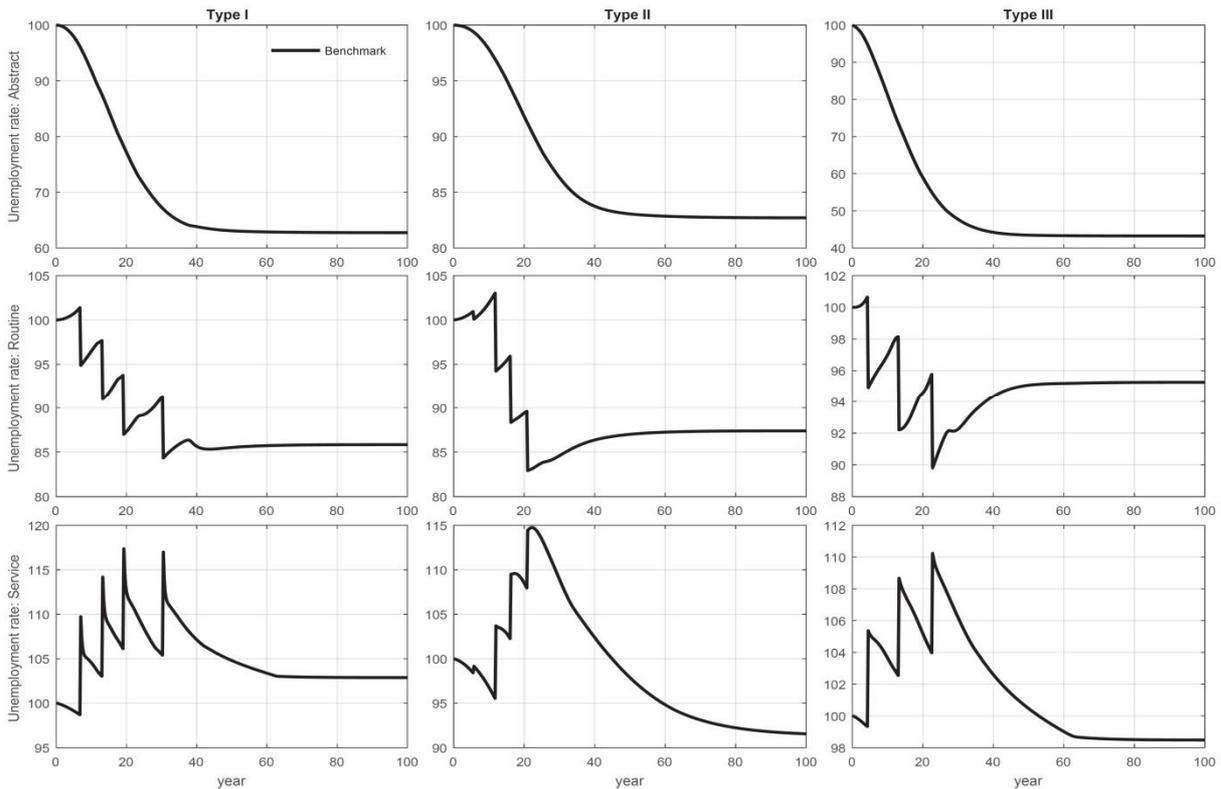
3.3.3 Why do labor market institutions matter?

Labor market institutions alter the labor allocation and its dynamic through wage-setting rules: the bargaining process as well as workers' outside options can be country-specific. Moreover, a minimum wage can be a substitute for this bargained wage for low-paid workers. Beyond this main channel, labor market institutions can also have an impact on hiring and firing costs. The basic effect of the heterogeneity in LMI among countries is the gap between Type I economies and levels of employment rates in types II and III (Figure 9).

Beyond these large effects of the distortions on the levels of the labor market outcomes, we are interested in the interaction between the LMI and the diffusion of TBTC in the economy, and thus in the heterogeneity in elasticities of employment rates. From an analytical point of view, one can summarize the impact of TBTC in Autor & Dorn (2013) model by the key relationships governing the labor reallocation across sectors. Occupational choice is based on the comparison of wages in both sectors, each wage being equal to the labor productivity. In a model with labor market frictions, the occupational choices are based on the evaluation of the search returns in each market by a worker. Unlike Autor & Dorn (2013)'s static model, occupational choices are based on intertemporal values, which takes into account the contemporaneous gains, but also the value of future opportunities. These expected values are summarized in the tightness, deduced from firms' free entry condition.[7] In a model with labor market frictions, the impact of TBTC also depends on the wage setting rule. The interaction between labor demand (the hiring decision) and wage bargaining yields the equilibrium solution for labor market tightness θ, which then depends on the interaction between LMI and technological progress, which is specific to each labor market. More precisely, LMI alters real wage through the reservation wage (w^r depends on replacement rate r and social assistance programs h), the Nash bargained surplus (w_{Nash} depends on the

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[7] Firms post vacancies until their expected returns are equal to their costs.

bargaining power and search costs sc) and real wage rigidities (the minimum wage MW, the level of the social norms w and their weight in the wage ω).

Hence, the responsiveness of the occupational choice to TBTC is market-specific, through the wage setting rules and the dynamics of each sector. Hence, asymmetries across labor markets, in addition to the productivity gap, are necessary to find a value for that differs from the ones proposed by Autor & Dorn (2013). The search and matching framework makes employment an investment decision: time matters, and so does the capitalization of the profit flows. If these profit flows are decreasing with time, the firm's incentive to open vacancies is reduced. This leads workers to quit the labor market of the routine jobs earlier than in a frictionless market. Even in this example where the chances to find a job are identical in the labor market segments at the "moving time", the job finding rate is lower than the one at which the worker has found her previous "routine" job: unemployment has then increased between these two episodes. Hence, our dynamic framework allows to account for "technological unemployment" which is the excess of unemployment linked to reallocations at times where the chance of finding a job in a new occupation is not yet very high, although it dominates that of finding in a declining demand for routine tasks.

Figure 12: Employment rate by task (base=100)
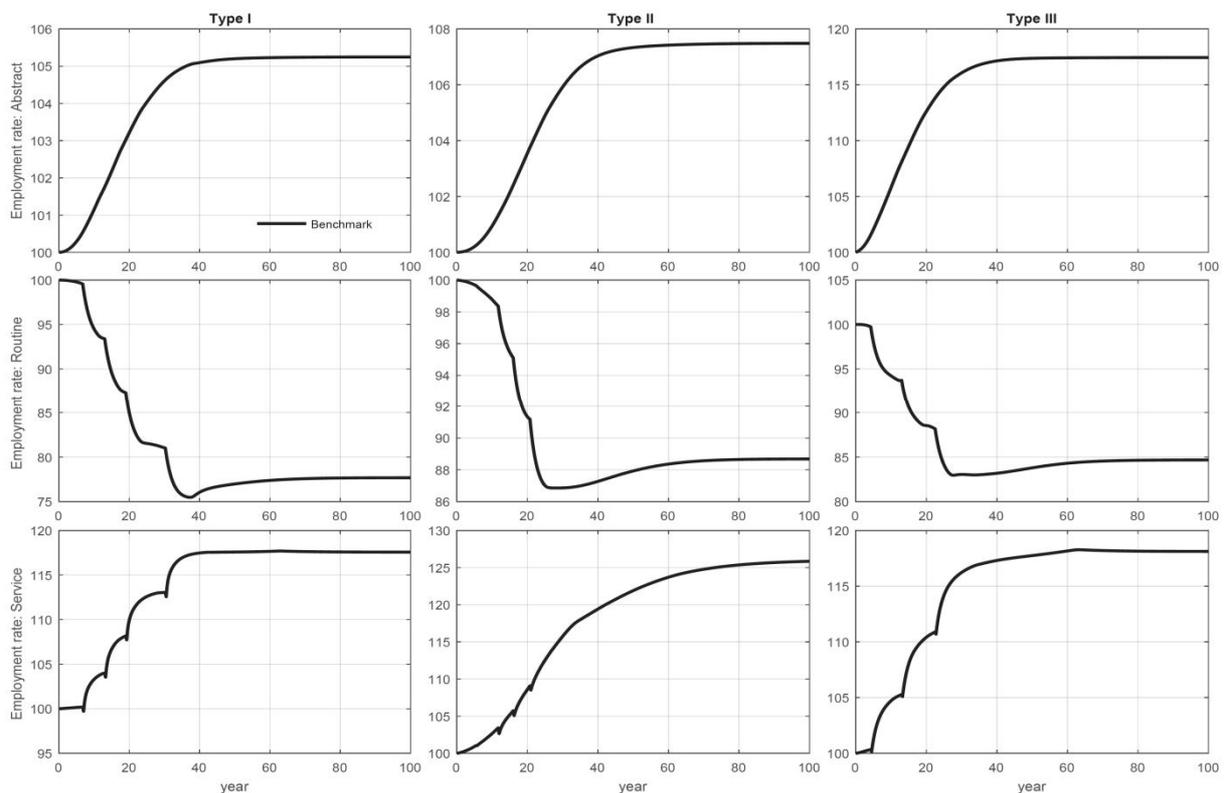
3.3.4   The wage-setting rule implications

In Figure 8, one of the main new elements is the shape of the WC. It allows to share labor market adjustments between wage and employment changes, as a supply curve of the labor supply. The elasticity of WC is thus central in the quantitative analysis. The steeper WC, the larger the adjustments of quantities. If quantities react rapidly, then unemployment duration is also highly elastic, so is the persistence of dynamic adjustments.

When discussing the wage response to TBTC, we need to look at the 2 dimensions of wage dynamics: i) households' real labor earnings, net of income taxes and divided by the CPI,

which is a primary indicator for policy makers interested in income distribution and ii) bargained wage including payroll taxes, which captures labor costs, whose dynamics determines labor demand decisions. In the discussion, the extent to which MW binds is crucial in countries of type II. The consumer price index is nearly stable over all the simulation paths because the increase of the price of services is compensated by the decline in the price of goods. Hence, in the benchmark scenario, the dynamics of the purchasing power of the workers is close to the one of labor cost, except for countries of type II with minimum wage. We then report in Figure 13 the dynamics of the real wage and, in Figure 19, Appendix C, the dynamics of labor costs. In the benchmark scenario, without change in payroll taxes, the main difference between the 2 sets of wage graphs lies on the binding MW for country II economies, in the service sector.

The main features that can be observed are that (i) average wages in routine jobs do not tend to fall in type III economies, (ii) the average wages on manual jobs increase in in type I and III economies, whereas it is constrained by the minimum wage in type II economies.

- The wage sluggishness in type III economy[8] imply that the quantities must largely decline in the market of the routine jobs in response to these relative losses of competitive-ness. In contrast, in type II economies, the decline in routine employment is less important, a large part of the adjustment being ensured by the wage (Figure 12 for the employment rates by task). In type II economies, routine jobs are maintained longer and their wages converge to the minimum wage: this generates a concentration of low-paid worker at the minimum wage level (Figure 19, Appendix C).

- In the service sector, the absence of a MW allows types I and III economies to start with a higher employment rate for manual tasks. The wage moderation allows them to generate a higher growth in service employment. In type II economics, the growth in the service sector is ensured by the rise in the price of service with a constant unit cost, the minimum wage. As a minimum wage is more rigid than a wage that accounts for "social norms", the employment growth is slower because the number of vacancies is smaller (level effect of the MW) and also because the number of workers that choose to move is smaller than in countries of types I or III.

A reform of the wage setting rules then leads to change the speed at which the economy transforms the new opportunities generated by the technological progress into (employment and wage) gains. If, in the long run, this seems to be trivial, in the short run, labor market frictions and institutions can stall this reallocation process.

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[8] The wage moderation is due to the "social" norm in the wage setting rule.

Figure 13: Real Wage dynamics (Base=100), households' labor earnings
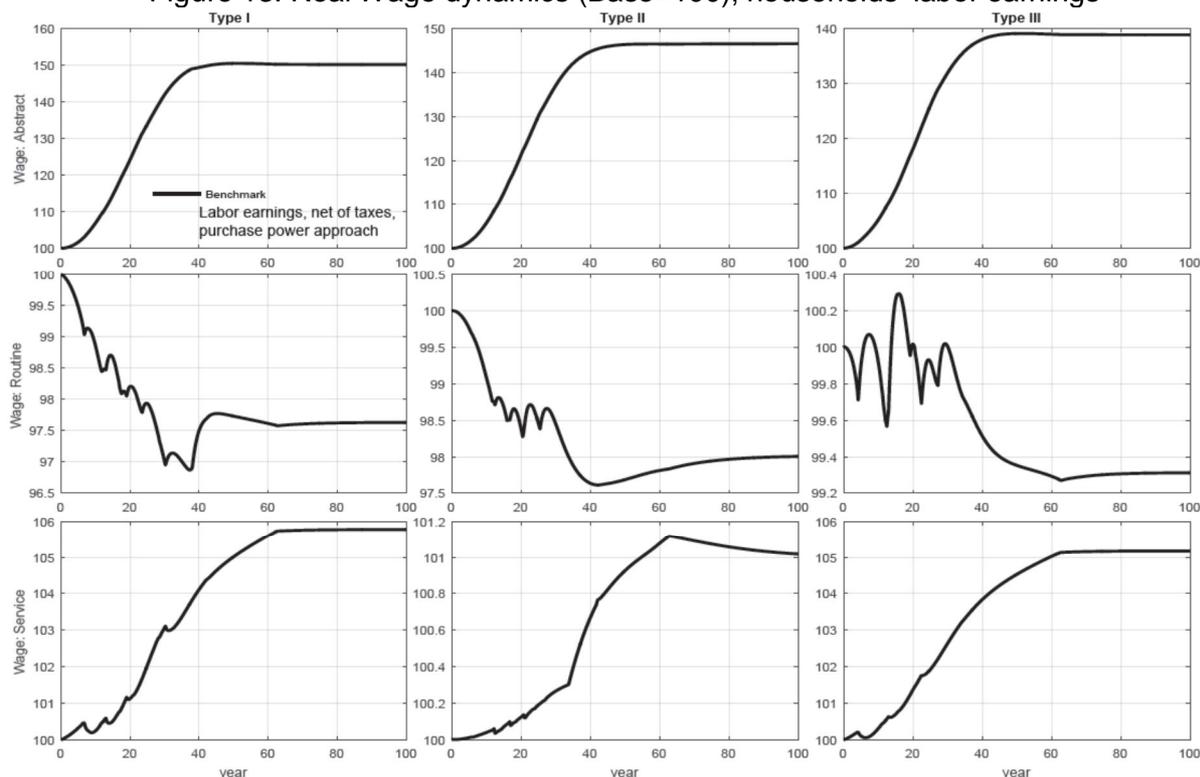
## 3.4 Introducing imperfect competition: consequences for job polarization

Job polarization depends on intensity of the reallocation between "routine" and "manual" jobs: thus, it depends on the substitution between goods (produced by "routine" jobs) and services (produced by "manual" jobs) in the consumer's basket and the production technology. In a perfectly competitive market, the price of service (that signals the direction of substitution) is only function of technology and preference parameters (Autor & Dorn (2013)'s result). In our analysis, this process can also be affected by the imperfect competition on the good and service markets.

In order to illustrate the importance of the endogenous markup on the product markets (goods and services), we assume that households become richer (the "wealth effect" induced by TBTC). The firm "Value", V_i, for i = g; n, provides the link, at the steady state, between the number of firms and the price induced by firm entry in the market: this relationship states that the entry cost must be equal to aggregate demand valued at its price, "shared" by the number of firms on the market. Hence, when consumer revenue increase the V schedule shifts down: at any given price and given the cost of entry, a larger number of firms can profitably operate in the market (Figure 14).[9] On the other hand, the other relationship between the price and the number of firms is given by the price setting rule P_i, for i = g; s: the larger the number of firms, the lower the markup, and thus the price. If marginal costs increase, this relationship shifts upward (Figure 14, service market). The new equilibria are such that the number of firms is larger than before TBTC. Entries of new firms intensify the competition and then reduce the markup (in the left panel of Figure 14 prices decrease until they reach their long run values, which is given by the intersection of the "price setting" curve

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[9] When the demand valued at its price increases, the expected capitalized gain of the firms rises and signals to potential new entrants that there are new profit opportunities

P$_i$, for i = g; s, with the curve representing the "Value" of the firm, V$_i$, for i = g; n). After the adjustments of the firm numbers, there is a multiplier effect: an increase in the aggregate demand is accompanied by a markup reduction, dampening the inflationary effect of the demand shock and leading to a production closer to its efficient level.

Figure 14: The dynamics of markups
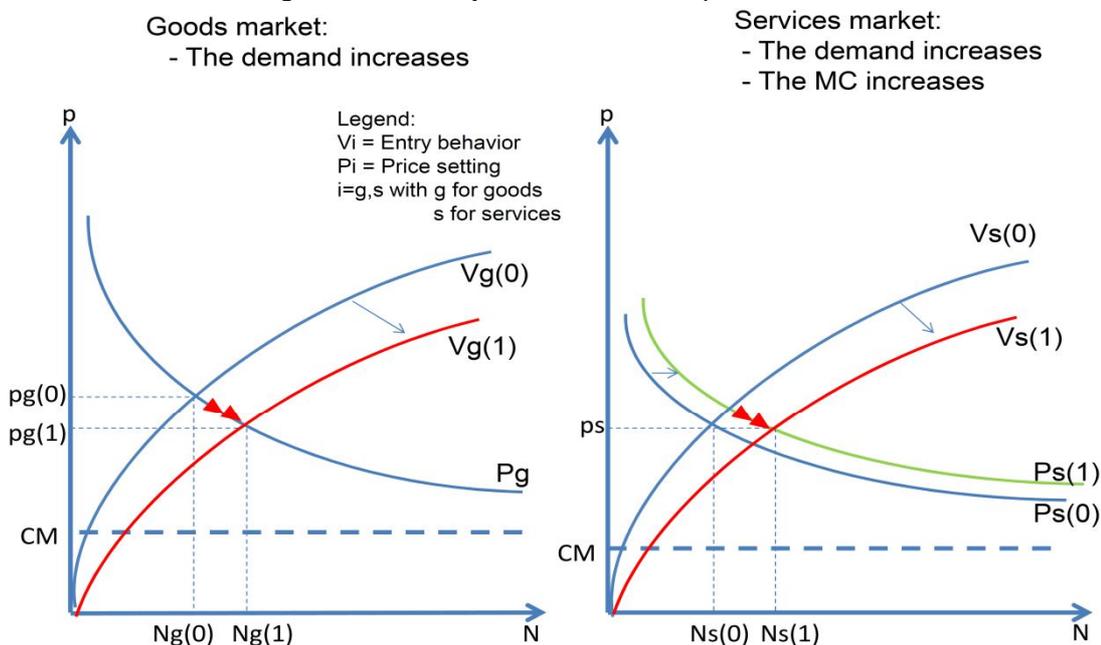
These figures give the equilibrium values for the prices pi, for $i = g, s$, and the numbers of firms Ni, for $i = g, s$, which are inverse measures of markups

This suggests that TBTC, by inducing a rise in aggregate demand, leads to a decline in the markup in all sectors: then, the impact of this "supply" shock is magnified by an increase in the competition on the product market. As a corollary, in countries with large entry costs, the amplification of TBTC by the rise in competition on the product market is less important, leading to slow job polarization. Lower entry costs would shift V curves downward, thereby triggering more entry.

Why are markup dynamics asymmetrical across sectors? The asymmetry comes from the opposite dynamics of marginal costs in each sector: for retailers in the goods sector, the cost of the transformation of a good into a final good does not change, whereas for service retailers, the unit cost in goods of the intermediate service increases, ie. its marginal cost increases (in Figure 14, the price setting curve is stable in the left panel that represents the dynamic of the market, whereas, on the right panel, the service market, this price setting curve shifts upward due to the rise in input price). Hence, for services, the increase in demand is accompanied by a relative increase in marginal costs: this dampens the decline in service prices and reduces the multiplier effect generated by a decrease in markup (Figure 14, panel "service market").[10] If we focus on the relative price between goods and services, this suggests that job polarization can be slowed down through a larger improvement in competition in good market, allowing this sector to retain longer its workers occupied on

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[10] In the AD/AS equilibrium depicted in panels (4) and (6) of Figure 8, the decreases in markups take the form of additional shifts downward of the AS curves. On the good market, entries of new firms are not restrained by the rise in the marginal cost: the fall in markups (the increase in competition) is larger on good market than on service market. Hence, the magnitude of the shift of the AS curve is larger on the good market than in services.

routine tasks. We deduce from this analysis that product market regulation, targeted at service markets, can be considered as an efficient policy in order to accelerate job polarization and to reduce the costs of the transition.

Hence, beyond the technological and the preference parameters, it seems that the elasticity of markups matters in the job reallocation process, relative to an economy with perfect competition. Moreover, given that the entry of firms is a dynamic process, due to time varying entry costs, these adjustments in markups take time: in the short run, a demand expansion leads to higher price, but, in the medium run, entries of new firms reduce markups and thus reduce prices.

Figure 15 provides the quantitative measures of these phenomena. It appears that (i) markups decline in all markets (goods and services), (ii) they decline more in good market than in the service market, but the gaps of the variations between the two markets, in all countries, is small. Hence, even if these evolutions of the competition are not theoretically identical, from a quantitative point of view, they are very close. We conclude that the dominant effect is the one driven by the increase in demand, leading to more competition in each sector: the entries of firms magnify the wealth effect of TBTC and thus exacerbate job polarization. The gap of the response of the markup across sector is a second order phenomenon. Finally, even if the quantitative changes in markups are small, this does imply that the product market regulation cannot have a significant impact on the speed of the reallocation process.

Figure 15: The dynamic of the markups (Base=100)
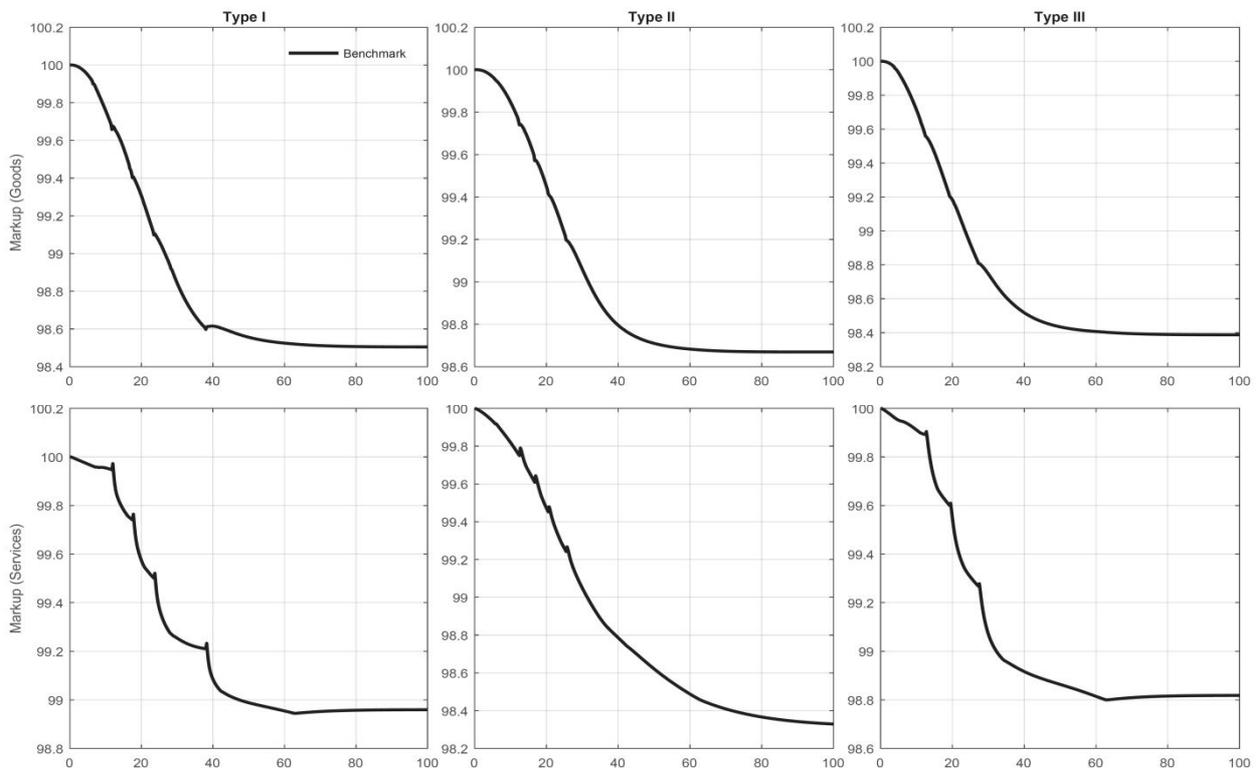
3.5 Job polarization and inequalities

By nature, job polarization generates a rise in inequalities that our model can predict. A structural model is well suited to measure the implications on inequalities of each reform, beyond the dynamics of the aggregates.

We focus on inequalities in wages and incomes.[11] In a previous study (Albertini, Hairault, Langot and Sopraseuth (2015)), focusing on the period 1970-2010, it has been shown that the "social model" in type III economies has two characteristics: it allows, during a structural change, to benefit from the technological progress in terms of employment, while containing the rise in wage inequalities. The main factor explaining this result comes from a wage moderation, particularly for high paid workers. From a theoretical point of view, these "social norms" that affect the wage bargaining process, fix a part of the contemporaneous wage to its historical value. This introduces real wage rigidities, and thus more adjustments are due to quantities. These dynamics dampen the rise in inequalities if the variation in the number of new jobs created at the top of the distribution is lower than the variation of individual gains for these workers. Our previous results show that even if the "social model" in countries of type III cannot stop the increase in the Gini index for wages, this country remains the most egalitarian.

A first set of new results can be deduced from the benchmark scenario of each country: how does technological progress, accompanied by an increase in the share of skilled workers, affect inequalities? These changes are evaluated in economies where labor market institutions and product market regulation are not modified during the adjustment path. Figure 16 shows that type I economies (type III economies) are characterized by the contemporaneous and the predicted highest (lowest) wage inequalities, type II economies being an intermediate case. With respect to the evolution of these predicted wage inequalities, the common feature for all countries is a large increase. Finally, in the types I and III economies, the Gini index of wages over-shoots its long run value: this comes from a rapid increase in wages at the top of the distribution (abstract tasks), whereas, at the bottom, new jobs are paid at low wage, the wage increase takes time.

Figure 16: Inequalities during the technological change

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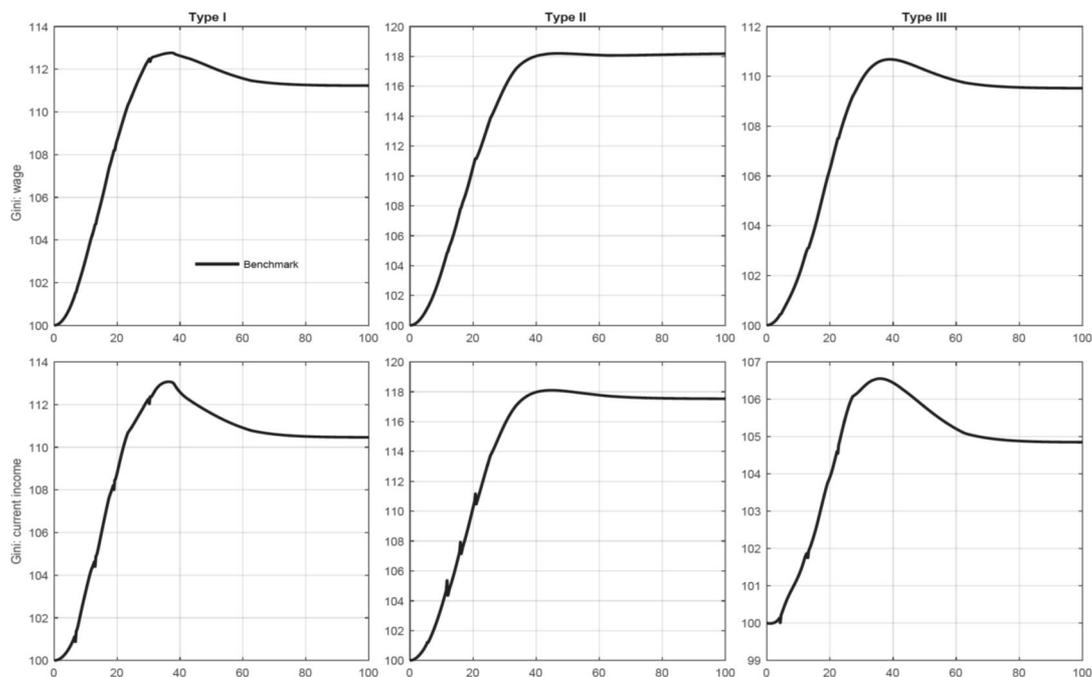
[11] Given that we have no financial asset, pension system,... in the model, the measure of the incomes that we consider, include only the wages and unemployment benefits and other social programs, target on individuals between 15 and 65 years old.

4 Labor Market Reforms

4.1 Employment gains

In Table 2, we provide a synthetic view on LMI reforms[12]. In the first column, we display the policy under study. In the second column, we report the number of the Figures that display the results (see Appendix D for the predicted levels of the aggregates, the Appendix F for the employment shares and Appendix G for inequalities). In the other columns, we provide a measure of the aggregate employment gains in the long-run as well as changes in deficit as % of output (with respect to baseline) in the short-run and the long-run.

In view of the results reported in Table 2, we can establish a ranking of policy reforms according to their effectiveness.

Table 2 : LMI reforms

	Policy	Figure	Type I			Type II			Type III		
			ΔN^{lr}	ΔD^{sr}	ΔD^{lr}	ΔN^{lr}	ΔD^{sr}	ΔD^{lr}	ΔN^{lr}	ΔD^{sr}	ΔD^{lr}
A	Lower ESSC (all)	26,33	0.1375	0.3946	0.2286	1.5710	1.2419	-0.1128	0.9924	0.8727	0.1551
B	Lower ESSC (unskilled)	27, 28, 34, 41	0.1252	0.2537	0.0847	1.1485	0.7723	-0.2300	0.9318	0.5330	-0.1328
C	lower RR	21, 22, 23, 24, 25, 35, 40	1.0372	-0.7469	-0.7842	3.7438	-2.0810	-3.7391	1.9179	-1.5013	-1.7267
D	ALMP (all)	36	2.4920	1.4659	-0.0285	1.0887	0.3741	-0.4857	0.7843	0.4786	-0.1282
E	ALMP (movers)	29, 30, 37, 42	0	0.1151	0	0.1229	-0.0021	-0.0716	0.3398	0.0980	-0.1115

ΔN^{lr} = N (final steady state, with policy, level of employment rate) - N (final steady state, benchmark, level of employment rate): variation in percentage points of the level of employment rate in the long run induced by the policy with respect to the case without policy. Figures from the table are percentage points while the Figures displayed in this report are percentages. As a result, the reader cannot directly infer the figures in this table from the graphs displayed in this report.

ΔD^{lr} = D(final steady state, with policy, deficit as % of GDP) - D(final steady state, benchmark, deficit as % of GDP) : Long-run difference in deficit induced by the policy, with respect to benchmark, as % of GDP
ΔD^{sr} = short-run measure (1 quarter after the policy change)

Lower ESSC, (all): Lower Employer's social security contribution, for all workers. Lower ESSC (unskilled): Lower Employer's social security contribution, unskilled workers; lower RR : Lower Replacement Rate; ALMP (all) : Active Labor Market Policy (all workers); ALMP (movers) : ALMP for workers who switched occupation

The fall in unemployment benefit replacement ratio

- The fall in replacement ratio (lower RR, line C) seems to be the most effective policy in terms of employment gains and change in deficit with respect to baseline. Indeed, all countries experience employment gains for skilled and unskilled workers. The magnitude of the effect is larger for countries of Type II as these economies start with a lower employment rate than the other countries. The high labor costs of the Types II and III economies are then reduced by this reduction in workers' reservation wage. The cost of this policy can be measured in terms of a rise in inequalities. An additional (trivial) dividend of the policy is to reduce government expenditures in the short run and in the long run.
- For Type I economies, the employment impact of the reduction in RR is low, compared with, e.g., an increase in ALMP (line D). This is because in Type I economies RR is already small, which limits the possibility to further lower it. Hence, in the Type I economy, the

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[12] Policy packages have been explored in the draft of this manuscript. Quantitative predictions are not improved with respect to the single policies reported below. Results are available upon request.

reduction in unemployment benefits does not lead to large employment gains.

Lowering payroll taxes:

- Altering the labor costs by lowering payroll taxes for all workers yields employment gains (line A) but generates short-run deficits due to lower fiscal revenues[13]. In the long run, the short-run deficit can be absorbed or not depending on the employment gains. With low employment gains in types I and III economies, government budget does not improve in the long-run. In contrast, with large employment gains, the deficit in type II economies is reduced in the long run, with respect to baseline.

- Table 2, line B, suggests that, what actually matters is the labor cost for unskilled workers. The effect of the fall in the payroll tax mainly lies in the employment boost for manual workers, in the context of occupational labor reallocation towards service jobs. This result is true for Type II and III economies, where the generosity of unemployment benefits and social incomes are higher. Hence, this suggests that the generosity of Type II and III economies can be compensated in term of chance to be employed for an unskilled worker only if the labor cost is reduced. This is in accordance with the view that the reallocation can be achieved only if manual jobs, at the bottom of the wage distribution, are created.

ALMP

- Altering ALMP for all workers (through a fall in hiring costs, Table 2, line D) yields employment gains, with short term worsening of government deficit and little improvement in deficit with respect to baseline (because of the small long run employment gains). Table 2 might suggest that ALMP for all workers yields interesting results, especially for type I economies. However, recall that abstract workers also benefit from ALMP. The policy mechanically boosts employment in an already expanding segment of the labor market.

- We also explore the quantitative implications of targeting ALMP only for workers who switch occupations. This policy is less expensive and directed to the workers directly affected by TBTC. Table 2, line E, might suggest that this is not a good idea, if we only look at the aggregate employment levels. Even though it is clearly not the most effective policy, notice that, in the short-run, the policy makes more routine workers willing to switch occupations which tends to increase unemployment in the short-run but, as employment gains materialize, employment rate actually goes up in the long-run. Hence, this policy, which is by definition transitory, has a permanent impact: it is then an interesting tool. Remark that the impact of this transitory policy (its duration depend on the spell of the reallocation process) has also a permanent impact on the government budget, leading to a

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[13] We report on Figure 26 the deficits, each period, as percentage of output. The short run deficits are visible.

surplus in the long-run in Type II and III countries (it generates short-run deficits, though).

4.2 Labor market reforms and inequalities

Labor market reforms aim at boosting employment, i.e. the opportunity to obtain a work and thus a wage. Hence, they increase the number of insiders. Does this entry of new workers lead to a rise in inequality between workers (wage inequalities)? Do these reforms reduce the gap between insiders and outsiders (income inequalities)? It could exist a trade-off : if it is easier to become a worker, but only at the top and the bottom of the wage distribution, this increase in the mobility can lead to more inequalities in wages. We analyze these questions using the predictions of the model. Some warnings are necessary: the Figures presented are forecasts. They are obtained by considering the past policies as given and above all stable. Thus the constancy observed in wage inequality in a Type II country, such as France, over the last decades cannot be reproduced here without a gradual and simultaneous rise in the tax exemptions on low wages and the increase in taxes on high earners, as this has been the case between 1990 and 2007.

4.2.1 Unemployment benefits

Wage inequality. The impact of the UB reduction on wage inequalities depends on the existence of MW. Without MW, for low paid workers, the reduction in UB significantly reduces wages, thereby raising inequalities (for high paid workers, the share of UB in the wage is less important). Wage inequalities then rise in type I and III. In countries of type II, insiders are protected from these wage cuts through the MW and thus the wage inequalities are not affected by the reform (Figure 40 in Appendix).

Income inequality. The costs for countries of type II from this neutrality on wage inequality, are the employment losses induced by the MW: given that the UB reduction does not change the labor costs at the bottom of the distribution in an economy with a MW, there is no employment gains induced by the reform in that part of the distribution, only unemployed workers who are less paid. Income inequalities increase in type II economies. This is not the case in countries where UB reduction leads to more employment at the bottom of the distribution (types I and III).

4.2.2 Payroll tax subsidies

In this section, we focus on the payroll tax subsidies, targeted at low skilled workers. The main impact of this policy is to increase the "employment chances" at the bottom of the distribution. Hence, its impact on wage inequalities is negligible, in all countries, as this is shown in Figure 41 in Appendix. Concerning income inequality, this policy reduces them in all countries. This contrasts with the reduction in UB: even in countries of type II, we observe a reduction in inequalities induced by the reform. Indeed, unskilled workers enjoy higher "employment opportunities", and do not suffer from a fall in their income when they are unemployed.

4.2.3 Active labor market policy

The evaluation of an active labor market policy (Figure 42) is the one of a subsidy on hiring costs for workers who choose to move from the routine labor market towards manual tasks. So this is a policy targeted at a small fraction of the total population.

If the impact on wage inequalities is insignificant, one can notice that this type of policy, extremely specific, generates a reduction in income inequalities, in all countries, its impact being the largest in type III economies. This result is driven by the reduction in "technological unemployment": the cost of the reallocation is reduced by a shorter unemployment spell. This reduces the number of workers receiving low revenues, thus income inequalities decrease.

5 Product Market Reforms

5.1 Employment gains

Table 3 summarizes the model's predictions on PMR reforms. In the second column, we report the number of Figure that displays the results.

Table 3: PMR reforms

	policy	Figure	Type I			Type II			Type III		
			ΔN^{lr}	ΔD^{sr}	ΔD^{lr}	ΔN^{lr}	ΔD^{sr}	ΔD^{lr}	ΔN^{lr}	ΔD^{sr}	ΔD^{lr}
A	PMR good	38, 43, 44, 45, 46	-0.0524	1.7867	1.7141	-0.0253	2.0381	1.9257	-0.0185	2.0117	1.8045
B	PMR good, faster innovation	47, 48, 49	-0.0524	1.3795	1.7141	0.0051	1.1964	1.9102	-0.0185	1.1808	1.8045
C	PMR service	31, 39, 50, 51, 52, 53	0.1215	1.2991	1.1031	0.2385	1.3460	1.0915	0.7659	1.3331	0.7949

ΔN^{lr} = N (final steady state, with policy, level of employment rate) - N (final steady state, benchmark, level of employment rate): variation in percentage points of the level of employment rate in the long run induced by the policy with respect to the case without policy. As results are displayed in variations in all figures (base 100), the reader cannot directly infer the figures in this table from the figures displayed in this document.

ΔD^{lr} = D(final steady state, with policy, deficit as % of GDP) - D(final steady state, benchmark, deficit as % of GDP) : Long-run difference in deficit induced by the policy, with respect to benchmark, as % of GDP

ΔD^{sr} = short-run measure (1 quarter after the policy change)

PMR good : Lower entry costs in the good sector; PMR good, faster innovation: faster fall in the price of capital; PMR service : Lower entry costs in the service sector

Lines A, B and C display the macroeconomic responses of each economy to PMR reforms alone, whether targeted at one sector (line A, good sector; line B, service sector) or not (line C). It can be seen that these policies are costly, as they generate larger deficits with respect to baseline. The employment gains are not large enough to compensate the direct cost of the fall in entry costs.

5.2 Product Market reform on the good market

The case of a simple drop in entry costs. The implemented policy is a subsidy that reduces the entry cost in the good market: these costs are divided by two. By increasing the competition in the goods sector, this reform dampens the impact of TBTC on routine jobs. The two impacts of TBCT are amplified in the good markets: the supply shock is magnified by the reduction in markups in this market (the shift of AS leads the supply is be closer to its efficient level), and this markup reduction allows firms to attract a higher share of the demand on the good markets (larger shift in AD than without policy). Given that the higher efficiency is not shared by services, their relative share in the demand expansion is lower than in the absence of reform. On the labor markets, these adjustments have two consequences: (i) for abstract jobs, the rise in competition leads to a higher demand which slightly increases the equilibrium rate of employment of skilled workers, and (ii) for routine jobs, the decline in markups dampens the negative impact of TBTC on these jobs. Finally, in the labor market of manual tasks, the rise in the labor demand is lower than without policy, but can also lead, as

in the case without reform, to an exit from the "MW trap" [14]. In economies without MW, adjustments are similar but there is no exit from the "MW trap".

Figure 43 provides the quantitative evaluations of the direct impact of the policy: the markups in the goods sector decline by 4% in the long run, with a large instantaneous jump. The effect of this policy on the markups in service is not negligible, the markup rising by 0.2% with respect to their "natural" decline predicted in the benchmark scenario. The competitiveness of the good sector is then reinforced.

In economies without MW (types I and III), this maintains longer employees on routine task in the short run (Figure 44). Labor hoarding generated by the policy in routine jobs does not imply that there are employment gains for the unskilled workers (Figure 45). Indeed, this policy acts more in favor of skilled and capital, the inputs that are complement with TBTC.[15]

The liberalization of the good market has an instantaneous large impact on the consumer price index (CPI): indeed, the reduction in the markup leads to a decline in the price of goods by an amount of 4% and then to a decline of 2% in the CPI. There is no persistence in the price adjustments. Hence, the reduction in the entry costs in the good market increase the real wage of all workers, in all countries. There are additional mechanisms at work in the real wage dynamics. Given that the decline in the incentives to use routine workers in goods sector is dampened in countries of type II by the intensive use of the two other inputs, there is a downward pressure in the wage dynamics for routine tasks, as in benchmark scenario (Figure 46). In type I economies, this downward wage pressure on routine jobs is more important than in the benchmark scenario. This comes from the homogeneous calibration of the subsidy across countries, whereas entry costs summarize congestion effects: given that it is more difficult to enter for the marginal firm when the market is large, the efficiency of a homogenous reform across countries is less important for countries where the competition is intense ex-ante. This explains why the impact is less important in countries of type I than those of type III. Hence, the rise in competition in countries of type I saves less jobs in routine than in countries of type III. As a corollary, the wage decline in routine jobs, driven by TBTC, is less dampened in countries of type I by the reduction in the markup than in countries of type III induced by the policy. In all countries, the downward pressures in the labor costs are over-compensated by the decline in the CPI, leading to an increase in the purchasing power of all workers (Figure 46).

When the fall in entry costs stimulates innovation. If the fall in entry costs in the good market leads to more firm entry, it could also stimulate innovation. We simulate this scenario by assuming that, at the time of the reform, the path of the price of capital decreases more rapidly. More precisely, whereas this price reaches its final value after 40 years in the benchmark scenario, when the innovation process is stimulated, it reaches this final value after only 20 years. Hence, the simulation combines two effects: a policy that increases competition on the good market and mechanically, a more rapid technological progress.
Figures 47 and 48 display the quantitative impact of the reform. Even if the drop in markups dampens the negative impact of TBTC on routine jobs, the acceleration of technological progress rapidly reduces labor demand for these tasks. The combination of the higher competition with TBTC leads to a large increase in skilled workers' employment rate. Notice that this phenomenon is only transitory. In economies without MW (types I and III), for the first set of worker types that must be displaced, reallocation is more rapid and more intense,

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[14] The Minimum Wage trap (or MW trap) refers to a situation in which the MW is binding along the technological transition.
[15] The largest gains are captured by capital, because the margins to increase the employment rate of skilled workers is small.

implying a quick rise in the employment rate in the service sector. After two waves of reallocation, the dampening effect linked to the rise in competition protects the good sector from these workforce reallocations. This explains the relative stagnation of employment rate in the service sector.

In type II economies, an economy with a minimum wage, the rapid decline in labor demand for routine jobs is magnified by the MW: a large part of workers occupied on routine jobs converge to a binding MW, leading firms to adjust using quantities. Hence a large amount of the workforce (3 types of workers[16]) decides to switch occupation at the same time, generating a large congestion effect on the labor market of manual tasks. Non-employment of unskilled workers strongly increases in the short run (Figure 48), whereas we observe the opposite phenomena for the non-employment rate of skilled workers. Hence, this reform in type II economies illustrates perfectly the phenomena of "technological unemployment" linked to reallocation. Given the impossibility to reduce the ages on the markets where the labor demand decreases extremely rapidly, workers move simultaneously on a labor market, congested and not highly profitable yet. This short term rise in unemployment of unskilled workers is less pronounced in countries of types I and III because wages can dampen the impact of the decline in the labor demand of routine tasks.

5.3 Product Market reform on the service market

The implemented policy is a subsidy that reduces the entry cost in the service market: these costs are divided by two. Figure 17 displays the essential mechanisms at work if this reform is implemented. Two cases are distinguished: the one of an economy without MW (panels 1 and 2 of Figure 17) and the other with a MW (panels 3 and 4 of Figure 17).

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[16] Workers are heterogeneous with respect to their ability. The model is solved using a discretization of the ability level on 20 abilility levels. When we mention that 3 types of workers switch occupation, this provides a measure of the fraction of unskilled workers who move from routine to manual workers.

Figure 17: Market regulation in services during job polarization
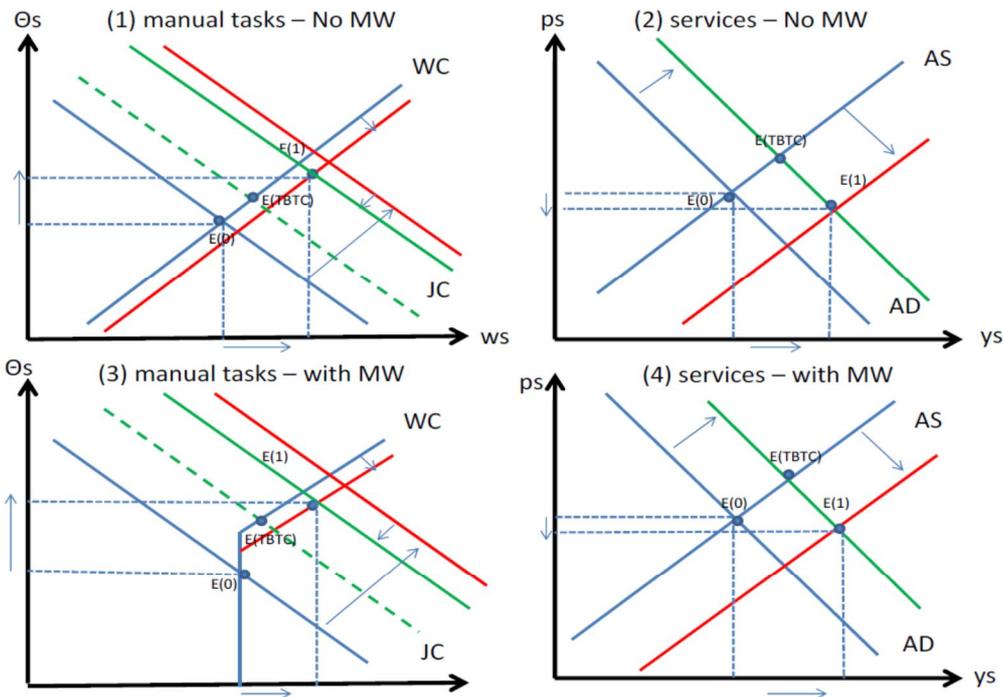
The subsidy of entry costs triggers a sizable increase in the number of new firms in the service sector, and thus largely reduces the markup in this sector. In the AD AS scheme, these gains are depicted as a shift downward of the AS curve (panel (2) of Figure 17). The keener competition among firms then shifts labor demand upward (JC curve), its new level being closest to its efficient level (panel (1) of Figure 17). When wages are bargained, part of the markup is captured by workers: when these inefficiencies are reduced, the wage curve (WC) shifts up, leading to lower wages, for a given level of tightness. These two forces drive a large increase in the employment in the service sector (panel (1) of Figure 17). TBTC generates at the same time an increase in the demand for services: the AD curve shifts upward. If the supply shock (the drop in markups) is larger than the demand shock (the rise in incomes driven by the technological change), the price of service falls. This slightly dampens the favorable impact of the markup decline in the labor market of services (the feedback effect of the general equilibrium (GE) in panels (1) and (2) in Figure 17). When there is a binding MW, TBTC can move the economy out of this trap (Figure 31a in Appendix E). Hence, if this technological change is accompanied by a rise in the competition in the service sector, we deduce that the exit out of this MW trap will occur more rapidly. This allows an increase in both wages and employment in services (panel (3) of Figure 17).[17]

Beyond these effects on manual labor and market of services, the fall in entry costs in the service sector also alters the equilibrium on the good market. Indeed, this policy increases the competitive advantage of services with respect to the benchmark scenario. Then, when agents become richer thanks to TBTC, they share this surplus more in favor of the services where the reform allows agents to benefit from keener competition. Hence, the GE effect

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[17] The adjustments of the AD AS curves are the same as the ones displayed without MW (panel (4) of Figure 17).

after the reform reinforces the expansion in the service sector. In the labor market, a larger number of workers choose to move from goods to services.

The quantitative impact of the policy is a decline in the markups in services by more than 5% in the long run, with a large instantaneous jump (Figure 50). The effect of this policy on the markups in the goods sector can be considered as negligible. The keener competition in services provides firms with a larger competitive advantage with respect to the allocation of unskilled labor: employment prospects improve, with respect to the benchmark scenario, driven by a larger redistribution of wealth towards services. The employment rate of routine workers loses 5% in countries of type I, whereas it loses 10% in type II economies (Figure 51). Given that the employment rate of unskilled workers goes up in the two economies, this implies that services absorb employment destructions in routine jobs, but they also create additional jobs.[18] Along the transitional dynamics, a new phenomenon appears in Figure 51. In countries of types I and III, TBTC leads 4 types of workers to move from goods toward services (from routine jobs towards manual jobs), whereas in countries of type II, the minimum wage prevents this reallocation process to occur for 3 types of workers. In countries of types I and III, the policy does not change the number of workers that choose to switch occupation during the technological change. In contrast, this policy allows type II economies to converge through the same amount of the workforce reallocated from routine jobs towards manual jobs.

The dynamics of the average wage by occupation is also affected by this policy (Figure 52). The liberalization of the service sector leads to an instantaneous reduction of the markup by an amount of 2%. The IPC is then reduced by 1%. Other things being equal, the purchasing power of all wages in all countries increases. The reform has also an impact on the labor costs, the other component of the real wages (Figure 31a in Appendix E). Firstly, note that given that the reform reduces markups in services, the wages of workers occupied on abstract tasks do not change with respect to the benchmark scenario. For unskilled workers, occupied on routine or manual tasks, there are changes in the labor cost dynamics. For routine jobs, the rise in labor costs is due to a stronger selective effect: only the most productive workers on these tasks are hoarded, this explains the increase in the average wage. This phenomenon over-compensates the decline in tightness in this market which pushes real wages downward. Hence, given that labor costs increase and that the CPI declines, this reform leads to an increase in the real wage of the workers occupied on a routine task. Finally, for workers occupied on a manual task, there are two cases. If there is no MW (types I and III), the two main forces that raise the labor cost (the rise in demand for services, and the decline in markup) largely dominate the loss for the insiders to capture a share of the high markup in an economy where the competition is low. Accompanied by the reduction in the IPC, these wage gains are permanent. If there is a MW (type II), this institutional constraint is still binding at the beginning of TBTC, even if the product market de-regulation induces more competition. The economy leaves the "MW trap" only 10 years after the PMR reform (Figure 31a in Appendix E): driven by the large increase in the demand for service, the bargained wage is then 2% higher than the MW.

5.4 Product market regulation and inequalities

PMR policies aim at increasing competition in the product market (goods and services) in order to reduce inefficiency gaps and thus to increase consumers' income. In a context of a

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[18] In countries of type III, the effects are smaller because real wage rigidity is higher.

technological progress bias in favor of some tasks, inequalities increase. PMR can then accelerate/dampen this process.

5.4.1 Regulating competition on the good markets

The main impact of the increase in competition in the good sector is a rise in wages at the top of the distribution. The decline in labor demand for routine tasks is accelerated when we introduce an acceleration of the technological change after the reform (more incentives to innovate for competitive firms). Hence, wages of these workers decrease rapidly. A large amount of reallocations arrives at the same time in labor market of the service sector. This generates congestion effects. All these mechanisms explain the large increase in inequalities in the short run (Figure 49): the wages of abstract workers go up whereas the others' are compressed at the bottom. For the incomes inequalities, the sizeable "technological unemployment" explains the gap with the benchmark (Figure 49).

In type II economies, the overshooting phenomenon of the long run value of inequality measures, observed in countries of types I and III, is dampened. This comes from the MW. Without any downward adjustments in the middle of the wage distribution, there is a concentration of the wage distribution at this MW and thus inequalities are contained at the bottom. In other countries, jobs of the middle class are destroyed less rapidly, at the price of wage cuts: wages inequalities increase. The counterpart of these wage adjustments, is that countries of type II will achieve a large growth of income inequalities, because a large number of individuals are rapidly excluded from routine tasks, at a time when the development of services is slow.

5.4.2 Regulating competition on the service markets

The main impact of the increase in competition in the service sector is a rise in wages at the bottom of the distribution: hence more competition in the service sector leads to reduced wage inequalities (Figure 53). Indeed, a market product regulation promoting the competition, and targeted on this sector, allows firms to benefit from a supply shock, in addition to the additional demand generated by the technological change. This boosts labor demand and thus wages in the service sector. In countries of type II, this policy leads to an exit out of the MW trap. The resulting effect of these wage increases in the service is a larger reallocation of the low productive workers on this market: thus, only the most productive workers remain in the labor market of routine tasks. The selection effect leads to higher wage on this last labor market.

Beyond these effects on wages, this policy also increases "employment opportunities": less individuals receive only an UB. This phenomenon is at work in all countries (Figure 53), and to a larger extent in the country where the labor market at the bottom of the distribution is initially distorted (Type II economies). Accompanying TBTC with this targeted PMR significantly reduces income inequalities by raising the gains at the bottom of the distribution.

6 Redistributive policies

6.1. Redistributive policy under the benchmark scenario

Under the benchmark scenario, absent any policy reform, TBTC generates 2 gains: employment increases and government surpluses. These government surpluses can be used for redistributive purposes in favor of the poorest population. Remember that the government budget is balanced through lump-sum transfers to the households. Without introducing any new distortions, redistribution can be achieved via a reshaping of the lump-sum transfers: whereas in the benchmark scenario, all the agents (skilled and unskilled) perceive the same lump-sum transfer, in the scenario with redistribution these lump-sum transfers are directed to unskilled employed and unemployed workers[19]. In this scenario, the government surplus induced by the gains in employment is used to reduce income inequalities

In Figure 18a, we report the evolution of Gini coefficients on income under various scenarios. Let us have a look at the 2 solid lines (black is benchmark scenario without redistributive policy and green is benchmark scenario with redistributive policy). The gap between the 2 solid lines captures the decrease in income inequality achieved through the redistributive policy.

The initial condition in each country matters: Type I and Type III have an initial positive government surplus which can be instantaneously used to reduce inequalities. This explains the drop in Gini coefficients in these two types of country when government redistributes its surplus only to unskilled workers (Figure 18a). In contrast, the Type II country has no initial surplus: it is not possible for the country to implement a redistributive policy at the beginning of the technological transition.

In each types of country, the long-run impact of TBTC is an increase of the level of the government surplus: these surpluses can then be used to redistribute incomes to the unskilled population (employed and unemployed). The reduction of the Gini coefficients lie between 6 and 10%, with a remarkable result: in the Type III economy, the redistribution of the government surpluses will lead to reduction of income inequality in the long-run.

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[17] The redistribution though lump-sum transfers does not distort the allocation: while wage inequalities cannot be modified, income inequalities are reduced.

Figure 18a: Dynamics of income inequality: the impact of the redistributive policy (ALMP targeted at occupational switchers, lower ESSC targeted at unskilled workers, lower entry costs in good sector)
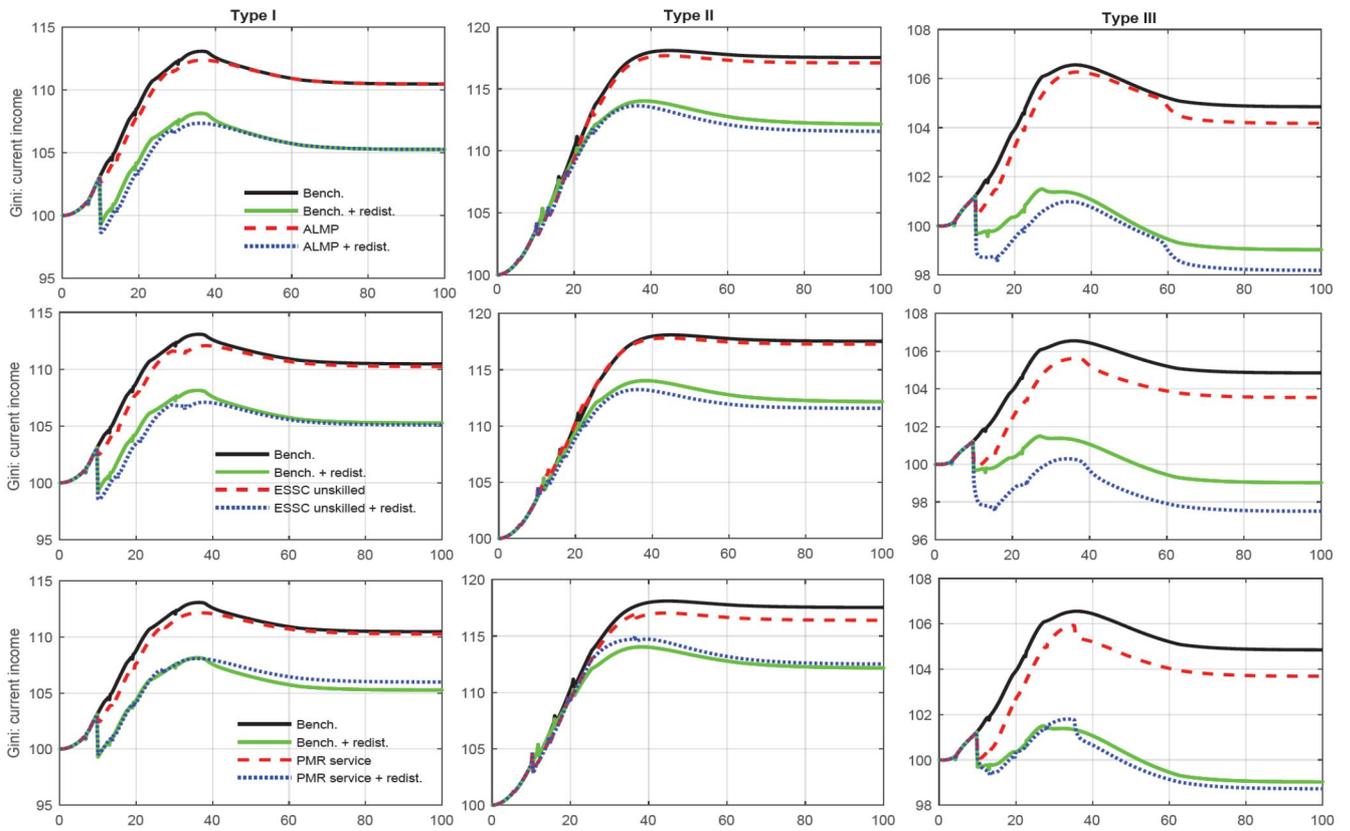
Figure 18b: Dynamics of income inequality: the impact of the redistributive policy (ALMP for all workers, lower ESSC for all workers, lower unemployment benefit)
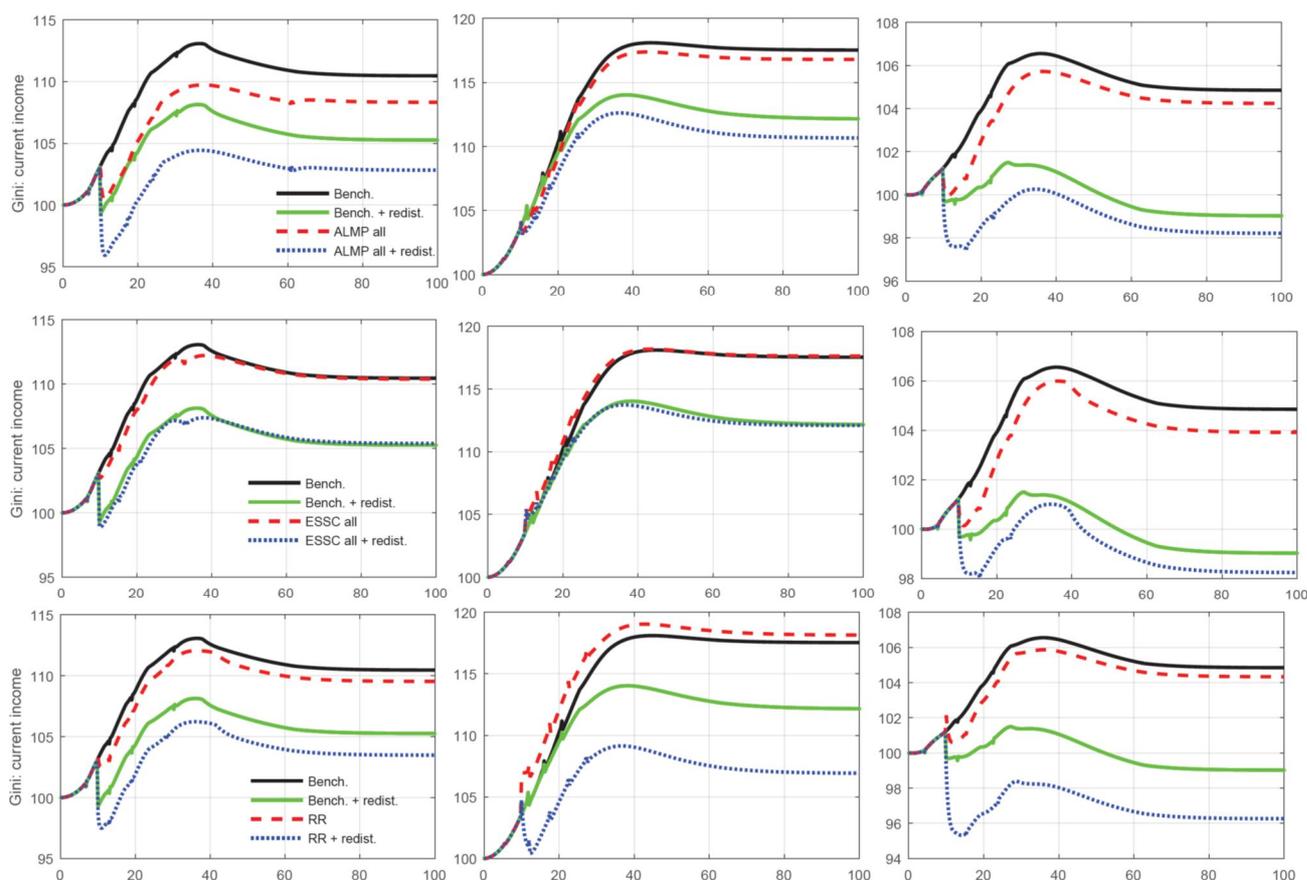
6.2. LMI or PMR reform combined with redistributive policy

The effectiveness of any reform can then be assessed with respect to its ability to improve efficiency (employment rates and the government budget) and inequalities: the ability of the reform to generate more employment gains than in the benchmark scenario and the impact of the reform on government surplus, which fuels a potential redistributive policy[20].

When we introduce policies, we know that some of them can induce a cost in the short-run, whereas in the long run, all of them increase the surplus of the benchmark scenario. This suggests that the long-run gains in efficiency can be also perceived as a cost in terms of the inequality reductions.

In Figures 18a and 18b, we report the response of Gini coefficients with the policy reform (ALMP for all, for movers only; lower ESSC for all, for unskilled only, lower entry cost in the service sector and lower RR) with or without redistributive policy (dot blue line and solid green line respectively). By comparing these 2 lines, we can assess the ability of each reform to generate enough government surplus to fund a redistributive policy.

The larger the effect of the policy of employment (reported in Table 2), the larger the government surplus and the higher the ability to fund redistributive policy. Figures 18a and 18b suggest that a fall in replacement ratio delivers a significant fall in Gini on income, especially in countries in which the reform on replacement ratio was the most effective

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[20] By altering the government surplus, a reform can lower the government's ability to reduce inequality, hence the reform can alter the evolution of Gini coefficients with respect to the benchmark scenario

(countries of types II and III). Consistently with Table 2, Gini coefficient in Type I economies are more responsive to the redistributive policy when combined with ALMP for all workers.

7 Concluding remarks

In the future, our economies will continue to experience a computerization of routine tasks, spurring a lengthy process of employment reallocation. The new allocation of workers to firms and sectors will depend on these technological opportunities and on the evolution of product and labour market institutions. In the short run, technological progress is "labor augmenting" for some workers and "labor saving" for others (the computerized tasks). The demand for routine task (the "middle" class) decreases whereas that for abstract and manual tasks (the top and the lower "classes") expands. This generates "job polarization". The economic impact of such changes will vary depending on the ability of each country to reallocate the "old" labor, now "saved" (routine tasks) towards "new" activities (manual tasks). Beyond these challenges in terms of efficiency, job polarization generates a rise in inequalities.

In this paper, we propose the first dynamic model to analyze this transition process, accounting in addition for the evolution of the skills composition, in particular the rise of the share of skilled workers. In this dynamic context, we show that this transition path is characterized by short-run costs and long-run gains.

7.1 Short-term costs / long-term gains in the benchmark scenario

The short-run costs and long-run gains can be discussed along 3 dimensions: dynamics of unskilled workers' employment rate, government deficit and inequalities.

Short-term costs / long-term gains in unskilled employment rate. Our model predicts that the employment rates for skilled and unskilled workers will be higher than the one prevailing before the technological change in all countries. These long-run employment gains are associated with short-run costs in the labor market of unskilled workers. Indeed, unskilled employment rate displays a "J-shape" with a decline in employment rate for unskilled workers at the beginning of the technological transition. This employment loss is gradually absorbed, then transformed into employment gains as workers reallocate towards services.

The depth of this J-curve (i.e. the magnitude of short-run costs) depends on the speed of reallocation from routine jobs to service occupations. In countries of type I, the flexibility of the labor market generates brief employment drops, quickly followed by employment gains. In more rigid labor markets (Types II and III economies), employment first declines, then gradually increases as unskilled workers reallocate from routine to manual jobs. Type II country experiences the larger short-term costs, implied by their high labor market rigidities. The time during which there can be employment losses, can last 30 years.

When we discuss the short-run costs of reforms, we assess the ability of the reform to reduce the short-run costs with respect to baseline, i.e. the ability of the reform to smooth employment rate of unskilled workers (make the employment J-curve less hollow at the beginning the transition).

Short-term costs / long-term gains in government deficits. In all countries, labor reallocation occurs when unemployment workers, those who were fired from routine jobs, decide to switch occupation to manual jobs. The short-run costs of TBTC are then spikes in government expenditures, through a temporary increase in the number of unemployed workers. With long-run employment gains, the government deficit goes down in the long-run. For Type II country, the necessary reallocations, and their persistence linked to the larger labor market rigidity, leads to larger costs in terms of government deficits. Moreover, given its initial low employment, it also has an initial deficit which makes the short term adjustment more difficult. For Type I and III economies, there is initially a surplus and the adjustment is less persistent (type I economy) or less sizeable (Type III economy).

Short-term costs / long-term gains in inequalities. In countries of types I and III, the Gini coefficient overshoots its long-run level, thereby suggesting that there are short-run increases in inequalities in these countries, with respect to the new steady state. This increase in inequalities at the beginning of the technological transition is due to the combination of i) sizable rise in the wage of abstract workers and ii) significant fall in the wage of unskilled routine workers. In addition, new jobs in the service sector remain poorly paid at the beginning of the technological transition. In contrast, in countries of type II, we do not observe the hump-shaped Gini as in countries of types I and III. The difference is due to the presence of the MW that limits the fall in the wage for unskilled workers. The Gini coefficient still rises (because abstract workers benefit from higher wages) but does not display any overshooting with respect to its long-run value.

When we discuss the short-run costs of reforms, we will assess the ability of the reform to reduce the short-run costs with respect to the baseline, i.e. the ability of the reform to smooth the overshooting of the Gini coefficients.

7.2 Short-term costs / long-term gains with policy reform

Hence, the structural change must be accompanied by policy measures that magnify its positive impact on job creation, thereby expanding employment opportunities, and at the same time, that prevents any increase in inequalities.

In the context of technological change that induces labor reallocation towards manual jobs, policy reforms are able to lower short-run costs when they speed up the occupational changes of unskilled workers. We show that policies targeted at the sector in expansion (namely product market deregulation of the service sector) or at the workers who reallocate towards expanding employment opportunities (namely ALMP targeted at movers) are able to lower the short-run costs associated with TBTC. The payroll tax subsidies targeted on low skilled workers give also incentive to create more jobs at the bottom of the wage distribution. In contrast, deregulation of the declining sector (namely the good sector) would only worsen the short-run costs, with respect to baseline, without possibly no long-run gains. If the fall in entry costs for the good sector also boosts innovation (i.e. faster fall in the price of computers), long-run gains can materialize as the economy converges towards a less distorted economy. The faster TBTC also benefits abstract workers who are already the winners of TBTC.

Employment of unskilled workers. Policies such as the ALMP targeted at workers switching occupations or product market deregulation in service can actually generate larger short-run losses in unskilled employment, with respect to baseline, as these policies make workers more willing to switch occupation in the short-run but they still need time to find a job. As a result, these policies generate larger unskilled employment fall in the short-run but also larger employment gains in the long-run, with respect to baseline.

Deregulation in the good sector,

- without faster innovation: the reallocation towards manual jobs is slowed down, which accounts for the larger short-run employment loss for unskilled workers
- with faster innovation: this actually accelerates the effects of TBTC, thereby yielding larger employment losses in the short-run than in the baseline scenario

Government Deficit. Short-run deficits are reduced (compared to baseline) as soon as the policy reforms generate enough employment gains in the short-run and covers the direct cost of the policy (such as lower entry costs or ALMP). This is the case for all policies, except the cut on payroll tax in countries of types II and III. Indeed, the fall in fiscal revenues is such that the deficit worsens in the short-run, with respect to baseline, while employment gains reduce the deficit in the long-run.

Inequalities. All reforms that affect abstract workers as well as unskilled workers tend to worsen inequalities in the short-run, compared with baseline. These policies tend to accentuate the hump-shaped dynamics of Gini coefficients. This is the case for the fall in the replacement ratio, the cut of payroll tax for all workers or the product market deregulation when associated with faster TBTC. With these policies, abstract workers also benefit from the reforms in terms of employment and wage growth. The policy-maker boosts a segment of the labor market that is already expanding, thereby increasing inequalities in the short-run. What matters here is the difference in speed of adjustment of abstract and unskilled workers. Abstract job creation and wage growth responds quickly to policy changes, while the unskilled segment of the labor market is affected by the time-consuming labor reallocation.
In contrast, policies that target key elements of the labor reallocation for unskilled workers, by boosting labor opportunities at the bottom of the wage distribution, tend to reduce inequalities. This is the case for product market deregulation in the service sector, ALMP targeted at workers who switch occupation, a tax cut on unskilled workers' payroll tax. All policies tend to yield less hump-shaped Gini dynamics.

Whatever the policy reform, a redistributive policy (section 6) constitutes a powerful policy tool to significantly reduce income inequalities along the transition path.

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Appendix

A The model

See companion file

B Numerical method used to solve the model

See companion file

C Labor cost dynamics

Figure 19 displays the dynamics of labor cost in the benchmark case.

Figure 19: Wage dynamics (labor cost, defined as bargained-wage including payroll taxes)
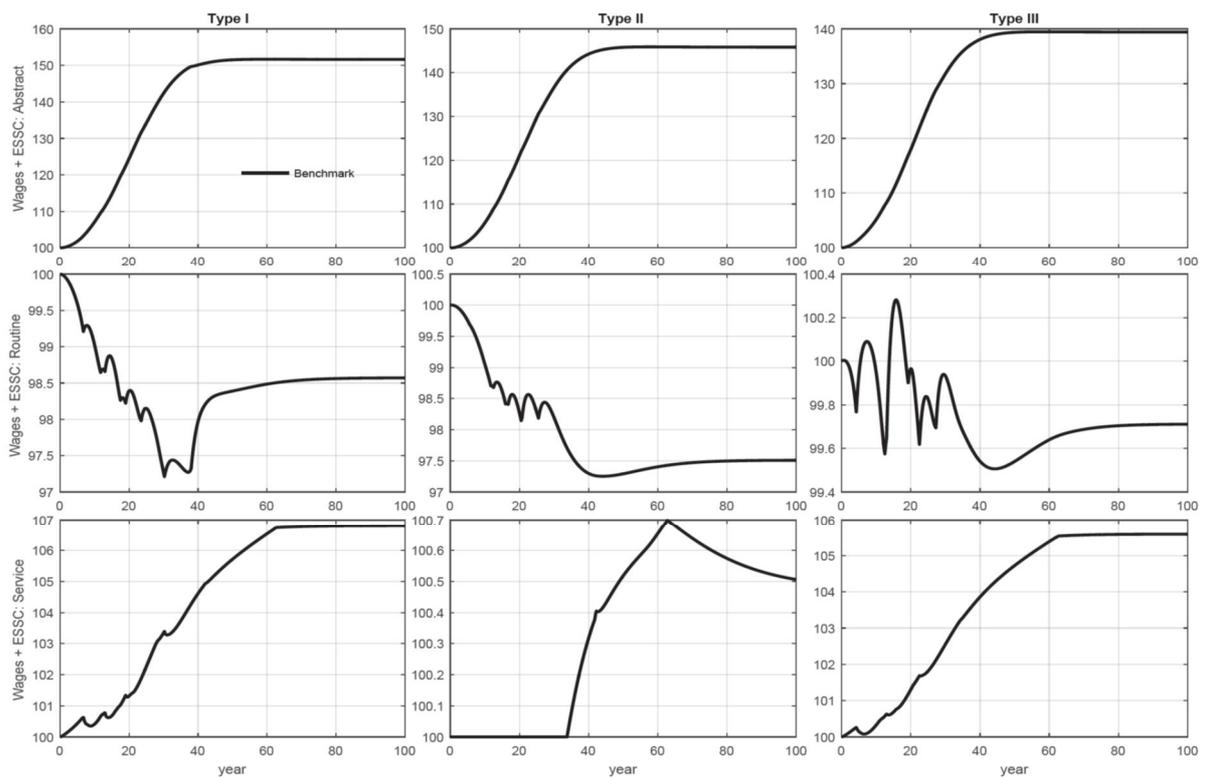
D Policy experiments: LMI

D.1 Unemployment benefits

Figure 20 provides an analytic framework to understand the main mechanisms at work in the model when the replacement rate is reduced (UB). We focus here only on the services. First of all, it is crucial to distinguish economies without Minimum Wage (MW) (panels (1) and (2) of Figure 20) from economies with a binding minimum wage (panels (3) and (4) of Figure 20).

Countries without MW. The reform reduces labor costs (W C shifts up): it acts as a supply shock. In the short run, the demand increase is small because all the gains of TBTC are not realized (the complete diffusion of TBTC, the hiring process after the workforce reallocations and thus the income effects). Hence, in the short term, wages in services fall whereas new vacant jobs are opened. When the magnitude of TBTC becomes larger, and thus the demand to service retailers converge to its long run value, the price of services go up (the shift up of the AD curve in green in panel (2) of Figure 20): This leads firms producing services to largely increase their labor demand (JC shifts up, the green line on panel (1) of Figure 20). The long run impact of the reform, by shifting down the AS (the impact of the UB reduction), is to moderate the price increase (the dynamics of service is not only driven by the expansion in the demand) relatively to the case without reform (the equilibrium E(T BCT) in panels (1) and (2) of Figure 20). Hence, this reform magnifies job creation in the expanding sector.

Figure 20: A reduction in UB during job polarization
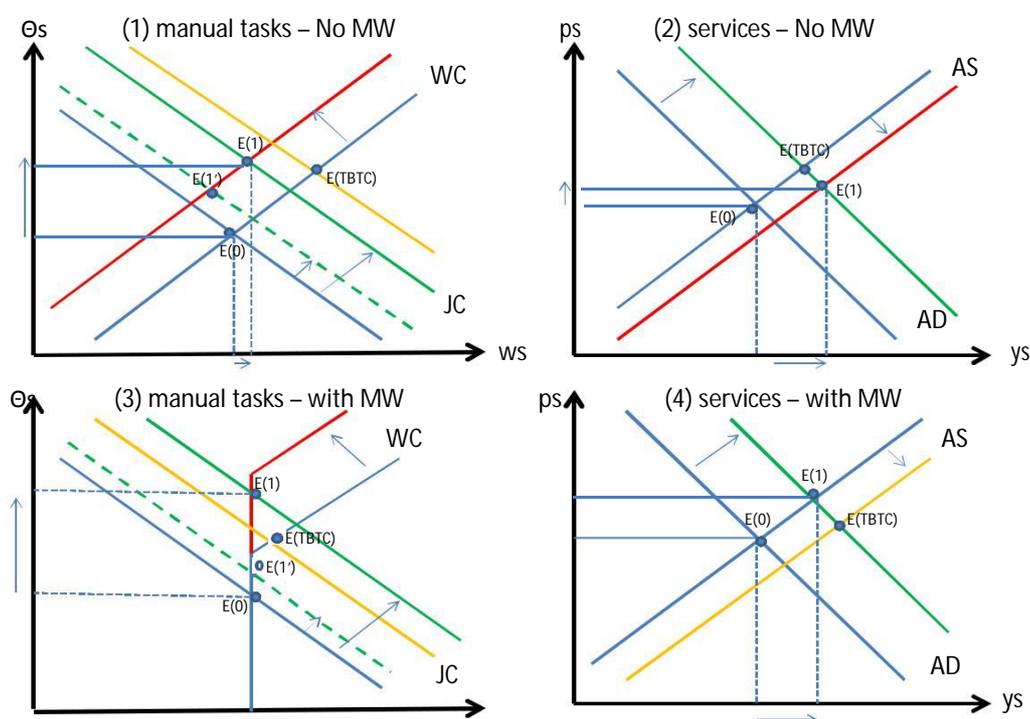
Legend: Blue lines = before TBTC and the   RR; Red lines = after TBTC and with   RR; Green lines = after TBTC and   RR with GE feedback; Dotted green line = Green line in the Short run; Orange line = after TBTC but without reform.

This decline in workers' outside opportunities also leads to wage moderation for routine tasks. This allows non-profitable jobs in the benchmark scenario to remain profitable, leading

firms to search a worker, after a separation. Indeed, the cut on UB partially compensates the losses of competitiveness of routine jobs. These wage cuts can be sufficient to maintain routine tasks for high ability workers, but not the ones having a productivity close to the threshold. Hence, the reform can reduce job polarization in the long run, but accelerates it in the short and medium run, when the more fragile workers previously employed on routine tasks choose to move towards services. For these workers, labor market adjustments of manual tasks ensure shorter unemployment spells: in the short run, the share of manual tasks can then be higher than in the benchmark scenario, whereas in the long run, the reform can maintain an employment share of the routine tasks larger than in the benchmark scenario.

Countries with MW. The reform reduces labor costs in the services only for the wages larger than the MW. If, for simplicity, the wage in the services is the MW, there is then no shifts in W C and in AS, contrary to the previous case. Hence, without any supply shock, services only benefit from the income effect generated by new technologies (the green lines for JC and AD in panel (3) and (4) of Figure 20). With respect to the benchmark scenario, the attractiveness of the service increases, but slowly, driven by the diffusion of TBTC and its redistribution effects across sectors. This redistribution effect is larger (hence the employment level in the services benefits from the reform) but dampened by the higher competitiveness of routine tasks induced by the reform. Indeed, as in the case without MW, the reduction in UB leads also to wage moderation for routine tasks, giving incentive to maintain these jobs. Thus this reform induces a bias on the relative wage in favor of routine jobs. In the short run, the share of routine (manual) jobs is higher (lower) than in the benchmark scenario, but, in the long run, after long unemployment durations, the reallocation can take place. These adjustments are slow because the downward wage rigidity in services do not entice firms to create new jobs more rapidly in this sector.

Quantitative results. We simulate an unexpected 10% decline in the replacement rate in each country, in period t = 10. This unexpected shock is perceived as a permanent shock. Figure 35 shows that employment rates increase, for all tasks and in all countries. Nevertheless, the sensitivity of employments rates to this type of reform are not the same across countries, and across sectors.

In type I economies, the contribution of unemployment benefits (UB) in the labor costs are small, even at their initial values. Thus, the same shock has a smaller impact than in other countries. When the contribution of UB is not negligible in labor costs as in countries of type III, this reform slows down the decline in the employment rate of routine task, whereas the employment rate of manual task gradually goes up. In countries of type II, where social norms is set by the State via a minimum wage, the reform has a large impact on the employment rate of routine jobs, but a very small impact, at least in the short run, on the employment rate in services.

Figure 21a: Employment rates, by task, after a reduction in the replacement ratio
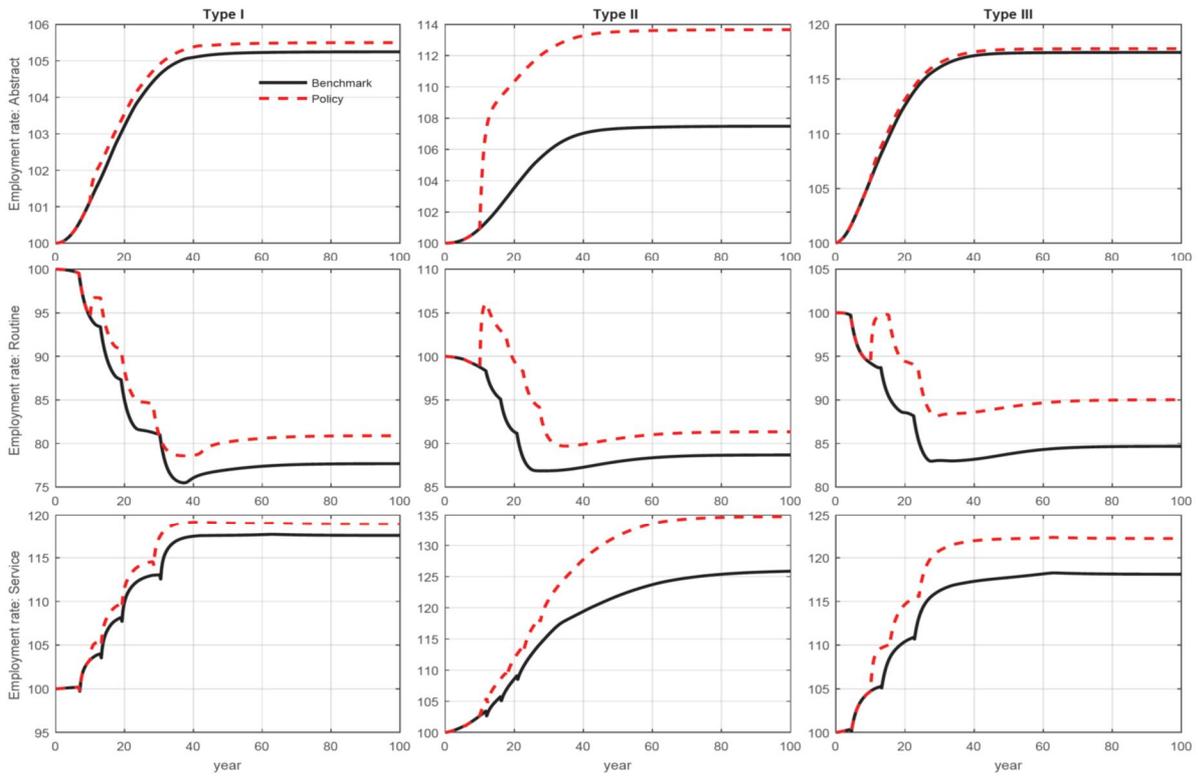
Figure 21b: Employment rates, by skill levels, after a reduction in the replacement ratio
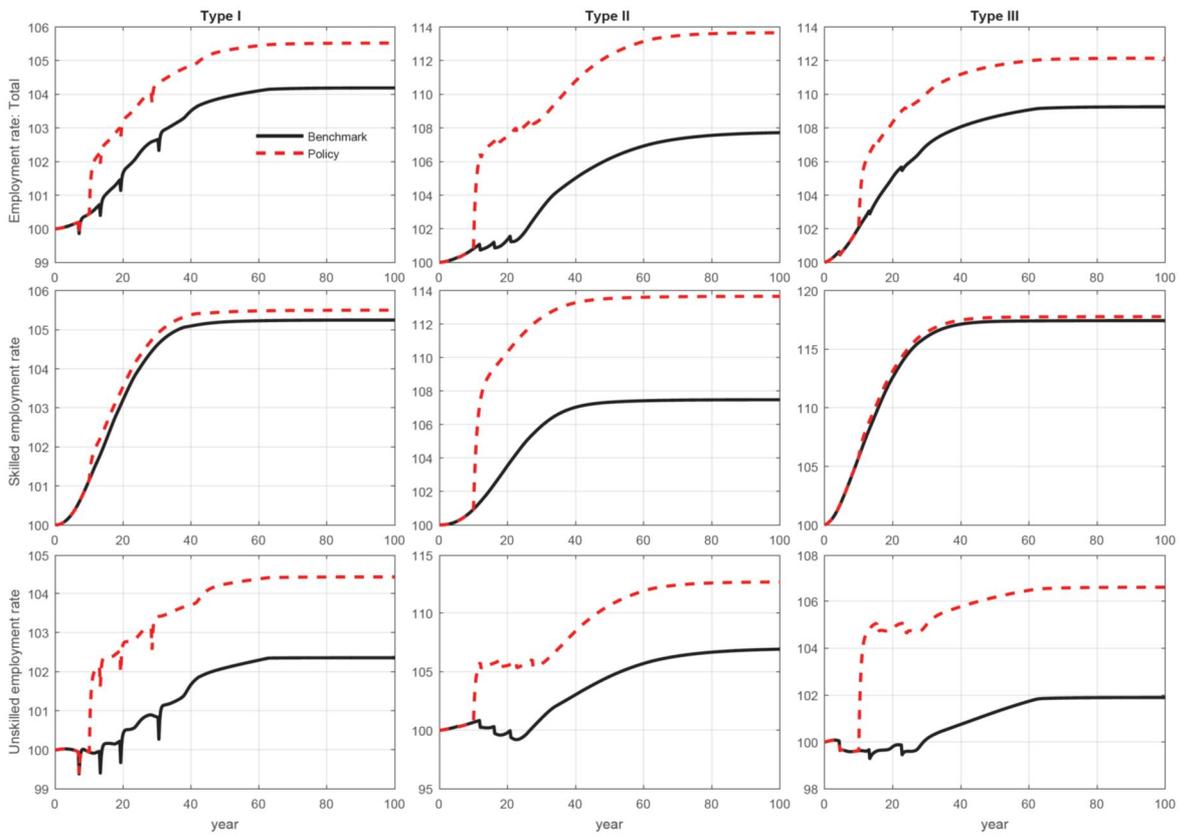
The large variations in employment rates in countries of types II and III also come from the large declines on non-employment induced by the larger incentives to accept a job (Figure 22). Not only reallocation from routine to manual task is at work, the extensive margin also allows employment rates in both routine and manual tasks to increase more than in the benchmark scenario.

Figure 22: Non-Employment rates, by task, after a reduction in the replacement ratio
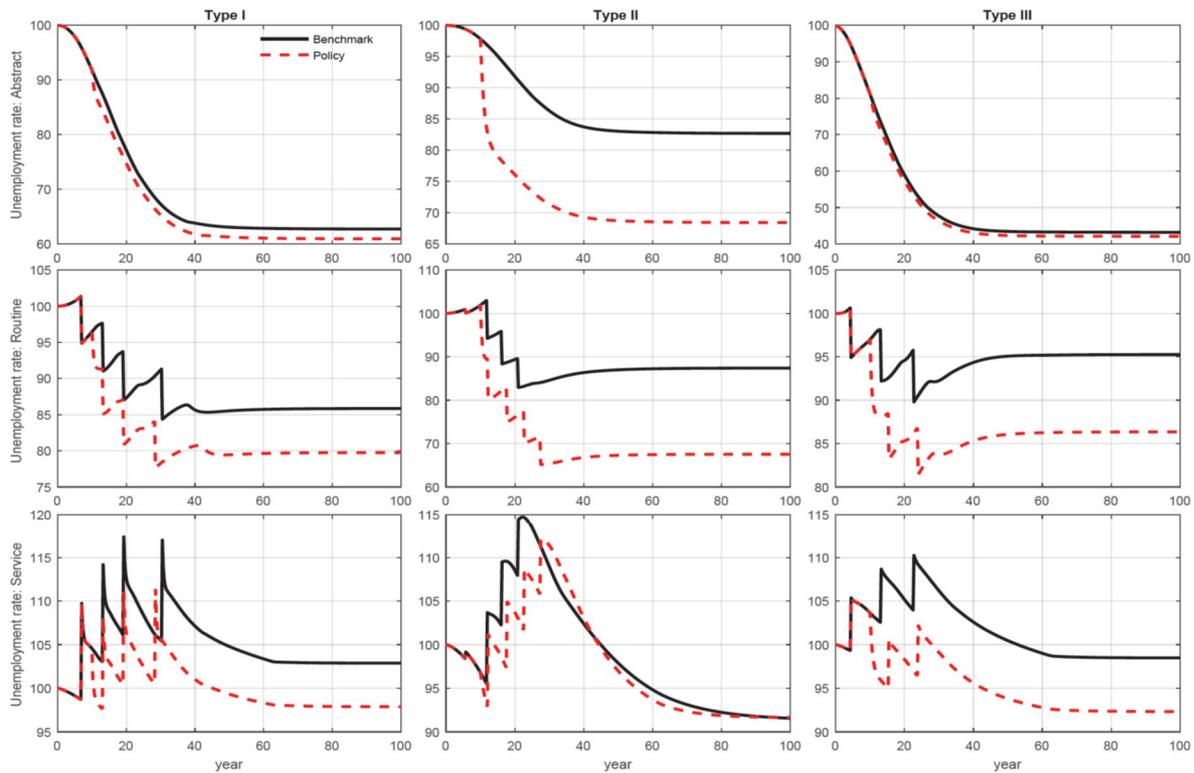
Hence, the relative impact of the UB reform on employment rates can be summarized by the dynamics of employment shares (Figure 23). In countries of type I, the reform is neutral because its impact on employment rates are negligible (the UB is a small component of labor cost). At the opposite, in European countries, the reform has a significant impact, but two different cases appear. First, the employment share of abstract task goes up more (less) rapidly after the reform in type II economies (type III economies). Secondly, in type II economies, the reform slows down job polarization in the medium run but magnifies it in the long run, whereas, in type III economies, we observe the opposite with an acceleration of job polarization in the medium run, whereas, in the long run, the reform slightly protects the employment in routine tasks. By taking into account the transitional dynamics, our model can predict the interaction between the path of TBTC and a change in the LMI at different horizons. We show that time matters because job polarization can be accelerated (slowed down) in the short run and slowed down (accelerated) in the long run in countries without MW (with MW).

How is competition affected on the product markets? Given that the new opportunities provided by the technological change increase agents' total income, aggregate demand increases because agents are richer than in the benchmark scenario. Hence, the number of retailers increases in both sectors (goods and services): new profit opportunities lead more new firms to enter in the market than in the benchmark scenario, increasing the competitiveness, and thus reducing retailers' prices. Figure 25 shows that there is a strong interaction between LMI and dynamics of competition on the product markets. In countries where wages can be adjusted downward, following a reduction in UB, the larger increase in competition is predicted in services, whereas in

the country characterized by a MW, the larger increase in competition is predicted in the good market. This result comes from the weight of the reform in the marginal costs. In services, produced only by labor, the reform affects 100% of the costs: this leads to a large drop in the marginal cost and thus a large number of new firms in services (this is the case in countries of types I and III). If this workforce is paid at the minimum wage, the reform is unable to change the marginal cost in services (this is the case in type II economies). It follows that the fall in UB reduces only the marginal cost of the good producer in type II economies: this increases their competitive advantage, thereby allowing them to attract more demand and giving incentive to create new firm on the good market.

Figure 23: Employment shares, by task, after a reduction in the replacement ratio
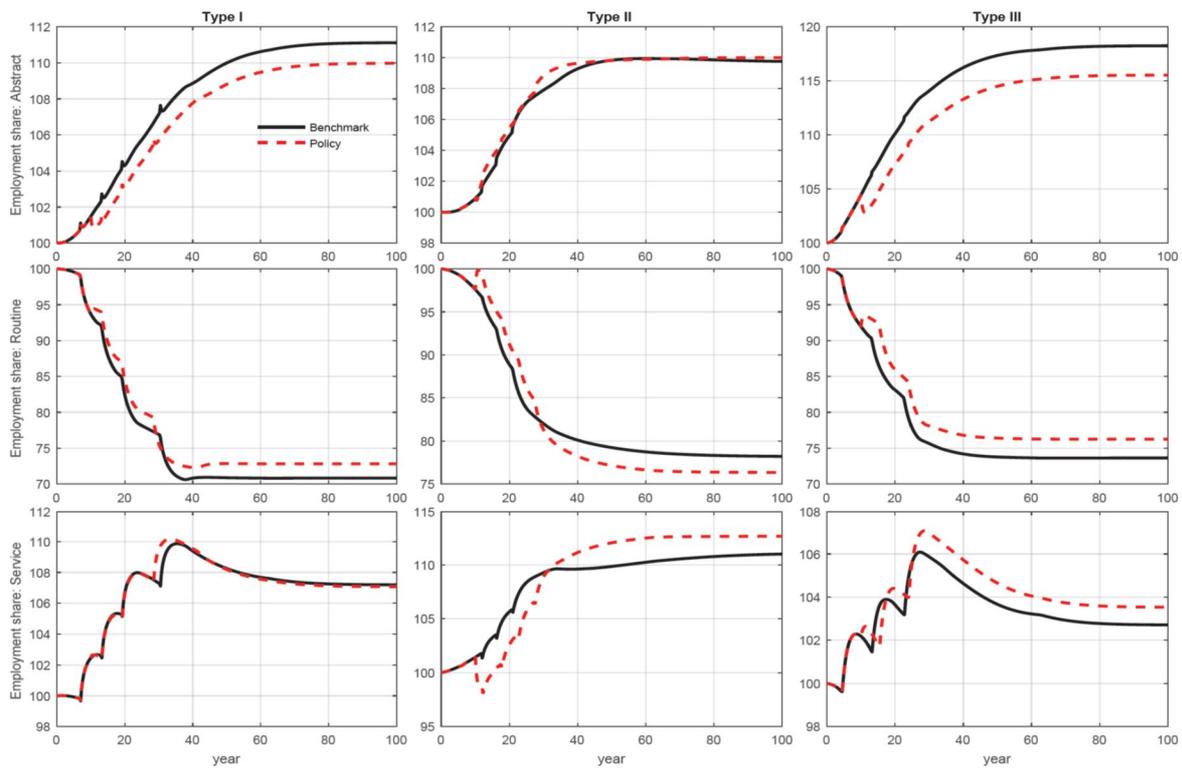
Figure 24: Labor cost dynamics, after a reduction in the replacement ratio
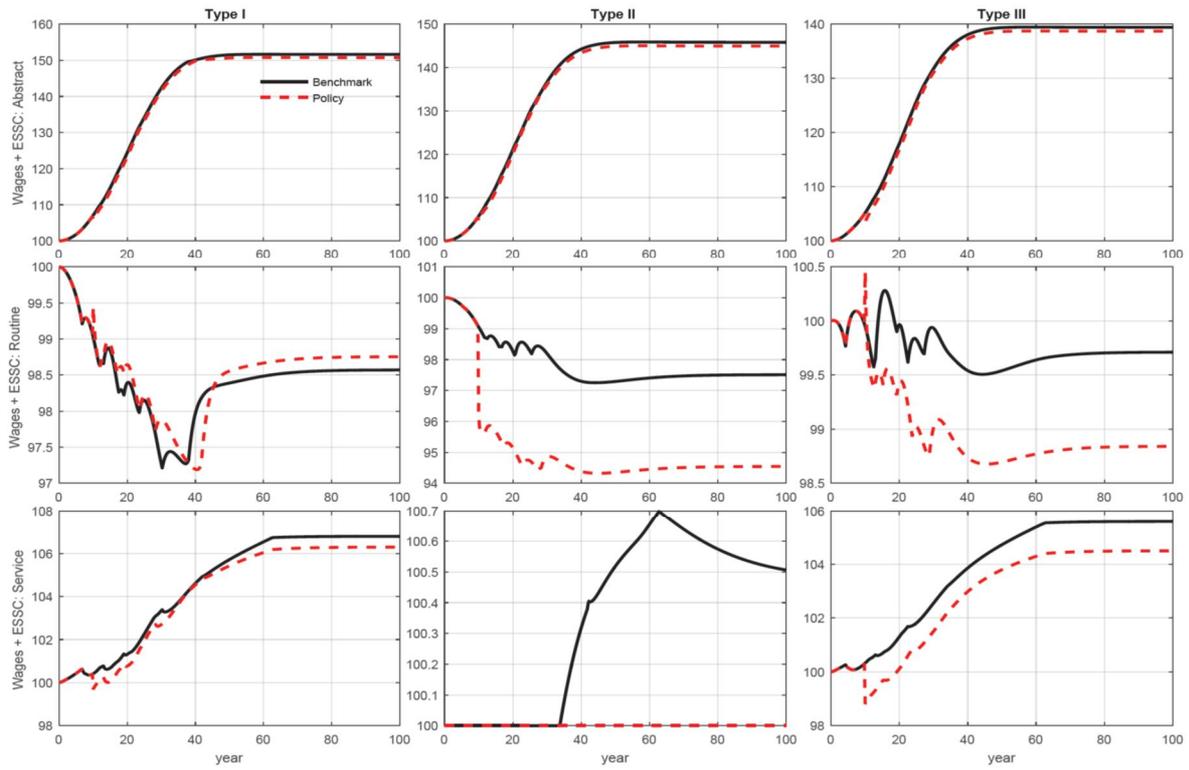
Figure 25: The Markup, after a reduction in the replacement ratio
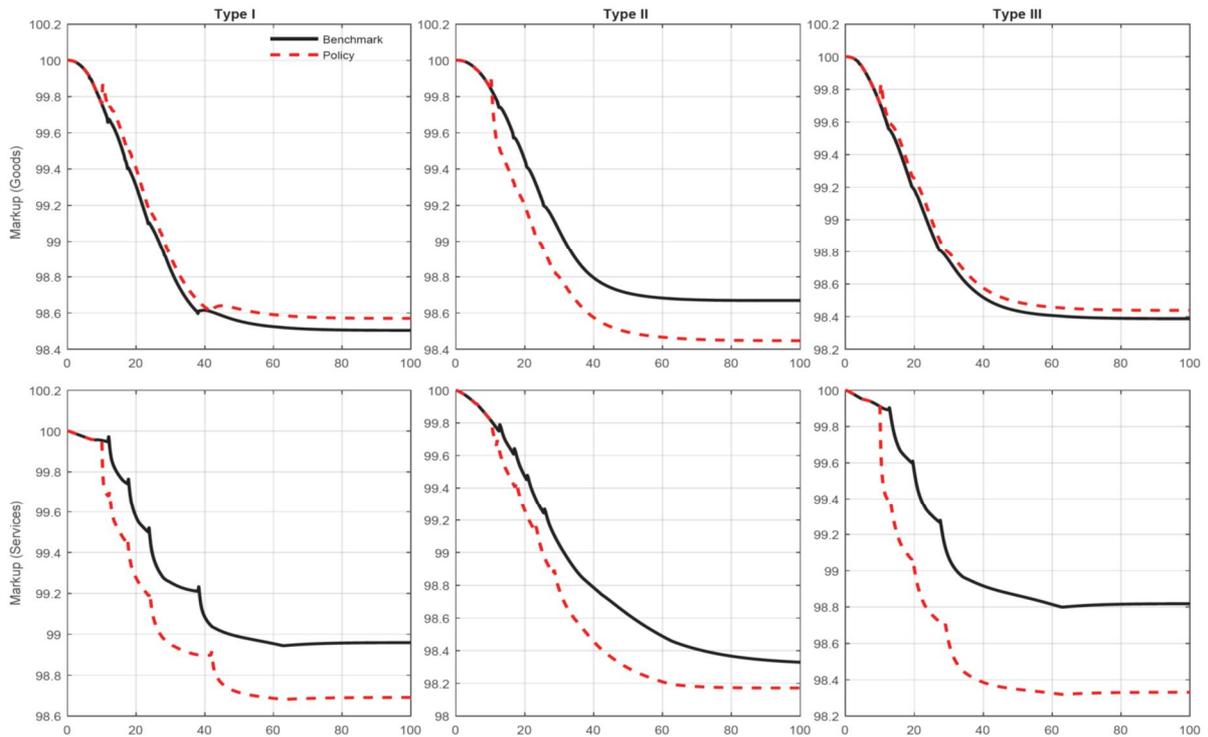
D.2 Payroll tax subsidies

Payroll tax subsidies can be implemented in two ways: (i) a homogenous decrease in the tax rates for all wages, or (ii) a specific policy targeted at low skilled workers. These policies reduce labor costs. In an economy without MW, the implications of this policy are close to a decline in unemployment benefits. The main difference between these two policies lies in their respective impacts on income inequalities. In an economy with MW, whiles the reduction in unemployment benefits is ineffective in the service sector, payroll tax subsidies have a direct impact on labor costs of low paid workers. Hence, we focus on an alternative scenario where payroll tax subsidies are targeted at unskilled workers, the fall in labor costs of skilled workers being the same as in the case of the UB reform.

Figure 26: Lower payroll tax for all workers: deficit as % of output
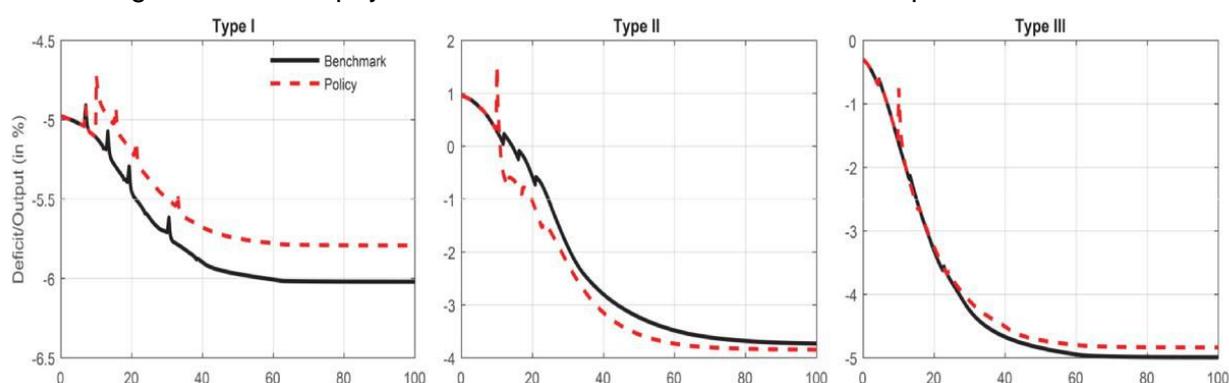
Payroll tax subsidies directed to unskilled workers. In countries of type I and III, payroll tax subsidies targeted at unskilled workers have the same impact as a cut in UB. Both manual and routine jobs are affected and thus the reallocation process is not significantly altered: the decline in labor costs allows firms to retain workers in routine jobs, whereas, at the same time, it also allows service-producing firms to open more jobs, these forces acting in opposite directions on the speed of the reallocation. Notice that the reform reduces the non-employment rate, the two tasks of unskilled workers being more profitable.

In countries of type II, there exists an important asymmetry between routine and manual jobs: the latter are paid at the minimum wage. Indeed, the drop in payroll taxes has an 100% impact on the labor cost at the level of the MW, whereas its impact is only proportional to the share of the outside options in the labor costs when the wage is bargained. This suggests that this policy is highly effective to give a competitive advantage to services. Figure 41 provides the quantitative results for this policy: only in countries of type II the reallocation is significantly accelerated.

Figure 27a: Employment rates, by task, after payroll tax subsidies targeted at unskilled workers
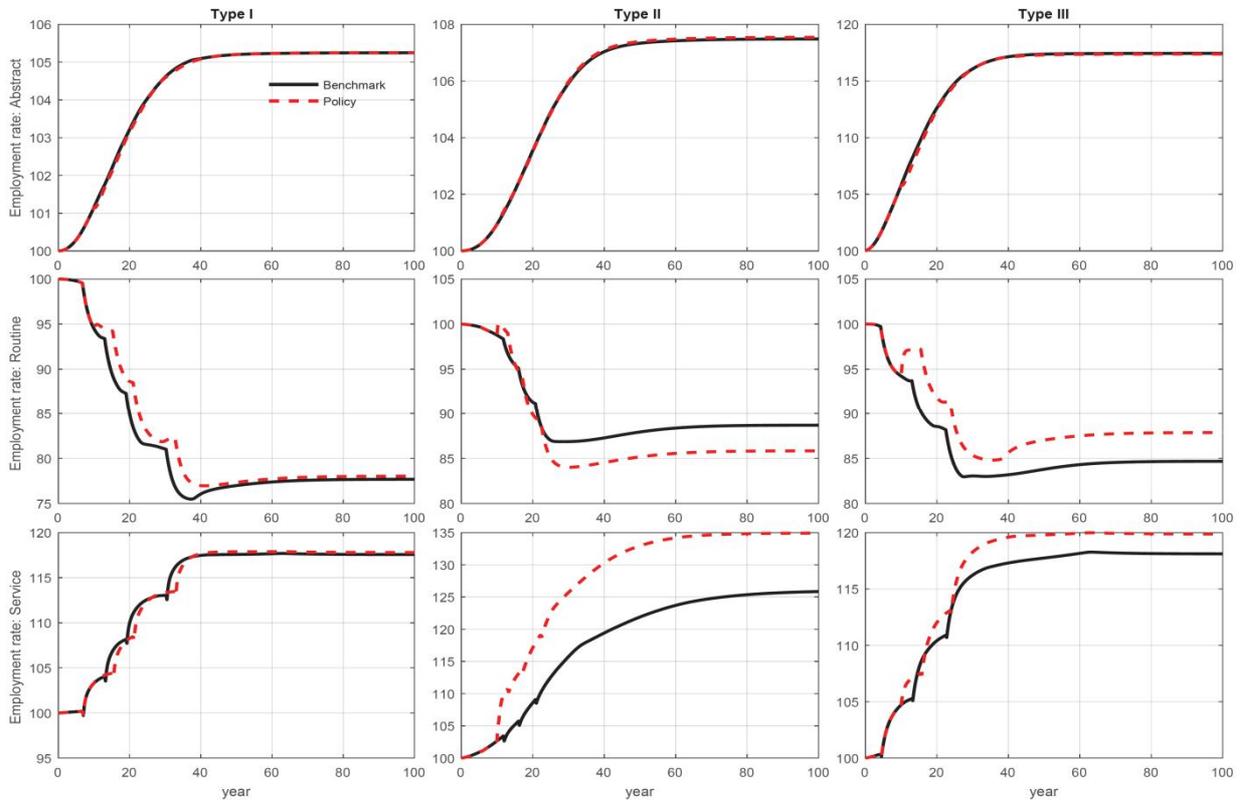
Figure 27b: Employment rates, by skill level, after payroll tax subsidies targeted at unskilled workers
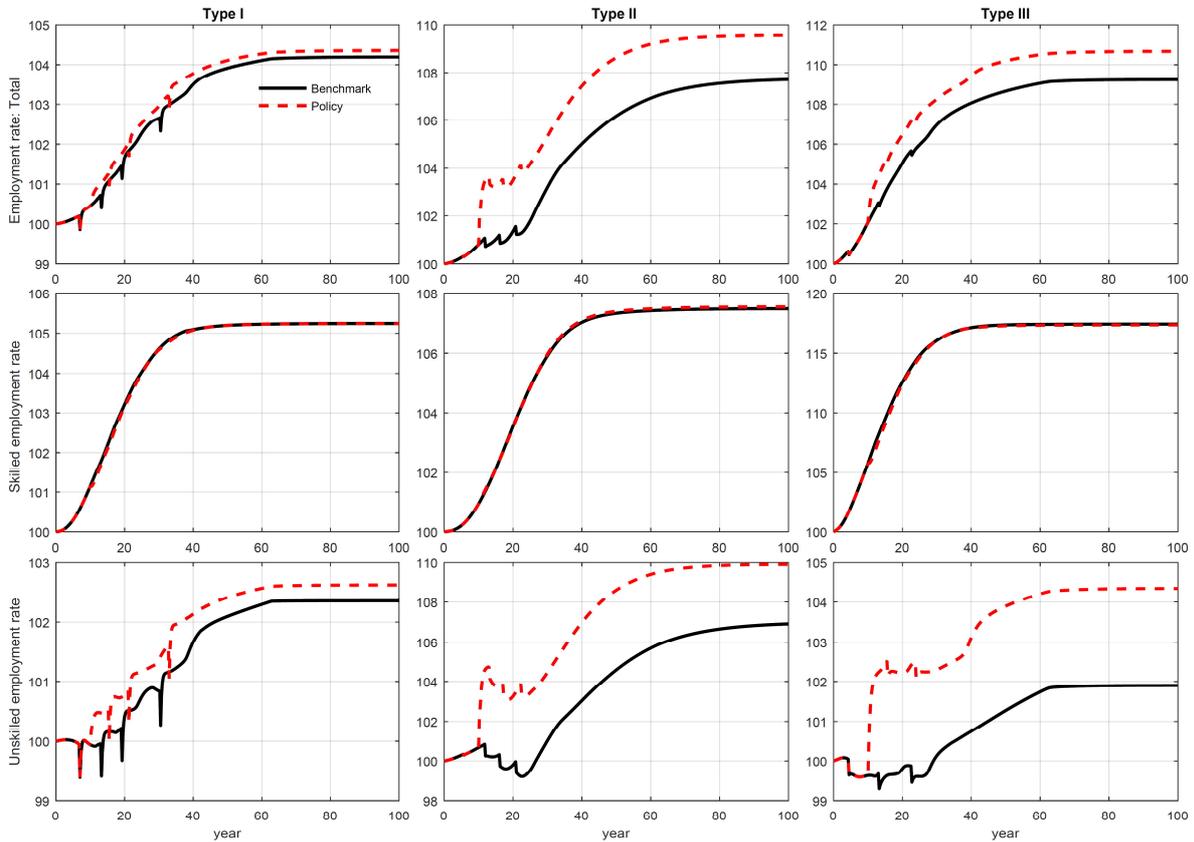
Notice that, when this policy is implemented, the dynamics of TBTC allows French labor market to exit from the "MW trap" more rapidly than in the benchmark. Hence, the effects for an economy with MW are close to ones obtained with a reduction in the MW, except for inequalities. Finally, concerning the feedback effect of this labor market policy on the good market and more specifically on the intensity of the competition, Figure 28 shows that the impact of this policy is quantitatively close to those obtained in the case of the MW. This comes from its large impact on the marginal costs of services, leading them to attract a larger share of the demand than in the benchmark scenario. This favors the entry of new firms and thus the competition. Even if the policy decreases the marginal costs of the goods-producing firms, this is not sufficient to maintain the share of the goods in the final consumption basket. Hence, these two opposite forces induce to an insignificant impact on the competition on the good market.

Figure 28: The markup, by sector, after payroll tax subsidies targeted at unskilled workers
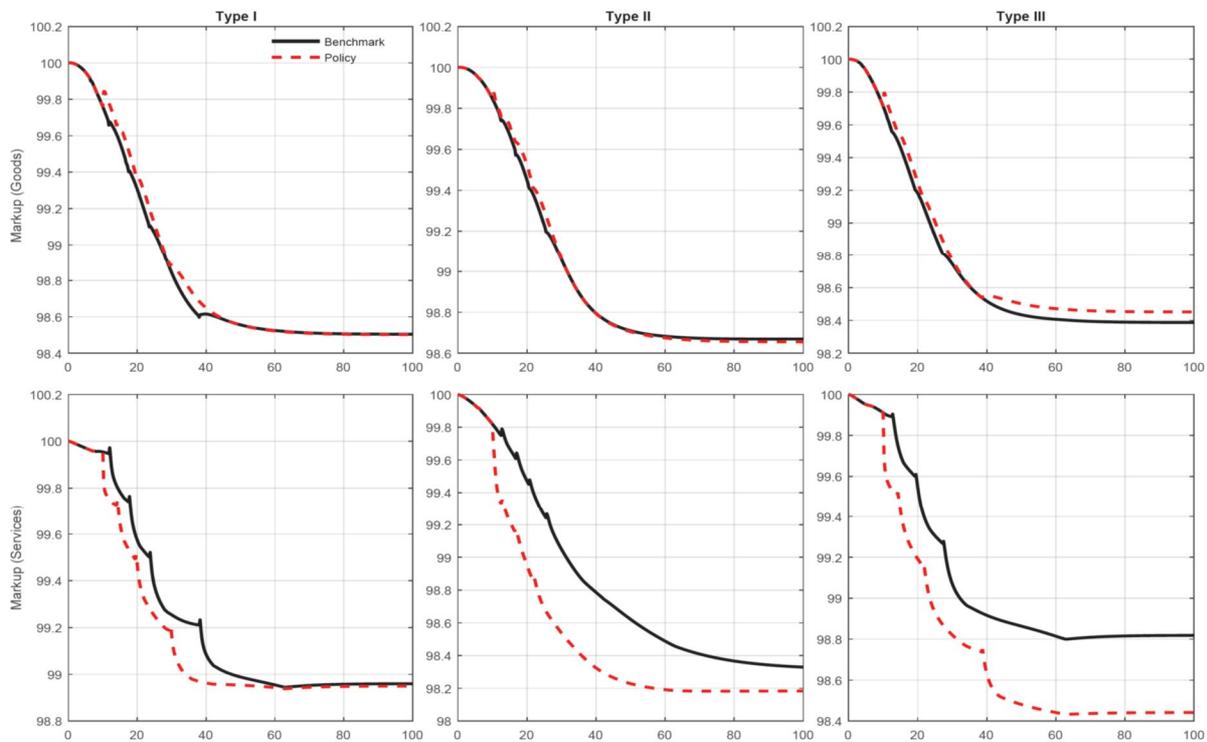
D.3 Active labor market policy

Active labor market policies (ALMP) are programs that help unemployed workers to find work. These programs consist of support provided by the public employment agency (job centers helping the unemployed improve their job search e ort by disseminating information on vacancies and by providing assistance with interview skills and writing a curriculum vitae) and training schemes (classes and apprenticeships, help the unemployed improve their vocational skills). In the model, information costs and training cost specific to a match are captured by

hiring costs k_i, for $i = a$; r; m; nm, which are specific to each task and each type of unemployment to employment transition (within the labor market previously occupied for $i = a$; r; m, or between labor markets for the new movers for $i = nm$). In what follows, we only present results for a specific policy aiming at improving the search activity of the unemployed workers who have switched occupation: on a

new labor market where they are less efficient than the other workers, it should be useful to fund part of their specific hiring costs.

ALMP directed to movers. When government subsidizes the fixed costs paid by service-producing firms when they hire an unemployed previously employed by a good-producing firms (a mover), it supports workers' mobility across sectors. This policy acts through two channels: firstly, it directly reduces hiring costs, and secondly, it reduces the wage by lowering the "hold-up" problem that generates the insider behaviors during the bargaining process. Hence, the number of vacancy posted to hire these "new movers" increases. Given that these are the very transitions that ensure the reallocation process from routine toward the manual jobs, this raises for sure employment in the service sector. It is important to notice that the subsidy on hiring costs is more effective for jobs paid at the MW.

- Without MW, the reduction of these costs directly gives an incentive to open more jobs, but this effect is dampened by the increase in wages linked to the higher tightness in the labor market: these opposite forces lead to a small impact of the policy for the new movers transiting through the labor market tightness of "new" services. If the gains on the job finding rate for the movers are small, the risk associated to a loss of a part of their unemployment benefits remains constant[21]: then, the attractiveness of the manual labor market can decline with the reform. Workers perceive this risk and thus ask for a risk-premium in their wage. In the limit, only this positive pressure on their wages persists: the policy can have a negative impact on the labor market of manual tasks.

- When workers are paid at the MW, this last effect does not exist and only the direct effect persists (the impact of the policy on the tightness is at its maximum). Finally, these more valuable opportunities in the labor market of manual tasks induce a pressure on the wages of routine tasks. Indeed, during the bargaining process, workers occupied on these tasks evaluate their outside option as the best option on alternative labor markets. The policy pushes up the value of these outside options by reducing the unemployment duration after a reallocation. These higher wages on routine tasks reduce their profitability: less jobs are created on this labor market segment, increasing the flow of reallocations.

Figure 29 shows that the impact of the policy is highly contingent to the initial rigidities of the labor market. In countries of types I and III, the flexibility of the labor market allows 4 types of workers to move between occupations in the benchmark scenario. The crowding out effect of the policy, via the wage adjustments, leads to retain the workforce on the labor market of routine tasks. This is the case in type I economies for the last type of workers which will choose to move in the long run, whereas in type III countries, this phenomena is present for the second and the third types of workers which will choose to move (Figure 29). In countries of type II, the opportunity to move is given to only 3 types of workers in the benchmark scenario, the MW blocking the creation of new jobs in the services (Figure 29). Given that the wage is inelastic, the impact of the policy is not evicted by upward wage pressures. In this case, employment opportunities (the job finding rate) largely increase in the labor market of new movers, over-compensating the risk to lose a high UB. Hence, workers move. Moreover, this large impact on the search return leads to include

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[21] This risk is associated with the possibility to fail to obtain a promotion, and to become an "old mover" after a period of unemployment in the labor market of services. In this case, the indexation of the UB on the wage previously received in a routine job is lost.

unemployment in the service in the outside option of routine workers. This upward wage pressure leads to a reduction in hirings on this labor market. This reinforces the initial effect that gives more incentive to search a manual job: as in countries of types I and III, 4 types of workers choose to change occupation (Figure 29). The process is now more rapid than in these two countries because the policy is highly effective in the short run, the MW remaining binding.

Figure 29a: Employment rates, by task, after an ALMP targeted at movers
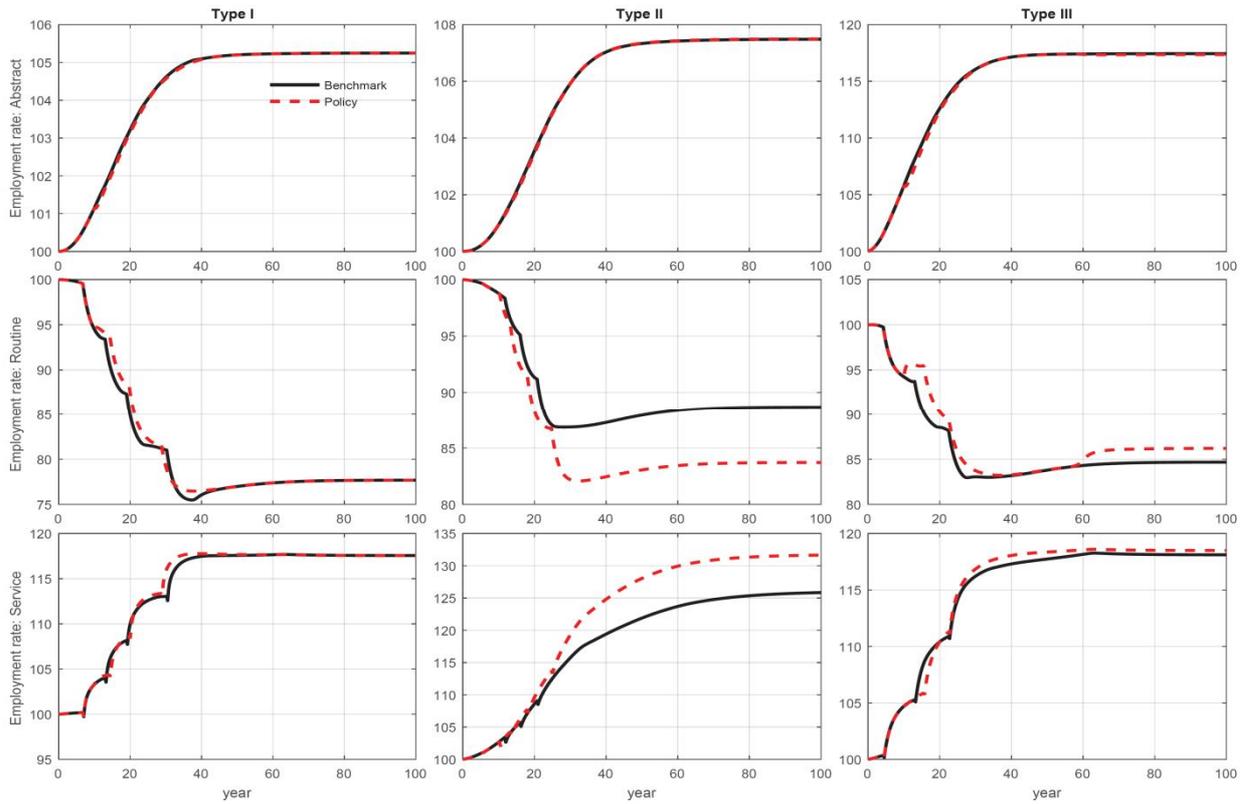
Figure 29b: Employment rates, by skill level, after an ALMP targeted at movers
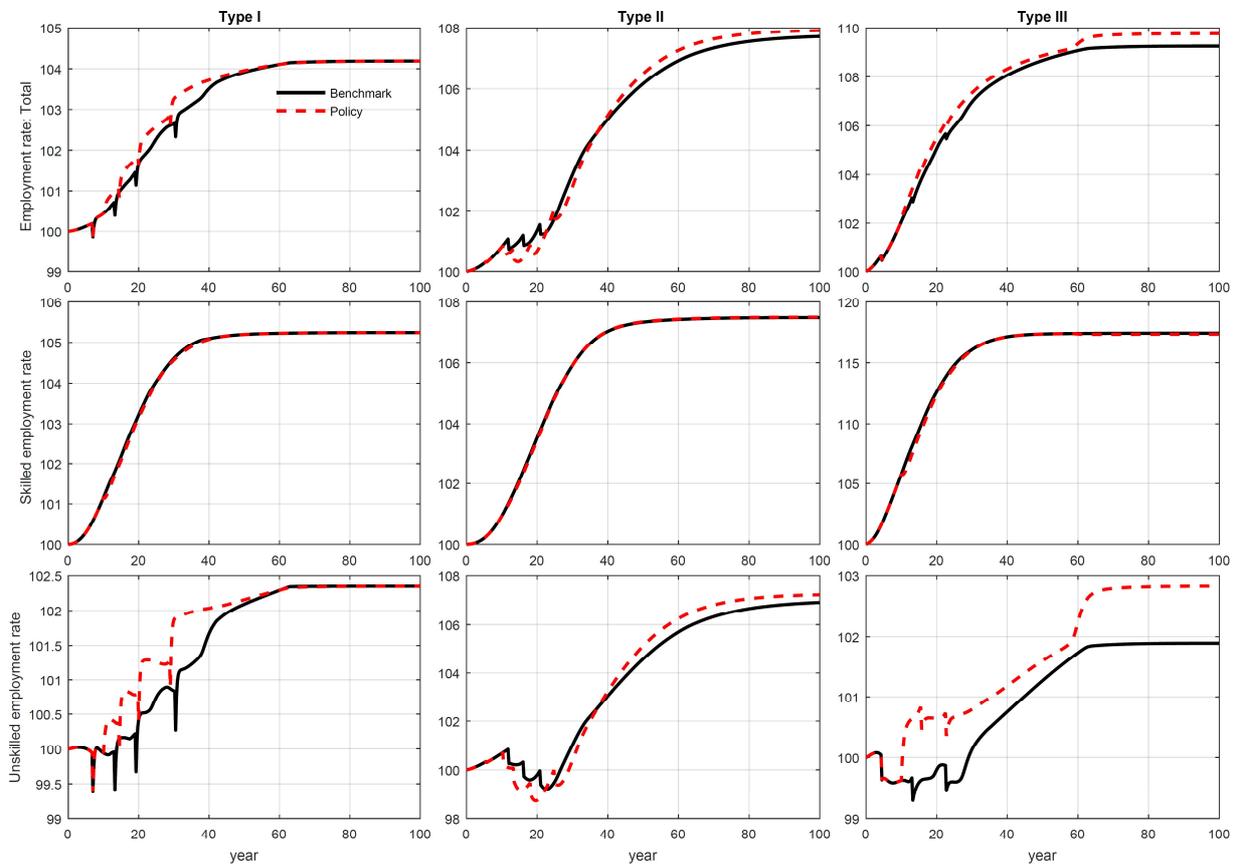
Figure 30: The markup, by sector, after a after an ALMP targeted at movers
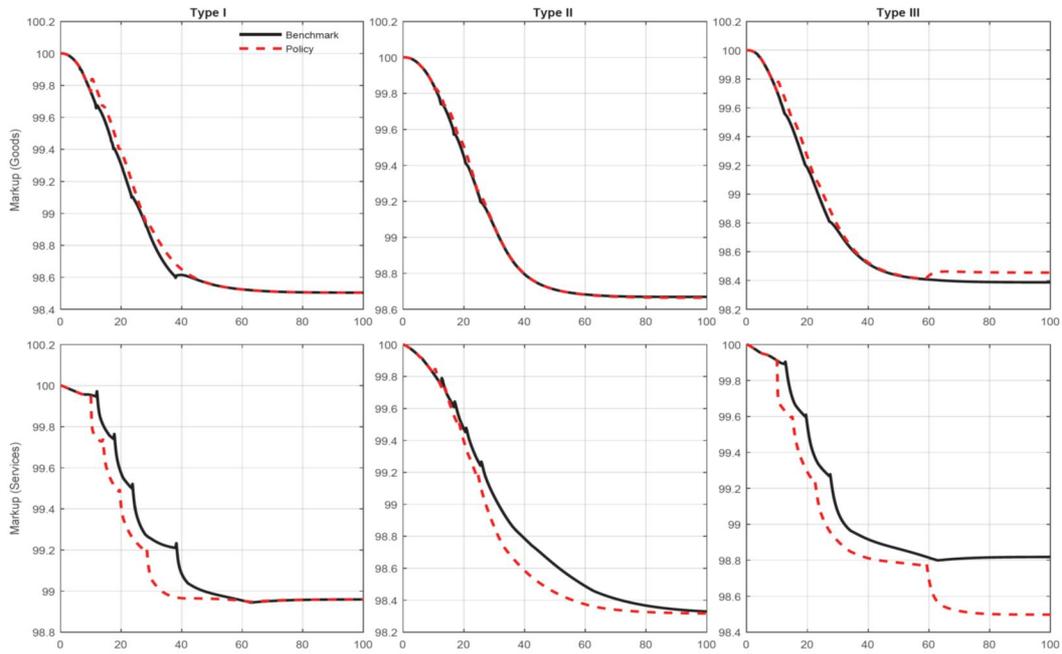
Figure 44 shows that this policy has only a small impact on the competition on the good markets. By significantly decreasing the marginal cost of employment in the service in countries of type II, it allows a small number of new firms to enter on the service market.

E Policy experiments: PMR

Figure 31a: Wage, as labor costs, after a fall in entry costs in service sector
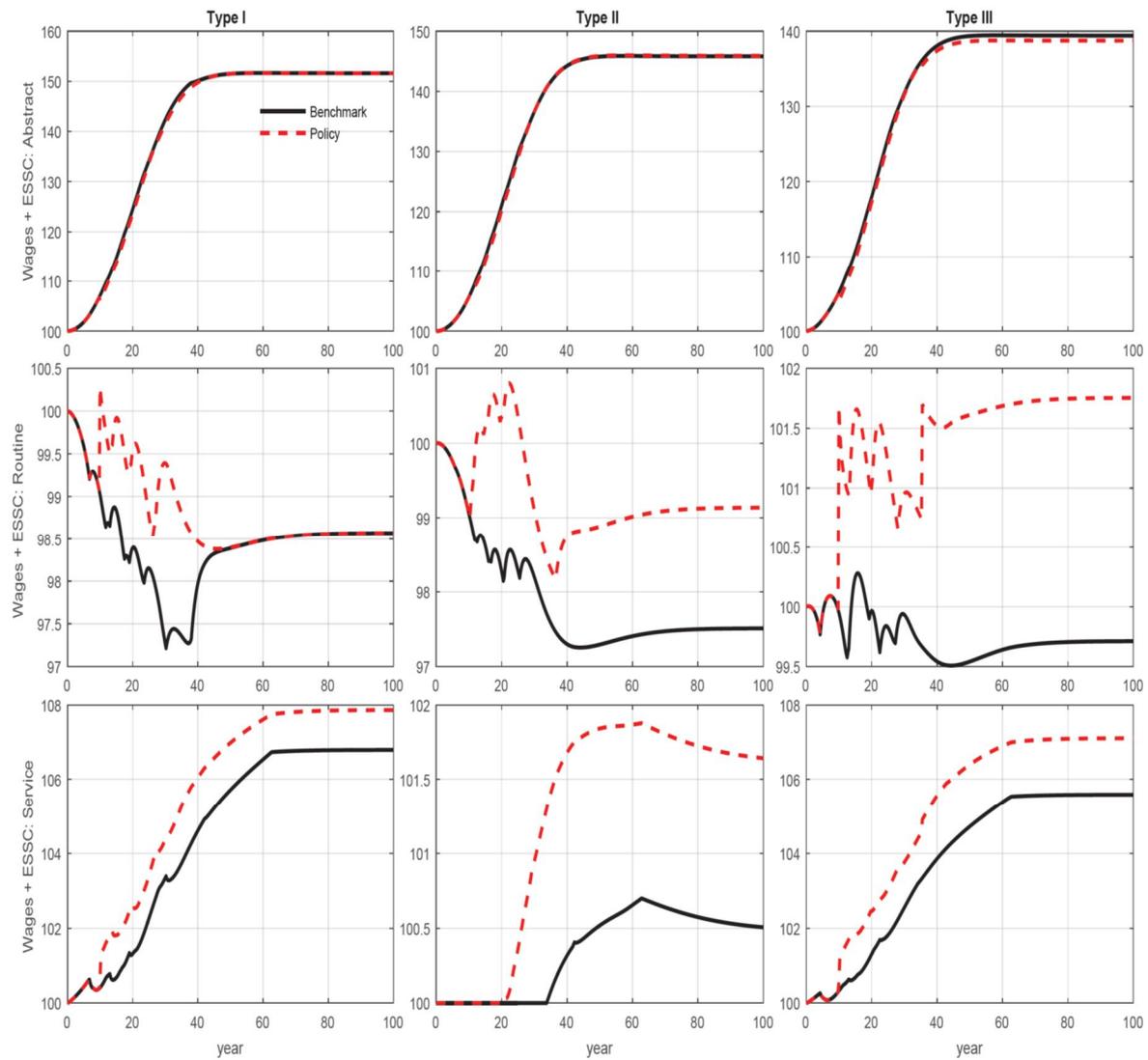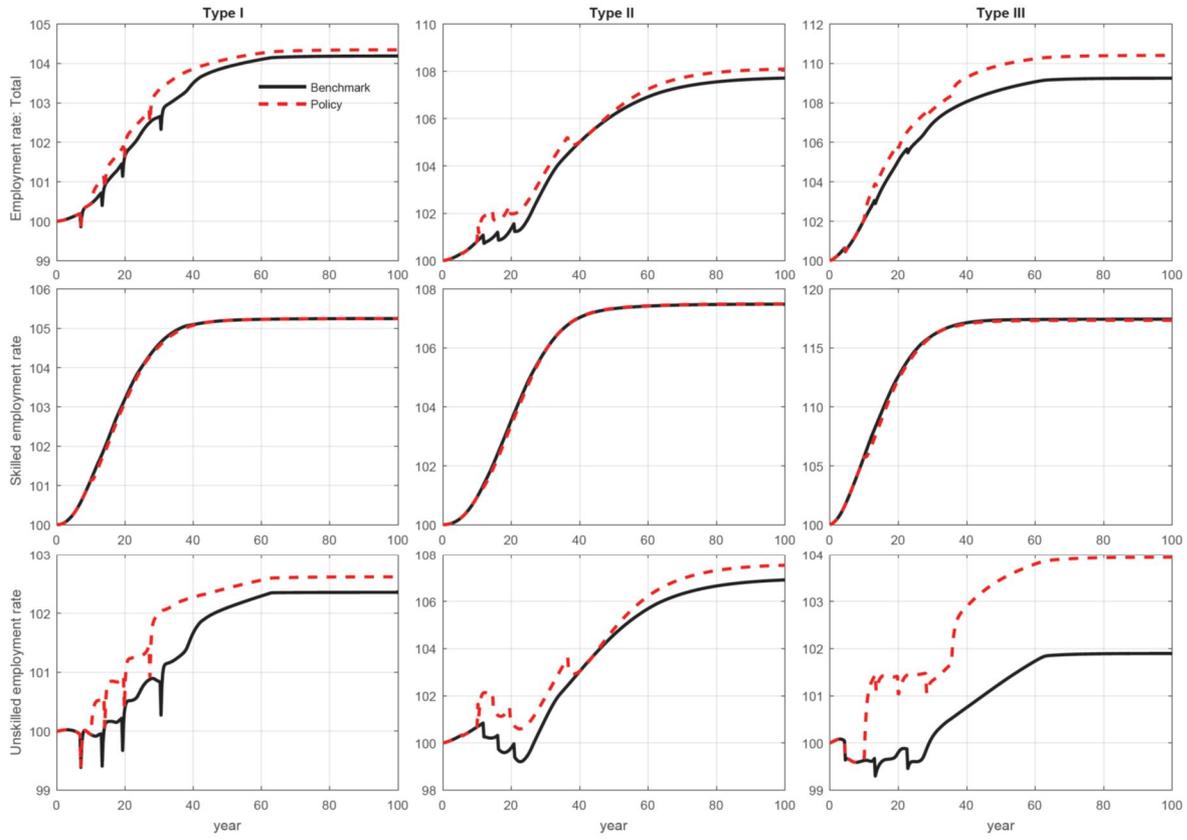
Figure 31b: Employment rate by skill level, after a fall in entry costs in the service sector

Figure 31c: Employment rate by skill level, after a fall in entry costs in the good sector
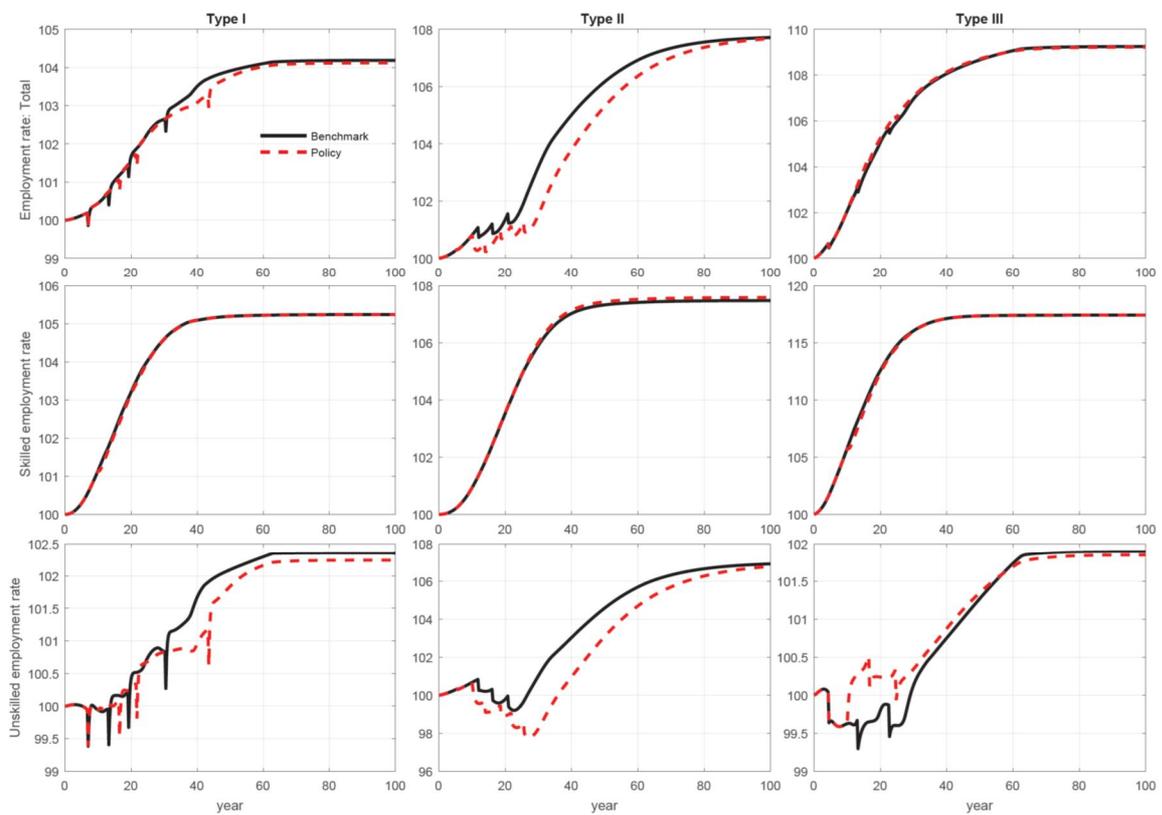
F. Employment shares

Figure 32: Employment shares - Benchmark economy
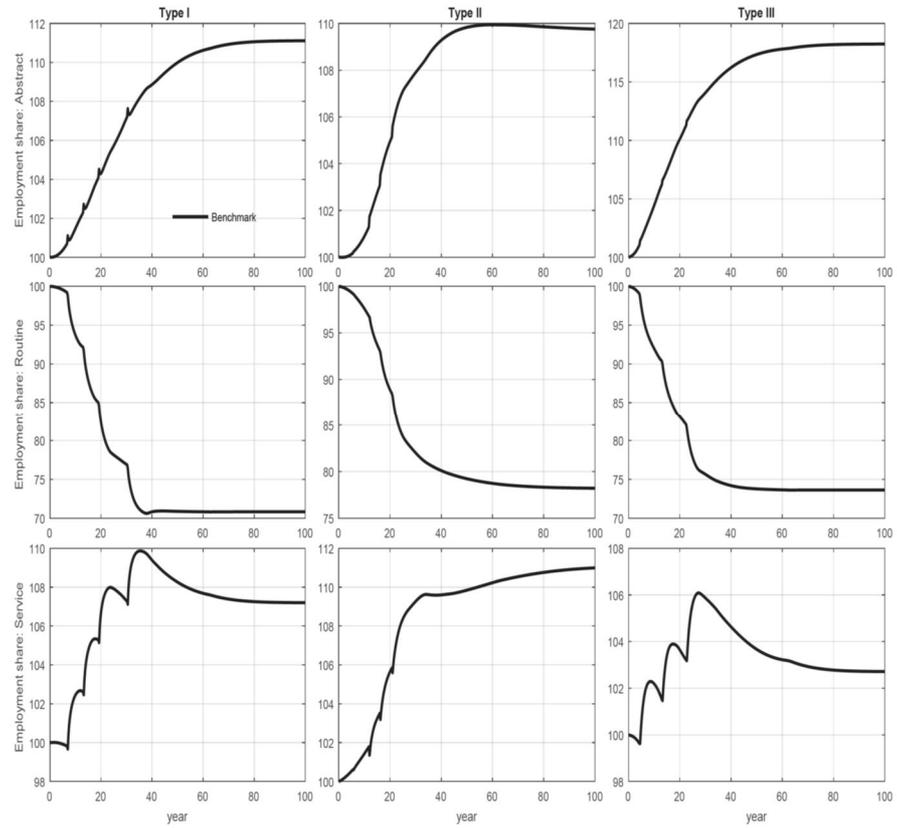
Figure 33: Employment shares - Fall in payroll taxes, all jobs (A in Table 2).
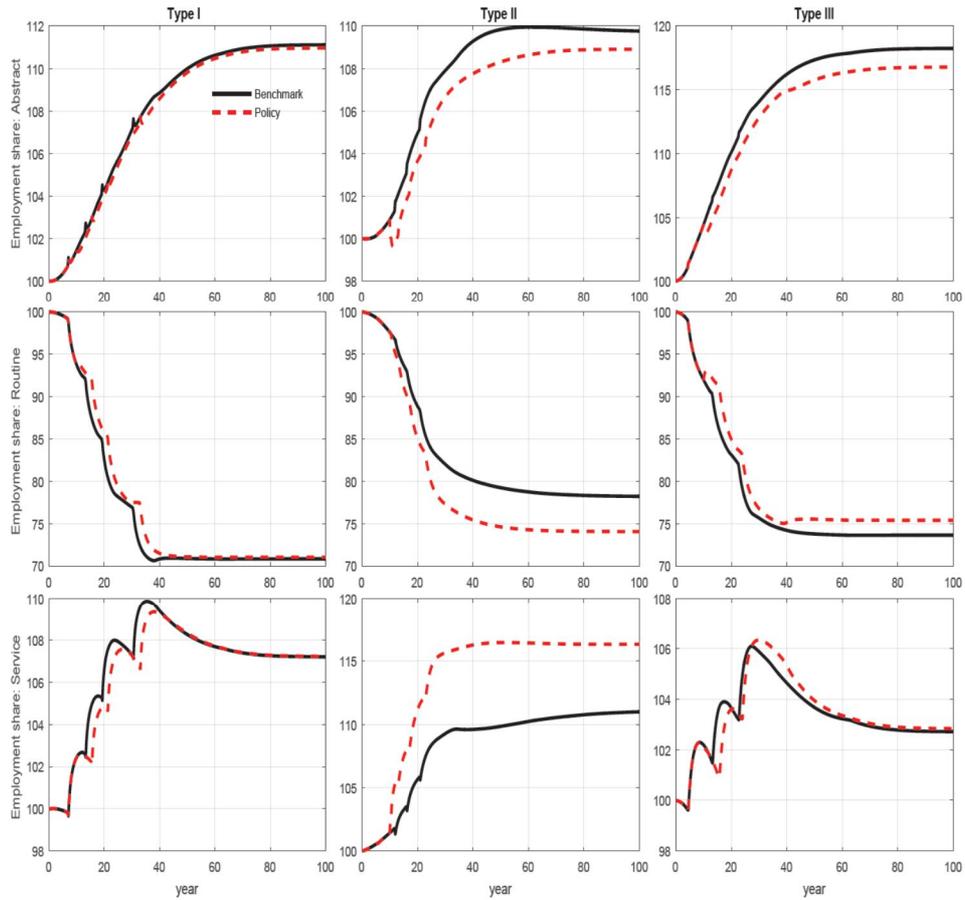
Figure 34: Employment shares - Fall in payroll taxes, unskilled jobs (B in Table 2).
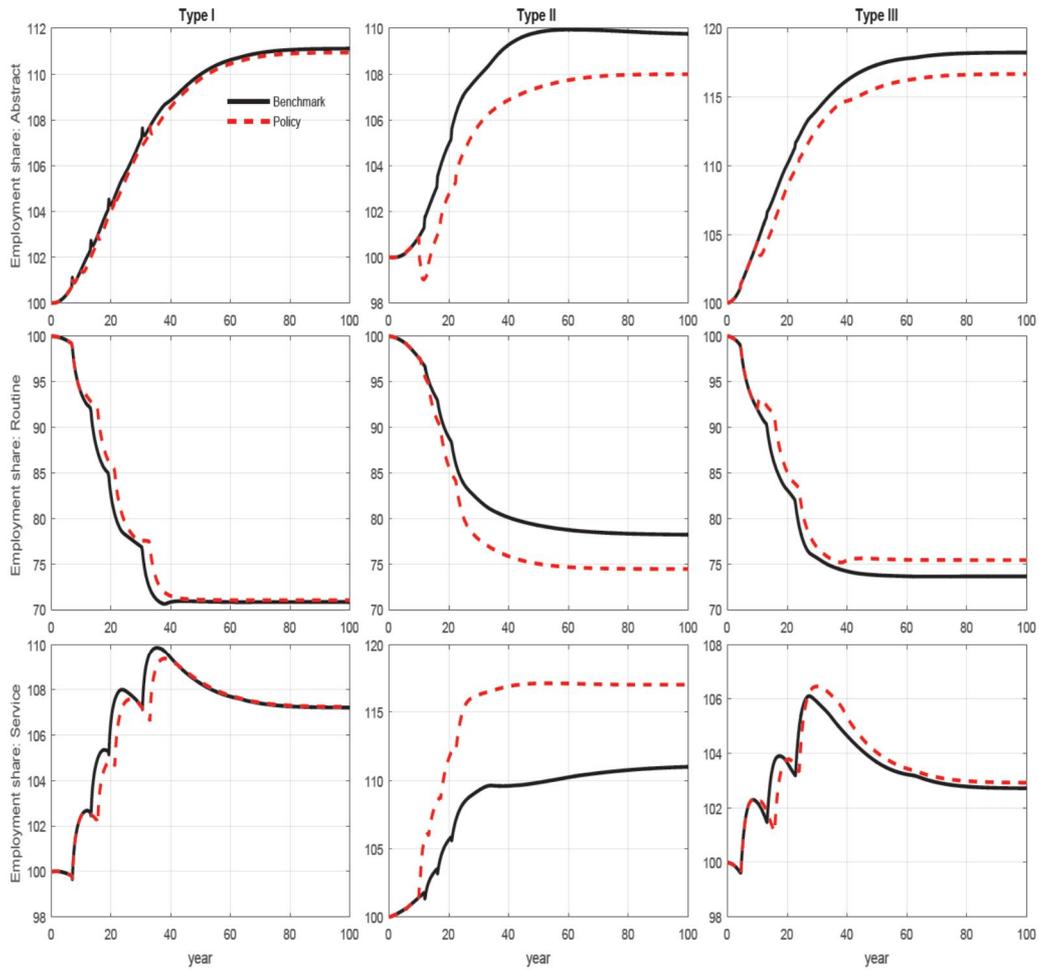
Figure 35: Employment shares - Fall in the replacement rate (C in Table 2).
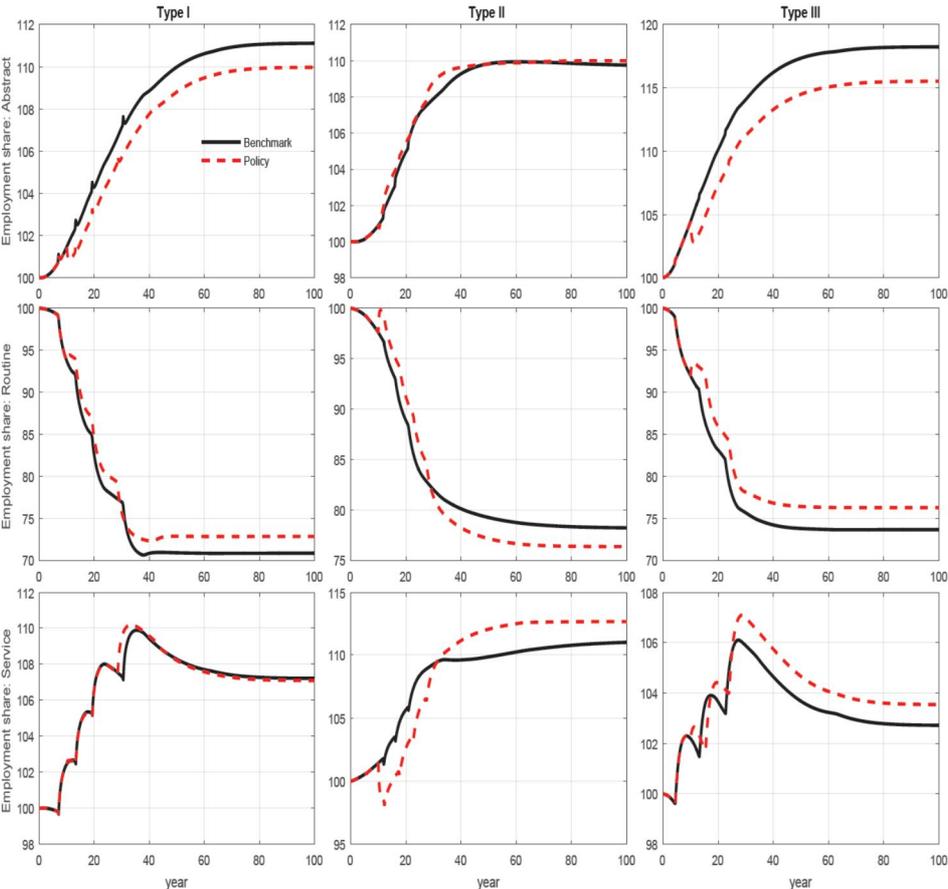
Figure 36: Employment shares - ALMP, all jobs (D in Table 2).
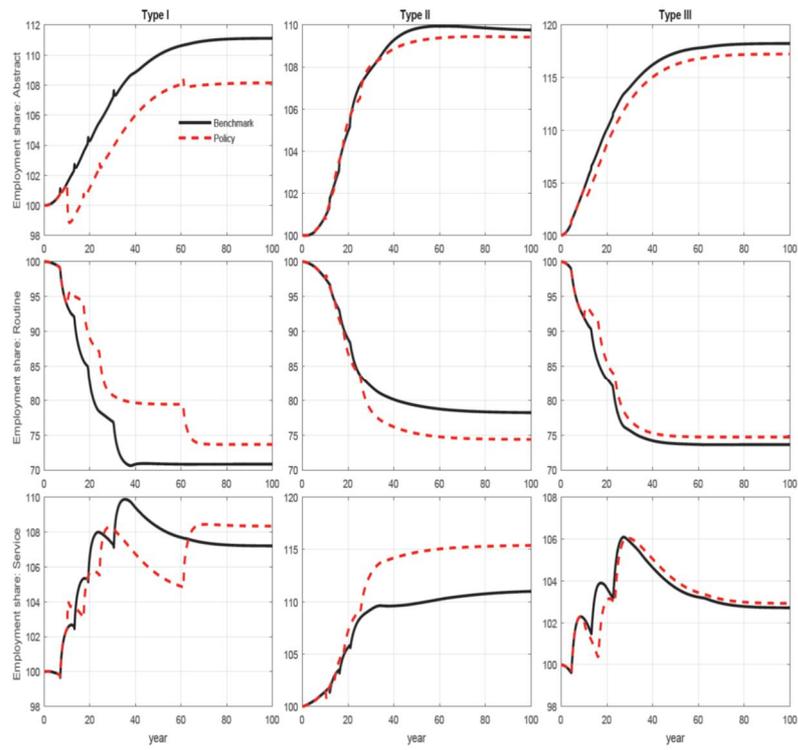
Figure 37: Employment shares - ALMP, movers only (E in Table 2).
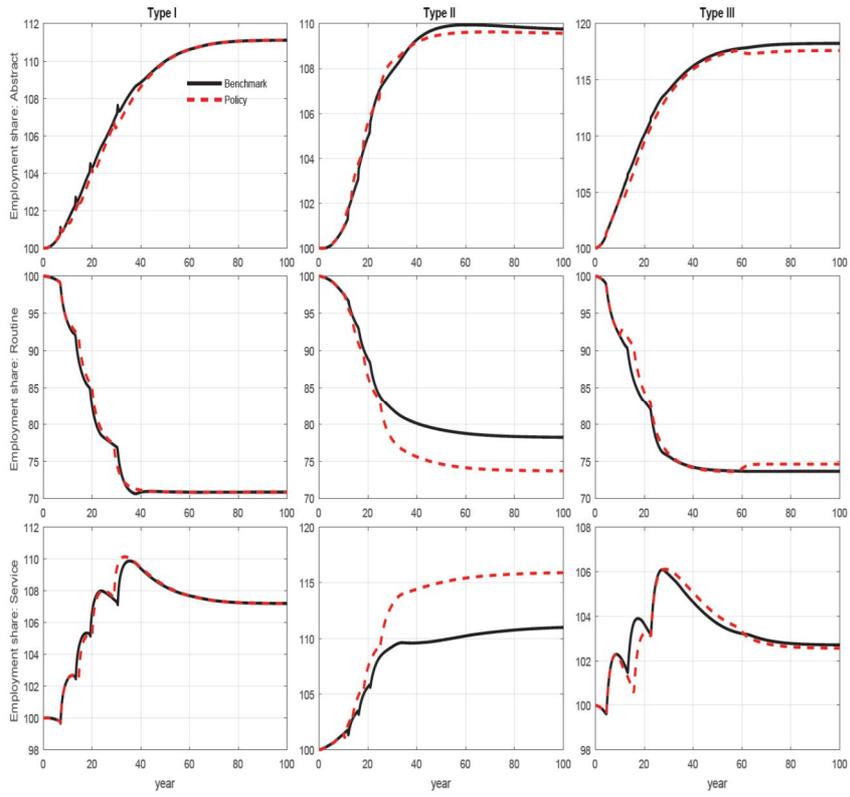
Figure 38: Employment shares - PMR goods sector (B in Table 3).
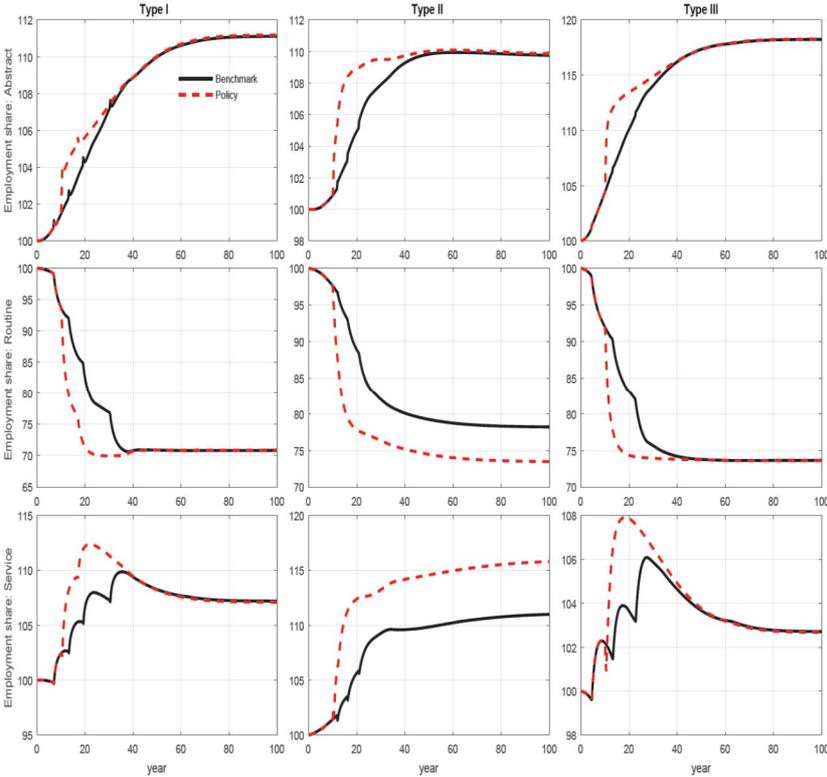
Figure 39: Employment shares - PMR services sector (C in Table 3).
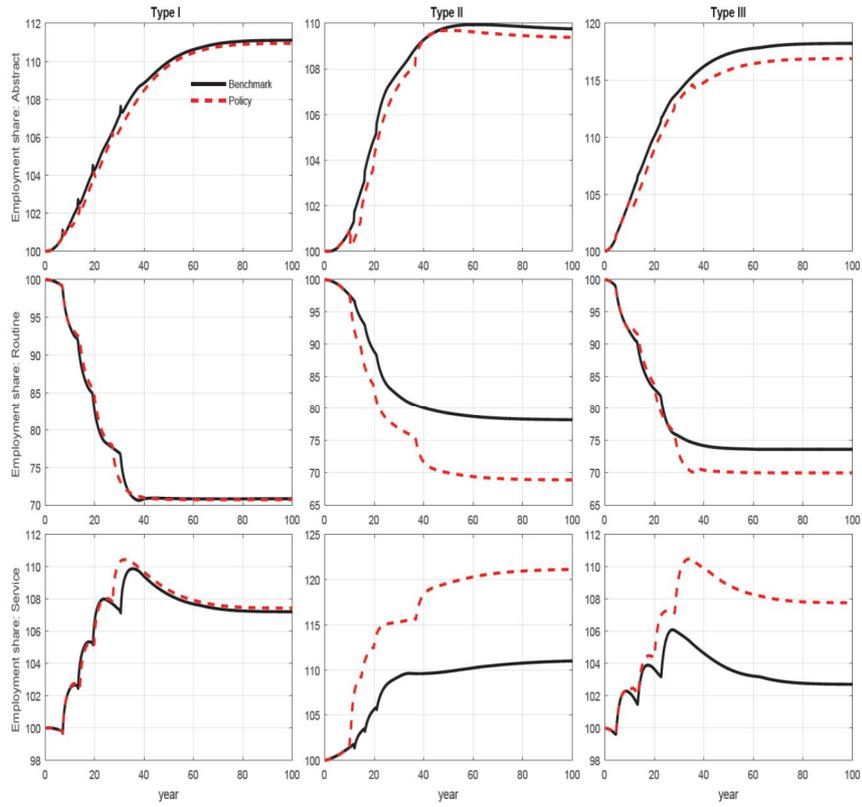
G. Inequalities: wages and incomes

G.1. LMI reforms

G.1.1. Variation of the replacement rate

Figure 17 shows the evolutions, for the 3 types of countries, of Gini coefficients for wages and incomes when UB are reduced just after the beginning of the technological change.

Figure 40: Inequalities after a reduction in the replacement rate
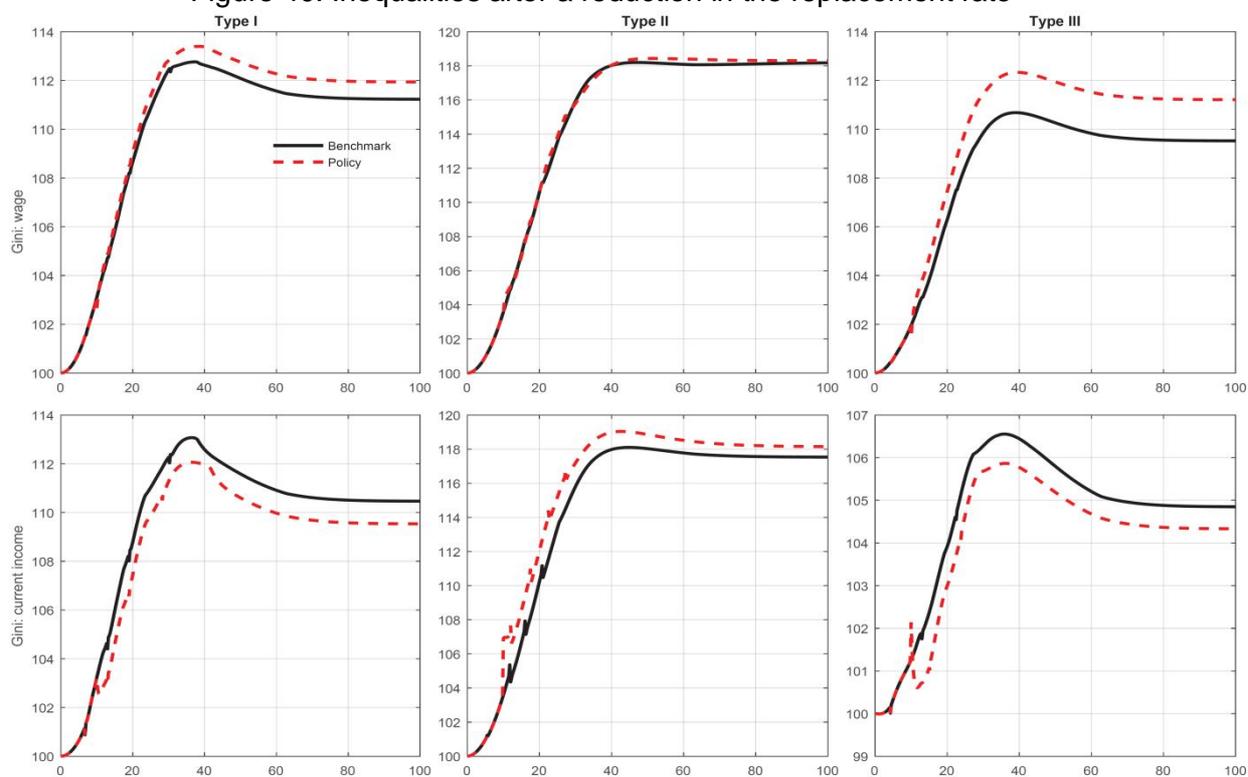
G.1.2 Variation of the payroll taxes

Figure 41: Inequalities after a payroll tax subsidy targeted at unskilled labor
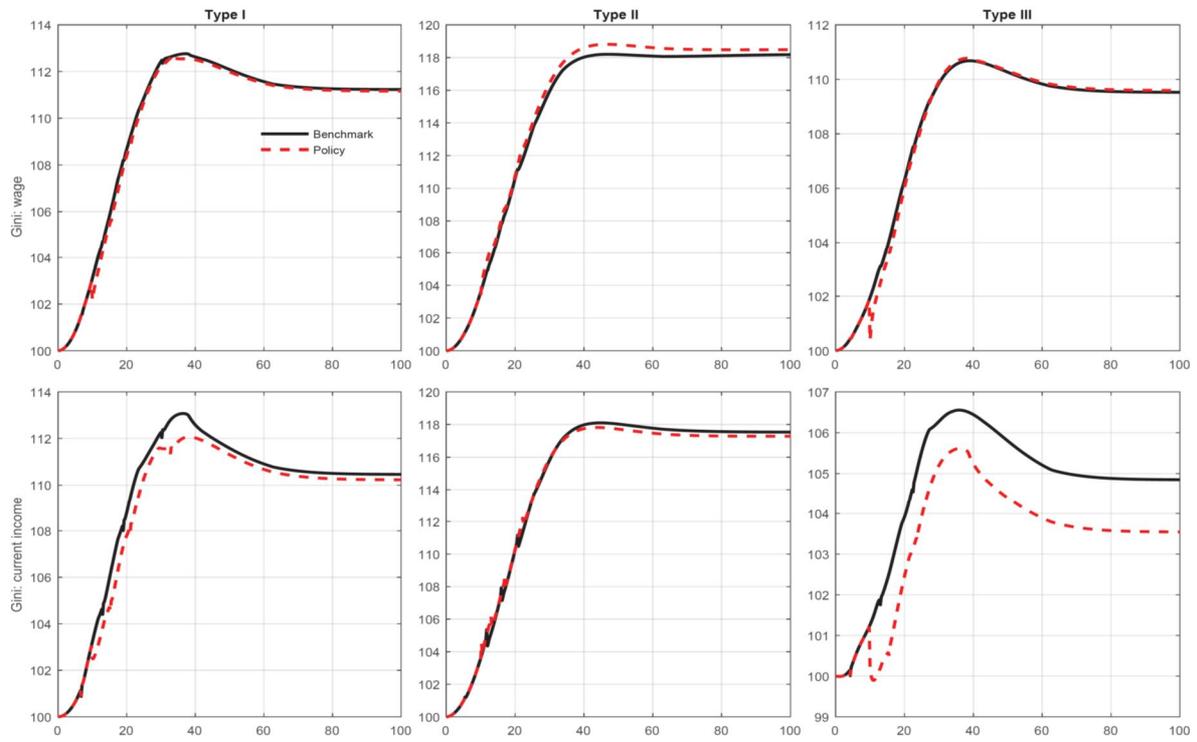
G.1.3 Variation of the ALMP

Figure 42: Inequalities after an active labor market policy targeted at movers
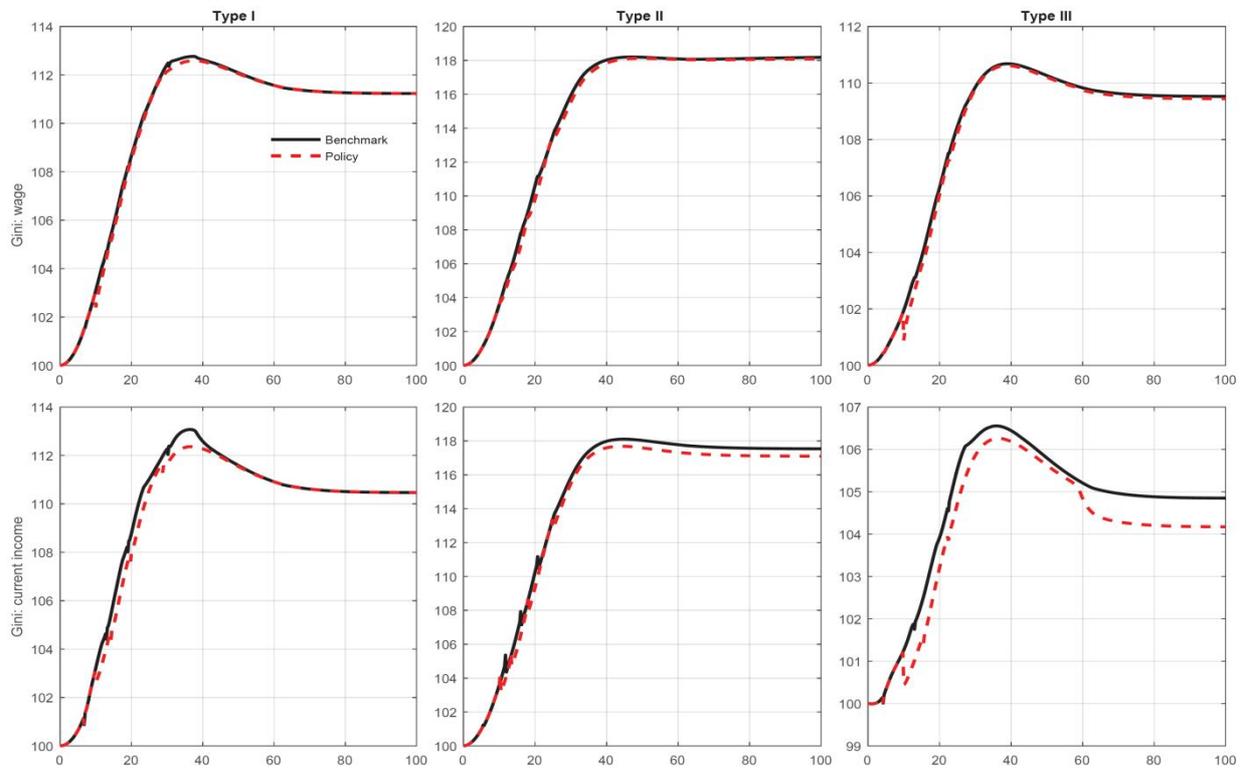
G.2. PMR reforms

G.1.1 PMR reforms on the good market

Figure 43: Markups, by sector, after a reduction in the entry costs in good sector
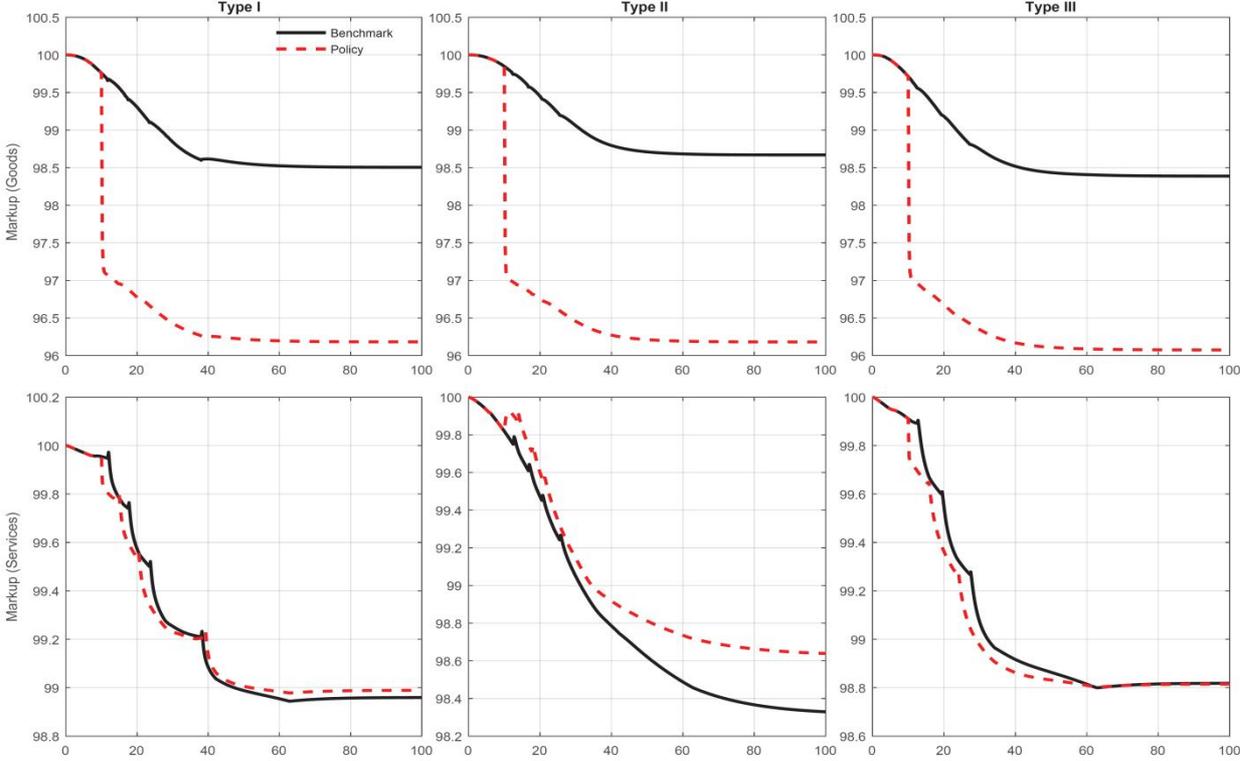
Figure 44: Employment rates, by task, after a reduction in the entry costs in good sector
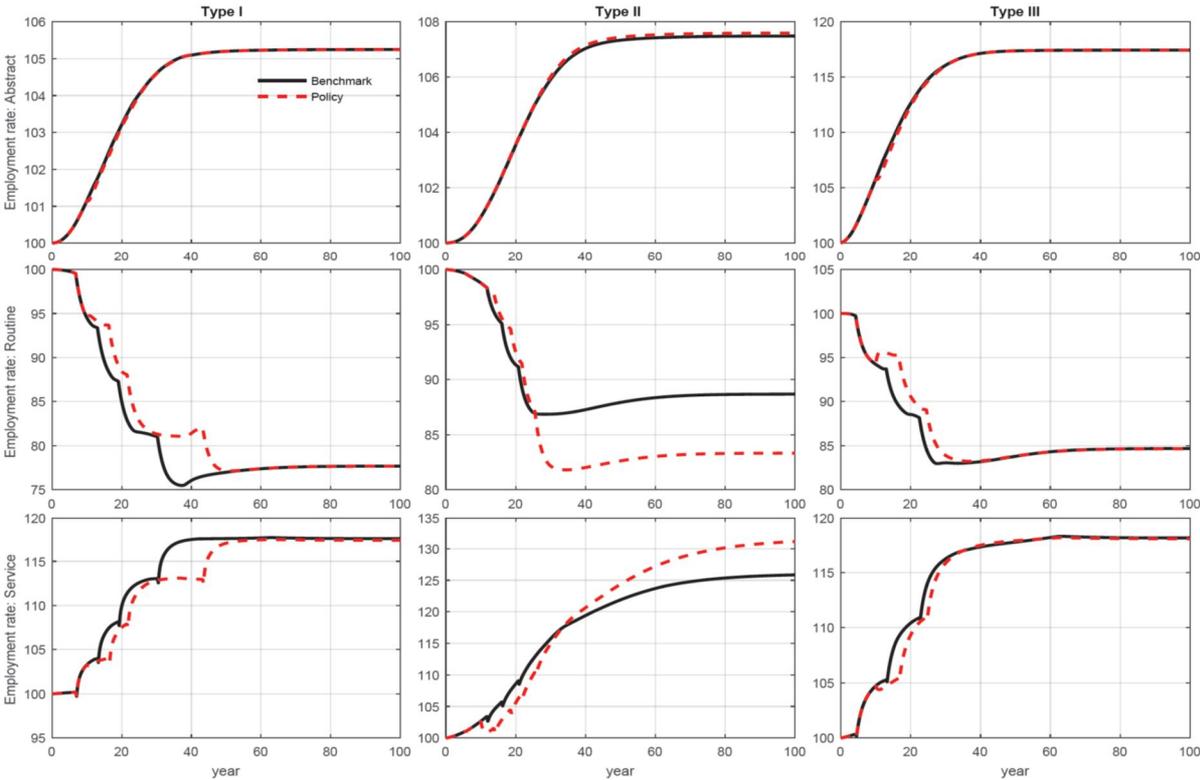
Figure 45: Employment rates, aggregate and by skill, after a reduction in the entry costs in good sector
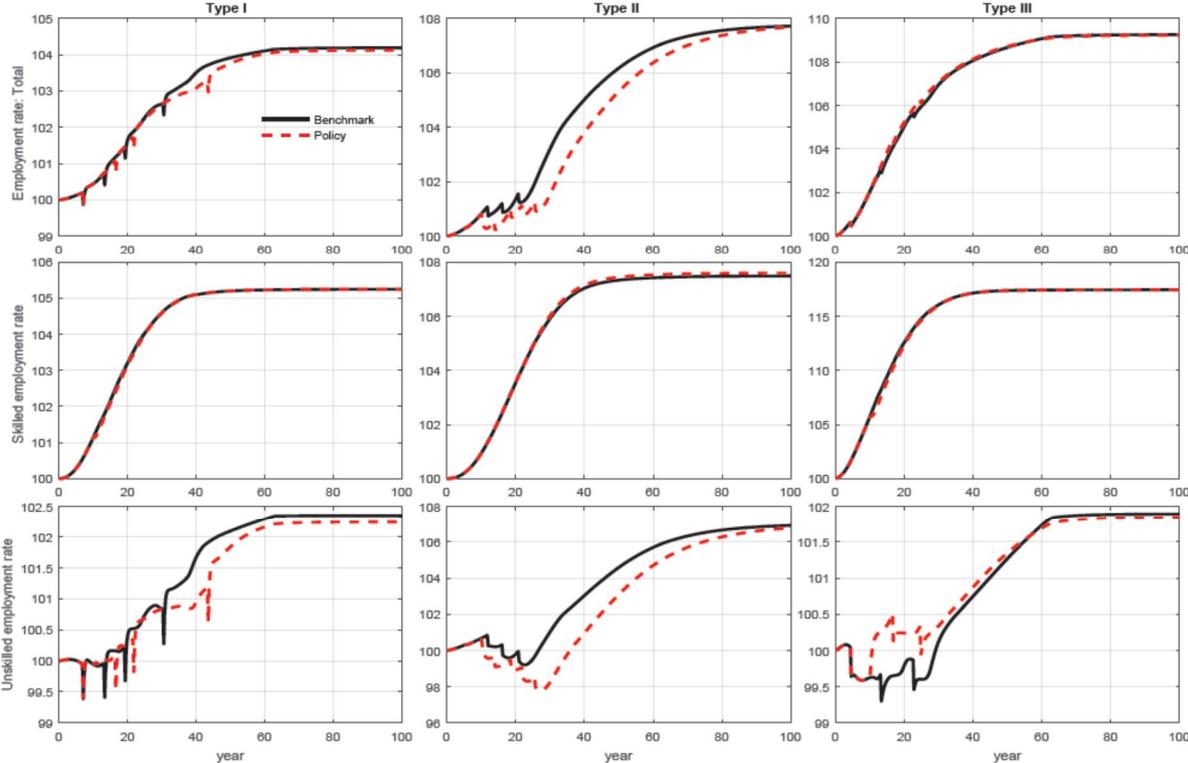
Figure 46: Wages (households' earnings), by task, after a reduction in the entry costs in good sector
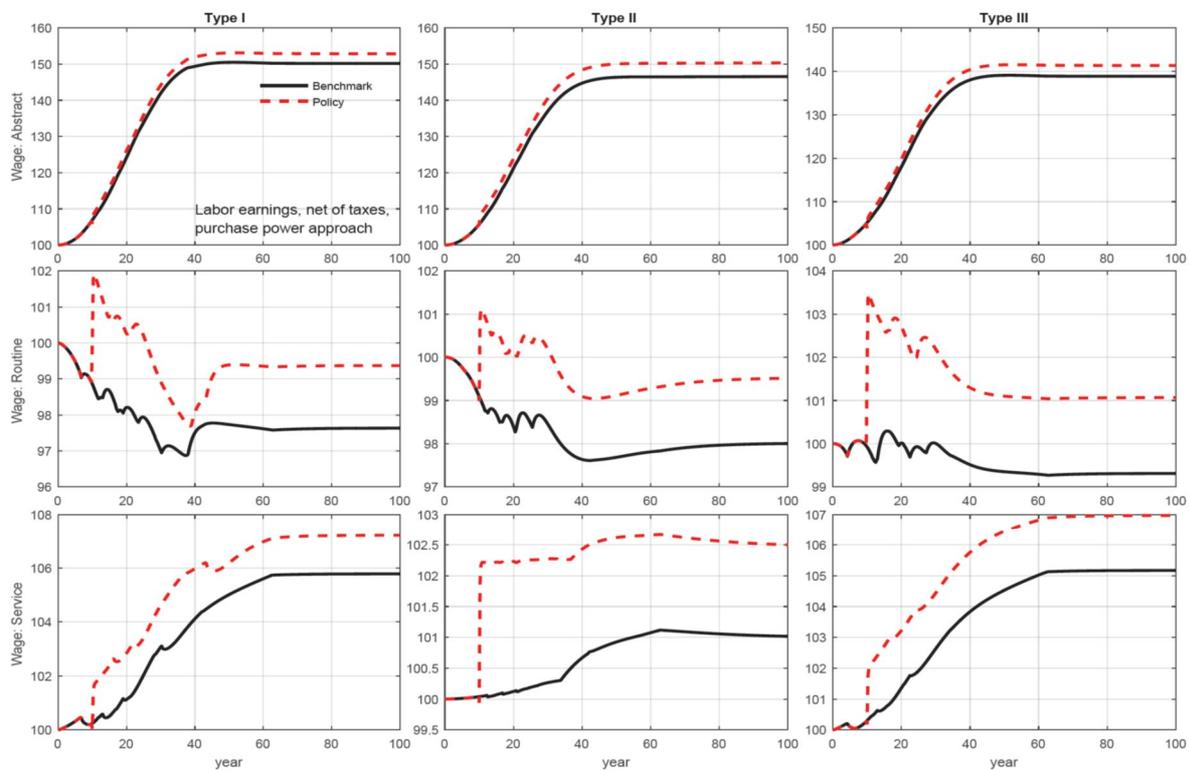
G.1.2 PMR reforms on the good market when policy stimulates innovation

Figure 47: Employment rates, by task, after a reduction in the entry costs in good sector. The case when policy stimulates innovation
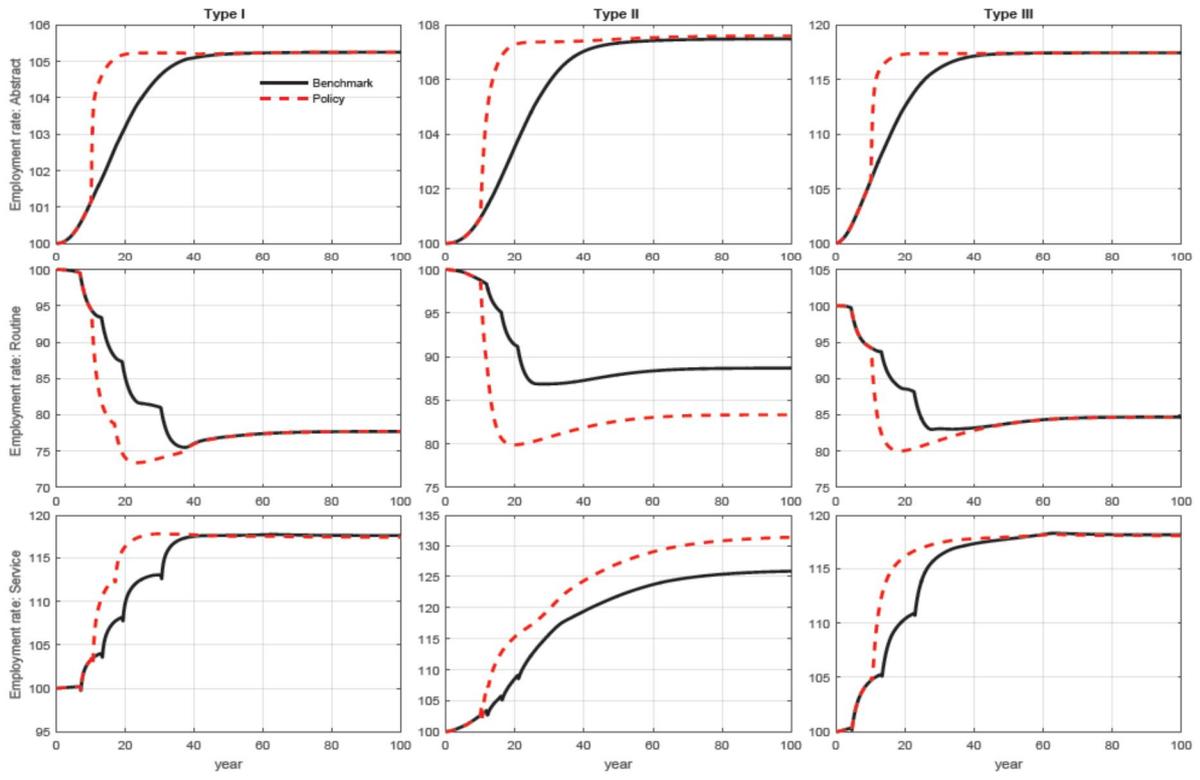
Figure 48: Employment rates, aggregate and by skill, after a reduction in the entry costs in good sector. The case when policy stimulates innovation
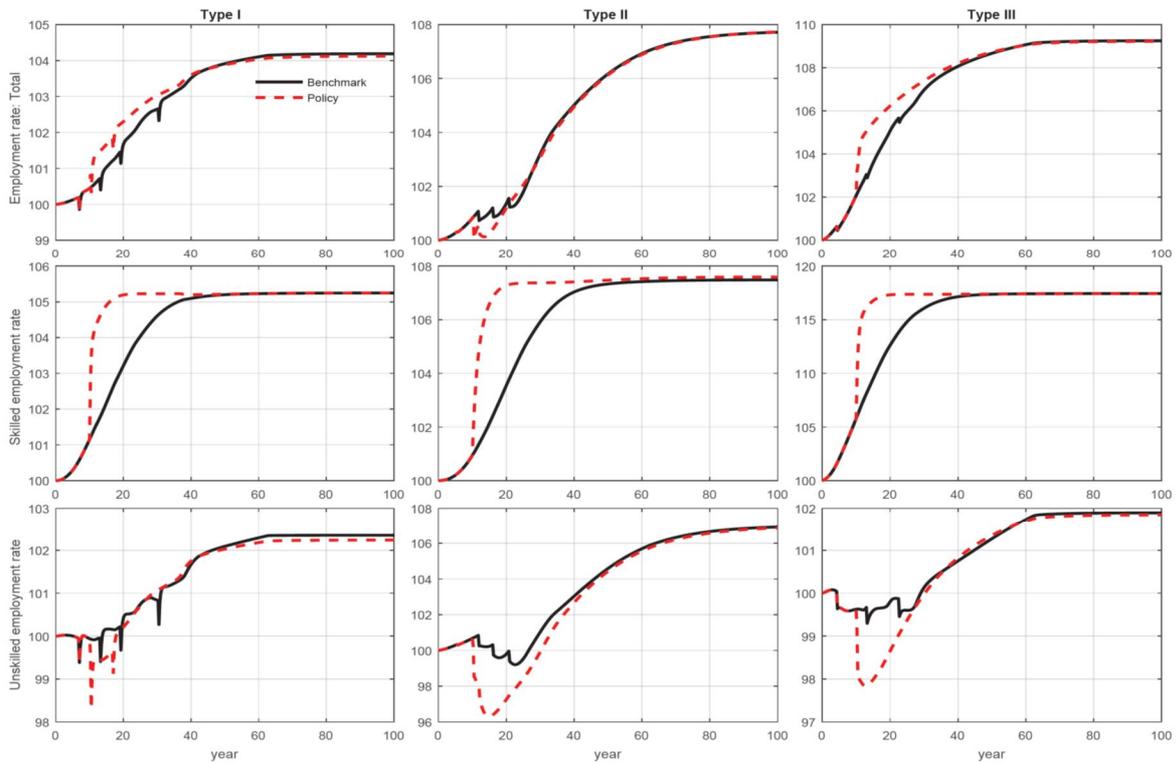
Figure 49: Inequalities after a reduction in entry costs in good sector. The case when policy accelerates innovation.
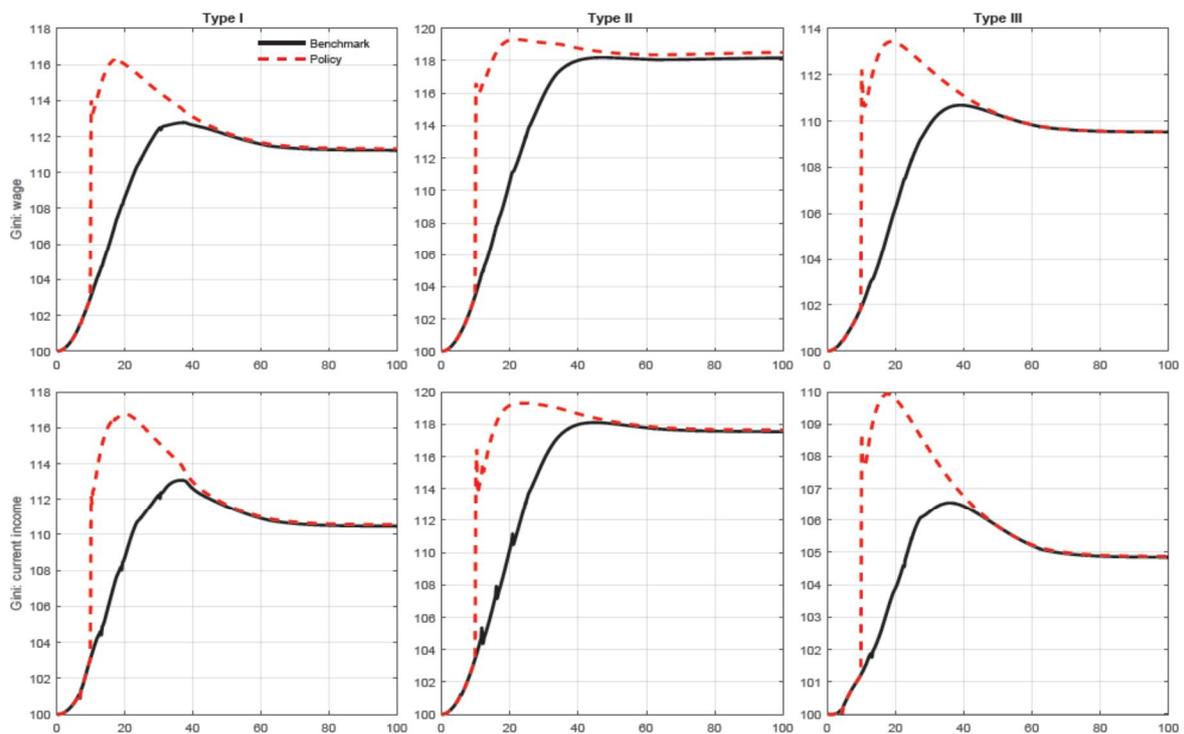
G.2.1 PMR reforms on the service market

Figure 50: Markups, by sector, after a reduction in the entry costs in services
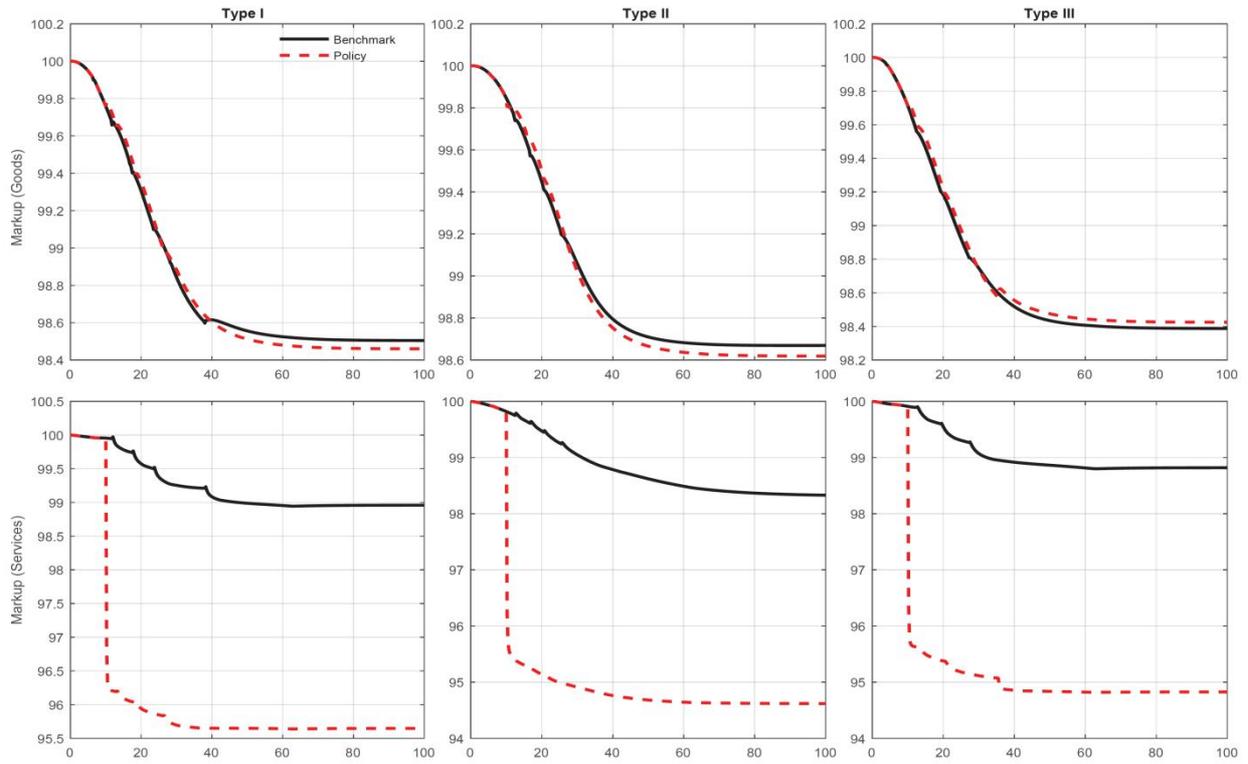
Figure 51: Employment rates, by task, after a reduction in the entry costs in services
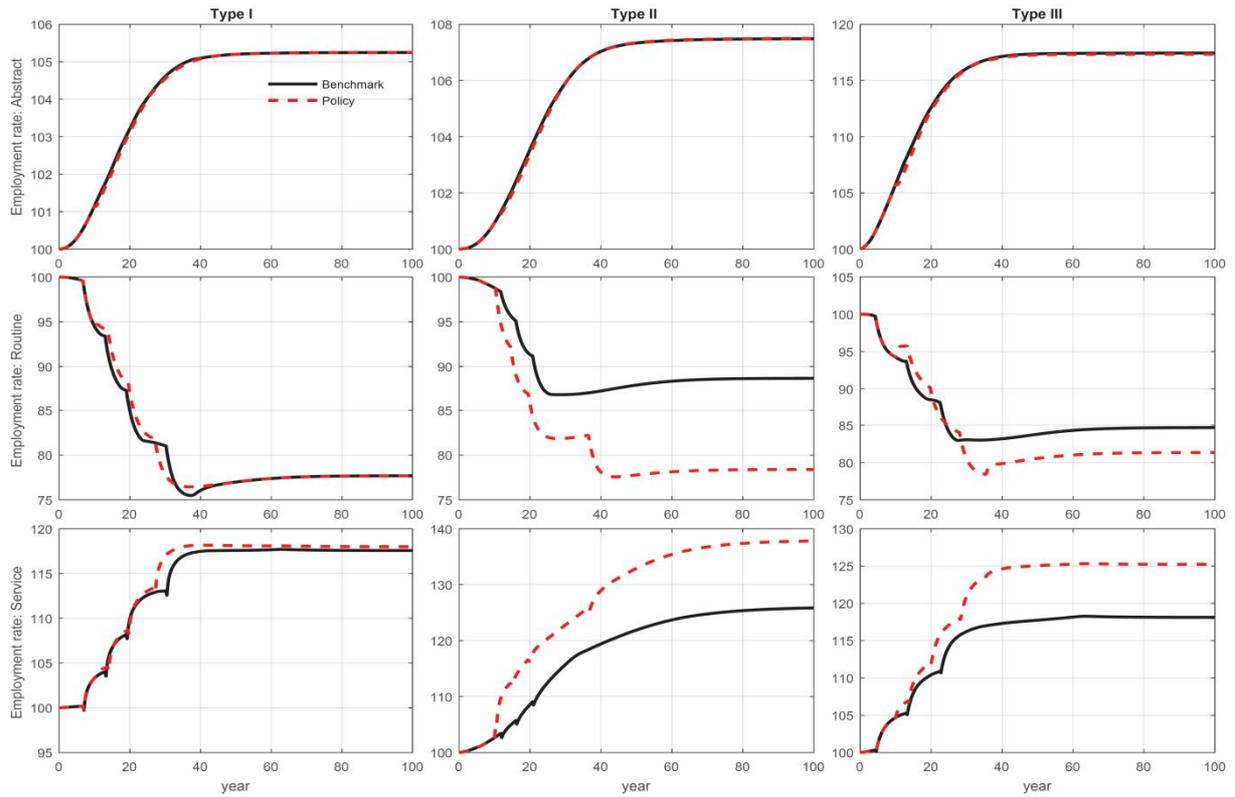

Figure 52: Wages (households' labor earnings), by task, after a reduction in the entry costs in Services
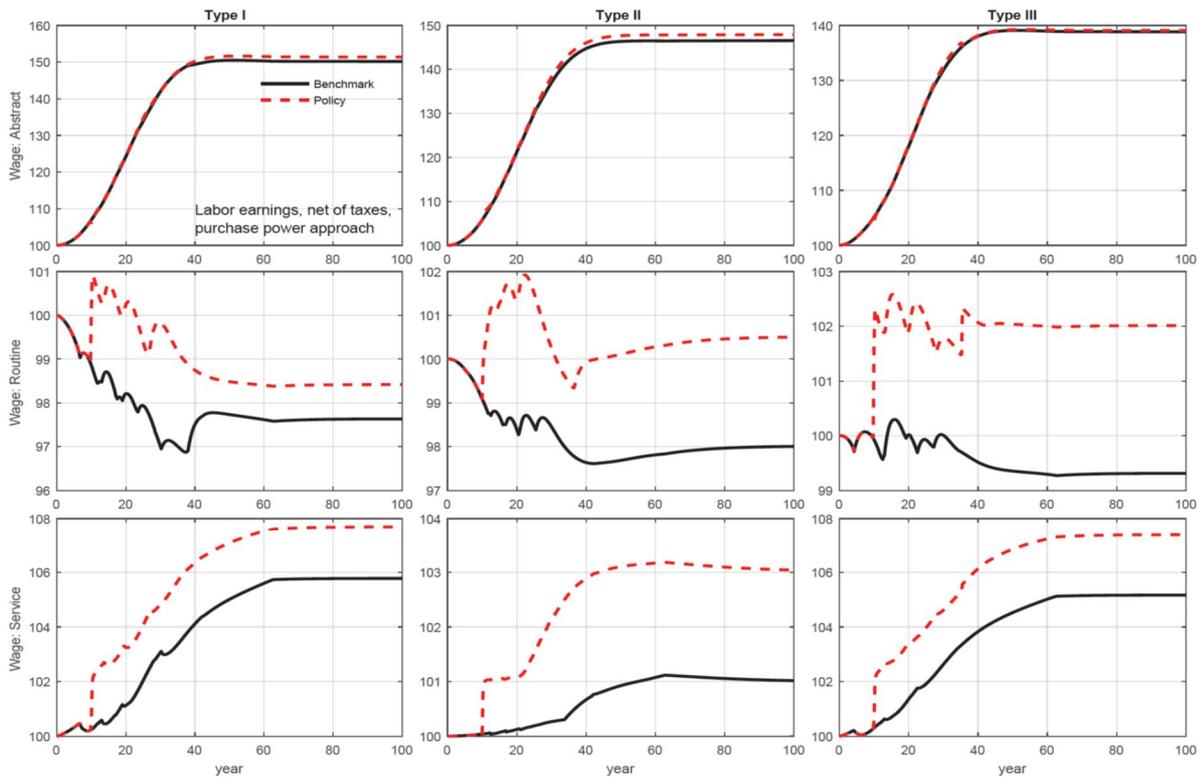
Figure 53: Inequalities after a reduction in entry costs in services