Routinization, Globalization and Rising Job Polarization : A Simple Model with Heterogeneous Agents

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September 2009

Abstract

Important transformations in labor markets have recently been identified both in the U.S. and in Europe, with job and wage polarization (that is, with rising employment shares and wages in occupations that are at the two extremes of the skill ladder). In this paper, we develop a simple two-sector general equilibrium model which acknowledges labor as heterogeneous by skill, and firms as heterogeneous by their production technology and location, with some making explicit offshore outsourcing decisions in a globalized imperfectly competitive world environment. We investigate the effects, on the wage and the employment distributions, of alternative potential causes that have been proposed in the literature to explain job polarization. We conclude in favor of the routinization-biased technical change proposed by Autor, Levy and Murnane (2003).

Keywords: Job polarization; Wage distribution; Routinization; Offshoring; Heterogeneous agents

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1 Introduction

The spectacular rise of wage inequalities since the late 70s, in particular in the U.S., has attracted considerable attention. One – arguably the most – popular explanation to emerge from this research builds on the role of technology transformation that would be biased in favor of skilled workers and against unskilled workers. See Katz and Autor (1999) for a survey of this literature. Evidence of a slowing of wage inequality growth over the last 15 years has however put the SBTC explanation under stress, with some authors strongly emphasizing changes in institutions (such as minimum wages and changes in unionization rates) as the more likely exogenous driving force behind the transformation of the U.S. wage structure: see *e.g.* Card and DiNardo (2002) and Lemieux (2006). But Autor, Levy and Murnane (2003) convincingly argue for a more nuanced way of understanding the impact of technology on the labor market: technology – and computers in particular – can replace labor in routine tasks – that is, in tasks that can be codified into repetitive step-by-step procedures – but not in non-routine tasks. Using U.S. data, they provide evidence in favor of their routinization-biased technological-change assumption (hereafter, RBTC).[1]

More recently, Goos and Manning (2007) have shown that those tasks that are typically non-routinizable tend to be concentrated at the two extremes of the skill distribution, and that employment shares have significantly grown in both of these activities during the last 25 years in the U.K.[2] This phenomenon they call "job polarization" is clearly consistent with the RBTC hypothesis and they test this assumption against other possible explanations to conclude in favor of the former. Goos and Manning (2007) also observe that, during the same period, the rise in the number of low-skill low-payed jobs has coincided with a decline in their pay, not just relatively to the high-skill high-payed jobs, but also relatively to those jobs in between, that are in decreasing numbers. This, as they observe, does not seem entirely consistent with a technology-only caused shift in the demand for some type of labor, except possibly through changes in the skill composition of the middling working class: the relative fall of efficiency wages in routine tasks would

[1] See also Spitz (2006) for the same evidence on Germany.

[2] Goos, Manning and Salomons (2009) show that the same transformations can be observed in other European economies.

be veiled by a disproportionate displacement out of those jobs of the least skilled workers.

Autor, Katz and Kearney (2006) perform a similar empirical analysis for the U.S. labor market and also find clear evidence of job polarization during the 90s. They in addition document that wage growth has also polarized since 1988: wage inequalities have ceased growing (and for some measures have even narrowed) in the bottom half of the distribution since the late 80s, while no significant change in trend is observed for upper-half inequality. They go one step beyond empirical investigation, and show using theoretical arguments how these transformations of the U.S. labor market can emerge as an indirect outcome of RBTC. Their model is partial equilibrium, however: focussing on technology, it abstracts from interactions between labor and product markets, and therefore from trade and the globalization of the world economy.

Our aim in this paper is to complement the theoretical work of Autor, Katz and Kearney (2006). We develop a simple two-sector general equilibrium model which acknowledges labor as heterogeneous by skill, and firms as heterogeneous by their production technology and location, with some making explicit offshore outsourcing decisions in a globalized imperfectly competitive world environment. The model we use is adapted from our previous work on offshore outsourcing – see Jung and Mercenier (2008) – that builds on Yeaple's (2005) heterogeneous agents framework. We investigate the effects, on the wage and the employment distributions, of the RBTC assumption, and show that it can indeed explain the stylized facts mentioned previously, that is (*i*) job polarization, (*ii*) a rise in the efficiency wage in non-routine low-skill jobs relative to that in routine tasks, together with a rise in the efficiency wage of non-routine high-skilled jobs relative to wages in both other occupations, as put forward by Autor, Katz and Kearney (2006) and (*iii*) monotonously rising average wages with the skill intensity of occupations as observed by Goos and Manning (2006). We also explore the effects of two other exogenous shocks – the rising globalization of the world economy, a shift in preferences due to population ageing – and conclude in favor of Autor, Levy and Murnane's (2003) routinization hypothesis. We supplement our theoretical discussion with numerical simulations that confirm our conclusions.

The paper is organized as follows. Our theoretical model is laid down in the next section. Section 3 discusses the effects of the RBTC hypothesis on this economy, whereas

Section 4 and 5 analyze the consequences of the two other potential explanations. Section 6 reports numerical results from a realistically parametrized version of the model. Section 7 offers a short conclusion.

2 The Model

Our model is a two-region North-South model, though our focus is on the domestic economy and the South will therefore remain essentially implicit.

2.1 Households

Domestic households have Cobb-Douglas preferences combining consumption goods from two different sectors, X and Y. Industry X produces a continuum of differentiated varieties, whereas goods from industry Y are homogeneous. We write household preferences as:

$$Con = \beta \ln X + (1-\beta) \ln Y \qquad 0 < \beta < 1 \tag{1}$$

$$X = \left[\int_{i \in N} x^d(i)^\rho di \right]^{\frac{1}{\rho}} \qquad 0 < \rho < 1 \tag{2}$$

where i indexes the varieties within sector X and $\sigma = 1/(1-\rho)$ is the differentiation elasticity. Maximizing utility subject to income immediately yields:

$$P_{Con} \cdot Con = Inc \tag{3}$$

$$\ln P_{Con} = \beta \ln P_X + (1-\beta) \ln P_Y \tag{4}$$

$$x^d(i) = \left(\frac{P_X}{p(i)} \right)^\sigma \frac{\beta Inc}{P_X} \tag{5}$$

$$P_X = \left[\int_{i \in N} p(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} \tag{6}$$

$$p_Y Y = (1-\beta) Inc. \tag{7}$$

Domestic households also supply labor from a continuum of workers with unit mass, differentiated by skill level z with cumulative distribution $G(z)$ on support $[z_{min}, z_{max}]$.[3]

[3] See Blanchard and Willmann (2008) for an effort to endogenize this skill distribution through investment decisions in education by individuals.

2.2 Firms and the labor market

Industry Y is competitive and non-traded. We have in mind here the production of tasks that are typically interactive and therefore cannot be routinized, even though they require poorly qualified labor (such as taxi driving, cleaning, health caring). The technology used for producing these tasks is assumed Ricardian in labor.

In the X-industry, each final-good variety is produced by a single firm. Output $x(i)$ of any variety requires combining two types of activities within a firm: the first groups non-repetitive cognitive activities, that are typically associated with white-collar headquarter services, and the second groups all routinizable cognitive and manual tasks – these include most blue-collar jobs but also a significant subset of (possibly sophisticated) white collar jobs such as bookkeeping. Both activities are associated with the production of intermediate input components, respectively in amount $h(i)$ and $m(i)$. We assume a Leontief production function with units conveniently chosen so that:

$$x(i) = h(i) = m(i). \tag{8}$$

Both tasks are performed by workers using Ricardian technologies. There are two competing technologies available for producing $h(i)$, a high- (H) or a low- (L) technology. Technology H is more expensive to set-up but cheaper to operate than L so that $F_L < F_H$ and $C_L > C_H$, where F_j and C_j denote respectively the set-up and the marginal costs involved by the use of technology $j = L, H$. Though born identical, firms will sort in equilibrium between these two types: this is one source of endogenously generated firm heterogeneity in the model.

Though headquarter services can only be produced domestically, repetitive intermediate activities can be either performed locally or offshored. In the home country, they involve using an M technology with marginal cost C_M; performed in the South, these activities have a lower unit production cost $C_M^* = \theta C_M$, $\theta < 1$. Offshore outsourcing however involves specific set-up costs F_I so that only the most productive X-firms will turn multinational.[4] There is ample evidence that multinational (MN) firms use more

[4] Note that, as will be made explicit shortly, the symbols F_L, F_H and F_I denote real fixed costs expressed in units of final output.

productive technologies than non-MNs;[5] we shall assume F_I and θ such that only firms using the H technology find it profitable to offshore the production of their repetitive intermediate activities.

Finally, X-firms differ from one another, and from Y-producers, by the skill level of the domestic workers they hire. Let $\varphi_j(z)$ denote the productivity of a worker of skill z when working with technology $j \in \{Y, M, L, H\}$. We assume $\varphi_j(z)$ continuous and increasing in z, so that, for any technology considered, a higher skilled worker is absolutely more productive than a less skilled one. We characterize comparative advantages as follows:

$$0 < \frac{d \ln \varphi_Y(z)}{dz} < \frac{d \ln \varphi_M(z)}{dz} < \frac{d \ln \varphi_L(z)}{dz} < \frac{d \ln \varphi_H(z)}{dz} \tag{9}$$

with $\varphi_Y(z_{\min}) = \varphi_M(z_{\min}) = \varphi_L(z_{\min}) = \varphi_H(z_{\min})$, so that a higher skilled worker is relatively more productive with more efficient technologies.

In equilibrium, with competitive labor markets, workers will sort between the four technology types according to their respective comparative advantage. Let z_0, z_1 and z_2 be equilibrium skill thresholds with $z_{\min} < z_0 < z_1 < z_2 < z_{\max}$.[6] Then, the least skilled workers, with $z \in [z_{\min}, z_0)$, will be employed in sector Y, those with talents $z \in [z_0, z_1)$ will be hired to perform repetitive tasks within X-firms, and the more talented, those with $z \in [z_1, z_2)$ and $z \in [z_2, z_{\max}]$ will be allocated to nonrepetitive cognitive activities in headquarters, respectively in low-tech and high-tech firms. See Figure 1, where we assume log-linear productivity functions $\varphi_j(z)$.

[5] See *e.g.* Doms and Jensen (1998), Conyon et al. (2002). Helpman et al. (2004) highlight that MNEs are substantially more productive than non-MNE exporters which outperform significantly purely domestic ones. See also Navaretti et al. (2006) for a discussion, and some empirical evidence, on technological upgrading related to firms switching from national to multinational.

[6] We assume hereafter an interior equilibrium solution, so that all four types of technologies are assumed in use.

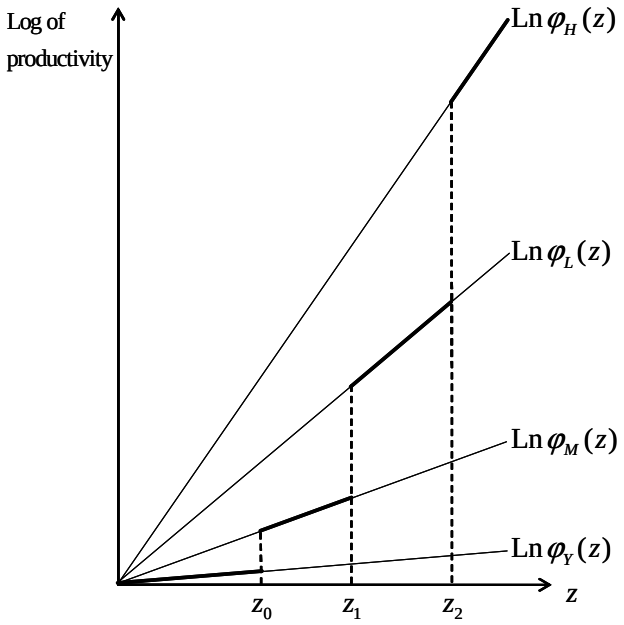


Figure 1: The technologies.

A worker z will earn a wage $w(z)$ that reflects both its talent and the technology on which he operates: the competitive wage distribution will satisfy

$$w(z) = \begin{cases} C_Y \varphi_Y(z) & z_{\min} \leq z < z_0 \\ C_M \varphi_M(z) & z_0 \leq z < z_1 \\ C_L \varphi_L(z) & z_1 \leq z < z_2 \\ C_H \varphi_H(z) & z_2 \leq z \leq z_{\max}. \end{cases} \tag{10}$$

Obviously, the marginal skill owners should be indifferent in equilibrium between two jobs performed with adjacent technologies, so that

$$\begin{aligned} C_Y \varphi_Y(z_0) &= C_M \varphi_M(z_0) \\ C_M \varphi_M(z_1) &= C_L \varphi_L(z_1) \\ C_L \varphi_L(z_2) &= C_H \varphi_H(z_2) \end{aligned} \tag{11}$$

and the equilibrium wage distribution will be as illustrated in Figure 2.

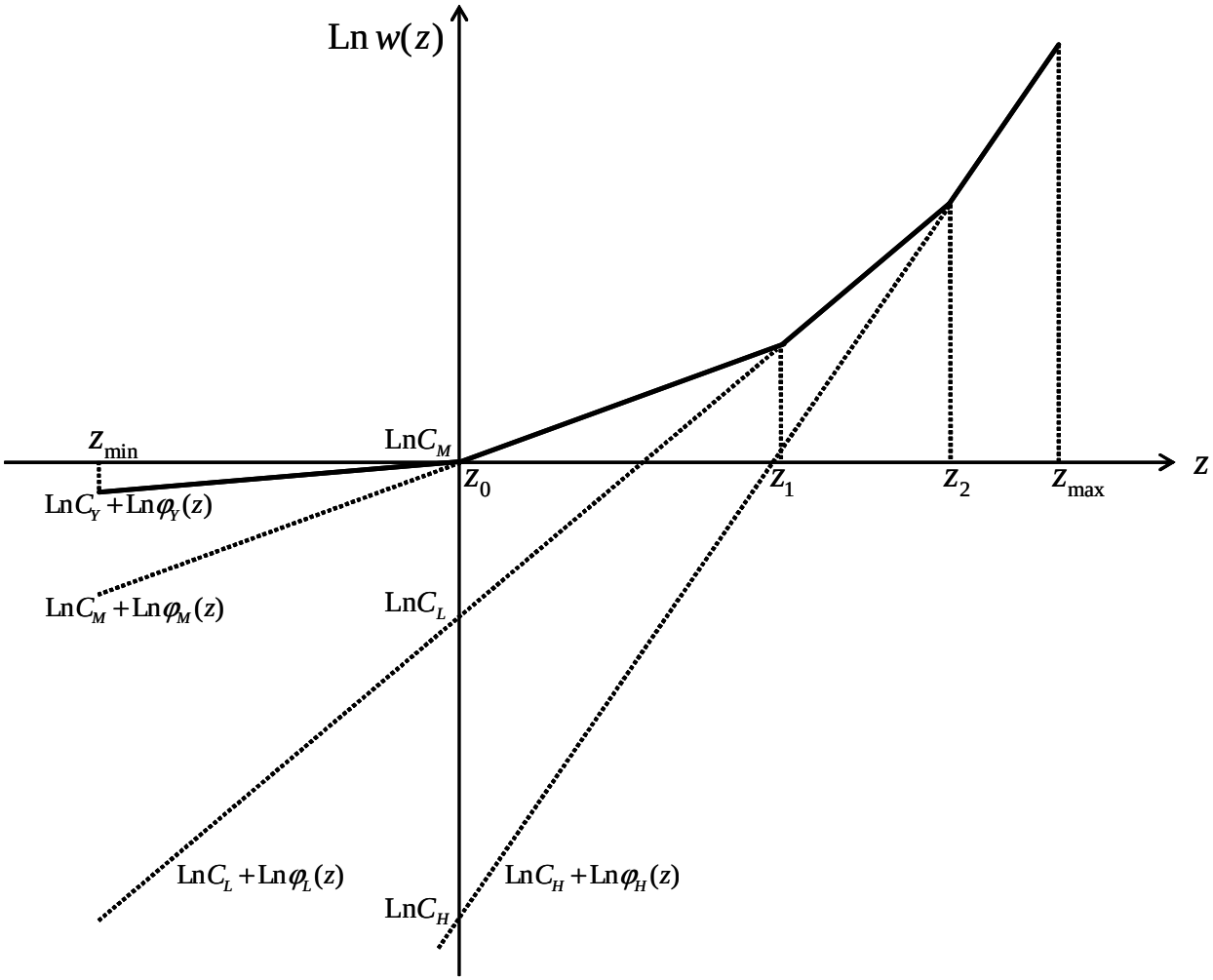


Figure 2: The equilibrium wage distribution.

C_Y serves as numeraire; the three previous indifference conditions therefore pin down the marginal costs of intermediate tasks in the X industry:

$$C_M = C_Y \frac{\varphi_Y(z_0)}{\varphi_M(z_0)} \tag{12}$$

$$C_L = C_M \frac{\varphi_M(z_1)}{\varphi_L(z_1)} \tag{13}$$

$$C_H = C_L \frac{\varphi_L(z_2)}{\varphi_H(z_2)}. \tag{14}$$

Observe from (9) that $C_Y > C_M > C_L > C_H$ and that C_M, C_L, C_H are decreasing respectively in z_0, z_1 and z_2.

Marginal cost pricing holds in the competitive Y industry so that $p_Y = C_Y$. In sector X, monopolistic competition prevails and firms therefore charge constant mark-up rates

over their marginal production costs:

$$\begin{aligned} p_L &= \tfrac{\sigma}{\sigma-1}\left(C_L + C_M\right) \\ p_H &= \tfrac{\sigma}{\sigma-1}\left(C_H + \theta C_M\right). \end{aligned} \tag{15}$$

Observe that multinationals will charge lower prices than their national-only competitors.

2.3 The foreign economy

Foreign workers earn wages from multinationals' offshored activities; from our assumptions on technology (8) and on production costs, we know that this income can be written as

$$Inc^* = \theta C_M \int_{z_2}^{z_{\max}} \varphi_H(z) dG(z). \tag{16}$$

We avoid unnecessary balance of payment complications by conveniently assuming that this income is spent entirely on imported X goods from the North, with preferences identical to (2), so that each X-firm exports in amount

$$x^{d*}(i) = \left(\frac{P_X}{p(i)}\right)^{\sigma} \frac{Inc^*}{P_X} \tag{17}$$

where P_X is given by (6).

2.4 Equilibrium

Y goods are non-traded, so that domestic production should fully cover local household demands:

$$\int_{Z_{\min}}^{z_0} \varphi_Y(z) dG(z) = Y. \tag{18}$$

In the X industry, each firm satisfies the demand for its own variety, so that

$$x_j = x^d(i) + x^{d*}(i) \qquad i \in N_j, \qquad j = L, H \tag{19}$$

where N_j is the number of firms of type j. Free entry ensures zero profits for both firm types, so that mark-up revenues exactly cover fixed costs. For convenience, we express fixed costs in the form of forgone output, and we price these accordingly:

$$\begin{aligned} \tfrac{1}{\sigma} p_L x_L &= \left(C_L + C_M\right) \cdot F_L \\ \tfrac{1}{\sigma} p_H x_H &= \left(C_H + \theta C_M\right) \cdot \left(F_H + F_I\right). \end{aligned} \tag{20}$$

Note that multinationals are larger, as realism suggests, than their national-only competitors: combining (15) and (20) reveals that in equilibrium, the individual firm's output is constant and proportional to its fixed costs.[7]

The amount of labor used in the production of headquarter services follows from the technology (8), as

$$N_L\left(x_L + F_L\right) = \int_{z_1}^{z_2} \varphi_L(z) dG(z) \tag{21}$$

$$N_H\left(x_H + F_H + F_I\right) = \int_{z_2}^{z_{\max}} \varphi_H(z) dG(z). \tag{22}$$

Domestically performed repetitive tasks are exclusively concentrated within low-tech firms, so that:

$$\int_{z_0}^{z_1} \varphi_M(z) dG(z) = \int_{z_1}^{z_2} \varphi_L(z) dG(z). \tag{23}$$

Finally, domestic income follows from full employment,

$$Inc = C_Y \int_{z_{\min}}^{z_0} \varphi_Y(z) dG(z) + C_M \int_{z_0}^{z_1} \varphi_M(z) dG(z) + C_L \int_{z_1}^{z_2} \varphi_L(z) dG(z) + C_H \int_{z_2}^{z_{\max}} \varphi_H(z) dG(z) \tag{24}$$

which completes the description of our model.

3 Routinization-biased technological change (RBTC)

We now turn to the analysis of the effects of routinization-biased technical-change in this model, and investigate if it can explain the recently observed transformations of the job and wage distributions. We quite naturally interpret RBTC as a positive productivity shock on M-activities that affects the slope of the Ln $\varphi_M(z)$ schedule in Figure 1, within the range consistent with (9).

To understand how this technical shock will affect the equilibrium wage distribution in Figure 2, we focus on how the skill thresholds z_0, z_1, z_2 are being affected. At the initially given skill distribution of jobs, the productivity induced wage increase in routine activities will spread to all headquarter workers : $d_1 C_L = d_1 C_H > 0$. From (23), however,

[7] This is convenient because changes in industry market-size will affect variety indices N_j $j = L, H$ only, without inducing within firm adjustments.

it is apparent that, for z_0 and z_2 given, z_1 will be reduced: the new technology forces low-tech X-firms to relocate those most talented among workers in repetitive M-tasks to headquarter activities, where they now operate on the better L-technology, and therefore become more productive. This contributes to push further up headquarter-task wages, $d_2C_L = d_2C_H > 0$, and, therefore, prices of the X-varieties p_L and p_H. Relative price and income effects therefore both contribute to boost the demand for the non-traded good,[8] the relative price of which rises ($dC_M = d_3C_L = d_3C_H < 0$) making it possible for producers in the Y industry to hire workers previously employed in repetitive intermediate activities M by offering better wages: the threshold z_0 is being pushed to the right with $d_4C_L = d_4C_H < 0$. For given z_2, this tends to mitigate the initial leftward shift of z_1, obviously without qualitatively affecting the mechanism described (by stability arguments). Note that, in absence of multinational firms, this would complete the description of the adjustment mechanism to equilibrium: z_2 would then coincide with $z_{\max}$ and be fixed by endowments, so that, was this economy closed, RBTC would unambiguously yield job and efficiency wage polarization.

To uncover how the presence of multinationals may affect this outcome, observe that, with z_2 up to now unchanged, the cost ratios C_M/C_M^* and C_L/C_H have remained unaffected by previous adjustments but not necessarily the output price ratio p_L/p_H: this will depend on the initial marginal input-cost shares. It is easy to show that changes in p_L/p_H will be $\gtreqless 0$ iff $C_H \lesseqgtr \theta C_L$, that is, iff $\varphi_L(z_2) \lesseqgtr \theta\varphi_H(z_2)$. Thus, at given z_2, if the technology gap between L and H firms is large enough, X-varieties from high-tech firms are in relative scarcity: product market equilibrium requires from these firms more output. Increasing the scale of offshored activities is no problem for multinational firms since labor is abundant enough in the South to leave unaffected the marginal production costs of these repetitive intermediate input tasks. In the home country, however, skilled labor has to be pulled out of the national-only competitors. This multinationals achieve by offering better wages so that z_2 is shifted leftward, with newly hired workers skill-upgrading as they move to high-tech equipment, therefore becoming more productive. The wage rise spreads to all workers with $z > z_2$ boosting the relative cost of headquarter activities

[8] The deterioration of the terms of trade of the South also contributes to the restructuring of aggregate demand in favor of the non-traded good Y.

within multinationals. The rise in C_H is passed over to p_H, inducing demand substitutions that also contribute to restore product market equilibrium. This adjustment will continue until the output price ratio p_L/p_H has recovered its initial equilibrium value.[9] In this case, therefore, the conclusions reached for the closed economy extend to the case of a globalized economy: offshore outsourcing by multinational firms tends to amplify the labor markets transformations induced by RBTC. But this is not the only possible equilibrium outcome, however. Indeed, if the technology advantage of MNEs is not large enough, so that $C_H > \theta C_L$, at given initial z_2, RBTC produces a costs advantage in favor of national only firms: the price ratio p_L/p_H will have changed in favor of domestic only firms. Demand substitution forces MNEs to downscale their labor force: z_2 moves to the right, and so does z_1. In this case, therefore, the impact of RBTC on the equilibrium job distribution is ambiguous. It will, in particular, crucially depend on the size of the demand substitution effect, that is, on the value of the preference parameter σ: the more X-varieties are differentiated (σ low), the more likely it is that RBTC will be consistent with the stylized facts.[10]

[9] Indeed, making use of (20), after substituting out prices and output (from (15) and (5)), it is easy to show from the ratio $\frac{p_L x_L}{p_H x_H}$ that, in equilibrium, $\frac{C_L+C_M}{C_H+\theta C_M} = \left[\frac{F_H+F_I}{F_L}\right]^{1/\sigma}$, a constant.

[10] In the very special case where $C_H = \theta C_L$, the equilibrium ratio p_L/p_H is fixed and RBTC does not affect the relative competitiveness of MNEs. Numerical simulations confirm that in this case, the equilibrium skill threshold z_2 remains unchanged.

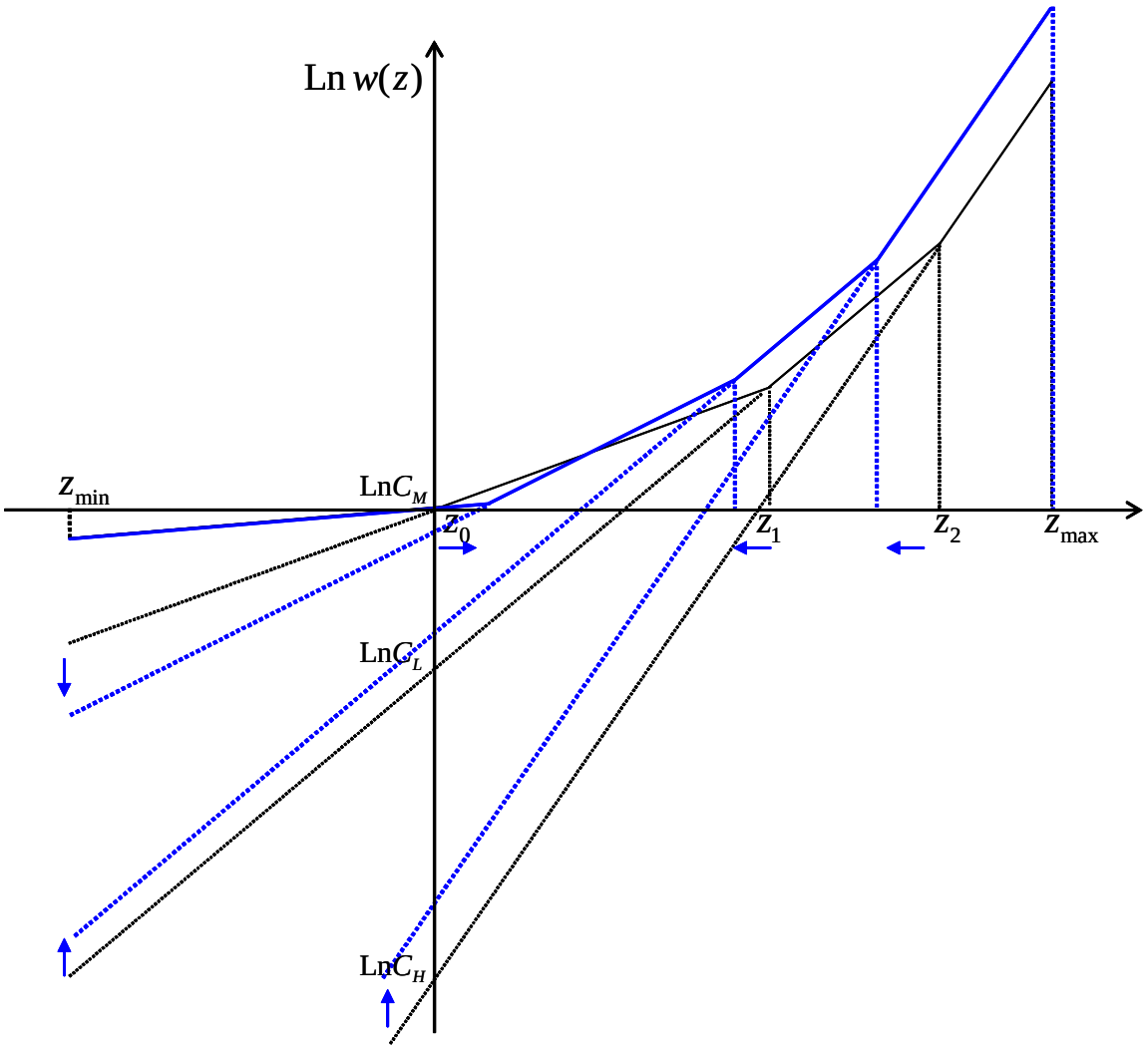


Figure 3: The effects of RBTC on the equilibrium wage distribution when the tech-gap between MNEs and NEs is large enough.

Figure 3 reports the case where MNEs enjoy a large enough productivity advantage over their national only competitors: the new equilibrium wage distribution is shown in bold. Clearly, in this case, RBTC generates unambiguous job polarization: a shrinking share of employment in intermediate predominantly repetitive activities, with a labor force being increasingly concentrated in both the lowest- and the highest-wage occupations typically characterized by the non-routinizable nature of the tasks performed. RBTC in this case also clearly induces changes in relative efficiency wages that are consistent with the second stylized fact. That is: a fall in the M- to Y- relative efficiency wage ($dC_M < 0$), and a rise of those in headquarter activities relative to those in both M and Y activities (dC_L and

$dC_H > dC_Y = 0 > dC_M$). What can be said, in this case, on the effect of RBTC on average wages by occupations? In the Y sector, the average wage unambiguously rises: with z_0 shifted to the right, some workers relocate themselves from M tasks to jobs within the sector with the least efficient technology. Though for those individual workers this is a skill-downgrading move associated with a wage loss, they come with better skill endowments than those previously in that industry and therefore contribute positively to the average wage in Y.[11] In other occupations, however, the sign of average-wage changes is unclear because of ambiguous composition effects. Though wages rise for all workers that initially held headquarter jobs, those newly hired to perform non-repetitive cognitive tasks are less talented and therefore contribute negatively to the average wage. The same ambiguity prevails in occupations M because workers that move out of the repetitive activities do so either by skill-upgrading or by skill-downgrading, and are respectively the most- and the least- talented originally employed in those industries. Finally, in the case depicted in Figure 3, RBTC generates changes in wage inequalities that are broadly consistent with observed recent trends reported by Autor, Katz and Kearney (2006): a rise in the upper-half inequality, as measured by the 90-50 log-wage differential, results unambiguously, whereas changes in the lower-half inequality will typically be much lower.[12]

To summarize our findings, both job and wage polarization can easily be generated in a closed economy general equilibrium context using the RBTC as driving force. Indeed, in the no-trade version of our model, labor market polarization is the only possible outcome. In the open-economy, however, things are more complicated: by their offshore outsourcing practices, MNEs could amplify, mitigate or even possibly counter, the direct effect of RBTC on the job and wage distributions. The productivity difference between MNEs and NEs plays here a crucial role: the higher this difference, the more RBTC is likely to cause labor market polarization.

[11] Observe that this story is quite consistent with the often reported observation that an increasing proportion of middle-skilled people report that they are employed in jobs for which they are overqualified. See *e.g.* Green and McIntosh (2002).

[12] A contraction in the 50-10 log-wage differential, as has been observed in the U.S. economy between 1987 and 2004 (Autor, Katz and Kearney, 2006) could also be obtained in this simple two sector model, but it would result from a special choice of technology gaps between activities and/or of initial relative positions of the equilibrium skill thresholds.

There is abundant evidence that multinationals are more productive than national-only firms (of course, after controlling for output scale). Is the tech-gap large enough to realistically make RBTC the main explanation? Before we venture an answer to that question, we have to understand the consequences of rising globalization on the labor market. This is what we turn to in the next section.

4 Rising Globalization

Rising globalization naturally takes two non-exclusive forms in this model: a fall in the fixed cost of engaging in offshore outsourcing practices ($dF_I < 0$), and a reduction of marginal production costs of repetitive tasks abroad ($d\theta < 0$), the latter interpreted to include transportation costs.[13] Both technology shocks yield identical qualitative equilibrium effects albeit through slightly different channels. With falling F_I, offshoring becomes more attractive and an increasing number of low-tech producers find it profitable to turn multinational and switch to high-tech.[14] In the case of θ falling, the price ratio p_L/p_H rises inducing demand substitution away from L-varieties. In both cases, for given z_0, the contraction of aggregate activity by national-only X-firms shifts to the left both z_1 and z_2, with a substantial skill upgrading of workers following, a mechanism well documented by Head and Ries (2002) and Hansson (2005) among others.[15] Efficiency wages rise in headquarter activities (dC_L and $dC_H > 0$). The rise in income boosts the demand for the

[13] Explicitely introducing ice-berg transportation costs is not difficult but complicates without adding much; it would only change income levels in the South, with no qualitative consequence.

[14] More rigorously, there is entry (exit) of firms in the high-tech (low-tech) subsectors. It can be shown –see Jung and Mercenier (2008)– that the total number of firms will increase, for given z_0.

[15] Head and Ries (2002) investigate the influence of offshore production by Japanese multinationals on domestic skill intensity, using firm-level data. They find that additional foreign affiliate employment in low income countries raises skill intensity at home, but that this effect falls as investment shifts towards high income countries. This is clearly consistent with vertical specialization, and provides evidence that vertical specialization by multinationals contributes to skill upgrading domestically. Hansson (2005) reaches similar conclusions on Swedish MNEs during the years 1990-97. The period is particularly interesting because it covers the years after the iron curtain was lifted: Swedish MNEs have extensively taken advantage of the large supply of cheap labor in the immediate neighborhood which the processes of transition in the CEECs has given rise to. He finds a non-trivial, significantly positive, impact on skill upgrading in Swedish MNE parents of the increased employment share in their affiliates in non-OECD countries.

competitive good requiring more labor in that sector: $dz_0 > 0$ as relative efficiency wages rise in nontraded activities and labor pours out of the intermediate M-activity. The new equilibrium wage distribution is shown in Figure 4, and clearly displays job and wage polarization. Observe the similarity between Figures 3 and 4. There is a sizeable difference between the two, however: the change reported in Figure 4 is the *only* possible equilibrium outcome of the globalization shock, whereas a special – albeit reasonable – parameter configuration is required to generate the bold line in Figure 3. One cannot therefore exclude the possibility that, the two shocks being simultaneously, they yield opposite effects on the job and wage distributions, with globalization providing the strongest driving force. The evidence provided by Goos and Manning (2006) clearly militates against such a case, however, so that for now at least, we are entitled to reject it as unrealistic, and to conclude that both shocks are equally likely to be the main cause of recent labor market transformations.

We have just concluded that RBTC and rising globalization have very similar effects in our model, there is nevertheless one important qualitative difference. With rising globalization, all workers that remain in M-activities suffer a same proportional wage loss, whichever their skill level. This is in clear violation of the third stylized fact, which suggests rejection of rising globalization as the main driving force behind recent labor market transformations. One interesting implication of this finding is that a contraction in the 50-10 log-wage differential appears to be a robust prediction of the globalization shock.[16] In contrast, RBTC unambiguously increases wage inequalities within sectors where most tasks are repetitive, so that a contraction in the 50-10 log-wage differential will only result in special circumstances. This is a testable difference that might help to empirically evaluate the relative importance of the two explanations in shaping the recent labor market transformations. For now, we believe that there is no evidence suggesting that wage inequality within routine-type activities is decreasing. If this was empirically confirmed, it would add against globalization and the rise of offshore outsourcing as the main driving force behind the job polarization, a conclusion consistent with most assessments: see *e.g.* Feenstra and Hanson (1998) and Freeman (2003).

[16] Provided, of course, that non-routine low-skill jobs account for more than 10%, and non-repetitive cognitive jobs less than 50%, of the labor force, as realism suggests.

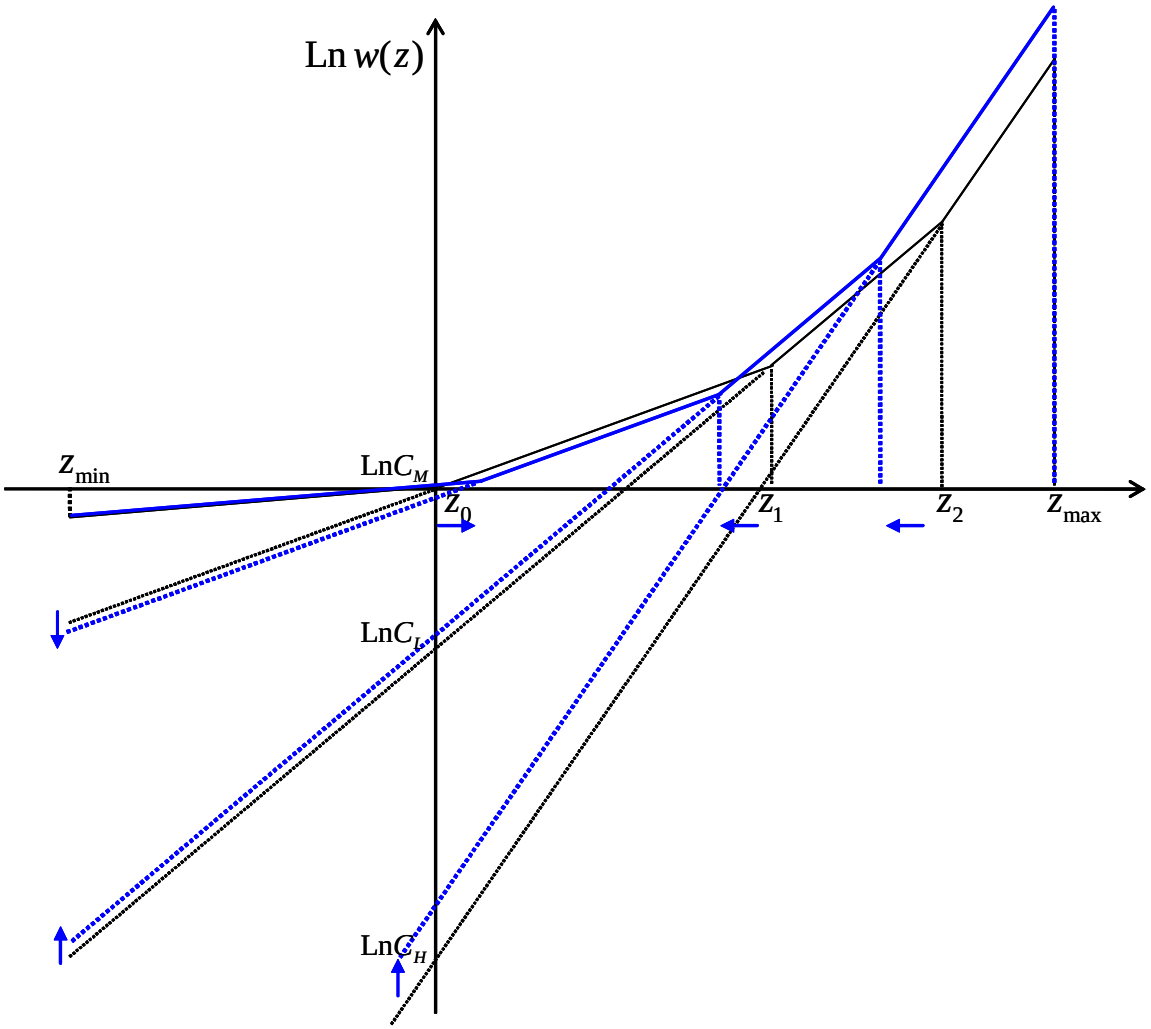


Figure 4: The effect of globalization on the equilibrium wage distribution.

5 Demand-composition shifts

Job polarization could be driven by factors other than technology or trade. A composition shift of demand towards skill-unintensive services is one of them. This could be due to demographic factors: an ageing population is likely to increase its demand share for services such as outside-family care and hospital assistants, that is, for non-easily routinized tasks that can typically be performed by low-skilled low-payed workers. Also, it has been suggested that rising wage inequalities may have contributed to displace demand in favor

of low quality jobs because of the relatively high income elastic nature of demand for services such as child care. How will such shift in preferences impact on the labor market in this model?

The answer is provided in Figure 5, where it is shown that no job and wage polarization can simultaneously result, which eliminates demand composition shifts as a candidate causal explanation.

To understand why, consider the effects of an exogenous reduction of β in (1). The impact effect is to increase the relative price of the competitive good, as well as wages in that industry ($dC_M = d_1C_L = d_1C_H < 0$), making it attractive for lower-skilled M-workers to move into the Y industry: z_0 shifts to the right. With z_2 given, low-tech X-firms are forced into restructuring, reducing wages in oversized headquarter activities ($d_2C_L < 0$); the least talented among the workers engaged in such activities now find it profitable to skill-downgrade and perform M-tasks within the firm: $dz_1 > 0$. Wage cuts in L-tech headquarter jobs have spread to multinational competitors who now can afford to reduce pays to their own headquarter workers in identical proportions ($d_2C_H = d_2C_L$) without affecting the size of their labor force ($dz_2 = 0$). With z_2 unchanged, however, the price ratio p_L/p_H will have changed, except in the special case where $C_H = \theta C_L$. If $C_H < \theta C_L$, demand substitution in favor of the high-tech X-varieties will displace z_2, and therefore z_1, to the left. Headquarter wages rise more rapidly in MNEs, pushing the relative prices up to their initial level. This substitution mechanism yields second order effects, so that, for stability reasons, the threshold level z_1 cannot be moved leftward beyond its initial position. In equilibrium therefore, aggregate employment in cognitive non-repetitive tasks cannot have expanded. In the opposite case where $C_H > \theta C_L$, high-tech X-varieties are in excess supply, and some MNEs are forced out of business: z_2 moves to the right. Thus, neither job polarization nor wage polarization is a possibility here.

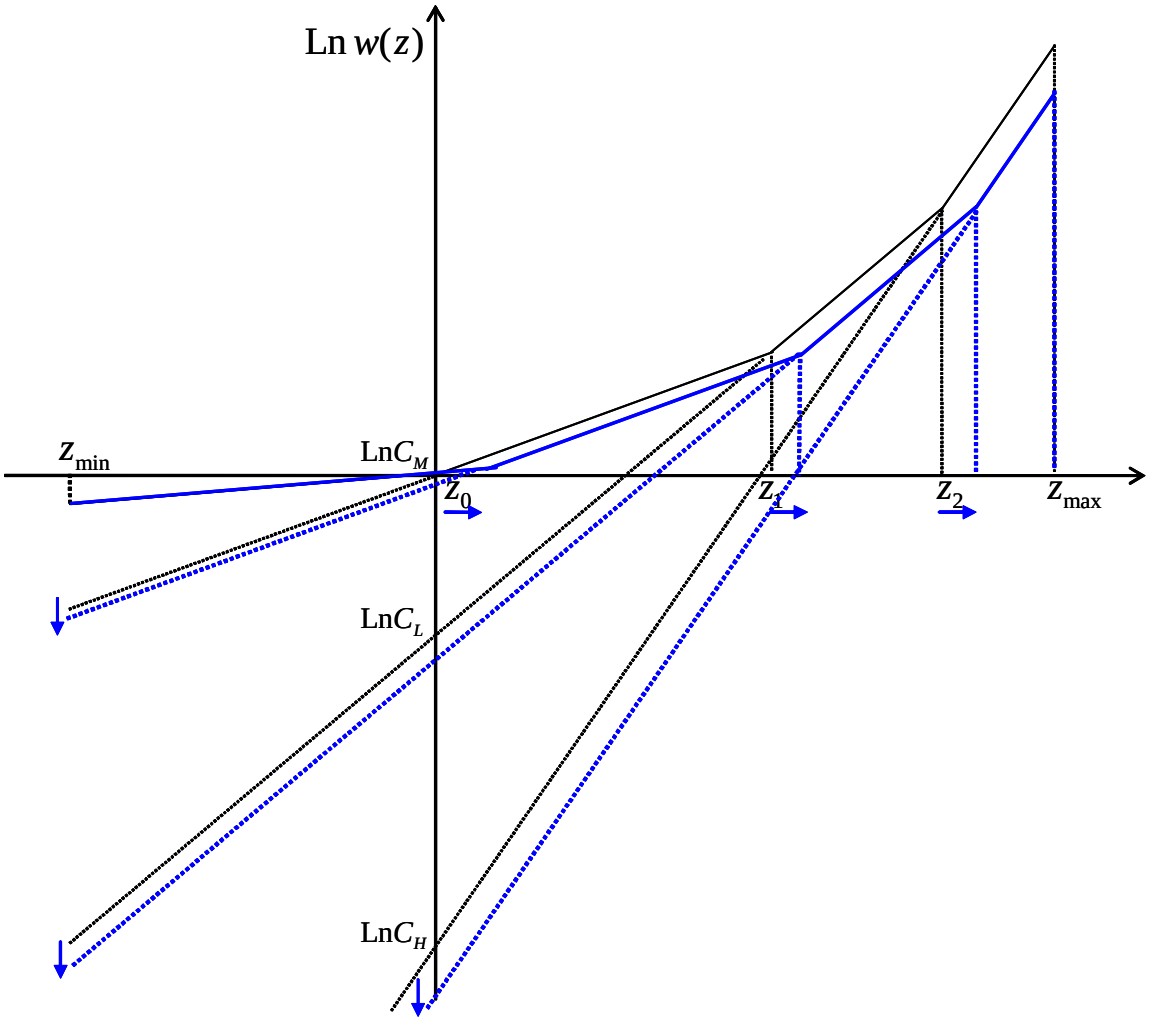


Figure 5: The effect of population ageing on the equilibrium wage distribution.

6 A numerical appraisal

In this section, we use a numerical version of our model to confirm our previous discussions and conclusions.

6.1 The initial equilibrium

For household preferences, we choose:

$$\beta = 0.80$$

$$\sigma = 4$$

and a uniform density distribution $g(z)$ of skills.

Technologies are assumed log-linear, consistently with Figure 1. We set:

$$\begin{aligned}
\text{Ln } \varphi_Y(z) &\approx 0.930 * z \\
\text{Ln } \varphi_M(z) &= 1.10 * \text{Ln } \varphi_Y(z) \\
\text{Ln } \varphi_L(z) &\approx 1.435 * z \\
\text{Ln } \varphi_H(z) &= 1.10 * \text{Ln } \varphi_L(z).
\end{aligned}$$

Empirical evidence on the level of the fixed costs is scarce but it is generally thought that the total fixed costs of a vertically fragmented firm is less than twice those of a domestic firm. We choose the following relative fixed costs:

$$\begin{aligned}
F_L &= 1.00 \\
F_H + F_I &= 1.62.
\end{aligned}$$

The previous assumptions on the technologies imply a calibrated value of $\theta \approx 0.90$. The equilibrium skill thresholds are then chosen as:

$$\begin{aligned}
z_{\min} &\approx -0.65 \\
z_0 &= 0.0 \\
z_1 &= 0.70 \\
z2 &= 1.00 \\
z_{\max} &\approx 1.05.
\end{aligned}$$

With these parameter values, we are able to compute the initial equilibrium, characterized by the following employment shares, GNP shares, and relative efficiency wages by activities:

	Employment shares	***GDP shares***	***Efficiency Wages***
Y	38 %	20 %	1.000
M	41 %	42 %	.941
L	18 %	32 %	.541
H	3 %	6 %	.427

These shares are quite reasonable, which suggests that the values chosen for the parameters bear some realism.

6.2 Numerical appraisal of each hypothesis

Table 1 reports the computed effects (as % deviations from base case) of the three alternative shocks on job shares, efficiency and average wages by activities, as well as wage inequality measures. The results are also graphed in Figures 6, as indices.

To get these numbers, the following shocks have been implemented: for RBTC, we multiply Ln $\varphi_M(z)$ by 2%; to capture the effect of increasing globalization, we reduce F_I by 1%;[17] an ageing population is assumed to reduce its consumption share β by 2%. The size of the shocks has been chosen so as to yield effects of approximately the same magnitudes: we have checked that none of the qualitative results depend on the amplitude of the shocks within the range consistent with an interior solution.[18]

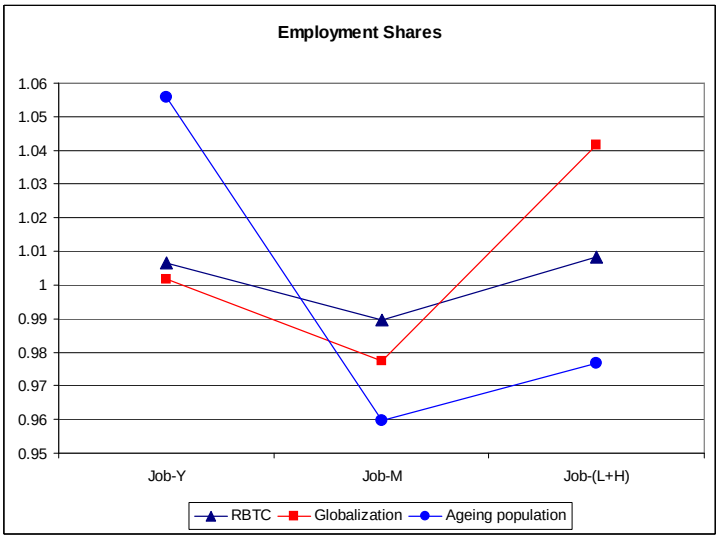
It is immediate to check that, of the three considered, the only two exogenous forces that can claim to cause job and efficiency wage polarization are those underlying the RBTC and the globalization explanations. Behind their apparently very similar effects, however, sharp differences emerge between the two when looking at average wages: the globalization-induced contraction of employment volumes in middling jobs comes with a fall in average labor earnings which, as we know from our theoretical discussion, is not only due to a possible composition effect, but to the fact that all workers that remain in those activities see their wages eroded in equal proportions. With RBTC, in contrast, rising wage inequalities tend to counter –or to add-up to– skill composition changes.

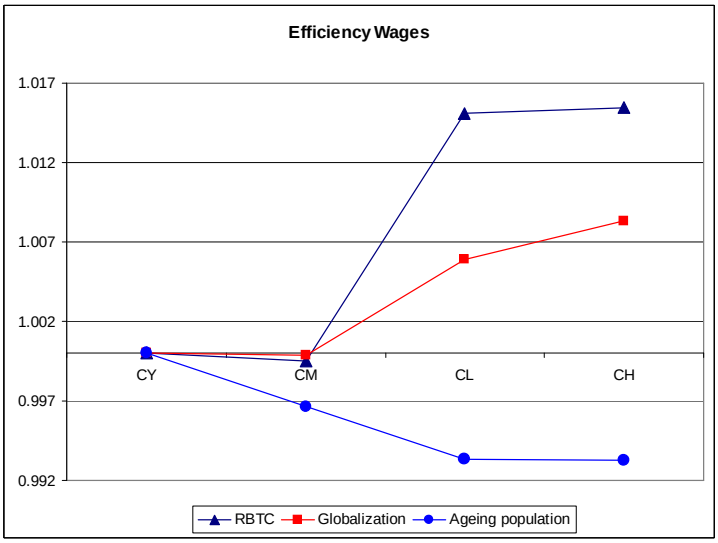
[17] We have checked that reducing θ has indeed the same qualitative effects.

[18] All multinational H firms exit from the market in some cases when the shock is excessively large.

	RBTC	***Globalization***	***Ageing population***
Employment shares			
Y	0.669	0.180	5.590
M	-1.036	-2.243	-4.017
L	0.170	-0.779	-2.543
H	5.021	35.337	-1.095
$L+H$	0.836	4.178	-2.344
Efficiency wages			
C_Y	0.000	0.000	0.000
C_M	-0.049	-0.011	-0.337
C_L	1.510	0.587	-0.670
C_H	1.545	0.830	-0.677
Average wage per job			
Y	0.223	0.060	1.881
M	0.786	-0.787	1.786
L	1.127	-1.665	-0.135
H	1.355	-0.483	-0.089
$L+H$	1.321	-0.324	-0.637
Wage inequality			
Log(90/10)	1.056	0.412	-0.474
Log(90/50)	1.482	0.776	-0.435
Log(50/10)	0.552	-0.017	-0.519

Table 1: Computed effects of alternative shocks (% changes)





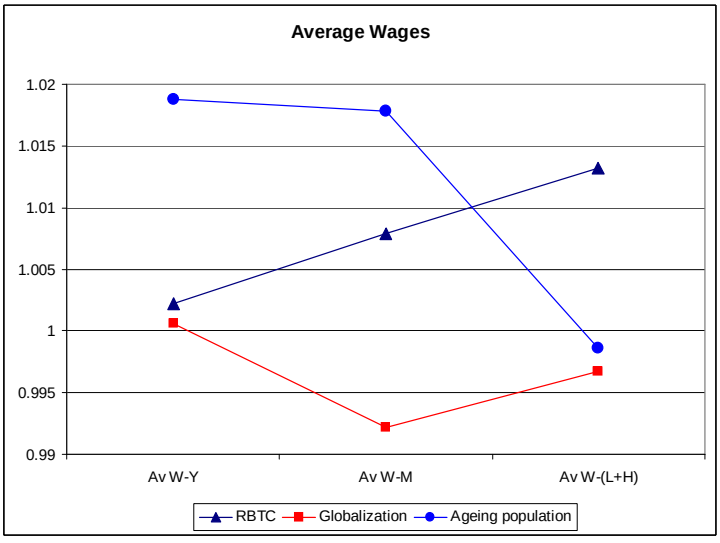


Figure 6: Effects on employment shares, efficiency and average wages (indices).

7 Conclusion

In this paper, we have proposed a simple two-sector general model of an economy in a globalized world. We have investigated how well alternative shocks that have been proposed in the literature are able to explain the recent observed transformations of the labor market. Our theoretical discussion has concluded that the routinization-biased technical change is the only one that seems to be able to reproduce the stylized facts: rising employment shares at the two extremes of the skill ladder, efficiency wage polarization, and monotonously rising average wages as occupations become more skill intensive. Numerical simulations have been reported that confirm this conclusion.

References

[1] Autor D., F. Levy and R. Murnane, 2003, "The Skill Content of Recent Technological Change: An Empirical Exploration", *Quarterly Journal of Economics* 118(4), pp. 1279-1233.

[2] Autor D., L. Katz and M. Kearney, 2006, "Measuring and Interpreting Trends in Economic Inequality", *American Economic Review* 96(2), pp. 189-194.

[3] Blanchard E. and G. Willmann, 2008, "Trade, Education and the Shrinking Middel Class", mimeo.

[4] Card D. and J.E. DiNardo, 2002, "Skill-Biased Technical Change and Rising Wage Inequality: Some Problems and Puzzles", *Journal of Labor Economics* 20(4), pp. 733-783.

[5] Conyon M.J., S. Girma, S. Thompson and P.W. Wright, 2002, "The Productivity and Wage Effects of Foreign Acquisition in the United Kingdom", *Journal of Industrial Economics*, 50 (1), pp. 85-102.

[6] Doms M.E. and J.B. Jensen, 1998, "Comparing Wages, Skills, and Productivity between Domestically and Foreign-Owned Manufacturing Establishments in the United Sates", in R.E. Baldwin, R.E. Lipsey and J.D. Richardson (eds), *Geography and ownership as bases for economic accounting*, NBER Studies in Income and Wealth, Vol. 59, University of Chicago Press, pp.235-255.

[7] Feenstra R.C. and G.H. Hanson, 1999, "The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the United States, 1979-1990", *Quarterly Journal of Economics*, 114 (3), pp. 907-940.

[8] Freeman R.B., 2003, "Trade Wars: The Exaggerated Impact of Trade in Economic Debate", NBER working paper.

[9] Goldin C. and L. Katz, 2007, "Long Run Changes in the Wage Structure: Narrowing, Widening, Polarizing", *Brookings Papers on Economic Activity*, #2, pp. 135-165.

[10] Goos and Manning, 2007, "Lousy and Lovely Jobs: the Rising polarization of Work in Britain", *Review of Economics and Statistics* 89(1), pp. 118-133.

[11] Goos, Manning and Salomons, 2009, "Job Polarization in Europe", *American Economic Review* forthcoming.

[12] Green F. and S. McIntosh, 2002, "Is there a Genuine Underutilisation of Skills Amongst the Over-Qualified", LSE CEP working paper.

[13] Head K. and J. Ries, 2002, "Offshore production and skill upgrading by Japanese manufacturing firms", *Journal of International Economics* 58 (1), pp. 81-105.

[14] Helpman E., M.J. Melitz and S.R. Yeaple, 2004, "Export versus FDI with Heterogeneous Firms", *American Economic Review* 94(1), pp. 300-316.

[15] Hansson P., 2005, "Skill Upgrading and Production Transfer within Swedish Multinationals in the 1990s", *Scandinavian Journal of Economics* 107 (4), pp. 673-692.

[16] Jung, J. and J. Mercenier, 2008, "A Simple Model of Offshore Outsourcing, Technology Upgrading and Welfare", mimeo.

[17] Katz L.F. and D.H. Autor, 1999, "Changes in the Wage Structure and Earnings Inequality" in O. Ashenfelter and D. Card (eds), *Handbook of Labor Economics*, Vol 3A, North-Holland, pp. 1463-1555.

[18] Lemieux T., 2006, "Increasing Residual Wage Inequality: Composition Effects, Noisy Data, or Rising Demand for Skill?", *American Economic Review* 96 (3), pp. 461-498.

[19] Navaretti G.B., D. Castellani and A. Disdier, 2006, "How Does Investing in Cheap Labour Countries Affect Performance at Home? France and Italy", CEPR Discussion Paper No. 5765.

[20] Spitz A., 2006, "Technical Change, Job Tasks, and Rising Educational Demands: Looking Outside the Wage Structure", *Journal of Labor Economics* 24 (2), pp. 235-270.

[21] Yeaple, S., 2005, "A simple model of firm heterogeneity, international trade, and wages", *Journal of International Economics* 65 (1), pp. 1-20.