Offshoring, Skill Distribution and Growth

Jaewon Jung

August 2011
Preliminary and incomplete

Abstract

This paper explores the impact of offshoring and changes in skill distribution on growth when firms and workers are heterogeneous. First, the model highlights four offshoring-and-growth links: redistribution effect, de-industrialization effect, technology-upgrading effect and South-industrialization effect, of which the first two slow growth while the latter two stimulate it so that the total effect is ambiguous. Second, the paper also highlights the important role of workers’ skill distribution in explaining market structure: market share of multinationals relative to national firms tends to be larger with more worker heterogeneity at a given skewness, while skill polarization leads to very ambiguous results. Finally, the model is explored numerically and highlights a potential conflict between short-term and long-term gains, which is quite different depending on the impact and the worker’s skill ladder.

Keywords: Endogenous growth, Firm/worker heterogeneity, Skill distribution, Inequality, Globalization

JEL codes: F43, F16, F23
1 Introduction

Even though most mainstream economists view globalization as an overall beneficial phenomenon for all, the issue still fuels political debates in developed countries on the consequences of the rapid integration of cheap labor countries such as China, India, the Eastern European countries, into the world economy. Many think the displacement of manufacturing activities to the South as job exporting, that will leave domestic workers massively unemployed and altogether slow down the growth of the home economy.

Many papers in the endogenous growth literature have tried to investigate the growth effect of globalization and acknowledged the pro-growth effects of openness. See among others, Rivera-Batiz and Romer (1991 a,b), Grossman and Helpman (1990, 1991), Young (1991), Baldwin and Forslid (1999, 2000) and Peretto (2003). Most papers in this literature have focused on trade between two symmetric countries and highlight the trade-and-growth links. Rivera-Batiz and Romer (1991 a,b) identify what they call the redundancy effect, the integration effect, and the reallocation effect of trade on the growth; Grossman and Helpman (1990, 1991) introduce an alternative decomposition of effects: the market size, the redundancy, the international knowledge spillover, and the allocation effects. However, their analyses do not say much on the potential consequences of the recent massive production-relocation phenomenon to the South. Furthermore, most papers in this literature are built on the simplifying assumption of homogenous agents, an overly simplistic assumption in view of the recent literature on heterogeneous firms.

One exception is found in Baldwin and Robert-Nicoud (2008) which explores the growth effects of greater openness when firms are heterogeneous. Embedding a heterogeneous firm trade model in a series of product-innovation endogenous growth models, they find that freer trade has an ambiguous impact on growth and there may be a tension between the dynamic and static welfare effects when greater openness would slow growth. However, they also only consider trade between two identical countries so that their analysis provides little guidance on the potential effects of the ongoing massive North-to-South offshoring phenomenon. It is the ambition of this paper to shed some light on the potential effects of the rise of offshore outsourcing on growth.

For this, we extend Jung and Mercenier (2008) –hereafter J-M(2008)– to a North-
South endogenous growth model. We are able to highlight four offshoring-and-growth links, which we call the \textit{redistribution effect}, the \textit{de-industrialization effect}, the \textit{technology upgrading through selection effect} and the \textit{South-industrialization effect}. Indeed, by pushing up relative wages of the most skilled workers, globalization tends to increase the marginal production cost in the R&D sector which slows growth: this is the redistribution effect. De-industrialization effect because of the displacement of some manufacturing activities to the South and the destruction of some (indeed, predominantly low-tech) domestic firms can only diminish, every thing else equal, the demand for R&D goods: this too will contribute to slow down the accumulation of knowledge capital, which is anti-growth. Globalization also induces a technology upgrading (selection) effect: the demand for capital rises thanks to the newly transformed MNs. Lastly, income rises in the South because of local industrialization, inducing new firms to enter and forward-looking capitalists to invest more. These two effects stimulate growth. The balance between the two pro- and the two anti-growth effects is theoretically ambiguous.

A numerical exploration of our set-up roughly calibrated on real-world data suggests that the technology upgrading and the South-industrialization effects together largely dominate the sum of the other two negative effects. We also highlight that, though the short-term welfare of the low skilled workers could be negatively affected by globalization, the long-term gains are large enough to ensure that their intertemporal welfare index rises.

Furthermore, the paper also highlights the important role of workers’ skill distribution in explaining market structure. Market share of multinationals relative to national firms tends to be larger with more worker heterogeneity at a given skewness. However, more worker heterogeneity accompanied by higher skewness (skill polarization) leads to very ambiguous results: in particular, it is shown by numerical simulation that skill polarization leads to a non-monotonous (inverse U-shaped) growth rate. We explore the model numerically and highlight that short-term and long-term welfare implications are quite different depending on the impact and the worker’s skill ladder.

The paper is organized as follows. In section 2, we extend the static model of J-M(2008) to an endogenous growth model using the Tobin’s $q$ approach following Baldwin and Forslid (2000). In section 3 and 4, we briefly discuss the effects of globalization and changes in skill distribution. Numerical results are reported in section 5 and a brief section
concludes.

2 The model

We extend the static one-sector model of J-M (2008) to an endogenous growth model with two sectors: manufacturing $X$ and innovation $I$.

2.1 Households

The infinitely lived representative consumer in the North has preferences:

$$\int_{t=0}^{\infty} e^{-\rho t} \ln(\text{Con}(t)) dt$$  \hspace{1cm} (1)

and industry $X$ supplies a continuum of differentiated varieties:

$$X = \left[ \int_{i \in N} x(i) \frac{1}{\sigma} \right]^{\frac{1}{\sigma - 1}}$$  \hspace{1cm} (2)

with $\text{Con}(t) = \frac{E(t)}{P_X(t)}$ and $P_X(t) = \left[ \int_{i \in N(t)} p(i, t)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}}$  \hspace{1cm} (3)

where $\rho > 0$ is the discount rate, and $\sigma > 1$ is the elasticity of substitution among varieties. Total consumption expenditure in the North is:\footnote{To ease notation, we drop the time index when no confusion can arise.}

$$E = \text{Rev}_L + \text{Rev}_K - \text{Inv}$$  \hspace{1cm} (4)

where $\text{Rev}_L$ is total labor earning, $\text{Rev}_K$ is the income earned from owning the assets that constitute the fixed costs of manufacturing ($X$-sector) firms, and $\text{Inv}$ is savings. Households’ utility optimization yields a CES demand for each variety:

$$x(i) = \left( \frac{P_X}{p(i)} \right)^{\sigma} X.$$  \hspace{1cm} (5)

Domestic households also supply labor from a continuum of workers with unit mass, differentiated by skill level $z$ with cumulative exogenously given distribution $G(z)$ on support $[0, \infty)$. 

1
2.2 Firms and innovation

Output $x(i)$ of any variety requires combining two types of activities within a firm: we refer to the first as conceptual activities associated with producing headquarter services, and to the second as repetitive tasks associated with the production of intermediate material inputs, respectively in amount $y(i)$ and $m(i)$. These tasks need not be performed in the same geographic location. We assume a Leontief production function with units chosen so that:

$$x(i) = y(i) = m(i).$$  \hspace{1cm} (6)

Both activities are performed by workers using Ricardian technologies. When entering the market, these firms incur a set-up cost in the form of blue-prints which they purchase from the innovation sector $I$. Headquarter services can only be produced in the home country, the North, either using a high- ($H$) or a low- ($L$) technology. Adopting the high technology requires $F_H$ units of R&D good (or knowledge capital), whereas opting for the low technology necessitates $F_L$ units of blue-prints. Technology $H$ is more expensive to set-up but cheaper to operate than technology $L$ 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.

Firms also choose where to produce their intermediate material inputs: domestically with an $M$ technology, at marginal cost $C_M$, or in the South where unit production cost $\theta C_M$ is lower: $\theta < 1$.\footnote{This cost can obviously be interpreted as including transportation costs.} To engage in offshoring firms face an additional cost of $F_I$ units of the knowledge good. The total stock of knowledge capital $K$ in the North is therefore:

$$K = F_L N_L + (F_H + F_I) N_H$$  \hspace{1cm} (7)

where $N_L$ and $N_H$ denote the number of each firm type. There is now considerable evidence that multinational (MN) firms use more productive technologies than non-MNs,\footnote{It is widely documented that affiliates of multinationals are more productive than national firms; see for example Doms and Jensen (1998), Conyon, Girma, Thompson and Wright (2002). In addition, Helpman, Melitz and Yeaple (2004) highlight also that MNEs are substantially more productive than non-MNE exporters which outperform significantly purely domestic ones.}
so we choose $F_I$ and $\theta$ such that only firms using the $H$ technology find it profitable to offshore outsource the production of their intermediate inputs. We define for future use $\theta_j = 1, \theta$ for $j = L, H$.

Finally, firms differ from one another 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 $j \in \{M, L, H\}$. $\varphi_j(z)$ is continuous and increasing in $z$, so that any worker is absolutely more productive than another with lower skills when both are using the same technology $j$. We characterize comparative advantages as follows:

$$
0 < \frac{\partial \varphi_M(z)}{\partial z} \frac{1}{\varphi_M(z)} < \frac{\partial \varphi_L(z)}{\partial z} \frac{1}{\varphi_L(z)} < \frac{\partial \varphi_H(z)}{\partial z} \frac{1}{\varphi_H(z)}, \tag{8}
$$

with $\varphi_M(0) = \varphi_L(0) = \varphi_H(0) = 1$, so that a higher skilled worker is relatively more productive with more efficient technologies. With competitive labor markets, workers will sort in equilibrium between the three technology types according to their respective comparative advantages.\textsuperscript{4} Let $z_1$ and $z_2$ be equilibrium skill thresholds with $0 < z_1 < z_2$. Then, the least skilled workers with $z \in [0, z_1)$ will be employed to perform repetitive tasks, whereas the intermediate (with $z \in [z_1, z_2)$) and most talented (with $z \in [z_2, \infty)$) workers will be hired to perform conceptual activities in headquarters, respectively with low- and high-tech. See Figure 1, where we have assumed log-linear functional forms.\textsuperscript{5}

\textsuperscript{4}For ease of exposition, we assume in what follows that all three types of technologies are used in equilibrium.

\textsuperscript{5}Here log-linear functional forms were adopted only for graphical simplicity, but any more general functional forms, consistent with (8), could of course be adopted.
Worker \( z \) will earn a wage \( w(z) \) that reflects both its talent and the technology on which he is employed. The competitive wage distribution will therefore satisfy:

\[
w(z) = \begin{cases} 
C_M \varphi_M(z) & 0 \leq z < z_1 \\
C_L \varphi_L(z) & z_1 \leq z < z_2 \\
C_H \varphi_H(z) & z_2 \leq z 
\end{cases}
\]  

with the skill-threshold owners being indifferent, so that

\[
C_M \varphi_M(z_1) = C_L \varphi_L(z_1) \\
C_L \varphi_L(z_2) = C_H \varphi_H(z_2)
\]  

as is illustrated in Figure 2.
With $C_M$ chosen as numeraire, these two indifference conditions pin down the variable unit costs in the two other tasks:

\[
\begin{align*}
C_M &= 1 \\
C_L &= C_M \frac{\varphi_M(z_1)}{\varphi_L(z_1)} \\
C_H &= C_L \frac{\varphi_L(z_2)}{\varphi_H(z_2)}.
\end{align*}
\]

Observe from (8) that $C_L$ and $C_H$ are decreasing respectively in $z_1$ and $z_2$.

Multinationals and non-multinationals compete on the output market. We assume monopolistic competition to prevail so that firms charge a constant mark-up rate over their marginal production costs:

\[
p_j = \frac{\sigma}{\sigma - 1} (C_j + \theta_j C_M) \quad j = L, H.
\]

Perfect competition is assumed to prevail in the $I$-sector. One unit of knowledge capital is produced with $a_I$ effective units of labor; we assume that in the R&D sector, workers have access to the most efficient technologies, the high tech, so that their productivity index is $\varphi_H(z)$ using high-tech. As is common in this endogenous growth literature, we
assume that producing knowledge capital has a sector-wide positive externality: \( a_I \) falls as the cumulative output of the \( I \) sector rises. Formally:

\[
a_I = \frac{1}{\lambda K}
\]

with \( \lambda \) a parameter. The flow of new \( K \) produced is:

\[
Q_K = \frac{L_I}{a_I}
\]

where \( L_I \) is the \( I \)-sector’s effective labor employment. The marginal cost of producing \( K \) is therefore:

\[
C_K = C_H a_I.
\]

### 2.3 Equilibrium

All domestically performed repetitive tasks are done within low-tech firms; from the technology (6), it follows that:

\[
\int_0^{z_1} \varphi_M(z) dG(z) = \int_{z_1}^{z_2} \varphi_L(z) dG(z). \tag{16}
\]

Free entry ensures zero profits for both firm types, so that mark-up revenues exactly cover fixed costs:

\[
\frac{1}{\sigma} p_j x_j = \pi (F_j + \delta_j F_I) \quad j = L, H
\]

where \( \pi \) is the factor reward of \( K \), and \( \delta_j = \{0, 1\} \) for \( j = \{L, H\} \).

From labor-market equilibrium, we have:

\[
Rev_L = C_M \int_{Z_{Min}}^{z_1} \varphi_M(z) dG(z) + C_L \int_{z_1}^{z_2} \varphi_L(z) dG(z) + C_H \int_{z_2}^{Z_{Max}} \varphi_H(z) dG(z). \tag{18}
\]

MNs offshore the production of their manufacturing intermediates to the South, in equal amount to their domestic production of headquarter services: \( \int_{z_2}^{Z_{Max}} \varphi_H(z) dG(z) = L_I \), at marginal cost \( C_M^* < C_M \), so that:

\[
E^* = C_M^* \left\{ \int_{z_2}^{Z_{Max}} \varphi_H(z) dG(z) - L_I \right\}. \tag{19}
\]

To avoid unnecessary balance of payment complications, we conveniently assume that labor costs in the South are paid by multinationals in units of the consumption basket (2). It then follows that \( P_X X = E + E^* \).
2.4 Steady-state growth

Let \( g \) be the growth rate of \( K \). From (13) and (14), we have:

\[
g \equiv \frac{\dot{K}}{K} = \frac{Q_K}{K} = \lambda L_I
\]

(20)

and we know, from (7), that \( N_L \) and \( N_H \) will grow at the rate \( g \).

Owners of \( K \) earn the operating profits (Ricardian surplus) \( \pi \) so that \( Rev_K = \pi K \), where

\[
\pi = \frac{E + E^*}{\sigma K}
\]

(21)
given that final goods are produced in the North only. Saving-Investment equilibrium imposes that:

\[
Inv = C_H L_I.
\]

(22)

It then follows from (4) and (21) that:

\[
E = \frac{\sigma (Rev_L - Inv) + E^*}{\sigma - 1}.
\]

(23)

In the steady state, with invariant \( Z_1 \) and \( Z_2 \), \( Rev_L, Inv \) and \( E^* \) all remain constant, as well as \( E \) so that \( \dot{E} = 0 \) and the Euler equation therefore yields:

\[
r = \rho.
\]

(24)

Observe that \( \dot{L}_I = 0 \) implies from (20) that \( g \) is time invariant in the steady state: we now proceed to determine the steady-state level of real investment \( L_I \). For this, we define Tobin’s \( q \). Its numerator, the market value of an asset, reflects the discounted stream of expected future income that it yields. In the steady state,

\[
V(0) \equiv \int_{t=0}^{\infty} e^{-\tau(t)} \pi(t) dt = \frac{\pi_0}{\rho + g}
\]

(25)

that is, the income stream is discounted at \( \rho \) and falls at the rate \( g \) from (21). The denominator of Tobin’s \( q \) is the replacement cost of capital, which is \( C_H a_I \) from (15). Making use of (21), (25), (15) and (23) gives:

\[
q = \frac{Rev_L + E^* - C_H L_I}{(\sigma - 1) C_H (\rho + g)}
\]

(26)
which, along a constant growth path, is equal to unity. The steady-state real investment level immediately follows from imposing this condition:

$$L_I = \frac{Revl + E^*}{\sigma C_H} - \frac{\rho}{\lambda} \left(1 - \frac{1}{\sigma}\right).$$  \hfill (27)

Making use of (20), the steady-state growth rate finally emerges as:

$$g = \frac{\lambda(Revl + E^*)}{\sigma C_H} - \frac{\rho}{\lambda} \left(1 - \frac{1}{\sigma}\right).$$  \hfill (28)

3 Globalization

Rising globalization naturally takes two non-exclusive forms in this model: a fall of the fixed cost of engaging in offshore outsourcing activities ($dF_I < 0$), and a reduction of marginal cost of producing material inputs abroad ($d\theta < 0$), the latter interpreted to include transportation costs. Both shocks provide a competitive advantage to multinational firms, and, albeit through slightly different channels, yield identical qualitative equilibrium effects. We therefore restrict our definition of globalization to the first.

We start by showing how the skill threshold $z_1$ and $z_2$ are affected by globalization. Totally differentiating equilibrium condition (16), we get:

$$\frac{dz_1}{dz_2} = \frac{\varphi_L(z_2)dG(z_2)}{\varphi_M(z_1)dG(z_1) + \varphi_L(z_1)dG(z_1)},$$  \hfill (29)

an expression that is unambiguously positive so that $z_1$ and $z_2$ move in the same direction. The reason is transparent: less labor used domestically for repetitive tasks ($dz_1 < 0$) can only imply a contraction of aggregate activity by non multinationals ($dz_2 < 0$) and, therefore, an expansion of total employment in multinational firms. Consider next the revenue ratio between a MN and a non-MN firm: from equilibrium condition (17) we have:

$$\frac{p_Hx_H}{p_Lx_L} = \frac{F_H + F_I}{F_L}$$

where prices and output can be substituted out with (12) and (5); rearranging, we get:

$$\left[\frac{C_H + \theta CM}{C_L + CM}\right]^{\frac{1}{1-\sigma}} = \left[\frac{F_H + F_I}{F_L}\right].$$  \hfill (30)
We learn from this equality that the equilibrium marginal-cost gap between MNs and non-MNs will narrow as $F_I$ is reduced. Making use of (11) we obtain

$$\frac{\varphi_M(z_1) \varphi_L(z_2)}{\varphi_L(z_1) \varphi_M(z_2)} + \theta = \left[ \frac{F_H + F_I}{F_L} \right]^{\frac{1}{1-\sigma}}.$$

(31)

Here, the initial input price ratio in the final good of each firm type might play a role. We assume:

$$\frac{\theta}{C_M} < \frac{C_H}{C_L},$$

(32)

implying that the price advantage of MNs comes relatively more from adopting offshoring technology (using cheap labor in the South and producing more cheaply intermediate materials) than producing headquarter service inputs more cheaply. Then, from our characterization (8) of technologies and the fact that, see (29), $z_1$ and $z_2$ move in the same direction, it is easy to check that the only possibility is for both $C_H$ and $C_L$ to increase, the first more than the second as the two skill thresholds move leftward. Globalization therefore affects the equilibrium wage distribution in this economy as illustrated in Figure 3.
Now we consider the growth effect of globalization.\(^6\) Remember that \(L_I\) effective units of labor of \(\int_{z_2}^{Z_{Max}} \varphi_H(z)dG(z)\) are employed in the \(I\)-sector and produce \(K\). In this model, perpetual growth follows from the fact that accumulation of new knowledge capital reduces the production cost of future innovations: see (13). Therefore, globalization affects growth by its effects on the economy’s aggregate need for knowledge capital. We can identify four different channels by which globalization will impact on growth.

To do this, let us rewrite (27) as:

\[
L_I = \frac{C_M + C_L}{(\sigma - 1)C_H} \text{Output}_L + \frac{1}{\sigma - 1} \text{Output}_H + \frac{C^*_M}{(\sigma - 1)C_H} \text{Output}_M^* - \frac{\rho}{\lambda} \tag{33}
\]

where \(\text{Output}_L = \int_{z_1}^{z_2} \varphi_L(z)dG(z) = \int_{Z_{Min}}^{Z_{Max}} \varphi_M(z)dG(z)\), \(\text{Output}_H = \int_{z_2}^{Z_{Max}} \varphi_H(z)dG(z)\) –

\(^6\)How individual firm behavior and industry concentration are affected is shown in J-M (2008). The only difference in J-M (2008) should be that the fixed costs of firms take the form of foregone outputs.
and \[ \text{Output}_{M^*} = \text{Output}_H. \] (These equalities immediately follow from our Leontief technologies.) We now identify:

1. A *redistribution effect* associated with the term \[ \frac{C_M + C_L}{(\sigma - 1)C_H}. \] Globalization increases the relative wage of the most skilled workers so that the relative replacement cost of capital increases from (15). By this channel, globalization harms growth.

2. A *de-industrialization effect* can be associated to the term \[ \int_{Z_{Min}}^{Z_{Max}} \varphi_M(z)dG(z). \] Globalization induces displacement of manufacturing activities to low-cost countries with a resulting contraction of activity by low-tech producers in the North (a fall in \( Z_1 \)). This depresses demand for knowledge capital by the domestic-only firms, and therefore affects negatively the steady-state growth rate.

3. A *technology-upgrading effect* emerges from the term \[ \frac{1}{\sigma - 1} \text{Output}_H. \] By making offshore outsourcing increasingly attractive, globalization boosts up the number of multinational firms and therefore the demand for knowledge capital. These new MNs are of course incumbent, previously domestic-only firms, that have switched to high technology and adopted offshore outsourcing. Doing so, they increase their demand for blue-prints (setting up the high technology costs more than setting up the low technology). By changing the incentive for firms to adopt more expensive to set-up but more productive technologies, globalization induces more growth.

4. A *South-industrialization effect*. The last term in (33), \[ \frac{C_M}{(\sigma - 1)C_H} \text{Output}_{M^*}, \] represents the industrialization effect in the South. Displacement of manufacturing activities to the South contributes to income increases in the South, and therefore demand for final goods. This market expansion attracts new firms purchasing new knowledge capital. This again contributes positively to growth.

Unfortunately, it is analytically impossible to determine which of these positive or negative forces will dominate, so we shall have to rely on simulations to get a feeling of the relative magnitude. This we do in Section 5.

Concerning the welfare effects of globalization, again, ambiguity prevails. Note that in this model the relative price of knowledge capital that constitutes the fixed costs affects crucially entry of firms, which was not the case in the static model of J-M (2008). Globalization attracts more low-tech firms to adopt high technology. Since switching to high technology requires greater knowledge capital, increased demand will lead to a rise in its
price so that total entry of firms is affected negatively. If such negative effect would be large enough, then the consumption price index could rise from (3), so that at least the least skilled workers are affected negatively. However, even though it would be the case, if globalization would generate positive growth effect and thus faster creation of new firms ever after, then their long-term gains or losses are ambiguous. In Section 5, we explore numerically to evaluate the intertemporal welfare effects of globalization.

4 Skill distribution

So far we have seen the effects of globalization at any given skill distribution $G(z)$. In this section, we consider the effects of skill distribution. We assume a log-normal distribution with probability density function:

$$
\frac{1}{z\sqrt{2\pi\varepsilon^2}}e^{-\frac{(\ln z - \mu)^2}{2\varepsilon^2}}, \quad z \in (0, +\infty)
$$

(34)

with variance: $(e^\varepsilon^2 - 1)e^{2\mu + \varepsilon^2}$ and skewness: $(e^{\varepsilon^2} + 2)\sqrt{e^{\varepsilon^2} - 1}$, where $\mu$ and $\varepsilon$ are the parameters.

Helpman, Melitz and Yeaple (2004) shows that intra-industry firm heterogeneity plays an important role in explaining international trade and investment. In the same spirit, here we show that workers’ skill distribution plays an important role in explaining market structure and growth. Here again, we restrict our attention to the case where assumption (32) holds.

4.1 More worker heterogeneity (increase of $\mu$)

First, consider a more dispersed skill distribution without affecting the skewness: an increase of $\mu$. This induces less low-skilled ($M$-workers) and more middle- and high-skilled ($L$- and $H$-workers). For given $Z_2$ and from our technologies (6), $Z_1$ should be shifted to the right so that $C_L$ decreases. Note that the uni-directional move of $Z_1$ and $Z_2$ from (29) will not hold anymore in this case. From (30) and (32), it is easy to check that a fall in $C_L$ induces a decrease of $C_H$, with $dC_H < dC_L$. Consequently $Z_2$ should be shifted to the left from (11). Following Figure 4 illustrates how an increase of $\mu$ affects the equilibrium wage distribution in this economy.
Thus, in this case more worker heterogeneity induces a contraction of domestic non-MNs and an expansion of MNs, as the case of globalization. However, the welfare implications should be completely different from those of globalization: here surprisingly, the least skilled workers gain the most (or lose the least) among the 3 types workers.

Now let us consider how such changes will impact on growth. We identify again four different channels from (33). We have again a negative de-industrialization effect, a positive technology-upgrading effect and a positive South-industrialization effect, as the case of globalization. However, it seems that one difference emerges concerning redistribution effect: here \( \frac{C_M + C_L}{(\sigma-1)C_H} \) seems to increase even though we have \( dC_H < dC_L \). Skill upgrading of the population by an increase of \( \mu \) decreases the relative wage of the most skilled workers so that the relative replacement cost of capital decreases, which stimulates the growth.
4.2 Skill polarization (increase of $\varepsilon$)

Now we consider a more dispersed skill distribution, but also more skewed. Recently, many labor economists report polarization of skills with rising jobs at the extremes of skill distribution since the early 90s, due to e.g. domestic technological change (Routinization-Biased Technical Change) and globalization, etc.\(^7\) Even though the model should be too simple to address fully this literature, our heterogeneous workers framework allows to consider how skill polarization would affect the income distribution and the growth. We consider an increase of $\varepsilon$ of our log-normal skill distribution (34). Following Figure 5 illustrates the impact of such change.

\(^7\)There is now ample evidence of this phenomenon in most developed countries. For this literature, see Jung and Mercenier (2010) and the references therein.
For given $Z_2$ and from our technologies (6), now $Z_1$ should be shifted to the left so that $C_L$ increases. Then, again from (30) and (32), we know that a rise in $C_L$ will induce an increase of $C_H$, with $dC_H < dC_L$: $Z_2$ shifts to the right.

Thus, in this case it would be the middling $L$-workers who gain the most, if any. However, here we have very ambiguous market concentration effect: how such change will affect domestic non-MNs activities and MNs activities should depend highly on the technology gaps between the 3 technologies, and the resulting variations of $Z_1$ and $Z_2$ given those gaps. Consequently, the impacts on the growth channels are ambiguous except for $\frac{C_M + C_L}{(\sigma - 1)C_H}$, which seems to decrease. Such large ambiguity might give rise to a non-monotonous growth rate. We explore this by simulations in the next section.

5 A numerical appraisal

5.1 Calibration

We characterize the initial equilibrium so that (i) domestic production $M$-workers represent 70% of the population, (ii) the share of non-production activities in total value added from labor is 42%, (iii) the share of total production that is due to MNs is 14%, and (iv) the initial growth rate is 3%, the average U.S. real GDP growth rate between 1980 to 2006. We normalize the skill level: $z \in [0, 1]$, and by scale adjustment keep the total labor supply to be unity. Here, we assume linear technologies for the reason of integrability with log-normal distribution. Finally, we set $\sigma=4$ as the benchmark value for the differentiation elasticity in preferences. Following table summarizes the chosen and calibrated parameter values and Figure 6 displays the three calibrated technologies.

<table>
<thead>
<tr>
<th>$Z_{Min}$</th>
<th>$Z_{Max}$</th>
<th>$\mu$</th>
<th>$\varepsilon$</th>
<th>$\sigma$</th>
<th>$\theta$</th>
<th>$F_L$</th>
<th>$F_H$</th>
<th>$F_I$</th>
<th>$\rho$</th>
<th>$\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0</td>
<td>$-1.309$</td>
<td>0.938</td>
<td>4.0</td>
<td>0.771</td>
<td>1.633</td>
<td>1.793</td>
<td>1.034</td>
<td>0.055</td>
<td>0.078</td>
</tr>
</tbody>
</table>
5.2 Effects of globalization

Globalization here again is implemented as a fall in the offshoring set-up costs $F_I$. In all figures below, $F_I$ is reported on the horizontal axis.

Of the four offshoring and growth links identified in the previous section, the two positive effect, *i.e.*, the technology upgrading and South-industrialization effects, largely dominate the other two. Resources are attracted into the innovation sector ($L_I$ increases) and growth accelerates: see Figure 7. In our benchmark case with $\sigma = 4$, the growth rate increases from 3.00% to 3.17% following a drift of $F_I$ from its initial value where MNs account for 14% of the $X$-sector activity to one where this share is close to 20%.
Figure 8 reports on the impact of globalization on prices. As previously highlighted, globalization induces a static redistribution effect so that $p_H$ and $p_L$ increase with $dp_H > dp_L$, and by boosting the demand for blue-prints that constitute the fixed costs, prices for these assets $\pi$ rise strongly.

The strong relative increase of $\pi$ w.r. to $p_L$ and $p_H$ affects negatively entry of firms: a negative market size effect follows with a fall in the total number of firms, as Figure 9 reports.
Both $p_L$ and $p_H$ rise, as already reported, and product diversity for consumers is reduced, so that globalization unambiguously boosts up the consumption price index $P_X$: see Figure 10.

The resulting welfare effects on the four typical households in this population, are reported in Figure 11. These can be appreciated by considering the following indices $\frac{\Delta H}{P_X}$, $\frac{\Delta L}{P_X}$, $\frac{\Delta H}{P_X}$ and $\frac{\pi}{P_X}$. Capitalists unquestionably gain the most whereas the least-skilled workers face an instantaneous real income loss.
This welfare conclusion is of course incomplete since it does not take into account the
dynamic gains to be reaped from growth. The economy jumps on a new growth path
where new firms (of both types) enter the market at an equal and higher-than-before rate,
so that $P_X$ decreases ever after. (From (7), (20) and (3) $P_X^{-1}$ is seen to grow at rate $\frac{g}{\sigma-1}$).

To evaluate the intertemporal welfare consequences of globalization on blue-collar
workers, we compute the equivalent variation index $\phi$ from the following utility indifference condition:

$$\int_{t=0}^{\infty} e^{-(\rho-\frac{g_0}{\sigma-1})t} \frac{C_M}{P_{X_0}} (1 + \phi) \, dt = \int_{t=0}^{\infty} e^{-(\rho-\frac{g_1}{\sigma-1})t} \frac{C_M}{P_{X_1}} \, dt$$

(35)

where subscripts 0 and 1 respectively indicate before and after globalization. In Figure
12, we report the computed values of $\phi$ for these workers. We see that, for every value of
$F_L$, the dynamic gains are large enough to compensate for the negative impact effect.
Finally, we are interested in how globalization affects income inequality, and what is the induced relationship between the income inequality and the growth rate. In Figure 13, we report the income inequality effect of globalization, measured by the Gini index, and Figure 14 displays the ratio between Gini index and the growth rate, which rises monotonously.

---

Fig.12: Intertemporal welfare gain of the low skilled

---

Fig.13: Income inequality effect of globalization

---

8The Gini index was calculated approximately by linear discretization of Lorenz curve, but using sufficiently small intervals. Here 1000 intervals were imposed between $Z_{Min}$ and $Z_{Max}$.
5.3 Skill distribution

5.3.1 Effects of more worker heterogeneity (increase of $\mu$)

Now we report the effects of more worker heterogeneity: first, the case of more dispersed skill distribution at a given skewness. In all figures below, $\mu$ is reported on the horizontal axis. Figure 15 report on the impact of an increase of $\mu$ on task prices. As discussed before, an increase of $\mu$ induces falls of both $C_L$ and $C_H$, with $dC_H < dC_L$. 

Fig.14: Impact of globalization on $\frac{g}{Gini}$
Skill upgrading of the population by an increase of $\mu$ affects positively the activities of MNs, so that more domestic firms adopt high-technology and turn to MNs. Following Figure 16 shows the resulting positive growth effect.

Figure 17 and 18 show the consequent instantaneous and intertemporal welfare effects.
Finally, Figure 19 and 20 display the impact on income inequality and the ratio between Gini index and the growth rate, in the case of an increase of $\mu$. 
5.3.2 Effects of skill polarization (increase of $\varepsilon$)

Below we report the effects of skill polarization. In all figures below, $\varepsilon$ is reported on the horizontal axis.
Fig. 21: Impact of an increase of $\varepsilon$ on task prices

Fig. 22: Growth effect of an increase of $\varepsilon$
Fig. 23: Welfare effect on the population

Fig. 24: Intertemporal welfare effect
5.3.3 Scale effect of growth & skill distribution

Most models in endogenous growth literature where the discovery of new (non-rivalrous) ideas is the engine of growth predict positive relationship between the size of the population
and the growth rate, which is strongly at odds with empirical evidences. This paper might
give an answer to this. From (27) and (28), we have also scale effect. However, from (18)
it should be clear that what matters is the skill distribution, and not the scale of the population itself.

Below we assume situations where population increase affects also either $\mu$ or $\varepsilon$: i) $\mu = \mu_0 \left( \frac{\text{Pop}}{\text{Pop}_0} \right)^{\eta_\mu}$ and ii) $\varepsilon = \varepsilon_0 \left( \frac{\text{Pop}}{\text{Pop}_0} \right)^{\eta_\varepsilon}$, where subscript 0 refers to the initial level. Figure 27 and 28 display how the same increase of population can be lead to different growth result depending on the elasticities, $\eta_\mu$ and $\eta_\varepsilon$.

![Figure 27: Scale effect of growth with a decrease of $\mu$](image)

\[ g (\eta_\mu = 0.0) \quad g (\eta_\mu = 0.5) \quad g (\eta_\mu = 1.0) \quad g (\eta_\mu = 1.5) \quad g (\eta_\mu = 2.0) \]

$\mu$ and $\varepsilon$ are negative initially.

\[ \mu = \mu_0 \left( \frac{\text{Pop}}{\text{Pop}_0} \right)^{\eta_\mu} \quad \varepsilon = \varepsilon_0 \left( \frac{\text{Pop}}{\text{Pop}_0} \right)^{\eta_\varepsilon} \]

Note that in our calibration $\mu$ is negative initially.
6 Conclusion

We have developed a North-South endogenous growth model and explored the growth effects of offshoring and changes in skill distribution when the North is populated by heterogeneous firms and workers. Using the Baldwin-Forslid (2000) Tobin q methodology, we have highlighted four growth links: a redistribution effect, a de-industrialization effect, a technology upgrading by selection effect and a South-industrialization effect. Because the first two of these effects tend to reduce growth, while the latter two contribute positively, the total effect is ambiguous.

A numerical exploration has suggested that the latter two effects tend to dominate, so that offshoring is likely to stimulate growth. We have highlighted a potential conflict between short-term losses due to static reallocations and long-term gains from improved growth prospect. This at least could be the case for those workers that are at the low end of the skill ladder: most blue-collar workers. Not surprisingly, capitalists and high-skilled white-collars never lose.

Furthermore, the paper also highlighted the important role of workers’ skill distribution in explaining market structure and growth, which might explain why scale effect of growth has not been supported empirically.
It goes without saying that our description of the innovative process as resulting from atomistic and perfectly competitive R&D firms is over-simplistic, though quite common in this literature. (This is presumably because it would only complicate the analysis without qualitatively changing the story; the quantitative evaluations could of course be significantly different.)

References


