On Modelling Task, Skill and Technology Upgrading Effects of Globalization with Heterogeneous Labor*

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Abstract

We adapt Yeaple's (2005) heterogeneous agents framework to model firms in the North as making explicit offshore outsourcing decisions to cheap-labor economies. We highlight how firms' technology transformations due to globalization will induce skill upgrading in the North, increase aggregate productivity, average wages and therefore total welfare at the cost of increased wage inequalities. We analytically derive conditions under which all consumers –including lower-skilled workers– might nevertheless gain from the surge of offshore outsourcing. We also show that extending the model to the more realistic case of multi-product firms tends to boost the potential welfare gains.

Keywords: Globalization; Offshore outsourcing; Technology upgrading; Skill upgrading; Task upgrading; Firm heterogeneity; Multi-product firms

JEL Classification: F12, F16, F23, F66

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1 Introduction

Recent revolutionary advances in transportation and communication technologies coupled with institutional progress in many cheap labor countries have provided firms in the North with strong new incentives to extensively adopt offshore outsourcing strategies and transfer larger parts of their production activities to the South. Though the transferred activities are bound to be dominantly low-tech manufacturing shifting the demand for production workers at home, some white collar jobs that were previously protected from foreign competition are now threatened by these new factor-cost saving opportunities. The prospect of massive offshoring in white collar services, and its potential negative welfare implications, has surged as a major political issue in the North today. Though the extent of outsourcing to low-wage countries is currently less than one might infer from media reports, it is hard to exclude the possibility that firms in the North could transfer much larger parts of their labor-intensive activities to the South. Assuming this does happen, and that Western multinationals start massively shipping products back to the home market, will that inevitably disrupt local labor markets?

Addressing this issue, Mankiw and Swagel (2006) note that, though there exists a large theoretical literature on the positive aspects of offshore outsourcing focusing on the factors influencing firms' choices of organizational structure and location of production, relatively little normative analysis is available on the welfare impact of offshoring. Most existing papers tend to suggest that offshore outsourcing is a modern form of trade, and that it will therefore almost inevitably imply that there are winners and losers –the curse of Stolper-Samuelson– the gains from the first being large enough however for the latter to be compensated.[1] Key to this Stolper-Samuelson prediction is the assumption that technologies are exogenously given. Our paper contributes to qualify this perception: we show that offshoring need not inevitably lead to lower welfare for domestic labor. The argument is that, by making profitable expensive-to-set-up but cheaper-to-operate technologies, globalization will induce domestic firms, as they turn multinational, to adopt more efficient technologies that previously existed but were too costly. Consequently, a potentially large subset of workers in the North is likely to be relocated to more productive

[1] See Deardorff (2005, 2006) for an illuminating discussion on this.

activities, earning better wages. There is ample evidence that this mechanism is of some empirical relevance. Indeed, it is well established that multinationals use better technologies and are therefore more efficient than their purely domestic competitors. Furthermore, Head and Ries (2002) have investigated 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: vertical specialization by multinationals does indeed seem to contribute to skill upgrading domestically.[2]

To model this mechanism, we adapt Yeaple (2005) to a North-South setting. Workers are heterogeneous by their (exogenously given) skill levels and therefore differ in their abilities to operate different technologies; firms are ex ante identical but become different by endogenously choosing among the available production technologies. Two types of tasks –"repetitive" versus "conceptual"– enter in the production process of two intermediate inputs, respectively "manufacturing" and "headquarter services", which enter complementarily in the production of final differentiated goods. The two tasks may be performed in different geographical locations: though conceptual tasks are exclusively performed in the North, repetitive tasks can also be performed in the South at lower cost than in the North. To produce headquarter services, two different technologies are available, a high fixed-cost low marginal-cost technology (the high tech) and a low fixed-cost high marginal-cost technology (the low tech). In equilibrium, workers will sort between production activities according to their abilities, with the ablest workers producing headquarter services and the less able producing manufacturing intermediates. Among non-production workers employed in headquarter services, the ablest will be employed by the high-tech firms. Since offshoring involves a fixed cost, a firm must have sufficiently large sales volumes for this activity to increase profits. Hence, only those firms that choose the high fixed-cost low marginal-cost technology will find it profitable to invest abroad, substituting cheap foreign

[2] 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.

labor for domestic labor in the production of manufacturing. Globalization is implemented as an exogenous reduction of the fixed cost of offshoring.[3] We demonstrate that this inevitably induces some initially low-tech domestic-only firms to technology upgrade as they turn multinationals. Consequently, some workers task upgrade as they are relocated to operate more efficient technologies, enhancing the economy's global productivity. Furthermore, the consecutive market size effect increases the set of product varieties available to consumers, in particular to the less-skilled.[4] We demonstrate that, under fairly mild conditions, real wages will rise even at the lower end of the skill ladder. These potential welfare gains are shown to increase when firms' product scope is made endogenous. To get a feeling of the quantitative effects involved, we run a few numerical simulations using a parameterized version of the model roughly calibrated on U.S. data.

We are not the first to reach such normative conclusions, though we use a very different modeling approach. An early paper by Feenstra and Hanson (1996) develops a Heckscher-Ohlin type model without factor-price equalization. They show that outsourcing leads to a productivity increase for firms which will lower the prices for final goods; this reduction in consumer prices, they stress, could exceed the fall in wages of the less-skilled workers. More recently, Grossman and Rossi-Hansberg (2007, 2008) also demonstrate that, depending on demand parameters, productivity growth induced by increased offshoring opportunities can benefit the factor intensely used in the sector with decreasing offshoring costs. An innovative aspect of their analysis is to focus, in a perfectly competitive environment, on the nature of tasks performed on the job; this, they advocate, is more relevant for a job's propensity to be offshored than either the skill-intensity of the occupation or the education level of the worker. The conceptual shift may prove extremely important (in particular for empirical investigations, see e.g., Becker, Ekholm and Muendler (2009)) but complexifies

[3] A drop in transportation costs will increase the cost advantage of multinationals, and hence yield identical qualitative results, as will become clear. Also, in some sectors of activity, Marshallian-type scale economies (externalities) can lead to dynamic productivity gains that will contribute to increase the competitive advantage of the South, and induce more firms to adopt offshore-outsourcing production strategies. Mitra and Ranjan (2008) strongly make this point, and develop an interesting dynamic model that rationalizes this latter mechanism, which we do not have in our model.

[4] See Broda and Weinstein (2006) for an empirical investigation of the gains from trade for the U.S. due to the worldwide expansion of available varieties of goods.

the theoretical analysis.[5] In contrast with the previous authors, we acknowledge the important role of economies of scale and within-firm scope decisions, and make imperfect competition an indispensable ingredient in the shaping of the new global economy.[6] In particular, we explicitly consider the effect of globalization on four firm-level decisions –entry, technology choice, whether or not to offshore outsource and the type of workers to employ– so that we can account for the observed fact that, to take advantage of the new low-cost opportunities, firms tend to upgrade technologically.[7] By modeling scope choices, we additionally highlight a globalization-induced rationalization effect –firms become more efficient by focusing on their core competence– and show that this tends to amplify the technology/skill upgrading mechanism, thereby leading to higher welfare gains. Our model remains nevertheless quite simple and the results intuitive. As we shall argue in the paper, the highlighted characteristics of firms that engage in offshore outsourcing is consistent with empirical evidence.

The paper is organized as follows: the model is laid down in Section 2 with single-product firms; the effects of globalization are analyzed in Section 3 with some numerical results reported in Section 4. We then extend the model to the case of multi-product firms in Section 5, and show that our previous conclusions are confirmed, and that the effects are amplified. The paper closes with a conclusion, followed by technical appendices.

2 The model

2.1 Households

Households are endowed with Dixit-Stiglitz preferences defined on a continuum of differentiated products. We write:

[5] Their result also hinges on an assumption on technical progress that raises questions: see Taylor (2006).

[6] Even though we focus on offshore outsourcing, our model could be seen as closely related to the traditional vertical FDI literature. See Helpman (1984) and Markusen (2002, Ch.9) for modeling of vertical MNEs under increasing returns to scale and imperfect competition.

[7] See e.g., Navaretti, Castellani and Disdier (2006) for a discussion on technological upgrading related to firms switching from national to multinational.

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

where N represents the mass of available varieties; $x^d(i)$ denotes consumption demand for each variety i and $\sigma = 1/(1-\rho)$ is a constant substitution elasticity between these varieties. Maximizing this homothetic utility function subject to income immediately yields the consumption demand system for varieties:

$$x^d(i) = \left(\frac{P_X}{p(i)} \right)^\sigma X \tag{2}$$

$$P_X = \left[\int_{i \in N} p(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} \tag{3}$$

where $p(i)$ is the market price for the i variety, and P_X is the aggregate consumption price index, the price of bundle X.

Households also supply labor. In the North, there is a continuum of workers differentiated by their skills, which we shall characterize by the single-dimensional skill index z. We focus in this paper on the endogenous assignment of workers to activities in the domestic economy –the North– and not on the process of skill acquisition, so we assume an exogenously given (cumulative) distribution $G(z)$ on support $[\underline{z}, \overline{z}]$; for simplicity of exposition, we shall further restrict the density to be uniform (even though our results do not require this). We shall refer to z indifferently as the worker's skill, or talent or ability.[8] Also, we abstract from modeling labor market adjustments in the South and assume labor is homogeneous and in infinite supply there, with given wages.

2.2 Firms and the labor market

There is a finite set of firms, each supplying a single differentiated variety i in amount $x(i)$. The production of any variety requires combining two types of activities within a firm: we loosely refer to the first as the "repetitive" or "blue-collar" activities associated with the production of intermediate material inputs, and to the second as the "conceptual" or "white-collar" activities associated with producing headquarter services. The two activities are performed by workers only, using Ricardian technologies (i.e. with fixed technical

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

coefficients). All workers are assumed to be perfectly substitutable in performing each activity, even though their productivity will differ reflecting both their individual abilities and the technology they are hired to operate.

Let $\varphi_M(z)$ be the productivity of worker z when producing intermediate material inputs; we impose that $\varphi_M(z)$ rises continuously with ability: $\frac{d\varphi_M(z)}{dz} > 0$. We set $\varphi_M(\underline{z}) = 1$, and normalize to unity C_M, the domestic marginal cost of producing M. Observe that this also sets to one the measured-in-efficiency-units wage associated with these activities. C_M will serve as our numeraire.

The two activities are assumed geographically separable so that the production of each input needs not be performed in the same location: firms have the possibility to offshore outsource the production of their material inputs to the South where the marginal production cost is lower, and assumed to be equal to θC_M, with $\theta < 1$.[9]

Offshore outsourcing however involves specific fixed costs $\widetilde{F_I}$. There is ample empirical evidence (a) that, everything else equal, multinationals (MNs) are systematically more efficient than non-MNs,[10] and (b) that when firms switch from national to multinational, they experience significant technological upgrading.[11] This clearly suggests that different technologies, some more efficient than others, are available, and that only a subset of firms, mostly multinationals, are able to take advantage of the best technologies, presumably because of the higher fixed costs involved. We capture this by introducing two different technologies for producing headquarter services, a high-productivity (H) and a low-productivity (L) technology. Technology H is cheaper to operate but more expensive to set-up than tech L so that $\widetilde{F_L} < \widetilde{F_H}$ and $C_L > C_H$, where $\widetilde{F_j}$ and C_j ($j = L, H$) denote respectively fixed and marginal production costs, and the subscript refers to technology types. We further assume –the conditions for this to be satisfied will be given later– that $\widetilde{F_I}$ and θ are such that, in equilibrium, only firms using the high technology are profitable enough to face the set-up cost of offshoring and therefore to take advantage

[9] This cost can obviously be interpreted as including transportation costs.

[10] See e.g., Doms and Jensen (1998), Conyon, Girma, Thompson and Wright (2002). Helpman, Melitz and Yeaple (2004) highlight that MNEs are substantially more productive than non-MNE exporters which outperform significantly purely domestic ones. See also Wagner (2011) and Schwörer (2013).

[11] See e.g., Navaretti, Castellani and Disdier (2006) for a discussion, and some empirical evidence, on technological upgrading related to firms switching from national to multinational.

of lower variable costs of producing material inputs abroad. Hence, all high-tech firms are multinationals, and all low-tech firms are domestic-only firms.

The two headquarter technologies $j = L, H$ are also assumed Ricardian in labor; firms are indifferent between perfectly substitutable workers with wages reflecting productivity that rises with ability: $\frac{d\varphi_j(z)}{dz} > 0$; without loss of generality, we set $\varphi_j(\underline{z}) = 1$.

We finally assume complementarity between blue-collar production $m(i)$ and headquarter services $y(i)$; hence, the two intermediate inputs are combined into a final variety using a Leontief technology; conveniently choosing units, we have for each firm i:

$$x(i) = m(i) = y(i). \tag{4}$$

Observe that our characterization of technologies ensures (a) that the marginal costs of the intermediate inputs – the C_M, C_L and C_H – are also the measured-in-efficiency-units wages associated with each technology; (b) that the marginal production cost of a final variety i is $(C_M + C_L)$ if produced by a domestic-only firm, or $(\theta C_M + C_H)$ if produced by a MN . We express, for future convenience, fixed costs in terms of forgone outputs so that $\widetilde{F_L} = (C_M + C_L)F_L$ and $\widetilde{F_H} + \widetilde{F_I} = (\theta C_M + C_H)(F_H + F_I)$.

In equilibrium, an individual worker's productivity will reflect both his talent and the specific activity he performs. We know that a worker with ability z is absolutely more productive than a lower-z worker if both are using the same technology. We now make the additional assumption that workers with higher z are relatively more efficient when operating more sophisticated technologies. Formally, we impose that

$$\frac{\partial\varphi_M(z)}{\partial z}\frac{1}{\varphi_M(z)} < \frac{\partial\varphi_L(z)}{\partial z}\frac{1}{\varphi_L(z)} < \frac{\partial\varphi_H(z)}{\partial z}\frac{1}{\varphi_H(z)} \quad . \tag{5}$$

This means that the least talented workers have a comparative advantage in performing blue-collar activities, whereas the most skilled workers have a comparative advantage in high-technology white-collar jobs. With competitive labor markets, workers will therefore sort in equilibrium between the three technology types according to their respective comparative advantages, and the continuum of workers is separated into three non overlapping segments of abilities.[12] Let z_1 and z_2 be equilibrium skill thresholds separating these categories of workers, with $\underline{z} < z_1 < z_2 < \overline{z}$. Then, the least skilled with $z \in [\underline{z}, z_1)$ will be

[12] We of course assume in what follows that the cost parameters take values such that all three types of technologies are used in equilibrium.

employed as blue-collar workers, whereas the intermediate (those with $z \in [z_1, z_2))$ and most talented (with $z \in [z_2, \overline{z}])$ workers will be hired to perform more conceptual activities in headquarters, respectively using the low-productivity or the high-productivity technologies. Figure 1 summarizes these assumptions for the particular case of log-linear functional forms, which we shall hereafter assume for ease of exposition.[13]

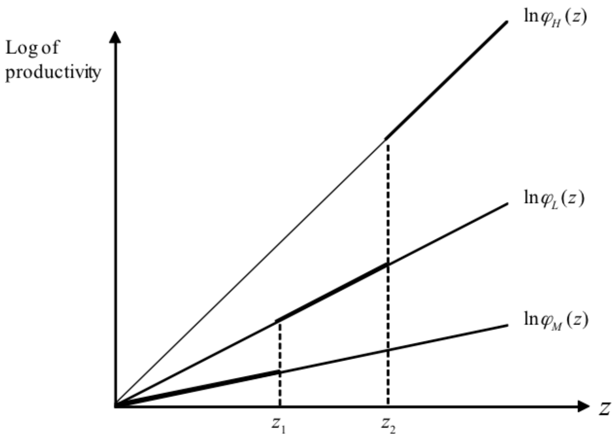

Figure 1: The technologies

Workers are paid at their marginal product, so that the equilibrium wage distribution satisfies:

$$w(z) = \begin{cases} C_M\varphi_M(z) & \underline{z} \leq z < z_1 \\ C_L\varphi_L(z) & z_1 \leq z < z_2 \\ C_H\varphi_H(z) & z_2 \leq z \leq \overline{z} \end{cases} \tag{6}$$

Individuals with skills z_1 and z_2 should have no incentive to relocate in equilibrium; the following two no-arbitrage conditions

$$\begin{aligned} C_M\varphi_M(z_1) &= C_L\varphi_L(z_1) \\ C_L\varphi_L(z_2) &= C_H\varphi_H(z_2) \end{aligned} \tag{7}$$

therefore tie together the three measured-in-efficiency-units wages and the marginal production costs $C_j,\ j = M, L, H$. Observe from (5) that $C_H < C_L < C_M = 1$ and that

[13] More general functional forms, consistent with our assumptions, exist and could be adopted, but that would drastically complicate the exposition with no additional insight gained.

C_L and C_H are decreasing in z_1 and z_2 respectively. With log-linear skill-productivity schedules, the equilibrium wage distribution is as illustrated in Figure 2.

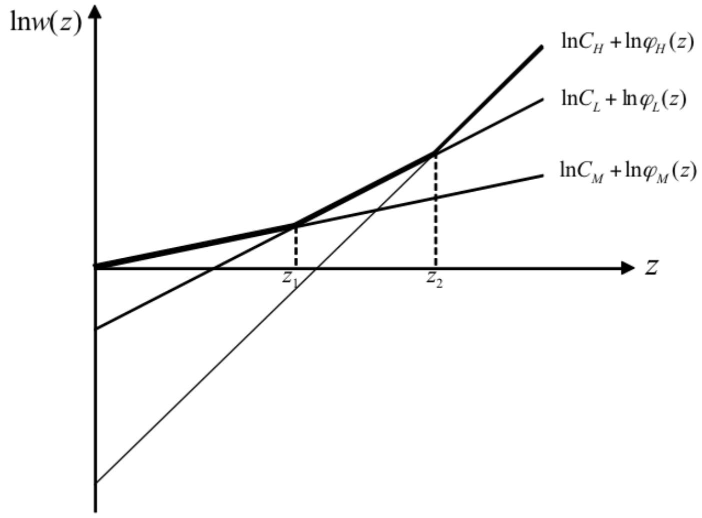

Figure 2: The wage distribution

We are not interested in unrealistically extreme cost differences between the North and the South in manufacturing[14], and shall restrict our attention to cases where [15]

$$C_H < C_L < \theta C_M < C_M. \tag{8}$$

Empirical evidence on the level of the fixed costs is scarce; we adopt the usual assumption (Markusen, 2002; The Knowledge-Capital Model) that the total fixed costs of a vertically fragmented firm is less than twice the fixed costs of a domestic firm, so that:

$$(\theta C_M + C_H)(F_H + F_I) < 2(C_M + C_L)F_L \ . \tag{9}$$

Multinationals and non-multinationals compete on the output market where marginal-cost pricing is clearly non sustainable because of the presence of fixed costs. We assume monopolistic competition to prevail; hence, with Dixit-Stiglitz preferences (1), producers

[14] See I.L.O. (2007) for unit labor cost comparisons.

[15] This restriction is by no means necessary for our results to hold, but prove sufficient to derive important analytical results.

will all charge an identical constant mark-up rate over marginal production costs. Symmetry prevails within each class of firms, so that we can index their variables by L or H according to the type of headquarter technologies they use. We have:

$$\begin{aligned} p_L &= \frac{\sigma}{\sigma - 1}(C_M + C_L) \qquad i \in N_L \\ p_H &= \frac{\sigma}{\sigma - 1}(\theta C_M + C_H) \qquad i \in N_H \end{aligned} \tag{10}$$

where N_L is the number of existing domestic-only producers, and N_H the number of MNs (hence, $N_L \cup N_H = N$). Observe that $p_H < p_L$ because of lower marginal costs: multinationals will charge lower prices than their domestic-only competitors, as realism suggests.

2.3 Equilibrium

Each firm's output meets the demand (2) for its own variety, so that:

$$\begin{aligned} x_L &= x^d(i) \qquad i \in N_L \\ x_H &= x^d(i) \qquad i \in N_H. \end{aligned} \tag{11}$$

From the Leontief technology (4) and our characterization of fixed costs as foregone output, it follows that the aggregate amount of headquarter services produced by each class of firm is:

$$\begin{aligned} \int_{z_1}^{z_2} \varphi_L(z) dG(z) &= N_L (x_L + F_L) \\ \int_{z_2}^{\overline{z}} \varphi_H(z) dG(z) &= N_H (x_H + F_H + F_I), \end{aligned} \tag{12}$$

and the balance between inputs within domestic-only firms requires that:

$$\int_{\underline{z}}^{z_1} \varphi_M(z) dG(z) = \int_{z_1}^{z_2} \varphi_L(z) dG(z). \tag{13}$$

Observe that these equilibrium conditions for goods, by determining z_1 and z_2, implicitly ensure that the labor market balances.

Because of free entry/exit of firms, no extra-normal profits can exist in equilibrium. Thus, mark-up revenues should exactly cover fixed production costs, and the number of each firm-type will adjust to ensure that:

$$\begin{aligned} \frac{1}{\sigma}p_L x_L &= (C_M + C_L)F_L & i \in N_L \\ \frac{1}{\sigma}p_H x_H &= (\theta C_M + C_H)(F_H + F_I) & i \in N_H \ . \end{aligned} \tag{14}$$

This implies that the individual firm's equilibrium output is constant.

Domestic income follows from full employment of domestic production factors:

$$Inc = C_M \int_{\underline{z}}^{z_1} \varphi_M(z)dG(z) + C_L \int_{z_1}^{z_2} \varphi_L(z)dG(z) + C_H \int_{z_2}^{\overline{z}} \varphi_H(z)dG(z) \tag{15}$$

and total wages paid to foreign workers by multinationals equal the total variable cost of producing material inputs abroad:

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

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 (1). It then follows that

$$P_X X = Inc + Inc^* \tag{17}$$

which completes the description of our model.[16]

Observe that our assumptions ensure that the equilibrium wage distribution is convex in this economy, as illustrated in Figure 2. An equilibrium therefore exists, and it is both globally unique and stable.

Observe also that the model could be generalized in various ways, making it more realistic albeit at the cost of additional complexity, with no qualitative effect on the predictions. For instance, blue-collar activities could be split into more than one sector of production, making (4) a two-level (nested) Leontief technology; provided all the technologies in the M-subsectors can be ranked as in (5) and placed to the left of those

[16] We have assumed that F_I and θ are such that only high-tech firms engage in offshore outsourcing. To exclude the possibility for a low-tech firm to turn multinational requires that the mark-up revenue it would then earn not be large enough to cover the set-up costs, that is:

$$\frac{1}{\sigma}p_L^* x_L^* < (\theta C_M + C_L)(F_L + F_I)$$

where $p_L^* = \frac{\sigma}{\sigma-1}(\theta C_M + C_L)$ and $x_L^* = \left[\frac{P_X}{p_L^*}\right]^\sigma X$, using (10), (11) and (2).

inequalities. Also, the assumption of input complementarity is by no means a necessary, but only a sufficient condition: relaxing this would only condition the conclusions to input substitutability not being too high.[17]

3 Globalization

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 the marginal cost of producing material inputs abroad ($d\theta < 0$), the latter interpreted to include transportation costs.[18] 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.

3.1 The mechanism

The intuition is fairly straightforward. Falling fixed costs increase profits of MNs: an increasing number of low-tech producers find it now profitable to turn multinational and switch to high-tech.[19] The economy therefore experiences technology upgrading. Aggregate output of MNs expands. Increasing the scale of offshored activities is no problem since labor is abundant enough in the South to leave unaffected the marginal production costs of these intermediate inputs; in the home country, however, labor will have to be pulled out of the domestic-only competitors. z_2 shifts leftward (say to $z_2^{'}$), as multinationals offer better wages: see Figure 3a. The measured-in-efficiency-units wage in high-tech headquarter activities must increase (from C_H to $C_H^{'}$) hence also benefiting to those workers with $z > z_2$ that were already previously employed by MNs.

[17] In a companion paper (Jung and Mercenier, 2010), we extend the present model to two final goods sectors. The model however becomes much more complicated, and analytical results are difficult to derive.

[18] Explicitly introducing ice-berg transportation costs is straightforward but only complicates without adding insight; it only affects income levels in the South.

[19] More rigorously, there is entry (exit) of high-tech (low-tech) firms. We shall formally establish that the number of H-creations exceeds the number of L-destructions.

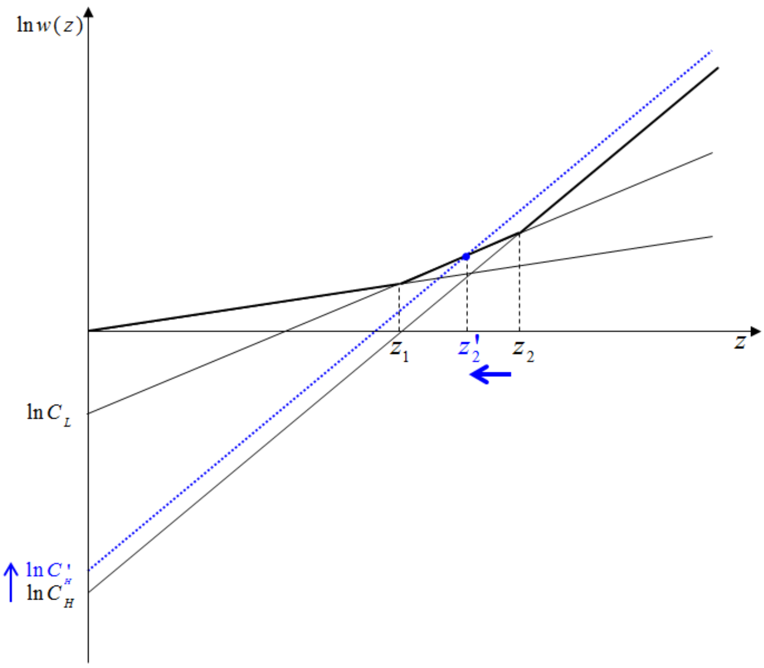

Figure 3a: Task upgrading of workers between non-MNs and MNs

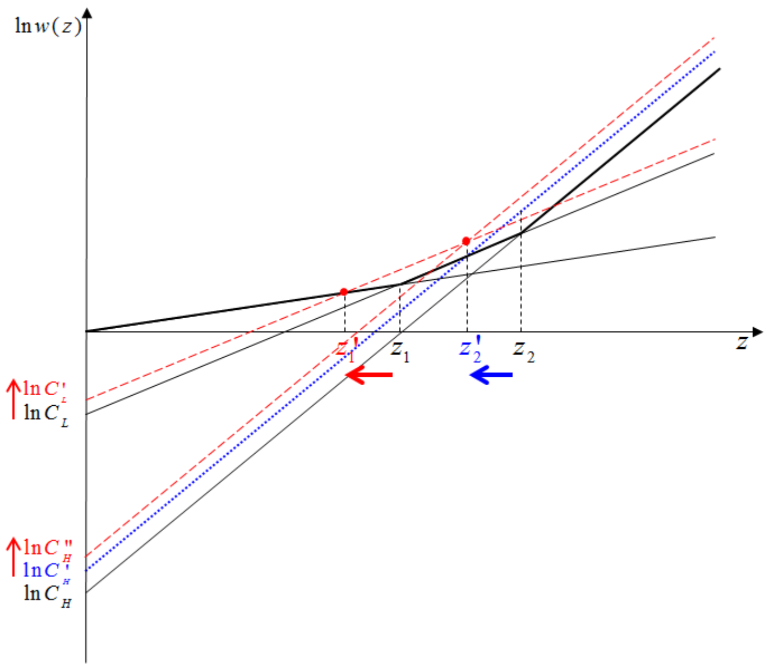

Figure 3b: Task upgrading of workers within non-MNs

The number of domestic-only firms falls, and so does their aggregate activity, with z_1 therefore being also shifted to the left (say to $z_1^{'}$) so as to restore the necessary balance between intermediate inputs: some workers, those with skills $z \in (z_1^{'}, z_1)$, are reallocated within the same low-tech firms to more sophisticated tasks. The workers experience task upgrading and the domestic-only firms experience skill upgrading. This, as is illustrated in Figure 3b, is achieved by increasing from C_L to $C_L^{'}$ the measured-in-efficiency-units wage in headquarter activities within these firms. By a general equilibrium effect, all workers with $z > z_2$ benefit from this wage increase, hence pushing C_H by an equal percentage further up.

Figure 3c displays the new equilibrium wage distribution.

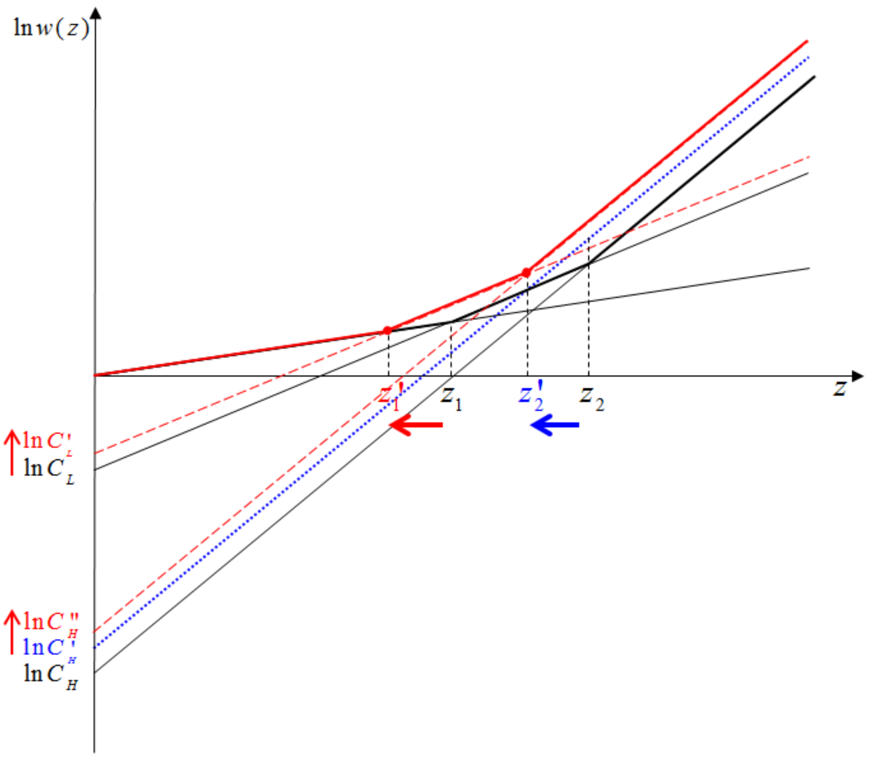

Figure 3c: The effects of globalization on the equilibrium wage distribution

To summarize, by indirectly reducing the barrier to high-technology adoption, globalization induces a subset of low-tech domestic-only firms to technology upgrade; this then requires of the surviving non-multinationals to skill upgrade, as some workers are task upgraded within these low-tech firms, and some others move to expanding high-tech MNs aggregate production. These two sets of workers become more productive and earn better wages. Such a mechanism is well documented, among others by Head and Ries (2002).[20]

We now confirm this intuitive discussion analytically, and derive welfare predictions.

3.2 The wage distribution

We start by showing how the equilibrium skill threshold z_1 and z_2 –and therefore the wage distribution– are affected by globalization. Totally differentiating equilibrium condition (13) yields an expression that is positive:

$$\frac{dz_1}{dz_2} = \frac{\varphi_L(z_2)dG(z_2)}{\varphi_M(z_1)dG(z_1) + \varphi_L(z_1)dG(z_1)} > 0 \ . \tag{18}$$

Hence, in equilibrium, z_1 and z_2 will unambiguously move in the same direction.[21] Consider next the revenue ratio between a MN and a non-MN firm: from equilibrium condition (14) we have:

$$\frac{p_H x_H}{p_L x_L} = \frac{(\theta C_M + C_H) \ \ (F_H + F_I)}{(C_M + C_L) \ \ F_L}$$

where prices and output can be substituted out using (10), (11) and (2); rearranging, we get:

$$\left[\frac{\theta C_M + C_H}{C_M + C_L}\right] = \left[\frac{F_H + F_I}{F_L}\right]^{-\frac{1}{\sigma}} . \tag{19}$$

The equilibrium marginal-cost ratio between MNs and non-MNs is inversely related to the ratio of their total fixed costs. Hence, the marginal-cost gap will narrow as F_I reduces. Making use of (7) and rearranging yields:

$$\frac{\frac{\varphi_M(z_1)}{\varphi_L(z_1)}\frac{\varphi_L(z_2)}{\varphi_H(z_2)} + \theta}{\frac{\varphi_M(z_1)}{\varphi_L(z_1)} + 1} = \left[\frac{F_H + F_I}{F_L}\right]^{-\frac{1}{\sigma}} . \tag{20}$$

[20] 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.

[21] Observe that this is not the case in Yeaple (2005).

From our characterization (5) of technologies and the fact that z_1 and z_2 move in the same direction, it is easy to check that the only possibility following a fall in F_I is for both C_H and C_L to increase, the first relatively more than the second, as the two skill thresholds move leftward. This confirms the intuition developed in the previous subsection: globalization affects the equilibrium wage distribution in this economy as illustrated in Figure 3c.

We summarize these findings in the following proposition:[22]

Proposition 1 *In this economy, globalization ($dF_I < 0$) unambiguously*

(a) lowers the equilibrium skill thresholds z_1 and z_2;

(b) increases the marginal-cost ratio of headquarter-services to manufacturing, both in MNs and in domestic-only firms, more so in the former;

(c) increases overall productivity, average wages, as well as wage inequalities.

Observe that, even though the average wage declines in the manufacturing sector, this is only a composition effect: for individual workers who remain in blue-collar jobs, wages remain unchanged in terms of the numeraire.

3.3 Individual firm behavior and industry concentration

We consider non-multinational firms first. It immediately follows from mark-up pricing (10) and free entry (14) that the individual non-MN's supply of final goods is proportional to its fixed production cost (expressed in real terms) and therefore remains constant: $x_L = (\sigma - 1)F_L$. We know from the leftward shift of z_1, and from the technology (4), that aggregate blue-collar employment in non-multinationals decreases, and so does their aggregate output: the number of domestic-only firms necessarily falls. Those firms that survive with L technologies do so by increasing the price of their output, an increase that is necessary to cover the higher wages paid to their headquarter workers (from (10) knowing that C_L is pushed up).

Consider next multinationals. We know from the previous discussion that the individual MN's output is unaffected by changes in marginal costs since its production scale

[22] A decreasing θ implies a mechanism that is slightly less direct: the price ratio p_L/p_H rises inducing demand substitutions away from the L varieties. This boosts the size of aggregate MN activities, with identical qualitative effect on z_1 and z_2.

is proportional to its fixed costs: $x_H = (\sigma - 1)(F_H + F_I)$; globalization, by reducing offshoring costs therefore unambiguously reduces the equilibrium MN firm size. We also know that the skill threshold z_2 is moved leftward which implies that the aggregate output of MNs increases. It therefore follows that the number of offshore outsourcing firms has unambiguously increased. Clearly, globalization has induced a number of domestic-only firms to upgrade their technologies and turn multinational; these new MN firms operate at larger scale than before, and sell final goods at cheaper prices than their surviving domestic-only competitors.

Hence, globalization implies both creation and destruction of firms. We now show that the net effect on the total number of firms is positive. From (13), (12), and the fact that output is proportional to fixed costs, we have:

$$\begin{aligned} \int_{\underline{z}}^{z_1} \varphi_M(z)dG(z) &= N_L\ \sigma F_L \qquad (21) \\ \int_{z_2}^{\overline{z}} \varphi_H(z)dG(z) &= N_H\ \sigma\,(F_H + F_I) \end{aligned}$$

Totally differentiating $N = N_L + N_H$ and making use of (18) yields

$$\frac{dN}{dz_2} = \frac{\varphi_M(z_1)dG(z_1)}{\sigma F_L(F_H + F_I)} \frac{dz_1}{dz_2} \left[(F_H + F_I) - \frac{\varphi_H(z_2)}{\varphi_L(z_2)} F_L (1 + \frac{\varphi_L(z_1)}{\varphi_M(z_1)}) \right] \ ;$$

using (7) one then obtains:

$$\frac{dN}{dz_2} = \frac{\varphi_M(z_1)dG(z_1)}{\sigma F_L(F_H + F_I)} \frac{dz_1}{dz_2} \left[(F_H + F_I) - \frac{C_M + C_L}{C_H} F_L \right]. \qquad (22)$$

Our assumptions (8) and (9) on technologies ensure that the term in brackets is unambiguously negative, which proves that globalization increases the total number of product varieties available to consumers.

We summarize these findings in the following proposition:

Proposition 2 *In this economy, globalization ($dF_I < 0$)*

(a) unambiguously reduces the number N_L of domestic-only firms and increases the number N_H of MNs;

(b) the net effect on the total number $N_L + N_H$ is unambiguously positive.

3.4 Welfare

We know that all workers see their wages increase in terms of the numeraire except those who remain attached to their blue-collar jobs within non-MN firms. It is shown in **Appendix 1** that the purchasing power of the average wage increases unambiguously, so that would be losers –the low-skilled– could always be compensated for by transfers from those who benefit from the new international environment.

We are more interested in the conditions under which low-wage workers will benefit from globalization even in absence of redistributive policies. We already know that for these workers with blue-collar jobs, wages remain unchanged in terms of the numeraire so that we need only focus our attention on the aggregate consumption price index (3), which we can rewrite as follows:

$$P_X = \left[N_L \; p_L^{1-\sigma} + N_H \; p_H^{1-\sigma}\right]^{\frac{1}{1-\sigma}} . \tag{23}$$

This makes it clear that globalization will impact on P_X through three different channels: by affecting the absolute price level of each varieties p_L and p_H; by affecting the total number of available varieties $N_L + N_H$; and finally by changing the relative weights of the different varieties in the consumption basket.

We know from Proposition 1 that globalization inflates wages in headquarter services with $d\ln C_H > d\ln C_L > 0$; from (10) it therefore follows that both p_L and p_H increase: this fist effect unambiguously redistributes welfare in favor of the headquarter workers at the expense of those that remain in blue-collar activities. We have also shown in Proposition 2 that globalization affects positively the total number of varieties available to consumers endowed with preferences (1) which satisfy the love-of-variety property. This second effect therefore clearly contributes positively to welfare of all workers by reducing the cost-of-living price index. Observe that these two effects are present in standard models of trade with Dixit-Stiglitz preferences and homogeneous monopolistically competitive firms, as in Krugman (1981), who refers to these as the "redistribution" and the "market-size" effects respectively. The two effects contribute to welfare with opposite signs, so that their net impact is ambiguous. From Krugman (1981) we know that the more final goods are differentiated –that is, the lower σ is– the more it is likely that market-size expansion gain from trade will outweigh the loss due to the redistribution effect.

Finally, specific to our setting, a composition effect emerges due to the existence of heterogeneous firms, that are differently affected by globalization. We know from Proposition 2 that a number of initially low-tech domestic-only firms transform into high-tech multinationals; what effect has this transformation on their output price? We know that they now produce their intermediate material inputs with cheaper labor reducing this marginal production cost by a factor $1-\theta$; however, they now face more costly headquarter services given that $dC_H > 0$, so that the impact on their final output price is yet ambiguous. It is easy to derive a sufficient condition for this price to fall. This will happen if $\frac{p_H^1}{p_L^0} = \frac{\theta C_M + C_H^1}{C_M + C_L^0} < 1$ where superscripts 0/1 refer to the firm's pre- and post-mutation variables respectively. Using (8), it follows that $\theta C_M + C_H^1 < 2\theta$ so that $p_H^1 < p_L^0$ if $\theta \leq \frac{C_M + C_L^0}{2}$, which in words means if international wage disparities of low-skilled labor is not too small, presumably the case that concerns us most. Under this reasonably mild sufficient condition, we therefore know that globalization will impact negatively on the price of the variety produced by the firms that turn multinational. This contributes positively to all workers' welfare, in particular to that of the low skilled. We call this composition effect the "selection effect of globalization": by changing the balance between the number of low- and high-productivity firms in favor of the latter, globalization acts as a selection devise in this world with heterogeneous firms. This "selection effect" adds to the market-size effect making the positive welfare outcome more likely, hence contributing to make the requirement on preferences less stringent.

We summarize these findings in the following proposition:

Proposition 3 *In this economy, the surge of offshore outsourcing needs not inevitably induce losers, even in absence of redistribution policies. The impact of globalization on the consumption price index P_X will be negative if varieties are sufficiently differentiated. If σ is not too large, even workers employed in activities that are most easily moved offshore will gain from globalization.*

Proof. *See **Appendix 2**.*[23] ■

[23] Our model abstracts from labor market adjustments in the South. Endogenizing wages in the South would only mitigate the welfare conclusions. To see this, consider the extreme case of inelastic labor supply abroad: as F_I decreases, wages in the South –and therefore θ– adjust upward constraining the aggregate volume of offshore production by MN firms to remain constant. z_1 and z_2 remain unchanged:

How realistic are the conditions for these welfare gains to materialize? We address this question in the next section by exploring numerically a parameterized version of the model roughly calibrated on U.S. data.

4 A numerical appraisal

4.1 Calibration

I.L.O. (2007) provides us with unit labor costs (relative to U.S.) in manufacturing for a number of cheap labor countries, from which we choose

$$\theta = 0.80 \; , \tag{24}$$

a value between those of Mexico and of the new E.U. Member States (Czech Republic, Hungary and Poland) in year 2002.

From Industry Statistics published by the U.S. Census Bureau (2002, Table 5, p.54) we choose

$$z_1 = 70\% \; , \tag{25}$$

as the ratio of the number of production workers to the total number of employees in Manufacturing in year 2002; from the same source, we pick the share of non-production activities in total value added from labor as:

$$\frac{C_L \int_{z_1}^{z_2} \varphi_L(z)dG(z) + C_H \int_{z_2}^{\overline{z}} \varphi_H(z)dG(z)}{C_M \int_{\underline{z}}^{z_1} \varphi_M(z)dG(z) + C_L \int_{z_1}^{z_2} \varphi_L(z)dG(z) + C_H \int_{z_2}^{\overline{z}} \varphi_H(z)dG(z)} = 42\% \; ; \tag{26}$$

we approximate the share of total production that is due to MN firms as the output share of establishments with 2500 or more employees:

$$\frac{\int_{z_2}^{\overline{z}} \varphi_H(z)dG(z)}{\int_{z_1}^{z_2} \varphi_L(z)dG(z) + \int_{z_2}^{\overline{z}} \varphi_H(z)dG(z)} = 14\% \; . \tag{27}$$

---

there is no technology upgrading by firms nor task upgrading by workers, and therefore no "selection effect" on welfare. From (10) we know that $dp_H > 0$ and from (21) that $dN_H > 0$: we have nothing more than the standard opposition between a "distribution loss" and a "market-size expansion gain" (Krugman, 1981). In this specific case, it is easy to see that the net effect is always positive. For this, consider (23); make use of (21) to substitute out N_L, N_H and then substitute out $F_H + F_I$ using (19); it follows that: $P_X = \frac{\sigma}{\sigma-1}\left[\frac{1}{\sigma F_L}\int_{\underline{z}}^{z_1}\varphi_M(z)dG(z)\left(C_M + C_L\right)^{1-\sigma} + \frac{1}{\sigma F_L}\int_{z_2}^{\overline{z}}\varphi_H(z)dG(z)\left(C_M + C_L\right)^{-\sigma}\left(\theta C_M + C_H\right)\right]^{\frac{1}{1-\sigma}}$. As F_I is reduced, everything remains constant in the RHS except θ that rises: P_X therefore unambiguously falls.

We have little guidance from empirical evidence on the fixed costs, which we choose somewhat arbitrarily within the ranges consistent with the constraints:[24]

$$F_L = 1.00;\ F_H = 1.18;\ F_I = 0.90\ . \tag{28}$$

We assume log-linear technologies (consistently with our graphical representations in previous sections) and particularize $G(z)$ to the case of a uniform distribution of talents with $\underline{z} = 0$ and $\overline{z} = 1$. Finally, we set

$$\sigma = 4 \tag{29}$$

as the benchmark value for the differentiation elasticity in preferences.

With this set of functional forms and parameter values, it is straightforward to calibrate the model: Figure 4 displays the three calibrated technologies.[25]

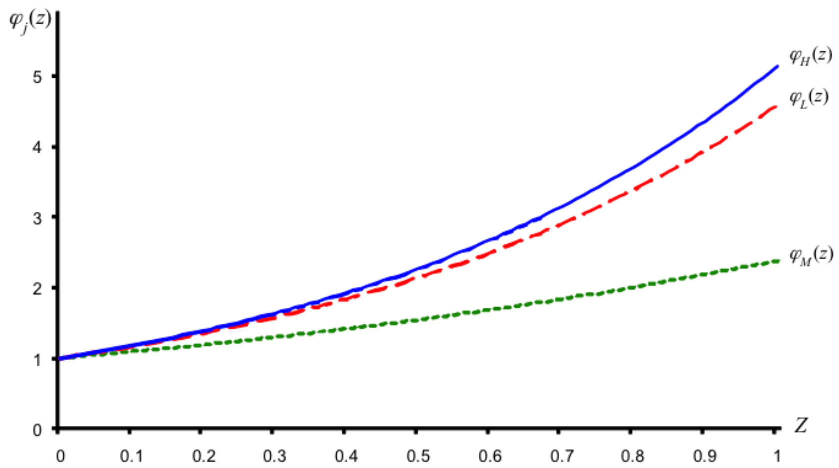

Figure 4: The three calibrated technologies

[24] In addition to constraints mentioned in a previous footnote, the theoretical consistency of the model imposes that: (a) some L-type firms exist, so that $\frac{1}{\sigma}p_L x_L \geq (C_M + C_L)\,F_L$; (b) all H-type firms adopt offshore outsourcing strategies so that $\frac{1}{\sigma}p_H x_H \geq (\theta C_M + C_H)\,(F_H + F_I)$ and $\frac{1}{\sigma}p_H^* x_H^* \leq (C_M + C_H)\,F_H$ where $p_H^* = \frac{\sigma}{\sigma-1}\,(C_M + C_H)$ and $x_H^* = \left[\frac{P_X}{p_H^*}\right]^{\sigma} X$. The value of F_H is actually chosen so that, at the initial equilibrium, $\frac{1}{\sigma}p_H^* x_H^* = (C_M + C_H)\,F_H$.

[25] **Appendix 3** reports the calibrated benchmark equilibrium values.

4.2 Welfare effects of globalization for alternative values of σ

Figure 5 reports the effect of globalization –measured on the horizontal axis by the level of the fixed cost of offshoring F_I– on the consumption price index P_X. Computations are reported for various values of the differentiation elasticity σ, and confirm our theoretical analysis.[26] We see that for realistic values of σ (i.e. for values not too different from 4) globalization comes with positive welfare gains even at the low-end of the skill ladder.

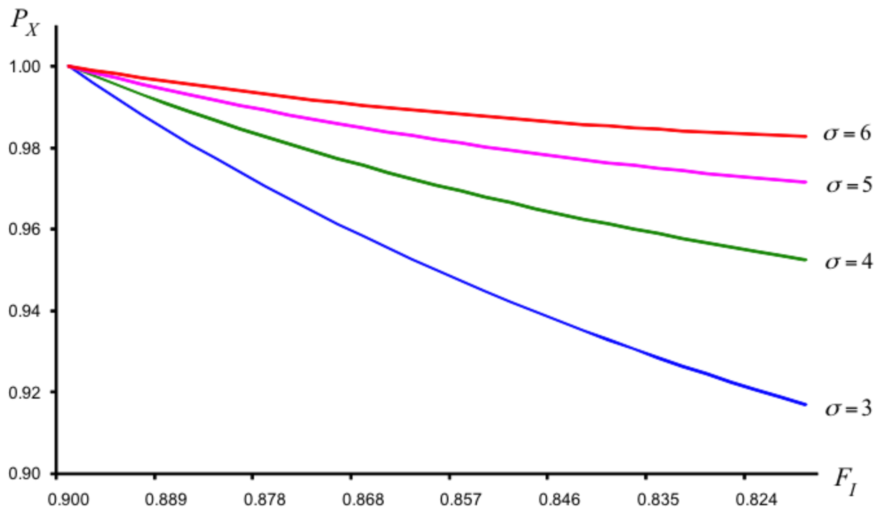

Figure 5: The impact of globalization on P_X (sensitivity with respect to σ)

How much of these results is due to the selection effect, and how much to the market-size expansion effect? We can get a rough idea of this by computing from (21) the impact on N_H of a reduction of F_I keeping z_2 constant, and comparing this with the equilibrium number of new MNs. In all the performed simulations, this ratio is just around 1%, which suggests that the selection effect contributes significantly to the welfare gains.

[26] Changing the values of σ obviously implies recalibrating the model. Doing this, we maintain conditions (25) to (27) and the values of F_L and F_I unchanged so as to keep z_2 and the marginal costs C_M, C_L, C_H unchanged; the two cost parameters that are affected are θ and F_H. To $\sigma \in [3, 6]$ are associated the calibrated values of $\theta \in [0.722, 0.867]$ and $F_H \in [1.132, 1.280]$. F_H is recalibrated so that $\frac{1}{\sigma} p_H^* x_H^* = (C_M + C_H) F_H$, as explained in footnote (24). See **Appendix 3** for more information on which of the equilibrium variables are unaffected by changes in σ.

5 Multi-product firms

Though convenient, the single-product firm apparatus bears little realism: as recently emphasized by Bernard, Redding and Schott (2010) among others, changes in product variety largely result from within-firm scope adjustment decisions rather than from entry/exit of producers in and out of an industry. Analytical work has furthermore emphasized how trade liberalization induced scope adjustments increase within-firm as well as overall productivity: see e.g. Bernard, Redding and Schott (2006), Eckel and Neary (2010) and Nocke and Yeaple (2008). In this section, we extend our analysis to a multi-product firm framework, and show that this move towards more realism only tends to reinforce our previous welfare conclusions.

5.1 Within-firm scope decisions

Individual firms now face the additional problem of deciding how many different varieties to produce. Let n_j be the number ($\in \Re$) of varieties produced by a single firm of type $j \in \{L, H\}$. Each extra variety will add to the fixed cost of production; we slightly adjust our previous notations and write the fixed costs as $F_j + n_j f_j + \delta_j F_I$, with $\delta_j = 0$ or 1 if $j = L$ or H. It is a widely documented fact in the corporate finance literature that there is a negative relationship between a firm's scope expansion and its overall productivity.[27] We acknowledge this by transforming the Leontief technology (4) as follows:

$$\lambda_j x_j = m_j = y_j \qquad j = L, H \tag{30}$$

where $\lambda_j = n_j^{\eta_j}$, $\eta_j > 0$, and x_j now refers to the amount produced of any single variety within a type-j firm. An individual firm's total operating profits now write as:

$$\begin{aligned} \pi_L &= n_L \left[p_L x_L - \lambda_L \left(C_M + C_L \right) \left(x_L + f_L \right) \right] \\ \pi_H &= n_H \left[p_H x_H - \lambda_H \left(\theta C_M + C_H \right) \left(x_H + f_H \right) \right] \end{aligned} \tag{31}$$

where we have expressed the variety-specific fixed costs as units of variety-specific foregone output. The first-order condition with respect to n_j immediately yields the optimal scope

[27] See Schoar (2002) and references therein. Using plant-level data, she finds that diversified conglomerates are more productive than stand-alone firms, but dynamically adding new products decreases the total factor productivity of all incumbent plants inside the firm.

choice:

$$(p_j - v_j)\, x_j - v_j f_j = n_j\, (x_j + f_j)\, \frac{\partial v_j}{\partial n_j} \qquad j = L, H \tag{32}$$

where v_j is the total marginal production cost of a variety in type-j firm ($v_L = \lambda_L\, (C_M + C_L)$ and $v_H = \lambda_H\, (\theta C_M + C_H)$) and $\frac{\partial v_j}{\partial n_j} = \frac{\eta_j}{n_j} v_j$. The LHS of (32) is the profit from adding a new variety, while the RHS represents the increased cost over all the infra-marginal products.

The free entry/exit conditions still hold, ensuring zero profits for both type firms in equilibrium:

$$\frac{1}{\sigma} n_j p_j x_j = v_j\, (F_j + n_j f_j + \delta_j F_I) \qquad j = L, H. \tag{33}$$

The rest of the model is either unchanged or to be amended in a trivial way that requires no comment.

5.2 Globalization

How will the presence of multi-product firms affect our previous welfare conclusions from globalization? We first evaluate how differently domestic-only and MNs are affected in their equilibrium scope decisions and sizes. From (32) and (33), we get:[28]

$$n_j = \frac{\left[1 - \eta_j(\sigma - 1)\right] (F_j + \delta_j F_I)}{\sigma \eta_j f_j} \qquad j = L, H. \tag{34}$$

Interestingly –though not unexpectedly– a fall in F_I, because it increases the number of competitors, reduces the optimal scope of MNs, while leaving unaffected that of the non-MNs. From (10) and (33), it follows that only the size of MNs (size measured as total sales) will be affected, indeed negatively so:

$$n_j x_j = (\sigma - 1)(F_j + n_j f_j + \delta_j F_I) \qquad j = L, H. \tag{35}$$

Given that the ratio $n_H / [F_H + F_I]$ is constant from (34), it immediately follows that our previous conclusion from (22) nevertheless remains true: the total number of varieties rises unambiguously $d(n_L N_L + n_H N_H) > 0$.

MNs have reduced the number of varieties produced to restore productivity. How will this rationalization affect the technology/skill/task upgrading mechanism described in the

[28] Obviously n_j cannot be negative which places an upper bound on η_j so that $\left[1 - \eta_j(\sigma - 1)\right] > 0$ which is innocuous given that η_j is clearly a very small number.

previous section? To answer this question, we have to consider the price ratio between MNs and non-MNs. From (33), (11) and (2), we know that:

$$\frac{p_H}{p_L} = \left[\left(\frac{F_L + n_L f_L}{F_H + F_I + n_H f_H} \right) \frac{n_H}{n_L} \right]^{\frac{1}{\sigma}} \tag{36}$$

and from (34) we learn that this remains constant. This is in sharp contrast with what we had in the single-product case. Indeed, from (19), we have seen that in the latter case, the output price ratio $\frac{p_H}{p_L}$ unambiguously increases as globalization proceeds. In the single-product case therefore, the leftward shift of both z_1 and z_2 contributes to push upwards both $\frac{C_H}{C_L}$ and $\frac{p_H}{p_L}$, so that the cost advantage of MNs is reduced as globalization proceeds. This tends to mitigate the technology/task upgrading mechanism, the more so as σ increases. In contrast, when scope choice is endogenous, the price ratio remains constant and the tech/skill/task upgrading are amplified.

We summarize these findings in the following proposition:

Proposition 4 *In this economy, other things equal, the fall in F_I will induce more technology, skill and task upgrading when firms are multi-product, and the positive welfare gains will be accordingly larger.*

The following numerical simulations illustrate this conclusion.

To ensure that the comparison between the two versions of the model is meaningful, we normalize n_L and n_H to unity at the initial equilibrium. We pick an *identical* (but arbitrary) value for η_L and η_H. For the benchmark case ($\sigma = 4$), we choose:

$$\eta_L = \eta_H = 0.29 \ . \tag{37}$$

The fixed costs are then calibrated, so that firms satisfy their optimal scope conditions (32) for unchanged values of the skill thresholds z_1 and z_2; we get:

$$F_L = 0.90; \quad F_H = 0.97; \quad f_L = 0.10; \quad f_H = 0.21 \ . \tag{38}$$

In this way, the two versions of the model reproduce the same base equilibrium. When performing sensitivity analyses with respect to σ, we adjust F_H and f_H but maintain the values of n_L, n_H unchanged: to $\sigma \in [3, 6]$ are associated the calibrated values $F_H \in [0.93, 1.06]$, $f_H \in [0.20, 0.22]$ and $\eta_L = \eta_H \in [0.43, 0.18]$.

Appendix 4 reports detailed numerical results. As is shown in Figure 6, the welfare gains are indeed amplified by the scope-rationalization mechanism, and this is true for every values of the differentiation elasticity σ.

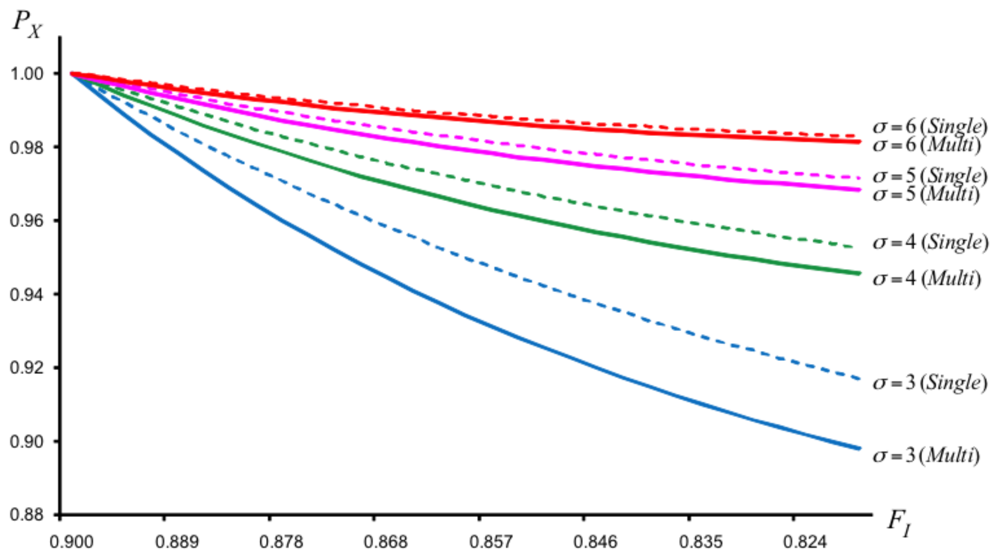

Figure 6: The impact of globalization on P_X (single- vs. multi-product cases compared)

6 Conclusion

It is widely believed both in academic and in policy circles, that globalization and offshore outsourcing to cheap labor countries will benefit some, mainly high-skilled workers within the North, at the expense of the others. Yet, up to now, empirical investigation fails to provide evidence in support of this view.[29] Furthermore, in Japan, a country where offshore outsourcing has been extensively practiced for decades, there seems to be strong evidence that vertical specialization by local multinationals has induced skill upgrading domestically (Head and Ries, 2002) with blue-collar workers being moved to more productive

[29] There is ample evidence highlighting how globalization has increased wage inequality between skilled and unskilled workers; see Feenstra and Hanson (2003) for an excellent survey on this literature. However, as Feenstra (2007) argues, so far there is no evidence that real wages of unskilled (production) workers are negatively impacted by outsourcing.

white-collar jobs within the same firms. This observed efficiency-improving reallocation of factors suggests that globalization need not be associated with falling real wages at the lower end of the skill ladder. Based on Yeaple (2005), we have developed a simple general equilibrium model with endogenously induced heterogeneity of firms from exogenously given skill heterogeneity of labor; these firms make explicit decisions on whether or not to geographically fragment their production to take advantage of more favorable cost-conditions offshore. As globalization proceeds, making increasingly profitable the displacement of manufacturing activities to low-cost countries, workers in the North are endogenously moved to less repetitive more productive tasks. We have shown analytically that, under reasonably mild conditions, real wages can rise even at the lower end of the skill ladder. These normative findings are strengthened when firms have the ability to endogenously adjust their scope decisions. Numerical exploration of the model roughly calibrated on U.S. data suggests that those conditions are not unrealistic. We believe that the basic mechanism behind our normative results, namely technology upgrading at the individual firm level and skill upgrading of workers, is simple enough to be plain to any citizen, and deemed quite reasonable by most. Yet, the implications are unlikely to be easily understood by non economists because they hinge on general equilibrium effects that are far more abstract. We think that the simplicity of the model will make those powerful general equilibrium effects more transparent, and hope that our paper will contribute to change the perception that globalization is a threat rather than an opportunity for all.

Needless to say, the model abstracts from some important elements of the real world, in particular labor market imperfections: introducing rigidities could indeed change the conclusions, at least in the short run.[30] But then the policy implication would clearly be that government action has to aim at reducing those imperfections, not at opposing to globalization as is often suggested: more rigid labor markets can only enhance the attractiveness to firms of offshore options. Rather than thwarting adjustment, public

[30] See Davidson, Matusz and Shevchenko (2008) for an analysis that includes heterogeneous labor and search. Mitra and Ranjan (2010) also explore the role of labor-market search frictions in a context of offshoring; they show that, in their two-sector set-up with unemployment, the unemployment rate always goes down and the wage rate always goes up in both sectors provided labor is not too immobile across sectors.

action should aim at protecting workers rather than jobs: this, in particular, calls for extensive and flexible re-training programs that could indeed be costly to set-up. But it is clear that such public action would in any case stand as a top priority even in absence of globalization, in view of the ongoing aging of populations in the North.

Appendix 1: Effect of globalization on the average wage

Let $\overline{w}$ be the average wage per worker; from (6) and (7):

$$\overline{w} = C_M \int_{\underline{z}}^{z_1} \varphi_M(z) dG(z) + C_L \int_{z_1}^{z_2} \varphi_L(z) dG(z) + C_H \int_{z_2}^{\overline{z}} \varphi_H(z) dG(z) \ ; \qquad (39)$$

making use of (13), $\overline{w}$ becomes:

$$\overline{w} = (C_M + C_L) \int_{\underline{z}}^{z_1} \varphi_M(z) dG(z) + C_H \int_{z_2}^{\overline{z}} \varphi_H(z) dG(z) \ . \qquad (40)$$

The consumption price index (3) can be written as:

$$P_X = \frac{1}{\rho} \left[N_L (C_M + C_L)^{1-\sigma} + N_H (\theta C_M + C_H)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \qquad (41)$$

so that, making use of (21) and rearranging, we get:

$$\begin{aligned} \left(\frac{\overline{w}}{\rho P_X} \right)^{\sigma-1} = & \left[(C_M + C_L) \int_{\underline{z}}^{z_1} \varphi_M(z) dG(z) + C_H \int_{z_2}^{\overline{z}} \varphi_H(z) dG(z) \right]^{\sigma-1} \cdot \\ & \left[\frac{1}{\sigma F_L} \int_{\underline{z}}^{z_1} \varphi_M(z) dG(z) (C_M + C_L)^{1-\sigma} + \frac{1}{\sigma(F_H + F_I)} \int_{z_2}^{\overline{z}} \varphi_H(z) dG(z) (\theta C_M + C_H)^{1-\sigma} \right] . \end{aligned} \qquad (42)$$

Differentiating the RHS of this expression with respect to z_2, and making use of (7), (18), (19) and (21) yields:

$$\begin{aligned} \frac{dRHS(42)}{dz_2} = & \ \theta C_M \overline{w}^{\sigma-2} \cdot \\ & \left[\begin{array}{l} (\sigma - 1) \ N_H \ \frac{(F_H + F_I)}{F_L} \frac{(C_M + C_L)^{-\sigma}}{C_L} (\overline{w} - N_L \sigma F_L) \frac{d(\frac{\varphi_M(z_1)}{\varphi_L(z_1)})}{dz_1} \frac{dz_1}{dz_2} \\ + (\sigma - 1) \ N_H^2 \ \sigma C_L \ (F_H + F_I)(\theta C_M + C_H)^{-\sigma} \frac{d(\frac{\varphi_L(z_2)}{\varphi_H(z_2)})}{dz_2} \\ - \frac{1}{\sigma(F_H + F_I)} (\theta C_M + C_H)^{-\sigma} \varphi_H(z_2) dG(z_2) \overline{w} \end{array} \right] , \end{aligned} \qquad (43)$$

an expression that is unambiguously negative since $\overline{w} - N_L \sigma F_L > 0$ from (39) and (21), $\frac{d(\frac{\varphi_M(z_1)}{\varphi_L(z_1)})}{dz_1} < 0$, $\frac{d(\frac{\varphi_L(z_2)}{\varphi_H(z_2)})}{dz_2} < 0$ and $\frac{dz_1}{dz_2} > 0$. We have therefore shown that $\frac{d(\frac{\overline{w}}{P_X})}{dz_2} < 0$, that is, globalization unambiguously improves aggregate welfare.

Appendix 2: Effect of globalization on the aggregate consumption price P_X

From (41) and making use of (21), we have:

$$[\rho P_X]^{1-\sigma} = \left[\frac{1}{\sigma F_L}\int_{\underline{z}}^{z_1}\varphi_M(z)dG(z)(C_M+C_L)^{1-\sigma} + \frac{1}{\sigma(F_H+F_I)}\int_{z_2}^{\overline{z}}\varphi_H(z)dG(z)(\theta C_M+C_H)^{1-\sigma}\right]. \tag{44}$$

Totally differentiating the RHS of (44) with respect to z_2 and making use of (7), we obtain:

$$\begin{aligned}\frac{dRHS(44)}{dz_2} = {} & (1-\sigma)\left[\begin{array}{l}\frac{1}{\sigma F_L}\int_{\underline{z}}^{z_1}\varphi_M(z)dG(z)(C_M+C_L)^{-\sigma}\frac{d(\frac{\varphi_M(z_1)}{\varphi_L(z_1)})}{dz_1} \\ +\frac{1}{\sigma(F_H+F_I)}\int_{z_2}^{\overline{z}}\varphi_H(z)dG(z)(\theta C_M+C_H)^{-\sigma}\frac{d(\frac{\varphi_M(z_1)}{\varphi_L(z_1)})}{dz_1}\frac{\varphi_L(z_2)}{\varphi_H(z_2)}\end{array}\right]\frac{dz_1}{dz_2} \\ & + \left[\frac{1}{\sigma F_L}\varphi_M(z_1)dG(z_1)(C_M+C_L)^{1-\sigma}\frac{dz_1}{dz_2} - \frac{1}{\sigma(F_H+F_I)}\varphi_H(z_2)dG(z_2)(\theta C_M+C_H)^{1-\sigma}\right] \\ & + \left[(1-\sigma)\ \frac{1}{\sigma(F_H+F_I)}\int_{z_2}^{\overline{z}}\varphi_H(z)dG(z)(\theta C_M+C_H)^{-\sigma}\frac{\varphi_M(z_1)}{\varphi_L(z_1)}\frac{d(\frac{\varphi_L(z_2)}{\varphi_H(z_2)})}{dz_2}\right].\end{aligned} \tag{45}$$

Using (21) and (7), the first bracket-term simplifies to:

$$(1-\sigma)(C_M+C_L)^{-\sigma}\left[N_L+N_H\left(\frac{\theta C_M+C_H}{C_M+C_L}\right)^{-\sigma}\frac{C_H}{C_L}\right]\frac{d(\frac{\varphi_M(z_1)}{\varphi_L(z_1)})}{dz_1}\frac{dz_1}{dz_2}$$

which, making use of (19) simplifies further to:

$$(1-\sigma)(C_M+C_L)^{-\sigma}\left[N_L+N_H\frac{F_H+F_I}{F_L}\frac{C_H}{C_L}\right]\frac{d(\frac{\varphi_M(z_1)}{\varphi_L(z_1)})}{dz_1}\frac{dz_1}{dz_2}\ . \tag{46}$$

From (18) and (7), $\frac{dz_1}{dz_2}$ can be written as:

$$\frac{dz_1}{dz_2} = \frac{C_H}{C_L}\frac{C_M}{C_M+C_L}\frac{\varphi_H(z_2)dG(z_2)}{\varphi_L(z_1)dG(z_1)}\ ;$$

substitution in the second bracket-term of (45) yields:

$$\frac{1}{\sigma F_L}(C_M+C_L)^{1-\sigma}\left[\frac{C_H}{C_L}\frac{C_M}{C_M+C_L}\frac{\varphi_M(z_1)}{\varphi_L(z_1)} - \frac{F_L}{F_H+F_I}\left(\frac{\theta C_M+C_H}{C_M+C_L}\right)^{1-\sigma}\right]\ \varphi_H(z_2)\ dG(z_2),$$

which, making use of (7) and (19), simplifies to:

$$-\theta C_M\frac{1}{\sigma F_L}(C_M+C_L)^{-\sigma}\varphi_H(z_2)dG(z_2). \tag{47}$$

Next, making use of (19) and (7), the third bracket-term of (45) can be written as:

$$(1-\sigma)\ \frac{1}{\sigma F_L}\ (C_M+C_L)^{-\sigma}\int_{z_2}^{\overline{z}}\varphi_H(z)dG(z)\ \frac{C_L}{C_M}\ \frac{d(\frac{\varphi_L(z_2)}{\varphi_H(z_2)})}{dz_2}\ . \tag{48}$$

Finally, making use of (46), (47) and (48) to rearrange (45), we obtain:

$$\frac{dRHS(44)}{dz_2} = (1-\sigma)(C_M+C_L)^{-\sigma}\left[N_L + N_H \frac{F_H+F_I}{F_L}\frac{C_H}{C_L}\right]\frac{d(\frac{\varphi_M(z_1)}{\varphi_L(z_1)})}{dz_1}\frac{dz_1}{dz_2}$$
$$+\frac{(C_M+C_L)^{-\sigma}}{\sigma F_L}\left[(1-\sigma)\int_{z_2}^{\overline{z}}\varphi_H(z)dG(z)\ \frac{C_L}{C_M}\ \frac{d(\frac{\varphi_L(z_2)}{\varphi_H(z_2)})}{dz_2} - \theta C_M\ \varphi_H(z_2)dG(z_2)\right].$$

Given that $\frac{d(\frac{\varphi_M(z_1)}{\varphi_L(z_1)})}{dz_1} < 0$ and that $\frac{dz_1}{dz_2} > 0$, the first term is unambiguously positive; given that $\frac{d(\frac{\varphi_L(z_2)}{\varphi_H(z_2)})}{dz_2} < 0$, the second term will be negative if σ is not too large. The impact of globalization on P_X will therefore be negative if there is enough product differentiation, that is, if σ is small enough.

Appendix 3: Calibrated initial equilibrium and simulated effects of globalization

$\sigma = 4$	F_I				
	0.900	0.881	0.862	0.843	0.824
θ	0.793	0.793	0.793	0.793	0.793
F_H	1.179	1.179	1.179	1.179	1.179
F_L	1.000	1.000	1.000	1.000	1.000
z_1	0.700	0.668	0.637	0.606	0.576
z_2	0.969	0.934	0.899	0.865	0.831
C_M	1.000	1.000	1.000	1.000	1.000
C_L	0.632	0.645	0.659	0.672	0.685
C_H	0.566	0.580	0.595	0.609	0.624
p_L	2.176	2.194	2.212	2.229	2.247
p_H	1.812	1.831	1.850	1.869	1.889
x_L	3.000	3.000	3.000	3.000	3.000
x_H	6.237	6.181	6.124	6.067	6.010
N_L	0.241	0.226	0.212	0.199	0.187
N_H	0.019	0.039	0.058	0.077	0.095
Inc	1.659	1.675	1.692	1.711	1.731
P_X	3.354	3.302	3.261	3.228	3.201

Table A3.1: Benchmark case

$\sigma = 3$	F_I				
	0.900	0.881	0.862	0.843	0.824
θ	0.722	0.722	0.722	0.722	0.722
F_H	1.132	1.132	1.132	1.132	1.132
F_L	1.000	1.000	1.000	1.000	1.000
z_1	0.700	0.665	0.631	0.597	0.564
z_2	0.969	0.931	0.893	0.855	0.817
C_M	1.000	1.000	1.000	1.000	1.000
C_L	0.632	0.647	0.661	0.676	0.691
C_H	0.566	0.582	0.597	0.613	0.630
p_L	2.448	2.470	2.492	2.514	2.536
p_H	1.933	1.956	1.980	2.004	2.028
x_L	2.000	2.000	2.000	2.000	2.000
x_H	4.063	4.025	3.987	3.950	3.912
N_L	0.321	0.300	0.280	0.261	0.242
N_H	0.026	0.056	0.084	0.112	0.138
Inc	1.659	1.676	1.696	1.717	1.740
P_X	4.069	3.963	3.876	3.805	3.746

$\sigma = 4$	F_I				
	0.900	0.881	0.862	0.843	0.824
θ	0.793	0.793	0.793	0.793	0.793
F_H	1.179	1.179	1.179	1.179	1.179
F_L	1.000	1.000	1.000	1.000	1.000
z_1	0.700	0.668	0.637	0.606	0.576
z_2	0.969	0.934	0.899	0.865	0.831
C_M	1.000	1.000	1.000	1.000	1.000
C_L	0.632	0.645	0.659	0.672	0.685
C_H	0.566	0.580	0.595	0.609	0.624
p_L	2.176	2.194	2.212	2.229	2.247
p_H	1.812	1.831	1.850	1.869	1.889
x_L	3.000	3.000	3.000	3.000	3.000
x_H	6.237	6.181	6.124	6.067	6.010
N_L	0.241	0.226	0.212	0.199	0.187
N_H	0.019	0.039	0.058	0.077	0.095
Inc	1.659	1.675	1.692	1.711	1.731
P_X	3.354	3.302	3.261	3.228	3.201

$\sigma = 5$	F_I				
	0.900	0.881	0.862	0.843	0.824
θ	0.837	0.837	0.837	0.837	0.837
F_H	1.229	1.229	1.229	1.229	1.229
F_L	1.000	1.000	1.000	1.000	1.000
z_1	0.700	0.671	0.642	0.614	0.587
z_2	0.969	0.937	0.905	0.874	0.843
C_M	1.000	1.000	1.000	1.000	1.000
C_L	0.632	0.644	0.656	0.668	0.681
C_H	0.566	0.579	0.592	0.605	0.618
p_L	2.040	2.055	2.070	2.086	2.101
p_H	1.754	1.770	1.786	1.803	1.819
x_L	4.000	4.000	4.000	4.000	4.000
x_H	8.515	8.439	8.363	8.288	8.212
N_L	0.192	0.182	0.172	0.162	0.153
N_H	0.015	0.029	0.043	0.056	0.069
Inc	1.659	1.673	1.689	1.706	1.724
P_X	2.981	2.952	2.930	2.912	2.899

$\sigma = 6$	F_I				
	0.900	0.881	0.862	0.843	0.824
θ	0.867	0.867	0.867	0.867	0.867
F_H	1.280	1.280	1.280	1.280	1.280
F_L	1.000	1.000	1.000	1.000	1.000
z_1	0.700	0.673	0.647	0.622	0.597
z_2	0.969	0.940	0.911	0.883	0.855
C_M	1.000	1.000	1.000	1.000	1.000
C_L	0.632	0.643	0.654	0.665	0.676
C_H	0.566	0.578	0.590	0.602	0.614
p_L	1.958	1.972	1.985	1.998	2.011
p_H	1.720	1.734	1.748	1.762	1.777
x_L	5.000	5.000	5.000	5.000	5.000
x_H	10.902	10.807	10.713	10.618	10.524
N_L	0.160	0.152	0.145	0.137	0.130
N_H	0.012	0.023	0.033	0.043	0.053
Inc	1.659	1.672	1.686	1.701	1.717
P_X	2.750	2.733	2.720	2.710	2.703

Table A3.2: Cases for alternative values of σ

Appendix 4: Multi-product firms

Calibrated initial equilibrium and simulated effects of globalization

$\sigma = 4$	F_I				
	0.900	0.881	0.862	0.843	0.824
θ	0.793	0.793	0.793	0.793	0.793
F_H	0.971	0.971	0.971	0.971	0.971
f_H	0.208	0.208	0.208	0.208	0.208
F_L	0.900	0.900	0.900	0.900	0.900
f_L	0.100	0.100	0.100	0.100	0.100
η_L	0.290	0.290	0.290	0.290	0.290
η_H	0.290	0.290	0.290	0.290	0.290
λ_L	1.000	1.000	1.000	1.000	1.000
λ_H	1.000	0.997	0.994	0.991	0.988
z_1	0.700	0.659	0.619	0.580	0.542
z_2	0.969	0.924	0.879	0.836	0.792
C_M	1.000	1.000	1.000	1.000	1.000
C_L	0.632	0.649	0.666	0.684	0.701
C_H	0.566	0.585	0.603	0.622	0.640
p_L	2.176	2.199	2.222	2.245	2.268
p_H	1.812	1.831	1.850	1.869	1.888
x_L	3.000	3.000	3.000	3.000	3.000
x_H	6.237	6.237	6.237	6.237	6.237
N_L	0.241	0.222	0.205	0.188	0.173
N_H	0.019	0.045	0.069	0.092	0.115
n_L	1.000	1.000	1.000	1.000	1.000
n_H	1.000	0.990	0.980	0.970	0.960
Inc	1.659	1.680	1.703	1.728	1.756
P_X	3.354	3.289	3.241	3.205	3.177

Table A4.1: Benchmark case

$\sigma = 3$	F_I				
	0.900	0.881	0.862	0.843	0.824
θ	0.722	0.722	0.722	0.722	0.722
F_H	0.928	0.928	0.928	0.928	0.928
f_H	0.203	0.203	0.203	0.203	0.203
F_L	0.900	0.900	0.900	0.900	0.900
f_L	0.100	0.100	0.100	0.100	0.100
η_L	0.429	0.429	0.429	0.429	0.429
η_H	0.429	0.429	0.429	0.429	0.429
λ_L	1.000	1.000	1.000	1.000	1.000
λ_H	1.000	0.996	0.991	0.987	0.982
z_1	0.700	0.651	0.602	0.556	0.510
z_2	0.969	0.914	0.861	0.807	0.754
C_M	1.000	1.000	1.000	1.000	1.000
C_L	0.632	0.653	0.674	0.695	0.716
C_H	0.566	0.588	0.611	0.634	0.657
p_L	2.448	2.479	2.511	2.542	2.574
p_H	1.933	1.958	1.982	2.007	2.032
x_L	2.000	2.000	2.000	2.000	2.000
x_H	4.063	4.063	4.063	4.063	4.063
N_L	0.321	0.291	0.264	0.238	0.214
N_H	0.026	0.068	0.108	0.146	0.181
n_L	1.000	1.000	1.000	1.000	1.000
n_H	1.000	0.990	0.979	0.969	0.959
Inc	1.659	1.684	1.713	1.746	1.782
P_X	4.069	3.924	3.815	3.732	3.669

$\sigma = 4$	F_I				
	0.900	0.881	0.862	0.843	0.824
θ	0.793	0.793	0.793	0.793	0.793
F_H	0.971	0.971	0.971	0.971	0.971
f_H	0.208	0.208	0.208	0.208	0.208
F_L	0.900	0.900	0.900	0.900	0.900
f_L	0.100	0.100	0.100	0.100	0.100
η_L	0.290	0.290	0.290	0.290	0.290
η_H	0.290	0.290	0.290	0.290	0.290
λ_L	1.000	1.000	1.000	1.000	1.000
λ_H	1.000	0.997	0.994	0.991	0.988
z_1	0.700	0.659	0.619	0.580	0.542
z_2	0.969	0.924	0.879	0.836	0.792
C_M	1.000	1.000	1.000	1.000	1.000
C_L	0.632	0.649	0.666	0.684	0.701
C_H	0.566	0.585	0.603	0.622	0.640
p_L	2.176	2.199	2.222	2.245	2.268
p_H	1.812	1.831	1.850	1.869	1.888
x_L	3.000	3.000	3.000	3.000	3.000
x_H	6.237	6.237	6.237	6.237	6.237
N_L	0.241	0.222	0.205	0.188	0.173
N_H	0.019	0.045	0.069	0.092	0.115
n_L	1.000	1.000	1.000	1.000	1.000
n_H	1.000	0.990	0.980	0.970	0.960
Inc	1.659	1.680	1.703	1.728	1.756
P_X	3.354	3.289	3.241	3.205	3.177

$\sigma = 5$	F_I				
	0.900	0.881	0.862	0.843	0.824
θ	0.837	0.837	0.837	0.837	0.837
F_H	1.016	1.016	1.016	1.016	1.016
f_H	0.213	0.213	0.213	0.213	0.213
F_L	0.900	0.900	0.900	0.900	0.900
f_L	0.100	0.100	0.100	0.100	0.100
η_L	0.220	0.220	0.220	0.220	0.220
η_H	0.220	0.220	0.220	0.220	0.220
λ_L	1.000	1.000	1.000	1.000	1.000
λ_H	1.000	0.998	0.996	0.993	0.991
z_1	0.700	0.665	0.630	0.597	0.564
z_2	0.969	0.930	0.892	0.854	0.817
C_M	1.000	1.000	1.000	1.000	1.000
C_L	0.632	0.647	0.662	0.676	0.691
C_H	0.566	0.582	0.598	0.614	0.630
p_L	2.040	2.059	2.077	2.095	2.114
p_H	1.754	1.770	1.786	1.802	1.817
x_L	4.000	4.000	4.000	4.000	4.000
x_H	8.515	8.515	8.515	8.515	8.515
N_L	0.192	0.180	0.168	0.156	0.145
N_H	0.015	0.032	0.049	0.065	0.080
n_L	1.000	1.000	1.000	1.000	1.000
n_H	1.000	0.990	0.980	0.970	0.961
Inc	1.659	1.676	1.696	1.717	1.740
P_X	2.981	2.947	2.922	2.903	2.890

$\sigma = 6$	F_I				
	0.900	0.881	0.862	0.843	0.824
θ	0.867	0.867	0.867	0.867	0.867
F_H	1.062	1.062	1.062	1.062	1.062
f_H	0.218	0.218	0.218	0.218	0.218
F_L	0.900	0.900	0.900	0.900	0.900
f_L	0.100	0.100	0.100	0.100	0.100
η_L	0.176	0.176	0.176	0.176	0.176
η_H	0.176	0.176	0.176	0.176	0.176
λ_L	1.000	1.000	1.000	1.000	1.000
λ_H	1.000	0.998	0.997	0.995	0.993
z_1	0.700	0.669	0.638	0.609	0.580
z_2	0.969	0.935	0.901	0.868	0.835
C_M	1.000	1.000	1.000	1.000	1.000
C_L	0.632	0.645	0.658	0.671	0.684
C_H	0.566	0.580	0.594	0.608	0.622
p_L	1.958	1.974	1.990	2.005	2.021
p_H	1.720	1.734	1.747	1.761	1.774
x_L	5.000	5.000	5.000	5.000	5.000
x_H	10.902	10.902	10.902	10.902	10.902
N_L	0.160	0.151	0.142	0.134	0.125
N_H	0.012	0.025	0.037	0.048	0.059
n_L	1.000	1.000	1.000	1.000	1.000
n_H	1.000	0.990	0.981	0.971	0.961
Inc	1.659	1.674	1.691	1.709	1.729
P_X	2.750	2.730	2.716	2.706	2.700

Table A4.2: Cases for alternative values of σ

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