

# Outsourcing in a Knowledge Economy

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## Abstract

How does the formation of cross-country teams affect the organization of work and the structure of wages? We answer this question through a model of the assignment of heterogeneous agents into hierarchical teams, where less skilled agents specialize in production and more skilled agents specialize in problem solving. We first study the properties of the competitive equilibrium of the model in a closed economy, and show that the model has a unique and efficient solution. We then study the equilibrium of a two-country model, in which agents drawn from the two countries' ability distributions can join together in teams. We describe how globalization changes the allocation of individuals to tasks and the matching between managers and workers. We also show that globalization leads to the destruction of certain firms and the creation of new ones, and also affects the size of the surviving firms. We next analyze how these changes in organization translate in changes in the levels and structure of earnings of individuals, which in turn determine the patterns of consumption and international trade in the global economy.

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# 1 Introduction

Globalization results in the formation of international teams. A number of technological and institutional developments have blurred the borders between national labor markets and have allowed members of a given team to locate in different countries, and to perform different roles in the production process. The headquarters of a firm may be in New York, while the production plants may be in China, Malaysia or Mexico. The possibility of ‘outsourcing’ certain aspects of production and forming international teams has had important effects on local labor markets, output, international trade, as well as the organizational structure of firms.

To analyze these effects, we present a theory of outsourcing in an economy in which production requires physical inputs and knowledge and where agents have heterogenous abilities and sort into firms competitively. Agents of different skill levels form teams, and they may specialize in either the ‘physical’ aspects of the production process (‘workers’) or in the knowledge aspects of this process (‘managers’). Relative to a less skilled manager, a better manager is able to increase the productivity of all the workers in his team, as he can deal with (i.e., communicate the solution to) a wider range of the problems his team confronts in production. Better production workers allow an individual to manage a larger team, as these workers can solve more problems by themselves and require less supervision. This results in a complementarity between manager and worker ability that determines the identity of agents working and managing different teams. It also determines, through comparative advantage, the occupational choice of agents. More able agents, although more productive as production workers, want to set up their own firms and manage their own teams of workers, instead of working for other managers. The distribution of skills in the population then determines the types of teams that are formed and the wages that different agents command.

To study the impact of the formation of international teams in this economy, we study a simple one-sector, two-country model in which countries differ only in their skill distributions. In particular, one country, the North, has a distribution of skills with a relatively high mean, while the other country, the South, has a distribution of skills with a relatively low mean. In our model, the ‘skill overlap’ implied by these skill differences is captured by a single parameter, which plays a crucial role in the analysis. The other key parameter in our model is the cost of communicating knowledge within teams (i.e., the state of communication technologies), which determines the extent to which managers can leverage their knowledge via larger teams.

We start in Section 2 by studying the properties of the competitive equilibrium of

the model in a closed economy, in which only domestic teams may be formed. We next analyze, in Section 3, the world equilibrium after globalization, when agents drawn from the two countries' ability distributions can join together in teams. We show that in both cases the model has a unique and efficient solution.

In Section 4 we study the effects of globalization by comparing these two equilibria. We first describe how globalization leads to the formation of international teams in which Northern managers supervise teams of Southern workers: international outsourcing thus allows for the geographic separation of production and problem solving. Globalization leads to job destruction (a decrease in the mass of workers) and firm creation (an increase in the mass of managers) in the North, but it leads to job creation and firm destruction in the South.<sup>1</sup> Furthermore, globalization compresses the size distribution of firms in both countries and reduces the size of all surviving firms in the South. Globalization also affects the level and structure of earnings of individuals, both in the North and in the South. We first show that our model is consistent with the empirical regularity that 'Southern' workers employed in multinational firms receive wages that are on average higher than those received by workers employed in domestic firms (see Aitken et al. (1996)).

We next analyze how globalization affects income inequality within each of the two countries. We first show that globalization leads to an increase in within-worker wage inequality in the South. This prediction is consistent with the findings of several empirical studies (e.g. Feenstra and Hanson (1997), Anderton et. al. (2002), and Marin (2004) among many others). These findings have received considerable attention in the trade literature since they cannot be easily rationalized with standard factor proportions trade frameworks. Our theory predicts an increase in within-worker inequality in the South as a result of changes in matching: globalization improves the quality of the manager with whom southern workers are matched, thus raising the productivity of these workers, and thereby leading to an increase in their marginal return to skill. This effect is reinforced by an occupational choice effect: more agents become workers, hence increasing the spread in the worker skill distribution.

The effect on wage inequality in the North is more complicated. On the one hand, low skilled workers in the North face increased competition from Southern workers and this tends to reduce their marginal return to skill. On the other hand, our model highlights a new force leading to an increase in wage inequality in the North. When

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<sup>1</sup>Our model highlights an important distinction between firm creation and production-plant creation. For instance, in the North, globalization leads to firm creation but also to production-plant destruction.

more low skilled agents are available, the time of high skilled managers becomes more scarce, and workers who are better able to economize on this time become relatively more valuable. As a result, the value of more skilled workers relatively to less skilled ones increases, as does the difference in matches between them. When communication costs or the skill overlap are sufficiently low, so that high skill managers are particularly valuable and scarce, this last effect dominates and globalization increases wage inequality not only in the South but also in the North. Conversely, when communication costs and the skill overlap are sufficiently large, the former effect dominates and outsourcing is associated with lower wage inequality in the North. This may help rationalize the puzzling findings of Feenstra and Hanson (1996b, 1999) that international outsourcing raised wage inequality in the United States in the 1980s but not in the 1970s. In our view, these findings could be explained by lower communication costs and deeper trade integration with less developed countries in the 1980s than in the 1970s.

More generally, we show that globalization has three separate effects on wage inequality. First, there is a simple *competition effect*: when more units of workers' skill are available, the price of workers' skill decreases; this effect would be common to any equilibrium model, whether teams play or not any role in it. Second, there is a *complementarity effect*: given complementarity in production, the productivity of a given agent depends on the skill of the other members in his team, and thus skill prices change when the team composition changes. Third, there is an *occupational choice effect*: globalization changes the mass of agents that choose to be workers or managers. The total impact on the economy wide equilibrium is the sum of these three effects.

The ability of our model to deliver the level of income for all agents in the economy also allows us to identify the winners and losers from globalization. In particular, we show that there is always a subset of workers that are hurt by globalization and that the size of the skill overlap and the state of communication technologies are again crucial in that they determine which country's workers will become the losers of globalization. If the skill overlap and communication costs are both low, globalization will lower the wages of the least-skilled Northern workers but will increase the wages of the least-skilled Southern workers. The intuition for these results is that a small skill overlap or low communication costs are associated with Northern least-skilled workers facing relatively tough competition from Southern workers, and also with Southern least-skilled workers substantially improving their match as a result of globalization. On the other hand, we find that if the skill overlap and communication costs are both high, the least-skilled Southern workers will be hurt by globalization, while the least-skilled Northern workers will tend to gain from it.

Finally, we discuss the aggregate effects of globalization on output, consumption and the pattern of trade. As argued above, globalization leads to a process of delocation of physical production towards the South. As a result, manufacturing output decreases in the North and increases in the South, while aggregate consumption (and thus welfare) increases in both countries. Furthermore, if international trade statistics do not appropriately record the managerial services inherent in the flow of knowledge within the multinational firm, we show that our model is consistent with the emergence of significant trade imbalances between the North (e.g., the United States) and the South (e.g., China).

In Section 5, we focus on the open-economy equilibrium with international outsourcing and perform smooth comparative static exercises with respect to the two parameters of the model: the cost of communication and the skill overlap between the two countries. We show that the characteristics of international outsourcing depend very much on the size of the skill overlap and on the state of communication technologies. The ‘quantity’ of outsourcing, as measured by the proportion of Southern workers that work for Northern managers, is weakly decreasing in both communication costs and the skill overlap, and converges to zero as the skill distributions completely overlap. Furthermore, we also show that when the skill overlap is large and communication costs are high, only the most productive, large firms will engage in outsourcing; while, when the skill overlap is small and communication costs are low, the firms that engage in outsourcing will actually be the least productive firms, those controlled by the lowest skilled managers. More generally, we show that the ‘quality’ of outsourcing, as measured by the average skill level of the workers that form international teams relative to the skill level of all Southern workers, is weakly increasing in both the skill overlap and communication costs.

In Section 5, we also analyze the effects of better informational technologies and higher overlap of skills on the matching between managers and workers, on the size distribution of firms, and on the structure of earnings in the economy. In the process, we describe how changes in these parameters affect skill prices on account of the complementarity, competition, and occupational choice effects identified above.<sup>2</sup>

One of the advantages of our approach is that outsourcing is not only the result of the relative aggregate supply of skills, but is the result of the competitive sorting of agents with different skill levels into teams. Paraphrasing Sattinger (1993) wages in

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<sup>2</sup>For instance, we show that our model is consistent with an increase in the relative endowment of skilled agents in the South leading to increased within-worker inequality in that country. This is consistent with the findings of Zhu and Treffer (2004) and is not easily rationalizable with standard general equilibrium models of international trade.

the economy play an allocative role rather than simply being rewards for the possession of particular characteristics. This allows us to derive conclusions on the characteristics of outsourcing firms as well as on the distribution of wages. Most other efforts to understand outsourcing do not have this feature. Feenstra and Hanson (1996a, 1997 and 2003), for example, assume factor endowments of skilled and unskilled workers in the North and South, and a production function that uses these inputs either to produce intermediate inputs or final goods.<sup>3</sup> In these models, outsourcing is the result of foreign direct investment and leads to changes in wage inequality as a result of changes in the sectoral composition of production. Their work is important in that it determines the change in wages due to these sectoral (in inputs or output) compositional change.<sup>4</sup> In general, however, it is silent about changes in wage inequality within narrowly-defined sectors as well as on the cross-sectional characteristics of outsourcing firms. Other papers have develop frameworks with similar characteristics that also abstract from the dimensions that we focus on, in particular Bernard et al. (2004), Zhu and Trefler (2004) and Verhoogen (2004).

Our paper is closely related to the work of Grossman and Maggi (2000) and Kremer and Maskin (2003), in that they also study the relationship between patterns of trade and patterns of matching between the skills of different workers. Grossman and Maggi (2000) consider the consequences of different types of production functions involving substitutability or complementarity in skills for the patterns of specialization and trade. A maintained assumption in their analysis is that international teams are not allowed to form. In this respect, our work is more closely related to Kremer and Maskin (2003), who study the patterns of trade and wages that result from production functions that are characterized by complementarity between inputs and imperfect substitutability between them.<sup>5</sup>

Consistently with any production function that may hope to address within worker wage inequality, the production function we study involves skill complementarity, imperfect substitutability between workers skill, and differential sensitivity to the skills of different workers (see Kremer and Maskin 1997). Our model is however differ-

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<sup>3</sup>Feenstra and Hanson (1997) assume that the supply of skill and unskilled labor does respond to relative wages, but they do not model the occupational choice decision or the sorting of agents into production teams.

<sup>4</sup>Feenstra and Hanson (2003) stress that these changes in the sectoral composition of production may occur within industries and may therefore not be picked up by industry-level price indices (c.f., Lawrence and Slaughter, 1993).

<sup>5</sup>Our paper is also related to a branch in the literature that has stressed the importance of heterogeneity in understanding the differential impact that globalization may have on different types of firms or workers (e.g. Manesse and Turrini (2001), Melitz (2003), Helpman et al. (2004), Antràs and Helpman (2004), and Yeaple (2004)).

ent in three key dimensions. First, following Garicano’s (2000) and Garicano and Rossi-Hansberg’s (2003, 2004) models, it is the only one to involve hierarchical one-to-many matching (rather than one-to-one-matching), where a manager is endogenously matched with a potentially large number of workers, and can potentially raise the output of all of them. As a result, our model has implications not only for the wage structure, but also for the distribution of firm sizes and the composition of hierarchical teams in the economy. Second, the actual team production function results naturally and endogenously from a production process which does not assume skill complementarities, but rather derives them from the specialization of agents in different aspects of the process – production and knowledge. Third, the relation between the skill of the manager and that of the worker is mediated by communication technology– that is, the state of communication technology determines the extent to which a manager can leverage his knowledge by communicating it to many or few production workers. As a result of these differences, we are able to move beyond previous contributions in formally analyzing how the process of globalization interacts with the state of communication technologies in determining the worldwide organization of production and the structure of rewards that support it.

The rest of the paper is organized as follows. Section 2 presents the basic framework for a closed economy and shows existence, uniqueness, and optimality. Section 3 constructs an equilibrium in the integrated economy and discusses its basic properties. Section 4 discusses the effects of economic integration or globalization. Section 5 presents comparative statics with respect to the skill overlap and to communication costs and Section 6 concludes. All the proofs in the paper are relegated to the Appendix.

## 2 The Model

Agents are endowed with one unit of time and a skill level  $z$ . The distribution of skills in the population is given by a cumulative distribution function  $G(z)$ , with density  $g(z)$ , that for the moment we will assume has support in  $[0, \bar{z}]$  with  $\bar{z} \leq 1$ . Agents rank consumption according to a linear utility function so they are income maximizers, given that we normalize the price of the only good in the economy to one.

Production is done by teams with one manager and production workers. While producing, workers face problems that have to be solved. If a worker knows the solution to his problem, he solves it and uses his time to produce one unit of output. If he does not know the solution, he can ask his manager. If the manager knows the solution to the

problem, the manager solves it immediately, communicates the solution to the worker, and the worker then uses his time to produce. The manager spend  $0 < h < 1$  units of time communicating what he knows to the worker no matter if he knows the solution to the problem or not. The skill level of an agent determines the set of problems he can solve. An agent with skill  $z$  can solve all problems that require knowledge between 0 and  $z$ , and we normalize the set of problems so that the skill level  $z$  is also the proportion of problems an agent can solve.<sup>6</sup> Hence, a manager in a team with workers of skill  $z_p$  can solve problems for

$$n(z_p) = \frac{1}{h(1 - z_p)}$$

workers. Production in a team formed by a manager with skill level  $z_m$  and workers with skill  $z_p$  is therefore given by

$$z_m n(z_p) = \frac{z_m}{h(1 - z_p)}.$$

Given wages, managers choose the ability of their workers to maximize rents,

$$R(z_m) = \max_{z_p} \frac{z_m - w(z_p)}{h(1 - z_p)}.$$

The first order condition of this problem is given by

$$w'(z_p) = \frac{z_m - w(z_p)}{1 - z_p}. \quad (1)$$

Agents choose whether to be become managers or workers so as to maximize their utility, that is, their income. Hence given their ability  $z$  they solve

$$\max \{R(z), w(z)\}.$$

This implies that the earnings function, the envelope of the wage and rent function given occupational choices, has to be continuous.

In equilibrium labor markets clear. At the equilibrium wages and earnings, the supply and demand of production workers equalize at all skill levels. Let  $w(\cdot)$  be an equilibrium wage function, and let the equilibrium occupational choice decision be such that agents with skill levels in  $[0, z^*]$  become workers and agents in  $[z^*, \bar{z}]$  become

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<sup>6</sup>The upper bound  $\bar{z}$  thus represents the fraction of problems that the most-skilled agent in the economy can solve.



managers. Agents with knowledge  $z^*$  are indifferent. This restriction turns out to be without loss of generality, as Theorem 1 below shows. Let  $m(z)$  be the skill level of the manager of a worker with ability  $z$ . We prove in Theorem 1 that an equilibrium allocation of this economy has to satisfy positive sorting, and therefore that  $m$  is invertible. Then, labor market clearing implies that

$$\int_0^{z_p} g(z) dz = \int_{m(0)}^{m(z_p)} n(m^{-1}(z)) g(z) dz \text{ all } z_p \leq z^*,$$

where  $m^{-1}(z)$  is the ability of the workers hired by a manager of ability  $z$ . The left-hand-side of this equation is the supply of workers between 0 and  $z_p$ . The right-hand-side is the demand for workers by managers between  $m(0) = z^*$  and  $m(z_p)$ . Market clearing is guaranteed when supply equals demand for every skill level of workers  $z_p < z^*$ . Substituting for  $n$  and deriving with respect to  $z_p$  we obtain that, as long as  $z < z^*$  and  $m(z)$  is increasing (positive sorting),

$$m'(z) = h(1-z) \frac{g(z)}{g(m(z))}. \quad (2)$$

Notice that in this economy positive sorting is always guaranteed because of the complementarity between workers' and managers' talent. Hence, better workers always work for better managers, a property we will exploit intensively below. This differential equation, together with the two boundary conditions  $m(0) = z^*$  and  $m(z^*) = \bar{z}$ , determines the equilibrium assignment function. Notice that the equilibrium assignment of workers to managers is independent of market prices, wages, and rents, once positive sorting is imposed.<sup>7</sup> The reason is that the span of control of managers is a technological restriction of the problem. Managers add agents to their teams until they do not have any time left. If agents could acquire skills, or could work by themselves, this helpful property of our economy would be lost and the analysis would be much more complicated. Garicano and Rossi-Hansberg (2003) and (2004) present closed economy frameworks that incorporate these dimensions.

A competitive equilibrium in our economy is therefore given by a wage function  $w$ , a rent function  $R$ , an assignment function  $m$ , and occupational choice decisions (in particular  $z^*$ ), such that managers maximize rents ((1) is satisfied and  $w'(z^*) < R'(z^*)$ )<sup>8</sup>, agents maximize utility ( $w(z^*) = R(z^*)$ ), and labor markets clear ((2) is

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<sup>7</sup>Of course, equilibrium wages and rents sustain the assignment as an equilibrium allocation, but we do not need to know them to compute the assignment function.

<sup>8</sup>The second condition is needed to guarantee that managers at  $\bar{z}$  do not profit by hiring agents with abilities slightly above  $z^*$ . The condition is necessary given that (1) only holds for  $z \in (0, z^*)$  but

satisfied together with  $m(0) = z^*$  and  $m(z^*) = \bar{z}$ ). The following theorem shows that an equilibrium of this economy exists as long as  $h$  is lower than a threshold  $h^*$ . It also shows that if an equilibrium exists, it is unique, efficient, and can be characterized by a threshold  $z^*$  as we have done so far.

**Theorem 1** *There exists a threshold  $h^* > 0$  such that if  $h \in [0, h^*]$  there exists a unique competitive equilibrium of this economy. In equilibrium the set of managers and the set of workers are connected and the equilibrium exhibits positive sorting. Furthermore, the equilibrium allocation is efficient.*

In the rest of the paper we will analyze the case in which we specify the distribution of abilities to be a piecewise uniform density. In this case we can show that  $h^* > 0.85$ , and so for the rest of the paper we will assume that communication costs are such that  $h \in [0, 0.85]$ . The reason that we need to restrict  $h$  for an equilibrium to exist, is that we are not allowing agents to be self-employed. If we were to allow them to work on their own, we could guarantee existence also for communication costs between 0.85 and 1 (see Garicano and Rossi-Hansberg (2004)). However, this would come at the cost of a more complicated analysis of the model, which we believe would obscure the main message of the paper.

## 2.1 Equilibrium in the Closed Economy

Consider a world formed by two completely independent economies. The first one, that we call the North, is exactly as described before but with a uniform distribution of skills in the population,  $G_N(z) = z$  for  $z \in [0, 1]$ , with density  $g_N(z) = 1$ . In the North, the best agents of the economy can therefore solve all the problems that arise in production. The second economy, that we call the South, also has a uniform distribution of skills, but the support of the distribution is the interval  $[0, \alpha]$  for  $\alpha < 1$ , with  $G_S(z) = z/\alpha$  for  $z \in [0, 1]$ , and density  $g_S(z) = 1/\alpha$ . The best agents in the South can thus solve only a fraction  $\alpha$  of the problems that they face while producing. The North is, therefore, relatively better endowed with skilled agents, but both countries are identical in all other respects, including population size. We will often refer to the parameter  $\alpha$  as the *skill overlap*. The uniform assumption for the distribution of skills in both countries serves two purposes. First it implies that the skewness in the wage distribution implied by our framework is the result of the economic forces we consider

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not for  $z^*$ . Garicano and Rossi-Hansberg (2003) show that this condition would always be satisfied if we were to allow agents to produce individually as well as in teams.

and not the distribution of skills we assume. Second, it allows us to solve the whole model analytically.

The northern economy is just a special case of the southern economy when  $\alpha$  is equal to 1. Therefore, we start by describing an equilibrium in the South. All the expressions are identical for the North if we substitute  $\alpha = 1$ . Using (2) and the boundary condition  $m_S(0) = z_S^*$ , we obtain that

$$m_S(z) = z_S^* + hz \left(1 - \frac{1}{2}z\right), \quad (3)$$

and using  $m_S(z_S^*) = \alpha$ , we can solve for the threshold ability  $z_S^*$ :

$$z_S^* = \frac{1 + h - \sqrt{1 + h^2 + 2h(1 - \alpha)}}{h}. \quad (4)$$

That is, all agents with skills between 0 and  $z_S^*$  become workers and all agents with skills between  $z_S^*$  and  $\alpha$  become managers. It is easy to show that  $z_S^*$  increases as communication technology improves, that is, as  $h$  declines. An increase in  $z_S^*$  implies that more agents become workers, which is the result of an increase in the span of control of managers. All managers can have larger teams, so in equilibrium there are less managers and more workers.

In an economy with more skilled agents, larger  $\alpha$ ,  $z_S^*$  is also higher. There are two forces that determine this effect. First, as  $\alpha$  increases and therefore the density  $1/\alpha$  decreases, we are reducing the mass of low skilled agents and increasing the mass of high skilled agents, which implies that, given the size of teams, agents with higher skills decide to become workers. Second, as we increase the skill level of the best agents in the economy, these agents manage larger teams which reduces the set of managers and increases the set of workers.

An economy with higher  $\alpha$ , or lower  $h$ , is an economy in which the skill levels of agents that become workers is more dispersed. Given wages, this higher skill dispersion will lead to higher measured wage inequality. We call this effect the *occupational choice effect*. Of course, there is also an equilibrium response of wages that needs to be combined with this effect to obtain conclusions on the implications of changes in  $h$  and  $\alpha$  on the distribution of wages. We study these general equilibrium effects in the next two sections.

A characteristic of this equilibrium is that, because of positive sorting, more skilled managers lead teams with more skilled workers. Since the size of a firm is uniquely determined by the skill levels of its workers and by an economy-wide parameter  $h$ ,

higher skilled agents work in larger firms. Because managers of these firms have more skills, they solve a larger proportion of the problems they face, and so these firms are more productive. The average product of labor is thus higher in these teams. As we will now see, this will result in both managers and workers in these teams earning more per unit of skill: The wage and rent functions will be convex in the level of skills.

We now turn to a formal analysis of the determination of earnings in this economy. Equation (1) together with  $w_S(z_S^*) = R_S(z_S^*)$  imply that the equilibrium wage function is given by

$$w_S(z) = z_S^* - \sigma_S(1 - z) + \frac{1}{2}hz^2, \quad (5)$$

where

$$\sigma_S = \frac{hz_S^*(1 + \frac{1}{2}hz_S^*)}{1 + h - hz_S^*}. \quad (6)$$

The slope of the wage function, the marginal return to skill for workers, is thus given by

$$w'_S(z) = \sigma_S + hz.$$

Notice that this implies that the wage function is convex and so the marginal return to skills increases with the skill level. The marginal return to skill can also be shown to be an increasing function of  $h$ , and so it decreases with an improvement in communication technology. There are two interacting equilibrium effects, which we identify throughout the paper. As communication costs decrease, given the threshold, team size increases. Since the difference between the skill levels of the managers of two different workers will be smaller the larger are team sizes, complementarity between worker and manager skills implies a decrease in the marginal return to skill. This effect is captured by the convexity term  $hz$ , and it reflects the imperfect substitutability between workers of different skills—the skill price per unit of skill varies with the skill level. Throughout the paper, we refer to this effect as the *complementarity effect*. There is a second equilibrium effect, given by the fact that more workers are needed and so the price per unit of skill increases: a *competition effect*. Overall, since teams sizes are larger, workers are matched with better managers, which increases their returns to skill.

The marginal return to skill is also increasing in  $\alpha$ , since  $\sigma_S$  is an increasing function of  $z_S^*$  which in turn increases with  $\alpha$ . In this case the complementarity effect is absent, and the *competition effect* implies that since agents are more skilled, there are too few workers per manager at the old threshold, so that equilibrium requires raising workers' return to skill. Again, workers are matched with better managers and this increases the returns to their own skills.

Manager's rents are in turn given by

$$R_S(z) = \frac{z - w_S(m_S^{-1}(z))}{h(1 - m_S^{-1}(z))}.$$

Using the envelope condition, the marginal return to skills for managers is given by

$$R'_S(z) = \frac{1}{h(1 - m_S^{-1}(z))}.$$

Given that the assignment function is increasing (positive sorting), the rent function is convex: The marginal return to skill for managers increases with their skill level. Note also that the marginal return to skill for managers is equal to the number of workers in their team. Hence, every time we derive conclusions about firm size the same applies for the marginal return to skill for managers and vice-versa.

A worker of ability  $z$  works for a manager with ability  $m(z)$ . This means that the total output produced by this worker is given by  $m(z)$ . Total production in the South is therefore given by

$$Y_S = \int_0^{z_S^*} m_S(z) g_S(z) dz = \frac{1}{6\alpha} z_S^{*2} (6 + 3h - h z_S^*). \quad (7)$$

It is easy to verify that  $Y_S$  decreases with  $h$  and increases with  $\alpha$ . The reasoning is simple: the larger is  $h$ , the higher are communication costs, the less can managers leverage their knowledge, and the lower is the implied average productivity. As  $\alpha$  increases, the average skill level in the economy increases, which also leads to larger output.

### 3 Equilibrium in the World Economy

Consider a world economy formed by the two countries described above, North and South. In the world equilibrium, agents can form production teams with agents in their own country or with agents in the other country. Throughout the paper we assume that the cost of communicating the solution to a problem,  $h$ , is the same whether communication happens between agents in the same or in different countries. We could add an extra cost of communicating with agents in another country. However, this extra cost would then influence the formation of international teams directly, thereby obscuring the economic forces determining the number of these type of teams in an equilibrium of our setup.

The equilibrium in the world economy is very similar to an equilibrium in the individual countries once we adjust the distribution of talent in the population. The distribution of skills in the world population is given by the sum of the distribution of skills in the South and in the North, namely,

$$G(z) = \begin{cases} \frac{1+\alpha}{\alpha} z & \text{if } 0 < z < \alpha \\ z & \text{if } \alpha < z < 1 \end{cases} .$$

The construction of an equilibrium in this economy parallels the one for a closed economy with one caveat. The fact that the density of skills in the world is not continuous implies that the derivative of the assignment function is not continuous. However, an equilibrium allocation must be such that the earnings function is continuous and differentiable for all  $z$  except at the threshold that divides workers and managers, at which it is not differentiable, just as in the closed economy. If this condition is not satisfied, at least one agent of some team would like to form a team with a different agent and that other agent would be willing to form such new team. This characteristic of an equilibrium allocation implies that the assignment function is continuous. Hence, Theorem (1) applies for the world economy as well.

Depending on the value of  $h$  and  $\alpha$  there are two types of equilibria in the world. The first one is an equilibrium in which all agents in the South are workers. Since there are no managers in the South, all of them work for northern managers. That is, they all work in international teams. Positive sorting implies that, because they are the lowest quality workers in the world (there is an identical set of workers in the North plus some more skilled ones), they work for the worst managers in the North. Hence, the international teams are associated with the worst managers in the world. We call this the *Low Quality Outsourcing Equilibrium (LQE)*.

The second type of equilibrium is one in which some of the agents in the South are managers. This equilibrium features the less skilled workers in the South working for these southern managers, and the more skilled ones working for the best managers in the North. We call this the *High Quality Outsourcing Equilibrium (HQE)*. These results are derived under the assumption that international teams are formed only if managers *strictly* prefer to hire foreign workers than domestic ones.

The type of equilibrium in the world depends on the values of  $h$  and  $\alpha$ . Given  $\alpha$ , a low communication cost  $h$  implies that teams are large and so the set of agents that choose to become managers in the world is small. Since the top managers are always in the North, by positive sorting, all agents in the South are workers. Thus, we will be in a LQE. Conversely, a high communication cost  $h$  implies that teams will be small,

the set of managers will be large, so some agents in the South will be managers, and we will be in a HQE. Given  $h$ , if  $\alpha$  is small all agents in the South will have relatively low skills, and so they will be workers: A LQE. If  $\alpha$  is large, some agents in the South have relatively high ability, and some of them will be managers: A HQE. In general, the set of parameter values that determines the boundary between these two equilibria is a non-linear function of  $h$  and  $\alpha$  that we will determine below, and which we plot in Figure 1. We analyze next each equilibrium in turn.

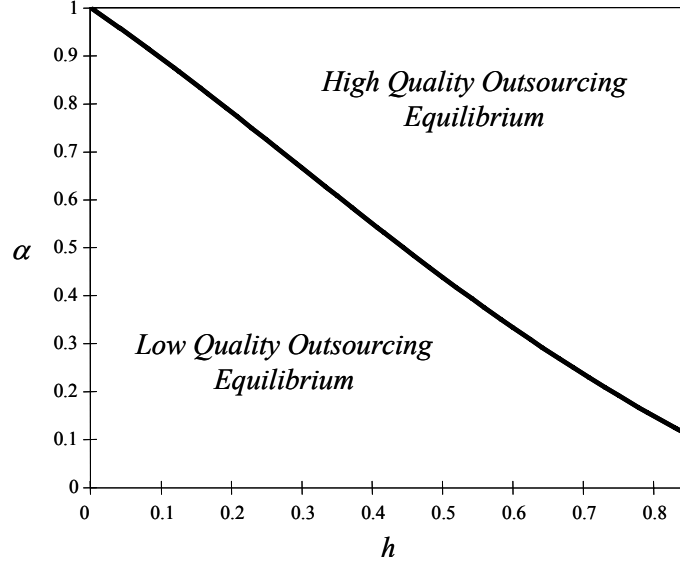


Figure 1: Types of Equilibria

### 3.1 Low Quality Outsourcing Equilibrium

Denote by  $z_{WL}^*$  the threshold that separates the ability of the agents that are workers or managers in a LQE. In order for the world equilibrium to be a LQE it must be the case that  $\alpha < z_{WL}^*$  (i.e., that all agents in the South are workers). For an assignment satisfy the world labor market equilibrium condition it has to satisfy (2) or, in this case,

$$m'(z) = \begin{cases} \frac{1+\alpha}{\alpha} h (1-z) & \text{if } 0 < z < \alpha \\ h (1-z) & \text{if } \alpha < z < z_{WL}^* \end{cases}.$$

Equilibrium in the labor market also implies that  $m(0) = z_{WL}^*$  and  $m(z_{WL}^*) = 1$ . In order for the wage function to be differentiable (see eq. (1)), the assignment function has to be continuous at all  $z < z_{WL}^*$ , and in particular at  $\alpha$ . This characteristic of the equilibrium allocation provides another boundary condition of the problem. Using the two differential equations and the three boundary conditions we can solve for the

assignment function

$$m_{WL}(z) = \begin{cases} z_{WL}^* + \frac{1+\alpha}{\alpha}hz \left(1 - \frac{1}{2}z\right) & \text{if } 0 < z < \alpha \\ z_{WL}^* + h \left(1 - \frac{1}{2}\alpha\right) + hz \left(1 - \frac{1}{2}z\right) & \text{if } \alpha < z < z_{WL}^* \end{cases}, \quad (8)$$

as well as for the threshold

$$z_{WL}^* = \frac{1 + h - \sqrt{1 + h^2(3 - \alpha)}}{h}. \quad (9)$$

Again, simple differentiation verifies that  $z_{WL}^*$ , the set of workers in the world, decreases with  $h$  and increases with  $\alpha$ , where the intuition is similar to the one for the closed economy. Note that the assignment function is continuous, but not differentiable at  $\alpha$ .

In order for the world to be in a LQE we need to guarantee that  $z_{WL}^* > \alpha$  or

$$h < \frac{2(1 - \alpha)}{2 + \alpha - \alpha^2}. \quad (10)$$

The right-hand-side of the inequality is decreasing in  $\alpha$  and is equal to zero for  $\alpha = 1$  and equal to one for  $\alpha = 0$ . This condition, with equality, is the line that separates the parameter set where we obtain each equilibrium and that was plotted in Figure 1.

Maximization of rents by managers implies that wages have to satisfy (1). Furthermore, in order for agents not to have incentives to join other firms in the economy that would be willing to hire them, we also know that the earnings function has to be continuous. In particular, the wage function has to be continuous at  $\alpha$  and wages and rents have to be equal at  $z_{WL}^*$ . The latter condition is given by  $w_{WL}(z_{WL}^*) = R_{WL}(z_{WL}^*)$ . Combining all these conditions we obtain

$$w_{WL}(z) = \begin{cases} z_{WL}^* - \sigma_{1L}(1 - z) + \frac{1}{2}\left(\frac{1+\alpha}{\alpha}\right)hz^2 & \text{if } 0 < z < \alpha \\ z_{WL}^* + h \left(1 - \frac{1}{2}\alpha\right) - \sigma_{2L}(1 - z) + \frac{1}{2}hz^2 & \text{if } \alpha < z < z_{WL}^* \end{cases}, \quad (11)$$

where

$$\sigma_{1L} = \frac{hz_{WL}^* \left(1 + h + \frac{1}{2}hz_{WL}^*\right) - \frac{1}{2}h^2\alpha}{1 + h - hz_{WL}^*} \quad (12)$$

and

$$\sigma_{2L} = \sigma_{1L} + h.$$

Note that at  $z_{WL}^*$ ,

$$w'_{WL}(z_{WL}^*) = \frac{1 - w_{WL}(z_{WL}^*)}{1 - z_{WL}^*} \leq \frac{1}{h} = R'_{WL}(z_{WL}^*),$$



for  $h < h^*$  (see the proof of Theorem 1). Hence, the earnings function has a kink, a non differentiability, at  $z_{WL}^*$ . This implies that, given that the wage and rent functions are convex, the marginal return to skill is larger for managers than for workers.

Figure 2 summarizes what we have discussed about a LQE. Agents with skills in  $[0, \alpha]$  in the South and North work for northern managers with skills in  $[z_{WL}^*, m_{WL}(\alpha)]$ . Agents in the North with skills in  $[\alpha, z_{WL}^*]$  work for managers in the North with skills in  $[m_{WL}(\alpha), 1]$ . The wage function of all workers in the world, and the rent function of northern managers, is a continuous and differentiable function of skills. The marginal return to skill of managers is larger than that of workers.

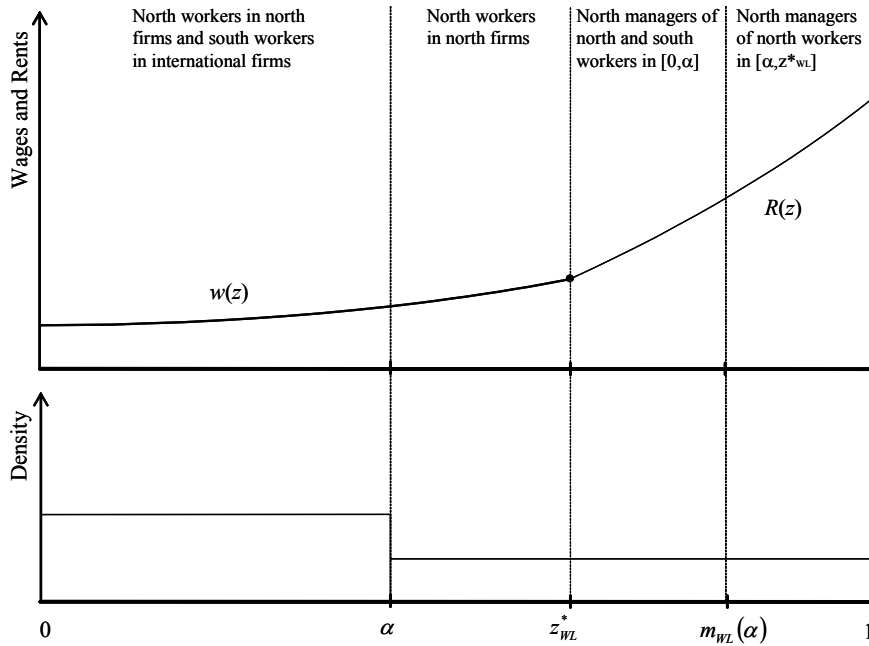


Figure 2: Low Quality Outsourcing Equilibrium

It is easy to draw an initial conclusion on the effect of globalization (moving from autarky to a world with international outsourcing). If the skill level of agents in the South is low and communication costs are also relatively low we will be in a LQE. After globalization, some agents will become workers in the South and some agents will become managers in the North. These occupational choice implications of globalization will have multiple consequences for wages, rents, output, consumption, as well as the cross-sectional differences between national and international teams. We will study those in Section 4 in detail. First we turn to the analysis of the second type of world equilibria: the HQE.

### 3.2 High Quality Outsourcing Equilibrium

A HQE is such that the highest skilled agents in the South decide to become managers. If we denote by  $z_{WH}^*$  the threshold such that agents with lower skills decide to become workers and agents with higher skill decide to become managers, in a HQE it must be the case that  $z_{WH}^* < \alpha$ . Positive sorting implies that, since the managers in the South are part of the group of the lowest skilled managers in the world, they are matched with the lowest skilled agents. In particular, agents in the set  $[0, z_\alpha]$ . Agents with skills lower than  $z_\alpha$  work for managers in their own country, and workers with skills greater than  $z_\alpha$  work in international teams. The threshold  $z_\alpha$  is defined by the worker that works for the best agent in the South, namely,  $m(z_\alpha) = \alpha$ . Then, labor market clearing implies that

$$m'_{WH}(z) = \begin{cases} h(1-z) & \text{if } 0 < z < z_\alpha \\ \frac{1+\alpha}{\alpha}h(1-z) & \text{if } z_\alpha < z < z_{WH}^* \end{cases},$$

which restates condition (2) for this case, together with the same boundary conditions as in the LQE:  $m(0) = z_{WH}^*$ ,  $m(z_{WH}^*) = 1$ . On top of this we have to guarantee again that the equilibrium assignment function is continuous, in particular at  $z_\alpha$ , in order for the wage function to be differentiable. These conditions then result in an equilibrium assignment function given by

$$m_{WH}(z) = \begin{cases} z_{WH}^* + hz(1 - \frac{1}{2}z) & \text{if } 0 < z < z_\alpha \\ z_{WH}^* - \frac{1}{\alpha}hz_\alpha(1 - \frac{1}{2}z_\alpha) + \frac{1+\alpha}{\alpha}hz(1 - \frac{1}{2}z) & \text{if } z_\alpha < z < z_{WH}^* \end{cases}, \quad (13)$$

and a threshold

$$z_{WH}^* = \frac{1+h - \sqrt{1+h^2 + (\frac{1-\alpha}{1+\alpha})2h}}{h}. \quad (14)$$

One can verify again that  $z_{WH}^*$  is decreasing in  $h$  and increasing in  $\alpha$ . Using the definition of  $z_\alpha$  we also obtain that

$$z_\alpha = 1 - \sqrt{1 - 2\left(\frac{\alpha - z_{WH}^*}{h}\right)}. \quad (15)$$

It is straightforward to show that the condition that ensures that this world equilibrium is of the HQE form (i.e.,  $z_W^* < \alpha$ ) is the reciprocal of condition (10).

Again, maximization of rents implies that condition (1) has to be satisfied, together with  $w_{WH}(z_{WH}^*) = R_{WH}(z_{WH}^*)$  and continuity of wages at  $z_\alpha$ . Solving the two

differential equations we obtain that

$$w_{WH}(z) = \begin{cases} z_{WH}^* - \sigma_{1H}(1-z) + \frac{1}{2}hz^2 & \text{if } 0 < z < z_\alpha \\ z_{WH}^* - \frac{1}{\alpha}hz_\alpha(1 - \frac{1}{2}z_\alpha) - \sigma_{2H}(1-z) + \frac{1}{2}\left(\frac{1+\alpha}{\alpha}\right)hz^2 & \text{if } z_\alpha < z < z_{WH}^* \end{cases} \quad (16)$$

where

$$\sigma_{1H} = \frac{hz_{WH}^* \left(1 - \frac{1}{\alpha}hz_\alpha + \frac{1+\alpha}{2\alpha}hz_{WH}^*\right) + \frac{1}{2\alpha}(hz_\alpha)^2}{1 + h - hz_{WH}^*} \quad (17)$$

and

$$\sigma_{2H} = \sigma_{1H} - \frac{h}{\alpha}z_\alpha.$$

As in the LQE, it is easy to show that the marginal return to skill is increasing in the level of skills and is larger for managers than for workers.

Let us summarize what we have shown for the HQE using Figure 3. Agents with skills in  $[0, z_\alpha]$  work in national firms for managers with skills in  $[z_{WH}^*, \alpha]$ . Agents with skills between  $z_\alpha = m^{-1}(\alpha)$  and  $z_{WH}^*$  work for northern managers with skills in  $[\alpha, 1]$ . This set of managers includes the ones that manage international teams. As before, the earnings function is continuous and differentiable everywhere except for  $z_{WH}^*$  in which its slope increases discretely.

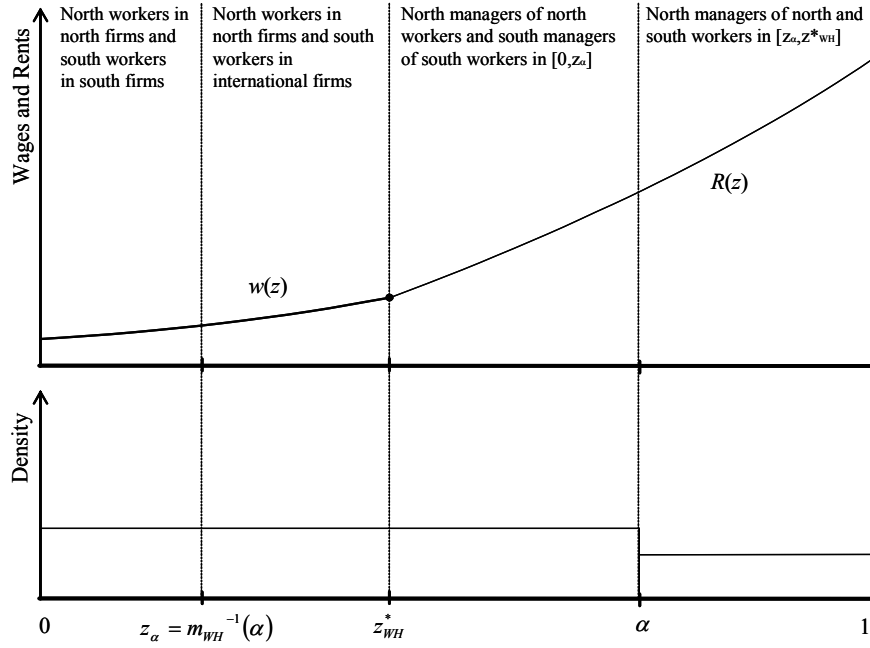


Figure 3: High Quality Outsourcing Equilibrium

### 3.3 Measuring Outsourcing and Wage Inequality

One of the main goals of this paper is to derive conclusions on the effect of globalization, as well as of smooth changes in communication costs and in the skill overlap, on outsourcing and wage inequality. To do this, we first need to propose suitable measures for the quantity and quality of outsourcing. We also need to propose a set of measures that will help us characterize the effect of these changes on the distribution of wages, and in particular wage inequality.

#### 3.3.1 Outsourcing

In Section 5 we will discuss how the quantity of outsourcing changes as communication costs or the skill overlap change. In order to do this we need a measure of outsourcing that captures the extent to which firms in the economy are formed by national versus international teams. Therefore, we define the *quantity* of outsourcing as the proportion of southern workers that work for international teams. In a LQE, all agents in the South are workers in international teams, so it follows that our measure of outsourcing equals one for all  $h$  and  $\alpha$  such that  $h < 2(1 - \alpha) / (2 + \alpha - \alpha^2)$ . Conversely, in a HQE, the quantity of outsourcing is given by

$$O_W \equiv \frac{z_W^* - z_\alpha}{z_W^*}.$$

This implies that the proportion of workers in international teams is always less than one, but converges to one as we change parameters to approach the boundary between both type of equilibria. Hence, in a LQE there is always more outsourcing than in a HQE.

In our framework it is also interesting to define what we call the *quality* of outsourcing. This will help us analyze the characteristics of the firms that engage in outsourcing. We measure the quality of outsourcing as the average skill level of the workers that form international teams relative to the skill level of all southern workers. Again, in a LQE the quality of outsourcing is always equal to one. Instead, in a HQE the quality of outsourcing is given by

$$Q_W \equiv \frac{z_W^* + z_\alpha}{z_W^*}.$$

Hence, in a HQE the quality of outsourcing is always larger than one and again converges to 1 as we change parameter values in a way that approaches the boundary

between equilibria. It thus follows that in a LQE the quality of outsourcing is always lower than in a HQE, thus justifying the names that we chose for the two types of world equilibria in our setup. Understanding the quality of outsourcing is informative about the cross-sectional characteristics of the firms that engage in outsourcing. In a HQE the firms that engage in outsourcing are on average larger than national firms and, therefore, are on average more productive in terms of output per capita. These firms will also pay on average higher wages than national firms both in absolute terms and in units of skills. In contrast, in a LQE the firms that engage in outsourcing are, on average, smaller, less productive, and pay lower absolute and per unit of skill wages. In Section 5 we will study how these properties change within an equilibrium as we change the skill overlap and communication costs.

### 3.3.2 Wage Inequality

Any change in communication technology  $h$ , the skill overlap  $\alpha$ , or a move from autarky to globalization will imply distinct changes in the distribution of wages. First, it may change the level of the wage function. In particular  $w(0)$ , the wage of the poorest agents in the world. In the next section we will analyze the effect of all these changes on poverty, by analyzing what happens to the wages of the agents with the lowest skill levels in the economy. Second, the slope of the wage function will change, and it will change potentially differently for agents with different levels of skills. To analyze these changes in the marginal return to skills we will use the derivative of the wage function, which is increasing in the skill level. This measure is informative in drawing conclusions on the dispersion of wages of agents that have similar skill levels. We also want measures that are closer to the ones used in the empirical literature, and that are informative about the changes in overall wage inequality in the world or a particular country.

One potential measure of wage inequality is the ratio of the wage of the highest skilled agent and the wage of the lowest skilled agent. That is,  $w(z_W^*)/w(0)$ , where

$$z_W^* \equiv \begin{cases} z_{WL}^* & \text{if } h < 2(1 - \alpha) / (2 + \alpha - \alpha^2) \\ z_{WH}^* & \text{if } h > 2(1 - \alpha) / (2 + \alpha - \alpha^2) \end{cases},$$

when we are referring to wage inequality in the world (we follow this notation for all variables and functions). The problem with this measure is that it combines the level and slope effects on the wage distribution in a way that is not always straightforward to disentangle. In particular, important level effects may imply reductions in inequality

in cases where the slope of the wage function is strictly increasing. To avoid this problem we focus on changes in the absolute differences between the wages of the highest skilled workers and the lowest ones. That is, for the particular case illustrated before,  $w_W(z_W^*) - w_W(0)$ . We will use this measure consistently every time we talk about wage inequality.

Changes in our measure of wage inequality can in turn be decomposed into two. The first part is the cumulative changes in the slope of the wage function and results from the combination of the complementarity and competition effects described above. The second part, the occupational choice effect, is the change in the set of agents that choose to become workers. The complementarity and occupational choice effects are novel in our theory, and are lacking in most of the other frameworks that study the effect of globalization on wages. In our model, the sets of agents that become workers is endogenous, which implies that changes in the economic environment will lead to potentially important occupational choice or composition effects. To illustrate this, suppose we analyze the effect of globalization on wage inequality in the South when the world equilibrium is of the HQE type. The change in wage inequality with composition effects would be calculated as  $(w_W(z_W^*) - w_W(0)) - (w_S(z_S^*) - w_S(0))$ . Without compositional effects we would calculate it as  $(w_W(z_S^*) - w_W(0)) - (w_S(z_S^*) - w_S(0))$ . The difference between these two measures is associated to the change in the set of workers,  $z_W^* - z_S^*$ .

An alternative measure of changes in wage inequality in the context of our model is the change in the non-linear (quadratic) term in the wage equation. This term, which we refer to throughout the analysis as the ‘*complementarity effect*’, measures the premium that a worker receives for possessing a particular skill level, in excess of what several separate workers would receive for possessing the same aggregate amount of skill. In other words, the term reflects the extent to which workers with different skill levels are imperfect substitutes in production, which is one fundamental measure of the extent to which they are unequal in production. This narrower measure may be more appealing from the perspective of recent empirical research in labor economics which uses wage ratios to evaluate wage inequality, and which would therefore not capture changes in inequality driven by increases in the price of skill that simply increased the price of skill proportionally for *all* skill levels. Whatever measure of inequality is used, a positive ‘complementarity effect’ will always unambiguously push the wage schedule towards higher inequality.

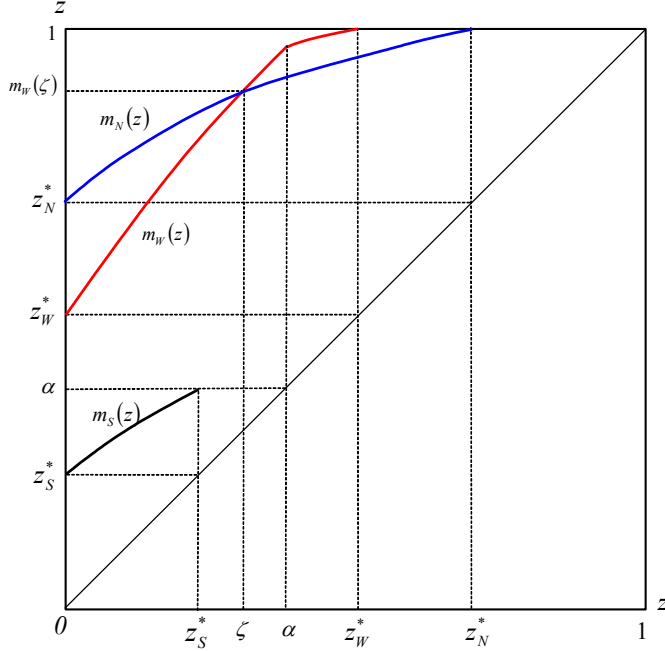


Figure 4a: Matching before and after globalization in a LQE

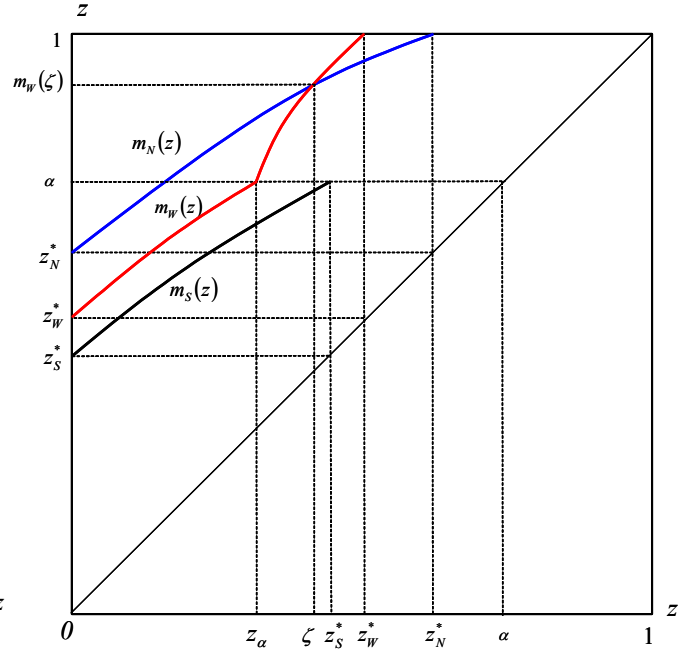


Figure 4b: Matching before and after globalization in a HQE

## 4 Effects of Globalization

We study here the impact of an exogenous policy or technological change, that we call globalization, that allows for the formation of international teams on the composition of teams, occupational choices, and the rewards structure of the economy. That is, in our framework, we compare the world equilibrium of Section 3 with the autarkic equilibria in North and South that we described in Section 2.

### 4.1 Matching, Occupational Choice and Firm Characteristics

How does globalization affect occupational choice? To compare the open and autarkic equilibria we use Figure 4. The figure presents the matching functions in autarky and the two type of world equilibria. The blending of the two skill distributions produces a rearrangement of the matches for both northern and southern workers. Independently of the equilibrium we are studying, it is evident from the figure that all the workers from the South strictly improve their match, that is, the presence of better managers in the international market improves their matches. This is the case even for southern workers that do not become matched with international managers, since some southern managers become workers in international teams, and the absence of these managers

increases the quality of the match of every worker. Agents who were managers before globalization may either become workers (as there is a supply of higher quality managers that can do better their problem solving job) or they may remain managers. In the latter case, they are matched with lower skilled workers, precisely because some of the southern managers who were previously managing low quality workers have become workers, and the remaining managers are displaced to lower quality agents. In other words, while workers always benefit from the higher quality managers available for matching, managers' matches suffer from the increasing competition of better international managers.

The picture is considerably different for workers in the North. The key change is in the opportunities of the middle-skilled agents in the North. Previously, they were not 'good enough' to be team managers. After globalization, their opportunities have greatly expanded, since there is a set of low-skilled agents who need managing. As a result, some of the marginal workers become managers of low skilled agents. This implies that matches of northern agents with sufficiently low skill necessarily become worse. However, the highly skilled workers in the North have now less competition, since some of their highly skilled competitors, particularly the ones who were previously matched with the best northern managers, have become managers. As a result, as we show formally in Proposition (1) and illustrate in Figure 4, there is a skill level  $\zeta$  below which the competition effect for workers dominates, and they have worse matches, while above it the higher demand for managers jobs dominates and the northern workers improve their matches. The story for northern managers is exactly the reverse side of this one.

The following proposition formalizes these results.

**Proposition 1** *Globalization has the following effects on team formation:*

- (i) *The mass of southern workers and the mass of northern managers both increase, i.e.,  $z_S^* < z_W^* < z_N^*$ .*
- (ii) (a) *Southern workers that were already workers are matched with a better manager.*  
 (b) *Southern managers that remain managers are matched with worse workers.*  
 (c) *Southern managers that become workers are matched with a northern manager.*
- (iii) (a) *There exists a unique threshold  $\zeta$  such that all northern workers that remain workers with  $z < \zeta$  are matched with a worse manager, while those with  $z > \zeta$  are matched with a better manager.*



- (b) *All northern managers that were already managers with  $z < m_W(\zeta)$  are matched with a better worker, while those with  $z > m_W(\zeta)$  are matched with a worse worker.*

Part (i) of Proposition (1) has interesting implications for the effects of globalization on job creation/destruction and firm creation/destruction in each of the two countries. In particular, if we associate the number of jobs with the measure of production workers, a corollary of the proposition is that globalization leads to job creation in the South and to job destruction in the North. Similarly, if firms are identified by the managers than run them, we can conclude that globalization leads to firm destruction in the South and to firm creation in the North.

Parts (ii) and (iii) of Proposition (1) also have interesting implications for the size distribution of firms in each country. Notice that, since the best workers in the North are now matched with a better manager, the size of the largest firms in the North decreases. However, the size of the smallest firms increases since those managers are matched with better workers. Hence, the range of firm sizes in the North decreases. In contrast, all businesses that remain alive in the South shrink, since all southern managers are matched with worst workers. Therefore size dispersion in the South also decreases. In sum, measured from the South perspective, globalization leads to firm destruction and to downsizing of the surviving businesses. At the end of this section we will show that this structural change, which at first glance may seem to be damaging for the South, actually results in welfare gains for both countries.

**Corollary 1** *Globalization leads to job creation and firm destruction in the South, and to job destruction and firm creation in the North. Furthermore, it compresses the size distribution of firms in both countries and reduces the size of all surviving southern firms.*

Proposition (1) also implies that the best workers in the South are in international teams and thus work for the most productive and larger firms doing business in the South. This is also evident in Figure 4: international matches (those that obtain for southern workers with managers of quality higher than  $\alpha$ ) always involve the higher skilled among the southern workers. This sorting may provide a rationale for the often-found result that ‘southern’ workers employed in multinational firms receive wages that are on average higher than those received by workers employed in domestic firms (see, for instance, Aitken, Harrison and Lipsey (1996) and Lipsey and Sjöholm (2004)). More specifically, a rationale for the regression result is simply that those that hold

outsourced jobs are unobservably more skilled than those that do not. Controlling linearly for the skill of workers is unlikely to solve this problem, as earnings are the result, as we show below, of the interaction between the skill of the worker and that of the (higher quality) international manager. In particular, Aitken et. al. (1996) only distinguish between skilled and unskilled workers and Lipsey and Sjöholm (2004) control linearly for educational attainment of workers, both of these controls would not eliminate the relationship wages and multinational generated by our framework.

**Corollary 2** *The best workers in the South work for northern managers and receive higher wages than southern workers that are employed by southern managers.*

## 4.2 Wage Inequality and Returns to Skill

The previous section focused on the quantity outcomes in the model. Corresponding to those quantities, prices have to adjust for equilibrium to be reached. That is, workers wages and managerial earnings must be such that the matches are rearranged. In particular, recall that equilibrium requires that earnings of the marginal worker be equal to those of the marginal manager; and that the slope of wages is such that managers do not want to change the workers they hire.

The model therefore allows us to study the changes in the return to skill driven by the changes in matching that globalization brings about. The analysis follows quite directly from the changes in matching. First, inequality within southern workers unambiguously increases. The marginal value of workers' skill is driven by the skill of the manager with whom they are matched, which increases for all southern workers. Thus, the sum of the *complementarity* and the *competition* effects unambiguously lead to higher returns to skill in this case. Moreover, measured within worker inequality will increase even more, since the mass of workers in the South unambiguously increases (*occupational choice* effect).

**Proposition 2** *Globalization increases within-worker wage inequality in the South. Furthermore, it increases the marginal return to skill for southern workers at all skill levels.*

The second result, also following from our understanding of matching, is that globalization decreases the quality of the match of those northern workers who are relatively unskilled and increases it for the more skilled among them. As we could expect, given that the marginal return to skill of all workers is a function of the quality of the match,

the returns to skill for relatively low skilled northern workers go down, and the returns to skill for the more skilled ones go up. There are two opposite economic forces that lead to these effects, which makes this conclusion not as straightforward as in the South. Notice that the change in the marginal return to skill can be written as

$$\left\{ \begin{array}{ll} \sigma_{1W} - \sigma_N + \frac{h}{\alpha}z & \text{if } 0 < z_p < \alpha \text{ and } h < 2(1 - \alpha) / (2 + \alpha - \alpha^2) \\ \sigma_{1W} - \sigma_N + h & \text{if } \alpha < z_p < z_{WL}^* \text{ and } h < 2(1 - \alpha) / (2 + \alpha - \alpha^2) \\ \sigma_{1W} - \sigma_N & \text{if } 0 < z_p < z_\alpha \text{ and } h > 2(1 - \alpha) / (2 + \alpha - \alpha^2) \\ \sigma_{1W} - \sigma_N + \frac{h}{\alpha}(z - z_\alpha) & \text{if } z_\alpha < z_p < z_{WH}^* \text{ and } h > 2(1 - \alpha) / (2 + \alpha - \alpha^2) \end{array} \right.$$

where

$$\sigma_{1W} = \begin{cases} \sigma_{1L} & \text{if } h < 2(1 - \alpha) / (2 + \alpha - \alpha^2) \\ \sigma_{1H} & \text{if } h > 2(1 - \alpha) / (2 + \alpha - \alpha^2) \end{cases} .$$

The equilibrium effect on the marginal return to skill can again be decomposed in two. On the one hand, because now there is more competition from workers in the South, the baseline return per unit of skill always goes down. The *competition* effect thus lowers the marginal return to skill. Figure 5 plots  $\sigma_{1W} - \sigma_N$  confirming numerically that in fact the term is negative for all  $h$  and  $\alpha$ .

On the other hand, since there are more workers for some skill levels, an increase in the skill level of workers increases the quality of their managers more after globalization. Thus the *complementarity* effect, captured by the convexity term in the marginal returns equation (i.e. the term of the form *constant*  $\times z$ ), tends to increase the marginal return to skill. The latter effect is more valuable the higher the ability of the workers, since they are part of larger teams, as long as southern and northern workers compete for the same manager. In fact, for workers without skills,  $z = 0$ , this effect is not present so the first effect has to dominate and the marginal return to skill decreases. Numerically, we can show that the second effect dominates for high skilled workers and so the marginal return to skill for them increases. The threshold of ability at which both effects are identical is a function of the parameters  $h$  and  $\alpha$ . The lower  $\alpha$  the more southern agents are being added at each skill level where workers in both countries compete, and so the larger the set of abilities in which the complementarity effect dominates. The lower  $h$ , the smaller the competition effect, and so again the threshold of abilities decreases.

In order to understand the effects on wage inequality, we need to combine this reasoning with the occupational choice effect. In particular the fact that after globalization less agents in the North become managers, which reduces wage disparity. Numerically

we can conclude that wage inequality in the North increases when  $h$  and  $\alpha$  are small. Figure 6 illustrates this claim with and without the occupational choice effect. The figure plots the points for which the change in wage inequality after globalization is zero. For all parameter combinations to the left of these curves, wage inequality in the North increases. Notice how for wage inequality to increase in the North the main requirement is for communication costs to be sufficiently low. We summarize these results below.

**Summary 1** *Globalization increases within-worker wage inequality in the North if  $h$  and  $\alpha$  are sufficiently low, but it decreases it if  $h$  and  $\alpha$  are sufficiently high. Furthermore, globalization decreases the marginal return to skill of all northern workers with knowledge  $z$  below a threshold but increases the marginal return to skill of all northern workers above this threshold.*

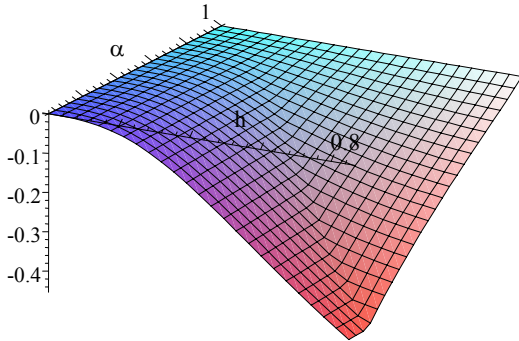


Figure 5: Change in average return per unit of worker skill,  $\sigma_{1W} - \sigma_N$ .

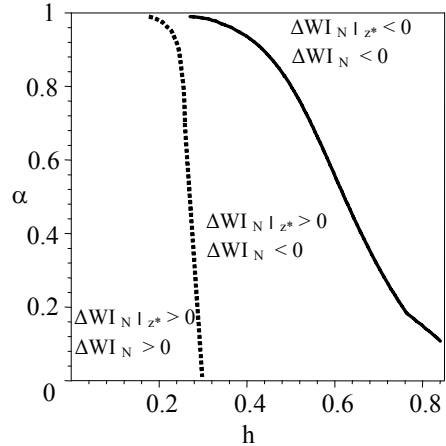


Figure 6: Change in northern wage inequality with (dashed) and without (solid) occupational choice effect.

We can also derive some conclusions on wage inequality among managers in both countries. In particular, remember that the marginal return to skills of managers is given by the size of their team. From Proposition (1) we know that all managers in the South will have smaller teams and so the marginal return to skills for them decreases. Since there is also fewer of them, within-manager income inequality in the South decreases. Again for the North the analysis is more complicated. First, from Proposition (1) we know that the lowest skilled managers, that were in managerial positions before globalization, will have larger teams, but the best managers will have

smaller teams. This implies that the return to skills of low ability managers increases and of high ability managers decreases. Second, there are more managers in the North, so the occupational choice effect leads to more income inequality among managers. This reasoning leads to the following corollary of Proposition (1).

**Corollary 3** *Globalization has the following effects on within-manager income inequality and on the marginal return to skill of managers:*

- (i) *Globalization decreases within-manager income inequality and the marginal return to skill of southern managers.*
- (ii) *Globalization increases the marginal return to skill for northern managers with knowledge  $z$  below a threshold but decreases it for the rest.*

### 4.3 Winners and Losers

As the previous sections have shown, globalization leads to an improvement in the matches of all southern workers, thus raising the marginal product of all of them. At the same time, it increases the competition among low skilled agents, since low skilled southern workers must now compete with northern workers for good matches. Which effect dominates the balance depends on communication costs and on the skill overlap between the two countries. If the South is relatively very unskilled ( $\alpha$  is low) the gain from the new available matches is very high and the competition effect is dominated by the improvement in matching. Moreover, if  $h$  is low, all agents are matched with the top agents available in the distribution, and thus opening the borders raises substantially the quality of the match. In fact, we can show numerically that for low enough  $h$  and  $\alpha$ , the gain in the quality of the match is sufficiently high that all southern workers with skills  $z = 0$  are better off. Conversely, if  $h$  and  $\alpha$  are sufficiently high southern workers are worse off. The change in  $w(0)$  is shown in Figure 7, where the areas to the left of the curve are the parameter combinations where the change is positive. In the previous section we showed that the marginal return to skill in the South increases for all workers, hence for  $h$  and  $\alpha$  low an increase in  $w(0)$  in the South implies that all workers are better off.

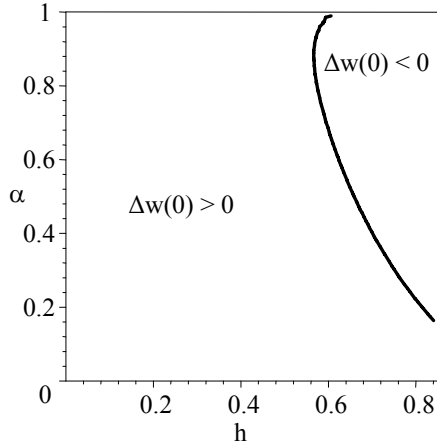


Figure 7: Effect of globalization  
on  $w(0)$  in the south

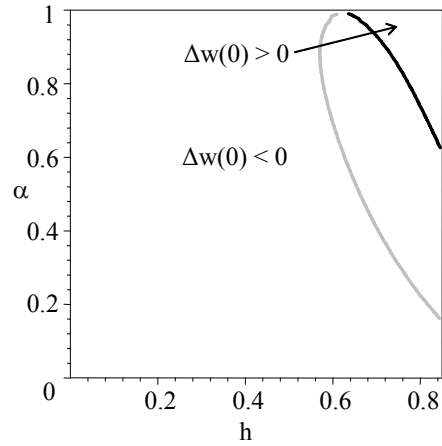


Figure 8: Effect of globalization  
on  $w(0)$  in the north

Northern workers suffer a direct damage from the increasing competition from the South; this is the standard market effect that would appear in any general equilibrium model, even without matching. However, as we saw in the previous subsection, the fact that the demand for northern managers increases with globalization means that some workers become managers and this raises the wage schedule for workers around them, who are matched with better managers. Thus, indirectly (through the drop in the number of northern production workers and the increase in managers) globalization increases the value of northern workers and may actually help them. What ultimately determines the balance of these two effects is, as before, the skill overlap and the costs of communication. If the country with which the outsourcing is undertaken is highly skilled (high  $\alpha$ ) this effectively limits the competitive effect. If communication costs are also high some of the southern agents will be managers thereby decreasing further the competition effect. Thus for high  $h$  and  $\alpha$ , northern workers are better off post globalization. The change in the wage of northern workers with no skills,  $w(0)$ , is shown in Figure 8 where the areas to the right of the dark line represent parameter combinations where the change is positive. Notice that Figure 7 and 8 combined imply that there are always losers from globalization, as illustrated in Figure 8 with the light curve. We now summarize this discussion and our numerical results:

**Summary 2** *Globalization has the following effects on wages:*

- (i) *Increases the wages of all southern workers for low  $h$  and  $\alpha$ , but decreases them for high  $h$  and  $\alpha$ .*
- (ii) *Decreases the wages of low skilled northern workers for low  $h$  and  $\alpha$ , but increases them for high  $h$  and  $\alpha$ .*

(iii) It decreases the wage of at least some low skilled agents.

## 4.4 Production, Consumption and Trade

As argued above, Theorem (1) applies also to the equilibrium of the world economy, and therefore this equilibrium is unique and efficient. Given this, since in the world economy we could always replicate the equilibrium in the closed economies of the North and the South, we know that in our framework there are always welfare gains from international outsourcing. The following corollary summarizes this conclusion.

**Corollary 4** *Globalization increases total production in the world economy. That is, there are gains from trade.*

How are these gains distributed between the countries? We want to derive conclusions on the effect of globalization on manufacturing production and consumption in both countries and, as an implication, on the balance of trade in goods. In order to talk about production in the different countries we need to take a stand on how we define manufacturing output. We define a countries' manufacturing production as the number of goods that are produced by its workers, since they are the ones that combine labor and knowledge to produce. That is, production in the South and North in the world economy are given by

$$Y_{WS} = \begin{cases} \int_0^\alpha m_W(z) \frac{1}{\alpha} dz & \text{if } h > \frac{2(1-\alpha)}{2+\alpha-\alpha^2} \\ \int_0^{z_{WH}^*} m_W(z) \frac{1}{\alpha} dz = \frac{1}{1+\alpha} Y_W & \text{if } h < \frac{2(1-\alpha)}{2+\alpha-\alpha^2} \end{cases},$$

and

$$Y_{WN} = \begin{cases} \int_0^{z_{WL}^*} m_W(z) dz & \text{if } h > \frac{2(1-\alpha)}{2+\alpha-\alpha^2} \\ \int_0^{z_{WH}^*} m_W(z) dz = \frac{\alpha}{1+\alpha} Y_W & \text{if } h < \frac{2(1-\alpha)}{2+\alpha-\alpha^2} \end{cases}.$$

From this definitions, we know that in a HQE, the South's share of production is always  $1/(1+\alpha)$  and the North share  $\alpha/(1+\alpha)$ , since in this equilibrium the sets of workers overlap perfectly.

In Proposition (1 part 1) we concluded that the number of workers increases in the South and falls in the North. This, in turn, will increase manufacturing production in the South and decrease it in the North. Other forces, however, come into play as well. In particular the other two parts of Proposition (1). Southern workers are

matched with a better manager after globalization and so each of them produces more. Low skilled northern workers are matched with worse managers and produce less while high skilled workers are matched with better managers. The implication for northern manufacturing production resulting from this effect is, thus, ambiguous. There is yet another force at work in the North. Namely, that in a HQE, the best northern managers may, after globalization, be working in international teams. It is easy to show numerically that for all combinations of  $h$  and  $\alpha$ , all these effects combined imply that, after globalization manufacturing production increases in the South and it decreases in the North. Hence, in terms of manufacturing value added growth, the winners of globalization are the southern countries. Figures 9 and 10 show these numerical results. The conclusion refers, of course, only to manufacturing production and not consumption or welfare to which we turn next.

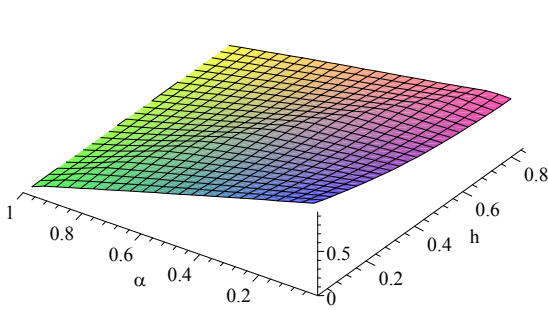


Figure 9: Change in southern manufacturing output after globalization

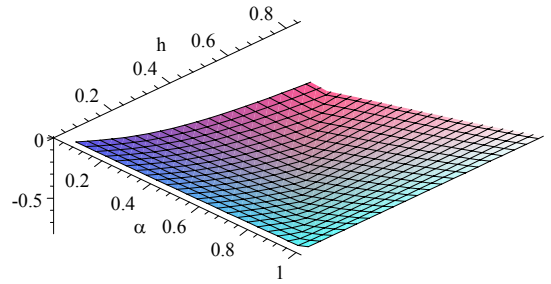


Figure 10: Change in northern manufacturing output after globalization

Consumption in the South and North in the world economy is given by

$$C_{WS} = \begin{cases} \int_0^\alpha w(z) \frac{1}{\alpha} dz & \text{if } h > \frac{2(1-\alpha)}{2+\alpha-\alpha^2} \\ \int_0^{z_\alpha} m_W(z) \frac{1}{\alpha} dz + \int_{z_\alpha}^{z^{*WH}} w(z) \frac{1}{\alpha} dz & \text{if } h < \frac{2(1-\alpha)}{2+\alpha-\alpha^2} \end{cases},$$

and

$$C_{WN} = Y_W - C_{WS}.$$

The reason why the North produces less after globalization is that manufacturing production does not take into account that managers' rents have to be repatriated. Managers consume in their own country and they receive –as compensation for their time spent helping and communicating with workers abroad– part of the production of these workers. These rents can be substantial and in fact imply that once we take them



into account consumption in both countries increases. This can be shown numerically, for all values of  $h$  and  $\alpha$ , as Figures 11 and 12 show.

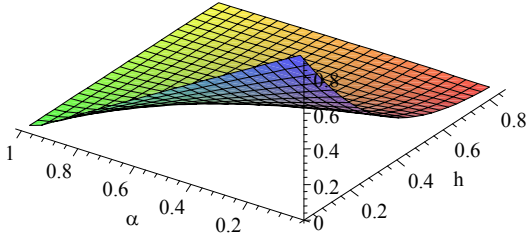


Figure 11: Change in southern consumption after globalization

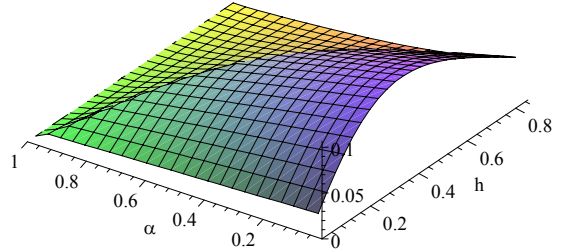


Figure 12: Change in northern consumption after globalization

Figures 11 and 12 show that both countries are better off in terms of total consumption and, since utility is linear, in terms of welfare. Hence, as countries globalize their economies, in general northern countries will be disappointed in terms of manufacturing output but pleased in terms of consumption, and southern countries will gain under both criteria but their consumption increases less than what their manufacturing output statistics may suggest. This difference in consumption and production outcomes has to be reflected in the trade balance of these countries. In particular, if knowledge transactions are not registered as imports for the South and exports for the North, the trade balance of the northern country will be in deficit and that of the southern country in surplus. This deficit or surplus is, however, not evidence of an imbalance, but just the result of miss-recording of knowledge transactions. This reasoning suggests that some of these forces may be at play when we look at the trade balance of the US with some of its Asian trade partners, like China. We summarize these conclusions below.

**Summary 3** *Globalization has the following effects on manufacturing production, consumption, and the trade balance:*

- (i) *It increases manufacturing production in the South and decreases manufacturing production in the North.*
- (ii) *It increases consumption (and thus welfare) in both countries.*
- (iii) *If knowledge transactions are not reported, globalization generates a trade surplus in the South and a trade deficit in the North.*

## 5 Comparative Statics in the World Economy

In this section we analyze the effect of changes in communication costs ( $h$ ) and the skill overlap ( $\alpha$ ) on the equilibrium outcome of the integrated economy. For each of the two parameters, we describe these effects sequentially. We first study the impact of these changes on the occupational choice decision and on the implied measures of workers and managers in each of the two countries. We next analyze the effects on the matching between managers and workers, which in turn determine the impact on the characteristics (quantity and quality) of international outsourcing, as well as the impact on the size distribution and productivity of firms. Finally, we study the implications for the structure of earnings in the world economy. In this latter respect, we show that the effect of changes in both parameters on wage inequality and the return to skill can again be decomposed into three effects.

### 5.1 Communication Costs

#### 5.1.1 Occupational Choice

As  $h$  decreases managers can deal with larger teams. This implies that firms will be larger in equilibrium, and therefore, for a given set of managers, the demand for workers increases. This will lead to higher wages for the best workers and will incentivate the worst managers to become workers. Since managers can leverage their knowledge more, given the lower communication costs, only the most able agents in the world become managers. In a LQE all agents in the South are workers and the decrease in communication costs implies that all of them will remain workers. In contrast, in the North, as the set of workers increases, the set of managers decreases. In a HQE the decrease in  $h$  implies that the set of workers in the both countries increases and the set of managers decreases. Notice that this is still the case if the decline in communication costs implies that we move from a HQE to a LQE. We formalize this result in the next proposition.

**Proposition 3** *The skill of the world's most-skilled worker ( $z_W^*$ ) is decreasing in communication costs ( $h$ ). Hence, the number of workers in the South weakly decreases with  $h$  and the number of workers in the North decreases with  $h$ . The number of managers in the South weakly increases with  $h$  and the number of managers in the North increases with  $h$ .*

From the previous proposition we can conclude that as communication costs in the world decrease, we will see firm destruction in the North and, if communication costs

and the skill level in the South are high, we will see it in the South as well. In contrast, an improvement in communication technology will lead to job creation in the North and, if  $h$  and  $\alpha$  are large, to job creation in the South as well.

### 5.1.2 The Quantity and Quality of Outsourcing

Proposition (3) is closely connected to the effect on the quantity and quality of outsourcing as communication costs decrease. In particular, an improvement in communication technology implies that the quantity of outsourcing increases and the quality of outsourcing decreases. To see this, note that from the previous proposition  $z_W^*$  decreases with  $h$ , which increases the quantity of outsourcing given  $z_\alpha$  (the skill level of the best worker that works for a national firm). The reason is that, given  $z_\alpha$ , more agents decide to become workers and they get to work for international firms. Of course,  $z_\alpha$  will change as well. As communication technology improves, there is a direct and an indirect effect on  $z_\alpha$ . The direct effect increases  $z_\alpha$  since a decrease in  $h$  increases the team sizes of national firms and therefore the number of workers that work for national managers. However, an improvement in communication technology increases  $z_W^*$  which has a negative effect on  $z_\alpha$ : Less agents in the South decide to become managers so they hire less workers. Hence the effect of  $h$  on  $z_\alpha$  is, in principle, ambiguous. The relationship that determines the increase or decrease in the quantity of outsourcing is the proportional change of  $z_\alpha$  versus the proportional change in  $z_W^*$ . The next proposition shows that both the proportion and the total number of workers in international firms increases with an improvement in communication technology.

**Proposition 4** *The quantity of international outsourcing is weakly decreasing in communication costs ( $h$ ). That is, the quantity of outsourcing increases with improvements in communication technology. The number of workers engaged in outsourcing also decreases with  $h$ .*

Proposition (4) has an immediate corollary on the quality of outsourcing. As the quantity of outsourcing increases, the average skill level of workers in international teams weakly decreases. The reason is that a reduction in  $h$  leads to an improvement in the average quality of the workers in both national and international firms. However, the increase in the quantity of outsourcing implies that the increase is larger for national than for international teams: International teams need to hire more workers and so they get workers that have lower skills than the other workers in international firms.

**Corollary 5** *The quality of outsourcing is weakly increasing in communication costs ( $h$ ). That is, the quality of outsourcing decreases with improvements in communication technology.*

### 5.1.3 Matching and Firm Characteristics

We now turn to the effect of improvements in communication technology on the characteristics of firms. As we have discussed in the previous propositions, a decline in  $h$  implies that more agents in the world become workers. Hence, a fall in  $h$  improves the skill level of the less skilled agent that decides to become a manager. Since these managers are always matched with workers without skills,  $z = 0$ , the match of these workers, and the productivity in terms of output per worker of these firms, improves. That is, the smallest firms become more productive. In contrast, the best worker, before the technological improvement was matched with the best manager in the world,  $z = 1$ , and now is matched with a worse manager since some agents became workers after the fall in  $h$ . Hence, the match of these workers, and therefore the productivity of the firms for which they work, decreases. Thus, as  $h$  declines, the productivity of the largest firms declines and the productivity of the smallest firms increases. In a LQE, the outsourcing firms are the smallest firms in the economy, so this conclusion implies that many of them, or all, will be more productive. In a HQE, the outsourcing firms are the smallest ones so this conclusion implies that the productivity of many of them, or all, will decline. Even though some of the firms in the world economy are less productive after the improvement in communication technology, we can show that the direct effect of the technological improvement on firm size dominates other effects thereby leading to an increase in the size of *all* firms in the economy. We formalize these conclusions in the next proposition.

**Proposition 5** *A decrease in communication costs ( $h$ ) has the following effects on matching and firm size:*

- (i) *it improves the match for workers below a threshold skill level  $\varphi$ , while it worsens the match for workers (that were already workers) above  $\varphi$ ;*
- (ii) *it decreases the productivity of the largest firms while increasing the productivity of the smallest firms;*
- (iii) *it increases the size of all firms.*

#### 5.1.4 Wage Inequality and Returns to Skill

So far we have analyzed changes of improvements in communication technology on allocations, namely, occupational choice, outsourcing and firm characteristics. These changes are, of course, the result of agents' reactions to changes in equilibrium prices. The whole distribution of wages and rents varies with an increase in  $h$ .

Concerning managerial rents, the implication of technological change follows as straightforward corollary of the previous proposition. Since all firm sizes increase, and the marginal return to skill of managers is just firm size, the marginal return to skill for managers increases with improvements in communication technology.

**Corollary 6** *A decrease in communication costs ( $h$ ) increases the marginal return to skill of managers.*

The effect on the returns to worker skill is more complex. There are three components determining the effect of changes in  $h$  on the marginal return to skill of workers: the complementarity effect, the effect on the baseline skill price, and an occupational choice effect.

First, the *complementarity* effect is the effect on the dispersion in the price of each unit of skill. The returns to skill are different for different workers, and depend on the amount that an individual possesses, since different workers are matched with different managers. This effect is simply captured in our model by the convexity of the wage function. It is easy to see that the degree of convexity of the wage function in (11) and (16) increases with  $h$ . Hence, as  $h$  declines, the increasing returns associated with possessing many units of skill decrease. The reason is that as  $h$  decreases, team sizes increases and, therefore, having more skills will not imply matching with a much better manager. This effect decreases the marginal return to skills of workers via a decrease in the dispersion in the price of units of skill. Hence, in our model this measure declines unambiguously with an improvement in communication technology.

Second, the change in the *baseline return* to a unit of ability, as captured by  $\sigma_{1L}$  and  $\sigma_{1H}$ . As  $h$  decreases, all managers run larger firms and so the demand for workers increases: the competition effect. Thus their units of skill are more valuable, which increases the average wage per unit of skill. However, the total sign of the effect on the  $\sigma$ 's is ambiguous, since there is also a direct effect of  $h$  on the  $\sigma$ 's that goes in the opposite direction.

Third, the set of workers in the world unambiguously increases. As a result, this *occupational choice effect* increases the dispersion in the return to skill.

The following corollary summarizes these results

**Summary 4** *A decline in communication costs ( $h$ ) has the following effects on the wage structure:*

- (i) it decreases the dispersion of the marginal return to skill of workers;*
- (ii) it has an ambiguous effect on the baseline return to skill;*
- (iii) it increases the variance in worker skill, leading, everything else equal, to increases in wage inequality.*

## 5.2 The Skill Overlap

### 5.2.1 Occupational Choice

As  $\alpha$  increases agents in the South become relatively more skilled. In a LQE an increase in  $\alpha$  decreases the supply of low skilled workers and increases the supply of high skilled ones. This in turn tends to increase the size of firms (firms hiring more able workers are larger) which increases the demand for workers' skills and decreases the demand for managers' skills. Hence, the set of skills of agents that become workers increases and the set of agents that become managers falls: an increase in  $z_W^*$ . After the increase in  $\alpha$ , only the best agents become managers. In a LQE, an increase in  $\alpha$  also leads to an increase in the number of workers in the North (all agents are workers in the South) and to a reduction in the number of managers, or firm destruction. In a HQE, an increase in  $\alpha$  has similar implications but due to different reasons. After an increase in  $\alpha$ , the relative ability of the agents that become workers does not change given occupational choices. The mass of workers decreases and the mass of managers increases which implies that, to restore equilibrium, wages will adjust so that more able agents decide to become workers: an increase in  $z_W^*$ . This change does not necessarily lead to an increase in the number of workers in the South, although it does in the North. The next proposition formalizes the result:

**Proposition 6** *The skill of the world's most-skilled worker ( $z_W^*$ ), is increasing in the skill overlap ( $\alpha$ ). The number of workers in the South weakly decreases with  $\alpha$ , whereas the number of workers in the North increases with  $\alpha$ . The number of managers in the South weakly increases with  $\alpha$ , whereas the number of managers in the North decreases with  $\alpha$ .*

### 5.2.2 The Quantity and Quality of Outsourcing

The effect of a change in the skill overlap on the quantity and quality of outsourcing is closely related to Proposition (6). In a LQE all agents in the South work for foreign

managers and so the quantity of outsourcing is always one. However, in a HQE, an increase in  $\alpha$  leads to a decrease in the quantity of outsourcing. The proportion of agents working in international teams decreases as agents in the South become more skilled. The main idea of why this is the case is simple: As agents in the South become more skilled, a larger proportion decide to become managers of national firms. Their higher skill level allows them to leverage their knowledge enough to earn more as managers of national firms than as workers of international firms. Of course, this has general equilibrium consequences, there is competition for national workers which raises the wages of low skilled workers thereby offsetting some of the direct effects. However, after taking all these effect into account, the simple logic still holds as we show in the next proposition.

**Proposition 7** *The quantity of international outsourcing is weakly decreasing in the skill overlap ( $\alpha$ ). That is, the quantity of outsourcing decreases as southern agents become more skilled. The number of workers engaged in outsourcing also decreases with  $\alpha$ .*

The previous proposition has an immediate corollary on the effect of  $\alpha$  on the quality of outsourcing. As the southern agents become more skilled the quality of outsourcing increases: The most productive and largest firms engage in outsourcing.

**Corollary 7** *The quality of outsourcing is weakly increasing in the skill overlap ( $\alpha$ ). That is, the quality of outsourcing increases as southern agents become more skilled.*

### 5.2.3 Matching and Firm Characteristics

Changes in the skill distribution of southern agents have distinct effects on small versus large firms, and the productivity of large versus small firms. In particular, as  $\alpha$  increases workers with low skill levels will now be matched with better managers, and will thus work for more productive firms. In contrast, workers with high skill levels will be matched with worse managers and so the productivity of the firms for which they work will decrease. As  $\alpha$  increases, in a LQE, the ability distribution of workers increases. This leads to larger teams, which in turn implies that the number of firms in the world decreases, as discussed before. Only the most productive firms survive, or, in other words, only the agents with the highest skills decide to become managers. On the one hand, this implies that the worst workers in the world now work for better managers. On the other hand, the best workers before the change, that used to work for managers with  $z = 1$ , now work for worse managers since they are not the best workers anymore.

In a HQE, an increase in  $\alpha$  implies that, given wages, there is an excess supply of managers, which reduces rents and increases wages, therefore leading to more agents choosing to become workers.

These results on matching imply that the managers that ran small firms, and are still managers after the change in  $\alpha$ , since they do not have to compete with the managers that became workers, hire worse workers. Therefore, they become smaller. Conversely, the managers that use to run the largest firms, now higher the workers that used to be managers. Since these workers are more skilled, the firms become larger. The same reasoning leads to the expansion of large outsourcing firms and an expansion of small outsourcing firms. The next proposition formalizes these claims.

**Proposition 8** *An increase in the skill overlap ( $\alpha$ ) has the following effects on matching and firm size:*

- (i) *it improves the match for workers below a threshold skill level, while it worsens the match for workers with skill above this threshold;*
- (ii) *it increases the size and productivity of the largest firms and decreases the size and productivity of the smallest firms;*
- (iii) *it increases the size and productivity of the largest outsourcers and decreases the size and productivity of the smallest outsourcers;*
- (iv) *it increases the size and productivity of all non-outsourcers in a LQE, but decreases the size and productivity of all non-outsourcers in a HQE.*

#### 5.2.4 Wage Inequality and Returns to Skill

Proposition (8) shows that the effect of  $\alpha$  on firm size is not the same for all firms. Since the size of firms is identical to the marginal return to skill of managers this implies that we cannot draw uniform conclusion on the effect of  $\alpha$  on the marginal return to skill of managers (as we did for communication costs). We can, however, conclude that the marginal return to skill of the worst managers decreases and the marginal return to skill of the best managers increases.

As in the case of communication costs, as the skill overlap ( $\alpha$ ) changes, we can observe three changes in the structure of wages.

First, there is the *complementarity effect*, the change in the dispersion of the prices of different units of skill. Again, this effect is captured by the quadratic term in both (11) and (16), which both weakly decrease with  $\alpha$ . The reason is that  $\alpha$  decreases the population density of all skill levels in the South, and skill levels of workers in the



North that face competition from workers in the South. This implies that a slightly better worker will now match with only a slightly better manager. The difference in the skill level of the managers that these agents work for decreases with  $\alpha$ , since there are less workers at each skill level. Hence, the drop in the dispersion in the price of units of skills. This effect is, as it was for  $h$ , unambiguous and may be what empirical studies capture when they control for different measures of ability or skills. By itself it implies a decrease in wage inequality as a result of increases in  $\alpha$ .

Second, the change in the *baseline return* to a unit of ability, as captured by  $\sigma_{1L}$  and  $\sigma_{1H}$ . We can show that an increase in  $\alpha$  increases both  $\sigma_{1L}$  and  $\sigma_{1H}$ . The baseline return to the skills of workers in international or national firms needs to go up, since workers became more skilled in a LQE or workers are more scarce in a HQE.

Third, the occupation choice effect. In a LQE an increase in  $\alpha$  has a direct effect on the dispersion in the skill level of agents in the South, and from Proposition (6) we know that in a HQE an increase in  $\alpha$  also increases this dispersion. Hence, the occupational choice effect always leads to an increase in wage inequality in the South. In the North Proposition (6) guarantees that this effect is positive in both equilibria. The following corollary captures this discussion.

**Summary 5** *An increase in the skill overlap ( $\alpha$ ) has the following three effects on the wage structure:*

- (i) *it decreases the dispersion of the marginal return to skill of workers;*
- (ii) *it increases the baseline return to skill;*
- (iii) *it increases the variance of worker skill, leading, everything else equal, to increases in wage inequality.*

## 6 Conclusions

We have developed a theory of outsourcing in which agents with heterogeneous abilities sort into teams competitively. In our model, the distribution of skills in the population determines both the types of teams that are formed and the wages that different agents command. We have interpreted globalization as a process that enables the formation of international teams and that thereby affects the distribution of skills available to agents in forming their teams. From the point of view of the North, globalization increases the mass of agents with relatively low ability, while from the point of view of the South, globalization increases the mass of agents with relatively high ability. We have analyzed the effects of globalization on the organization of work, the size distribution

of firms, and the structure of earnings of individuals, and we have illustrated how these outcomes in turn determine the patterns of production, consumption and international trade in the global economy.

We have shown that the effects of globalization interact in nontrivial ways with the state of communication technologies. For example, in our model globalization always increases within-worker wage inequality in the South, but it increases within-worker inequality in the North only if the costs of communicating knowledge are relatively low. Similarly, we have shown that the characteristics of international outsourcing also depend very much on the state of communication technologies: the lower are communication costs, the higher is the amount of international outsourcing, but the lower is its quality, as measured by the average skill level of the workers that form international teams relative to the skill level of all southern workers.

In order to highlight the main forces in the model, our theoretical framework has abstracted from certain aspects that are central in shaping the international organization of production. First, we have imposed that production is undertaken by two-layer teams consisting of a manager and a set of workers. It would be interesting to incorporate the possibility of both self-employment and multiple layers in our model. This would open the door for a study of how globalization affects the incentives to form teams as well as the hierarchical structure of firms. Second, we have presented a purely technological theory of the international organization of production. A caveat of this approach is that we can explain why a northern manager might have an incentive to form a team with a group of southern workers, but we have less to say about why this international exchange of knowledge will occur within firm boundaries (i.e., within multinationals), rather than through arm's length subcontracting or licensing. It would be interesting to incorporate contractual frictions in our setup in order to obtain a more well-defined trade-off between in-house versus arm's-length offshoring.<sup>9</sup>

Beyond providing a range of testable hypothesis concerning the relation between firm size, inequality, and technology, our model points out some new avenues for empirical research. In particular, it suggests that empirical analysis of the labor market must focus on three separate channels through which the formation of international teams affects the wage structure and economic organization. First, what labor economists have normally called compositional effect, which is equivalent to the occupational choice effect in our analysis—globalization affects the proportion of managers (or more

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<sup>9</sup>In a similar vein, Antràs (2003a,b) and Antràs and Helpman (2004) embed the property-rights approach of Grossman and Hart (1986) in standard trade models. Grossman and Helpman (2004) in turn develop a model of the international organization of production that shares certain features with the multi-task approach of Holmstrom and Milgrom (1994).

broadly, knowledge workers) in the economy of each country – it increases it in the North and decreases it in the South. Second, the competition effect, typical of any equilibrium model – globalization increases the relative supply of low skilled workers in the North (and that of high skilled workers in the South), leading as a result to a drop in the unit skill prices in the North and a raise in the South. Third, the *complementarity* effect – globalization increases the difference in the manager assigned to a low and a high skill worker, and as a result raises the difference between the marginal productivities of their skills. Empirical studies of wage inequality, which focus on the average price of a year of education or experience, miss this third effect, which is novel in our model. The effect could be captured empirically in several ways, using rich data including organizational variables (such as matched employee employer data). First, by directly analyzing the heterogeneity in the observable skill of the managers matched with different workers. Second, by studying whether the impact of an interaction term between worker and manager skill increased with globalization, suggesting increasing unobservable heterogeneity. Finally, the model motivates taking a more structural approach. Since the equilibrium distribution of wages results simply from a change of variable in the distribution of skills, and wages and rents are monotonic in skill, all of the objects in the model are empirically identified and can be directly estimated, or may be inferred by using (like in Juhn, Murphy and Pierce, (1993)) the percentiles of the workers in the skill distribution to proxy for the skill ranking. Any of these approaches may contribute further to illuminate the question that this paper addressed: to what extent the formation of cross-country teams affects the matches between workers and managers, changing the organization of work and the returns to skills in the world.

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# A Appendix

**Proof of Theorem 1:** We first show that an equilibrium of this economy exhibits positive sorting. Let  $\Pi(z_m, z_p)$  denote the rents of a manager of ability  $z_m$  and hires workers with ability  $z_p$ . From our definitions above, we know that  $\Pi(m(z), z) = R(m(z))$  if  $m(\cdot)$  is the equilibrium assignment function. In equilibrium we know that managers choose the ability of their workers optimally so

$$\frac{\partial \Pi(z_m, z_p)}{\partial z_p} = 0.$$

Totally differentiating this expression we obtain that

$$\frac{\partial z_m}{\partial z_p} = -\frac{\frac{\partial^2 \Pi(z_m, z_p)}{\partial z_p^2}}{\frac{\partial^2 \Pi(z_m, z_p)}{\partial z_p \partial z_m}}.$$

The numerator has to be negative since managers are maximizing rents in equilibrium. To show that the denominator is positive, notice that

$$\frac{\partial^2 \Pi(z_m, z_p)}{\partial z_p \partial z_m} = \frac{\partial \left( \frac{1}{h(1-z_p)} \right)}{\partial z_p} = \frac{1}{h(1-z_p)^2} > 0.$$

Hence,

$$\frac{\partial z_m}{\partial z_p} > 0.$$

Since the argument is valid for all workers, we conclude that in an equilibrium allocation  $m'(z) > 0$  for all workers with ability  $z$ .

Let  $w(\cdot)$  be an equilibrium wage function, and let  $W(w)$  and  $M(w)$  be the equilibrium set of agents that become workers and managers respectively. Let  $m(z)$  be the skill level of the manager of a worker with ability  $z$  then

$$h \int_{W \cap [0, z_p]} (1-z) g(z) dz = \int_{M \cap [m(0), m(z_p)]} g(z) dz \quad \text{all } z_p \in W.$$

Deriving with respect to  $z_p$  we obtain that, as long as  $z_p$  is in the interior of  $W$  and  $m(z)$  is increasing, as we showed above,

$$m'(z_p) = h(1-z_p) \frac{g(z_p)}{g(m(z_p))}.$$

We want to prove that an equilibrium in this economy implies that  $W(w)$  is a connected interval. Suppose it is not. In particular, suppose  $W = [a_1, a_2] \cup [a_3, a_4]$  and  $M = [a_2, a_3] \cup [a_4, a_5]$ . Then given  $a_1$  and  $a_3$  we know that  $m(a_1) = a_2$  and  $m(a_2) = a_3$ . This plus the above expressions, that have to hold in the interior of this set, we can solve for a wage function  $w_{13}$ , a rent function  $R_{13}$  and a threshold  $a_2$ . Similarly, given  $a_3$  and  $a_5$  we can solve for a wage function  $w_{35}$ , a rent function  $R_{35}$  and a threshold  $a_4$  that satisfy all the equilibrium

conditions in the interval  $[a_3, a_5]$ . In order for  $W$  and  $M$  to be an equilibrium, we have to guarantee that agents in the interval  $[a_3, a_5]$  do not want to form teams with agents in the interval  $[a_1, a_3]$ . The first necessary condition is that

$$R_{13}(a_3) = w_{35}(a_3).$$

Since, if  $R_{13}(a_3) > w_{35}(a_3)$  agents with skills above but arbitrarily close to  $a_3$  would like to become managers. If  $R_{13}(a_3) < w_{35}(a_3)$  agents with skills marginally below  $a_3$  would like to become workers and agents at  $a_4$  would like to hire them at a wage marginally larger than  $R_{13}(a_3)$ . The next condition is that

$$\lim_{z \uparrow a_3} \frac{\partial R_{13}(z)}{\partial z} > \lim_{z \downarrow a_3} \frac{\partial w_{35}(z)}{\partial z}. \quad (18)$$

To show that this is the case, notice that

$$\frac{\partial R_{13}(a_3)}{\partial z} = \frac{1}{h(1-a_2)} > 1$$

by the envelope theorem. We will prove that the inequality above has to hold in equilibrium in two distinct cases: for the case when  $w_{13}(a_2) \geq a_2$  and for the case when  $w_{13}(a_2) < a_2$ . Suppose that  $w_{13}(a_2) \geq a_2$ , then, since  $\partial R_{13}(z)/\partial z > 1$  for all  $z \in [a_2, a_3]$ , we know that  $R_{13}(a_3) > a_3$  and since  $R_{13}(a_3) = w_{35}(a_3)$ ,  $w_{35}(a_3) > a_3$ . Then since  $h < 1$  and  $a_2 < a_3 < a_4 < \bar{z} \leq 1$ , we can conclude that

$$\frac{\partial R_{13}(a_3)}{\partial z} = \frac{1}{h(1-a_2)} > 1 > \frac{a_4 - w_{35}(a_3)}{1 - a_3} = \frac{\partial w_{35}(a_3)}{\partial z},$$

which proves condition (18) if  $w_{13}(a_2) \geq a_2$ . Now suppose that  $w_{13}(a_2) < a_2$ , then, since  $w_{35}(a_3) = R_{13}(a_3)$ , we can rewrite the right-hand-side of the inequality as

$$\frac{\partial w_{35}(a_3)}{\partial z} = \frac{a_4 - w_{35}(a_3)}{1 - a_3} = \frac{a_4 h(1 - a_2) - a_3 + w_{13}(a_2)}{(1 - a_3) h(1 - a_2)}.$$

Proving that condition (18) holds then amounts to prove that

$$a_4 h(1 - a_2) + w_{13}(a_2) < 1$$

or

$$a_4 < \frac{1 - w_{13}(a_2)}{h(1 - a_2)}.$$

But this is trivially satisfied given that  $a_4 < \bar{z} \leq 1$ , and  $w_{13}(a_2) < a_2$ .

We have established that condition (18) has to hold in equilibrium, but then  $a_4$  would like to hire  $a_3 - \varepsilon$  at a better wage than what he makes as a manager, and  $a_3 - \varepsilon$  would accept the offer. To show this, consider the rents that  $a_4$  would get from hiring  $a_3 - \varepsilon$  at

wage  $R_{13}(a_3 - \varepsilon)$ ,

$$\Pi(a_4, a_3 - \varepsilon) = \frac{a_4 - R_{13}(a_3 - \varepsilon)}{h(1 - (a_3 - \varepsilon))},$$

and note that

$$\lim_{\varepsilon \rightarrow 0} \frac{\partial \Pi(a_4, a_3 - \varepsilon)}{\partial \varepsilon} = \frac{R'_{13}(a_3) - w'_{35}(a_3)}{h(1 - a_3)} > 0,$$

where the inequality comes from the result above. Hence, an allocation where  $W$  is not connected implies that there are incentives for agents to form different teams. This implies that an equilibrium requires that  $W$  be a connected interval of the form  $[0, z^*]$ . Hence, in equilibrium  $m(0) = z^*$  and  $m(z^*) = \bar{z}$ . An allocation that (i) satisfies the two differential equations above, (ii) satisfies the previous boundary conditions for assignment function  $m$ , and (iii) yields a continuous earnings function, exists and is unique (see Garicano and Rossi-Hansberg (2003), but basically there always exists a solution and we have the same number of equations as variables to determine).

The final step is to prove that such an allocation is in fact an equilibrium. For this we need to prove that there exists an  $h^* > 0$  such that the allocation guaranteed to exist by the above reasoning is such that  $R'(z^*) > w'(z^*)$ . But notice that, since  $R(z^*) = w(z^*)$ ,

$$w'(z^*) = \frac{\bar{z} - w(z^*)}{1 - z^*} = \frac{h\bar{z} - z^* + w(0)}{(1 - z^*)h}$$

which is smaller than  $1/h$  if  $h\bar{z} + w(0) < 1$ . Hence, since  $w(0) < 1$  (since if not rents of all managers would be negative), this implies that there exists an  $h^* > 0$  such that for all  $h < h^*$ ,

$$w'(z^*) < \frac{1}{h} = R'(z^*).$$

Hence, for all  $h < h^*$ , there exists a unique competitive equilibrium in this economy. Given that markets are complete and competitive, this implies that the equilibrium allocation in the economy is Pareto Optimal. ■

**Proof of Proposition 1:** (i) We first show that the mass of workers increases in the South. This is obviously the case in a narrow-overlap equilibrium, because  $z_S^* < \alpha < z_{WL}^*$ .<sup>10</sup> On the other hand, for the wide-overlap equilibrium, it suffices to show that  $z_S^* < z_{WH}^*$ , but this follows from simple inspection of the formulas for these thresholds. That the mass of workers decreases in the North follows from  $z_{WH}^* < z_N^*$  and  $z_{WL}^* < z_N^*$ , which are both clearly true from the expressions for these thresholds.

(ii) For the first statement we want to show that both  $m_S(z) < m_{WL}(z)$  and  $m_S(z) < m_{WH}(z)$  for all  $z \leq z_S^*$ . The first inequality follows directly from  $z_{WL}^* > z_S^*$  in a narrow overlap equilibrium. Similarly,  $z_{WH}^* > z_S^*$  immediately implies that  $m_S(z) < m_{WH}(z)$  for  $z \leq z_\alpha$ . For the interval  $z_\alpha < z < z_{WH}^*$ , it is useful to rewrite  $m_{WH}(z)$  as  $m_{WH}(z) = hz(1 - \frac{1}{2}z) + z_{WH}^* + \frac{1}{\alpha}h[z(1 - \frac{1}{2}z) - z_\alpha(1 - \frac{1}{2}z_\alpha)]$ . The inequality then follows from  $z_{WH}^* > z_S^*$  and the fact that  $x(1 - \frac{1}{2}x)$  is non-decreasing in  $x$  for  $x \in [0, 1]$ . The second statement

<sup>10</sup>There are parameter values for which  $z_S^* > z_{WL}^*$ , but these are inconsistent with the existence of a narrow-overlap equilibrium.



is an immediate corollary of this first result. For the third statement, it is sufficient to show that  $m_{WH}(z_S^*) > \alpha$  for all  $z_S^* < z < z_{WH}^*$ . But notice that with a couple of substitutions,  $m_{WH}(z_S^*) = \alpha + \frac{1+\alpha}{\alpha}(z_{WH}^* - z_S^*) > \alpha$ , and the result follows from the monotonicity of  $m_{WH}(\cdot)$ .<sup>11</sup>

(iii) To prove the first part, we simply write  $m_W(z) - m_N(z)$  for each of the two equilibria. For the narrow-overlap one, this equals

$$m_{WL}(z) - m_N(z) = \begin{cases} z_{WL}^* - z_N^* + \frac{h}{\alpha}z(1 - \frac{1}{2}z) & \text{if } 0 < z < \alpha \\ z_{WL}^* - z_N^* + h(1 - \frac{1}{2}\alpha) & \text{if } \alpha < z < z_{WL}^* \end{cases},$$

which is non-decreasing in  $z$ , is negative for low enough  $z$  and is positive for high enough  $z$  (notice that  $z_{WL}^* - z_N^* + h(1 - \frac{1}{2}\alpha) > 0$  is implied by  $m_N(z_{WL}^*) < 1$ ). For the wide-overlap case, this equals

$$m_{WH}(z) - m_N(z) = \begin{cases} z_{WH}^* - z_N^* & \text{if } 0 < z < z_\alpha \\ z_{WH}^* - z_N^* + \frac{1}{\alpha}hz_p(1 - \frac{1}{2}z_p) - \frac{1}{\alpha}hz_\alpha(1 - \frac{1}{2}z_\alpha) & \text{if } z_\alpha < z < z_{WH}^* \end{cases},$$

which is again non-decreasing in  $z$ , is negative for low enough  $z$  and is positive for high enough  $z$  (the latter is implied by  $m_N(z_{WH}^*) < 1$ ). The second part follows immediately, since the matching functions are monotonic and thus invertible. That is, at the same point at which workers are matched with better managers, managers are matched with worse workers. See Figure 4 for an illustration. ■

**Proof of Proposition 2:** Let us start with the last claim. The difference in the marginal return to skill in the South with and without globalization is given by

$$\begin{aligned} \sigma_{1L} - \sigma_S + \frac{h}{\alpha}z & \quad \text{if } 0 < z < \alpha \text{ and } h < \frac{2(1-\alpha)}{2+\alpha-\alpha^2}, \\ \sigma_{1L} - \sigma_S + h & \quad \text{if } \alpha < z < z_S^* \text{ and } h < \frac{2(1-\alpha)}{2+\alpha-\alpha^2}, \\ \sigma_{1H} - \sigma_S & \quad \text{if } 0 < z < z_\alpha \text{ and } h > \frac{2(1-\alpha)}{2+\alpha-\alpha^2}, \\ \sigma_{1H} - \sigma_S + \frac{h}{\alpha}(z - z_\alpha) & \quad \text{if } z_\alpha < z < z_S^* \text{ and } h > \frac{2(1-\alpha)}{2+\alpha-\alpha^2}. \end{aligned}$$

It is thus sufficient to show that  $\sigma_{1L} > \sigma_S$  and  $\sigma_{1H} > \sigma_S$ . That  $\sigma_{1L} > \sigma_S$  follows directly from the expressions after realizing that  $z_{WL}^* > z_S^*$  and  $z_{WL}^* > \frac{1}{2}\alpha$  in a LQE. For  $\sigma_{1H} > \sigma_S$ , rewrite (17) as

$$\sigma_{1H} = \frac{hz_{WH}^*(1 + \frac{1}{2}hz_{WH}^*)}{1 + h - hz_{WH}^*} + \frac{\frac{h^2}{2\alpha}(z_{WH}^* - z_\alpha)^2}{1 + h - hz_{WH}^*} > \sigma_S$$

where the inequality follows since the first term is increasing in  $z_{WH}^*$  and  $z_{WH}^* > z_S^*$ , and the second term is positive. This result, combined with  $z_{WH}^* > z_S^*$ , implies that wage inequality in the South increases with globalization. ■

<sup>11</sup>Notice that  $m_{WH}(z_S^*) = hz_S^*(1 - \frac{1}{2}z_S^*) + z_{WH}^* + \frac{1}{\alpha}h[z_S^*(1 - \frac{1}{2}z_S^*) - z_\alpha(1 - \frac{1}{2}z_\alpha)]$ . The two substitutions are  $hz_S^*(1 - \frac{1}{2}z_S^*) + z_S^* = \alpha$  and  $hz_\alpha(1 - \frac{1}{2}z_\alpha) + z_{WH}^* = \alpha$ .

**Proof of Proposition 3:** Simple differentiation of (9) yields

$$\frac{\partial z_{WL}^*}{\partial h} = -\frac{\sqrt{1+h^2(3-\alpha)}-1}{h^2\sqrt{1+h^2(3-\alpha)}} < 0,$$

and differentiation of (14) results in

$$\frac{\partial z_{WH}^*}{\partial h} = \frac{1+h+\alpha-h\alpha-(1+\alpha)\sqrt{1+h^2+\left(\frac{1-\alpha}{1+\alpha}\right)2h}}{(\alpha+1)h^2\sqrt{1+h^2+\left(\frac{1-\alpha}{1+\alpha}\right)2h}} < 0$$

where the sign follows from

$$(1+h+\alpha-h\alpha)^2 - (1+\alpha)^2 \left(1+h^2+\left(\frac{1-\alpha}{1+\alpha}\right)2h\right) = -4\alpha h^2.$$

The conclusions on the set of workers and managers follow directly from this result and the definitions of a LQE and HQE.

**Proof of Proposition 4:** The measure of the quantity of outsourcing is given by

$$O_W = \begin{cases} 1 & \text{if } h < \frac{2(1-\alpha)}{2+\alpha-\alpha^2} \\ 1 - \frac{z_\alpha}{z_{WH}^*} & \text{if } h > \frac{2(1-\alpha)}{2+\alpha-\alpha^2} \end{cases}.$$

That is, the quantity of outsourcing is the proportion of southern workers in international teams. The quantity of workers engaged in outsourcing is in turn given by  $\alpha$  in a LQE and by  $z_{WH}^* - z_\alpha$  in a HQE. We first prove the first statement of the Proposition, namely, that  $z_{WH}^* - z_\alpha$  is a decreasing function of  $h$ . Towards a contradiction, suppose that  $z_{WH}^* - z_\alpha$  is a weakly increasing function of  $h$ . Then, the number of workers hired by northern managers in  $[\alpha, 1]$  weakly increases with  $h$ . But as we show below in the proof of Proposition 5, firm size (given by  $1/h(1 - m_{WH}^{-1}(z))$ ) is decreasing in  $h$  for any skill level  $z_m$  of the manager. Hence, since the number of managers in  $[\alpha, 1]$  has not changed, the number of workers in their firms must have gone down: A contradiction. Hence  $z_{WH}^* - z_\alpha$  decreases with  $h$  or

$$\frac{\partial z_{WH}^*}{\partial h} - \frac{\partial z_\alpha}{\partial h} < 0.$$

Moving to the first statement of the Proposition, notice that since  $z_\alpha < z_W^*$ , the above inequality implies

$$\frac{\partial z_{WH}^*}{\partial h} z_\alpha < \frac{\partial z_\alpha}{\partial h} z_{WH}^*$$

and thus  $z_\alpha/z_W$  is increasing in  $h$ . This in turn implies that the quantity of outsourcing is weakly decreasing in  $h$ . ■

**Proof of Proposition 5:** From Proposition (3), a decrease in  $h$  increases  $z_W^*$ , say from  $z_{W0}^*$  to  $z_{W1}^*$ . From the boundary condition  $m_W(0) = z_W^*$ , it follows that the worst agent is

matched with a better manager. Similarly, the boundary condition  $m_W(z_W^*) = 1$ , implies that the match for workers with  $z_p = z_{W0}^*$  worsens. It remains to show that the change in the match is a monotonic function of the skill of the worker. But simple inspection of the formulas for  $m_{WL}(z_p)$  and  $m_{WH}(z_p)$  reveals that  $\partial^2 m_{WL}(z_p) / \partial h \partial z_p > 0$  because  $z_p(1 - \frac{1}{2}z_p)$  is increasing in  $z_p$ . To prove the second claim we need to show that  $h(1 - m_W^{-1}(z_m))$  increases in  $h$  for all  $z_m$  in  $[z_W^*, 1]$ . This amounts to computing these partial derivatives for each segment of each equilibrium and showing they are positive. Simple but tedious derivation confirms this claim. ■

**Proof of Proposition 6:** The proposition comes directly from differentiating  $z_W^*$  with respect to  $\alpha$ , namely

$$\frac{\partial z_{WL}^*}{\partial \alpha} = \frac{h}{2\sqrt{1+h^2(3-\alpha)}} > 0$$

and

$$\frac{\partial z_{WH}^*}{\partial \alpha} = \frac{2}{(1+\alpha)^2 \sqrt{\frac{(1+\alpha)(1+h^2)+2h(1-\alpha)}{1+\alpha}}} > 0.$$

The last two statements follow from this result as well as from the fact that  $z_{WH}^*/\alpha$  is decreasing in  $\alpha$  (i.e.,  $\frac{\partial z_{WH}^*}{\partial \alpha} \alpha < z_{WH}^*$ ), as shown in the proof of Proposition 7. ■

**Proof of Proposition 7:** Simple differentiation and equation (13) imply that

$$\begin{aligned} \frac{\partial \frac{z_\alpha}{z_{WH}^*}}{\partial \alpha} &= \frac{1}{(1-z_\alpha)hz_{WH}^{*2}} \left( z_{WH}^* \left( 1 - \frac{\partial z_{WH}^*}{\partial \alpha} \right) - hz_\alpha(1-z_\alpha) \frac{\partial z_{WH}^*}{\partial \alpha} \right) \\ &= \frac{1}{(1-z_\alpha)hz_{WH}^{*2}} \left( z_{WH}^* - \frac{\partial z_{WH}^*}{\partial \alpha} \left( \alpha - \frac{1}{2}hz_\alpha^2 \right) \right) \\ &> \frac{1}{(1-z_\alpha)hz_{WH}^{*2}} \left( z_{WH}^* - \alpha \frac{\partial z_{WH}^*}{\partial \alpha} \right), \end{aligned}$$

and so  $\partial(z_\alpha/z_{WH}^*)/\partial\alpha > 0$  if  $z_{WH}^* > \alpha \frac{\partial z_{WH}^*}{\partial \alpha}$ . But simple algebra delivers

$$z_{WH}^* - \left( \frac{\partial z_{WH}^*}{\partial \alpha} \right) \alpha = \frac{v_1(h, \alpha) - v_2(h, \alpha)}{h(\alpha+1)^2 \left( \sqrt{\frac{1}{\alpha+1}} (2h + \alpha - 2h\alpha + h^2 + h^2\alpha + 1) \right)}$$

where

$$\begin{aligned} v_1(h, \alpha) &= (\alpha+1)^2 (h+1) \left( \sqrt{\frac{1}{\alpha+1}} (2h + \alpha - 2h\alpha + h^2 + h^2\alpha + 1) \right) \\ v_2(h, \alpha) &= (2h + 2\alpha + 2h\alpha + h^2 + \alpha^2 - 2h\alpha^2 + 2h^2\alpha + h^2\alpha^2 + 1). \end{aligned}$$

Now note that  $v_1(h, \alpha) > v_2(h, \alpha)$  if and only if

$$(v_1(h, \alpha))^2 - (v_2(h, \alpha))^2 = 4\alpha^2 h (h + 2\alpha + h^2 + \alpha^2 - 2h\alpha^2 + 2h^2\alpha + h^2\alpha^2 + 1) > 0,$$

which is clearly true. Hence,

$$\frac{\partial \frac{z_\alpha}{z_{WH}^*}}{\partial \alpha} > 0,$$

which implies from the definition of  $O_W$  that the quantity of outsourcing is strictly decreasing in  $\alpha$ .

Finally, we next want to show that the measure of workers engaged in outsourcing also decreases with  $\alpha$ , that is,

$$\frac{\partial \left( \frac{z_{WH}^* - z_\alpha}{\alpha} \right)}{\partial \alpha} < 0.$$

To see this, notice that

$$\begin{aligned} -\frac{\partial \left( \frac{z_{WH}^* - z_\alpha}{\alpha} \right)}{\partial \alpha} &= \frac{1}{\alpha^2} \left( \left[ z_{WH}^* - \frac{\partial z_{WH}^*}{\partial \alpha} \alpha \right] + \left[ \frac{\alpha}{h(1-z_\alpha)} \left( 1 - \frac{\partial z_{WH}^*}{\partial \alpha} \right) - z_\alpha \right] \right) \\ &> \frac{1}{\alpha^2 h(1-z_\alpha)} \left( \alpha \left( 1 - \frac{\partial z_{WH}^*}{\partial \alpha} \right) - h z_\alpha (1-z_\alpha) \right) \\ &> \frac{1}{\alpha^2 h(1-z_\alpha)} \left( \alpha \left( 1 - \frac{\partial z_{WH}^*}{\partial \alpha} \right) - h z_\alpha \left( 1 - \frac{1}{2} z_\alpha \right) \right) \\ &= \frac{1}{\alpha^2 h(1-z_\alpha)} \left( \alpha \left( 1 - \frac{\partial z_{WH}^*}{\partial \alpha} \right) - (\alpha - z_{WH}^*) \right) > 0 \end{aligned}$$

where we have used twice that  $z_{WH}^* > \alpha \frac{\partial z_{WH}^*}{\partial \alpha}$  as well as  $m_{WH}(z_\alpha) = \alpha$ . ■

**Proof of Proposition 8:** Again, making use of the boundary conditions as well  $\partial z_{WL}^*/\partial \alpha > 0$ , it is straightforward to see that the least-skilled worker is matched with a better manager, while the ex-ante most-skilled worker is matched with worse manager. For claim (i), it remains to show that the change in the match is a monotonic function of the skill of the worker, i.e.  $\partial^2 m_W(z_p)/\partial \alpha \partial z \leq 0$ . Again this is clear from inspection of the formulas for  $m_{WL}(z)$  and  $m_{WH}(z)$  because  $z(1 - \frac{1}{2}z)$  is increasing in  $z_p$ . Hence, for each equilibrium, there exist a thresholds  $\varphi_i < z_{Wj}^*$ ,  $j = H, L$ , such that all workers with  $z < \varphi_j$  are matched with a better manager, while all workers with  $z > \varphi_j$  are matched with a worse manager.

A corollary of this result is that all managers with skill below  $m_{Wj}(\varphi_j)$  are matched with lower-skilled workers, while all managers with skill above  $m_{Wj}(\varphi_j)$  are matched with higher-skilled workers. This immediately delivers claim (ii) because remember that firm size is the inverse of  $h(1 - m_W^{-1}(z_m))$ .

For claims (iii) and (iv), notice that  $\partial^2 m_{WL}(z)/\partial \alpha \partial z = 0$  for  $\alpha < z < z_{WL}^*$  which implies (given the effect on the boundary agents) that  $0 < \varphi_L < \alpha$ . Similarly,  $\partial^2 m_{WH}(z)/\partial \alpha \partial z = 0$  for  $0 < z_p < z_\alpha$  implies that  $z_\alpha < \varphi_H < z_{WH}^*$ . By the monotonicity of  $m_W(z)$ , these inequalities in turn imply  $z_{WL}^* < m_{WL}(\varphi_L) < m_{WL}(\alpha)$  and  $\alpha < m_{WH}(\varphi_H) < 1$ . To see that this is sufficient for claims (iii) and (iv) simply remember that the interval of managers that outsource in each equilibrium is  $(z_{WL}^*, m_{WL}(\alpha))$  and  $(\alpha, 1)$ , respectively; while the interval of non-outsourcers is  $(m_{WL}(\alpha), 1)$  and  $(z_{WH}^*, \alpha)$ , respectively. ■