

# Offshoring in a Knowledge Economy

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# Main Question

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- Study the impact of cross-country teams formation on
  - the organization of work
  - the structure of wages
- Globalization leads to the formation of international teams
  - Headquarters may locate in NY but production plants may be located in China or India
- Key Idea: Agents can match with different agents than otherwise. This leads to new teams, new matching and affects
  - occupational choices
  - size distribution of teams (firms)
  - earnings structure (wages and rents)

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## Related Approaches

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- Pattern of trade and matching:
  - Grossman and Maggi (2000);
  - Kremer and Maskin (2003)
- Equilibrium analysis in a knowledge economy:
  - Garicano (2000), Garicano and Rossi-Hansberg (2003 and 2004)

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# What is Missing

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- Hierarchical teams:
  - many to one matching
  - organization, firm size, etc.
- Communication technology
- Multiple tasks (occupational choice decision)
  - knowledge work versus production work

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# Our Framework

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- Production requires physical inputs and knowledge
- Agents of heterogenous ability sort into teams competitively.
- Agents specialize in either the production (workers) or knowledge (managers) work
- Complementarity between worker and manager skills
  - Skilled managers increase the productivity of their team
  - Skilled workers save manager's time allowing them to manage larger teams and leverage their skills
  - Results in positive sorting or assortative matching

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## Our Framework (II)

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- Natural interpretation of communication technology:
  - Represented by the time managers spent communicating knowledge to workers.
- We can then study the wage schedule in equilibrium and characterize the universe of firms in the economy
  - Wages serve an allocative role: sustain the universe of firms
  - Units of skill are priced differently

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# Globalization

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- Study the effect of globalization by comparing equilibrium in the closed economy and the integrated economy
- Analyze two countries (North and South) that differ only in their ability distributions;
- Globalization leads to:
  - Production job creation, Knowledge job destruction, and smaller firms in the south
  - Production job destruction and Knowledge job creation in the north, and smaller dispersion of firm sizes
  - Manufacturing output increases in South decreases in North.
  - Southern workers in multinationals earn relatively more than other southern workers (Aitken et. al. (1996))

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## Globalization (II)

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- Leads to higher wage inequality in South (as in empirical literature)
- Leads to higher wage inequality in North if outsourcing partner relatively unskilled or communication costs are low (Feenstra and Hanson (1996b and 1999))
- Globalization always hurts some workers
  - If communication costs low or skill gap high, it hurts low-skilled workers in North
  - If communication costs high or skill gap low, it hurts low skilled workers in South
- We also define and characterize the quantity and quality of outsourcing as a function of communication technology

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# Outline of the Talk

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- Closed economy model
  - comparative statics, existence uniqueness
- Open economy
- Comparison
  - effects of being able to form international teams
- Comparative statics

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# The Model: Endowments and Preferences \_\_\_\_\_

- Production requires time and knowledge
- Agents are endowed with 1 unit of time and knowledge level  $z$ .
- The distribution of skills in the population is given by a cumulative distribution function  $G(z)$ , with support in  $[0, \bar{z}]$  for  $\bar{z} \leq 1$ .
- Agents order consumption according to a linear utility,

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

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## The Model: Production

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- Workers face problems while producing. If they know the solution, production occurs and one unit of a numeraire good is produced.
- There is a continuum of possible problems indexed in  $[0, 1]$ .
- An agent with skill  $z$  can (has the require knowledge to) solve all problems between 0 and  $z$ .
  - $z$  denotes the proportion of problems a particular worker can solve.

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## The Model: Communication

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- Knowledge can be communicated
  - Agents **can ask** about problems when they do not know the solution
- This allows an agent to combine his/her own knowledge with the time of other agents.
- There is a cost  $h$  of communicating knowledge:
  - Cost incurred whether answer is known or not
  - Average cost of helping a worker with knowledge  $z_p$  is thus

$$(1 - z_p)h.$$

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## The Model: Teams

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- Agents form hierarchical teams:
  - Some workers specialize in problem solving (managers) and others in production (workers).
- Output of a two-layer team with  $n$  production workers with knowledge  $z_p$  and one problem solver with knowledge  $z_m$  is

$$y = z_m n$$

- Subject to the helping time constraint of managers

$$h(1 - z_p) \times n = 1$$

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## The Model: Production Function

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- The latter constraint pins down team size

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

- Output is thus

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

- Complementarity  $\rightarrow$  Positive assortative matching

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# Equilibrium

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1. Assignment of agents to positions – production workers, managers
  2. Matching of production workers to managers
  3. Earnings function such that no agent has an incentive to deviate
- An equilibrium is such that agents with skills in  $[0, z^*]$  become workers and agents with skills in  $[z^*, \bar{z}]$  become managers.

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# Earnings Function

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- The problem of a manager with ability  $z_m$  is to choose the ability of her workers to maximize

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

- The first order condition of this problem implies

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

- If this condition was not satisfied, managers would deviate from equilibrium.
  - In order to guarantee that managers maximize rents we also need to guarantee that  $w'(z^*) < R'(z^*)$ .

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# Assignment

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- Let  $m(z)$  denote the ability of the manager that hires worker  $z$
- Equilibrium in the labor market then implies that  $m(z^*) = \bar{z}$  and

$$\underbrace{\int_0^{z_p} g(z) dz}_{\text{Supply of Workers}} = \underbrace{\int_{m(0)}^{m(z_p)} n(m^{-1}(z)) g(z) dz}_{\text{Demand of Workers}} \quad \text{all } z_p \leq z^*$$

- Hence, in equilibrium  $m(z^*) = \bar{z}$ ,  $m(0) = z^*$  and

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

- One differential equation, two boundary conditions  $\rightarrow$  obtain  $m(z)$  and  $z^*$ .

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## Occupational Choice

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- Agents order consumption according to a linear utility,

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

- This condition implies

$$R(z^*) = w(z^*)$$

which together with (1) pins down  $w(z)$ .

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## The model: Existence and Uniqueness

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**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 what follows let  $h < .85$  so we can guarantee existence

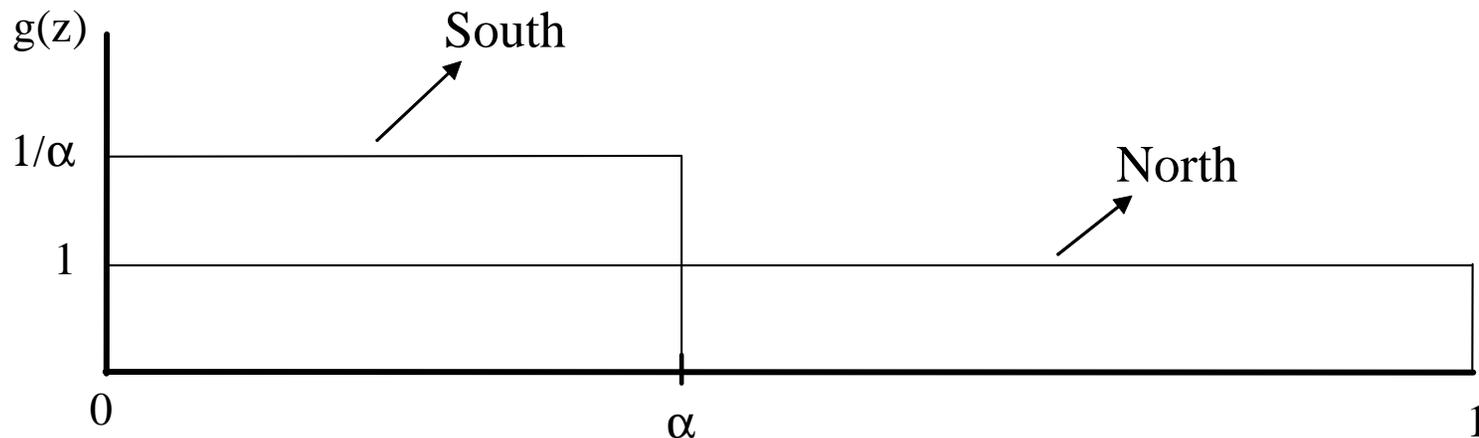
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# Equilibrium in the Closed Economy

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Two countries, North and South, identical except for

- $G_N(z) = z$  for  $z \in [0, 1]$ , with density  $g_N(z) = 1$
- $G_S(z) = z/\alpha$  for  $z \in [0, \alpha]$ , and density  $g_S(z) = 1/\alpha$



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# Equilibrium in the Closed Economy

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- Matching:

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

–  $z_S^*$  decreasing with  $h$  and increases with  $\alpha$

- Wages:

$$w_S(z) = z_S^* - \sigma_S(1 - z) + \frac{1}{2}hz^2$$
$$\sigma_S = \frac{hz_S^* \left(1 + \frac{1}{2}hz_S^*\right)}{1 + h - hz_S^*}$$

–  $w'_S(z) = \sigma_S + hz : \begin{cases} \text{Competition effect in } \sigma \\ \text{Complementarity effect in } hz \end{cases}$

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## Equilibrium in the Closed Economy

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- Rents:

$$R_S(z) = \frac{z - w_S(m_S^{-1}(z))}{h(1 - m_S^{-1}(z))}, \quad R'_S(z) = \frac{1}{h(1 - m_S^{-1}(z))}$$

- Production:

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

– Decreases with  $h$  and increases with  $\alpha$

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## Equilibrium in the World Economy

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- 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,

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

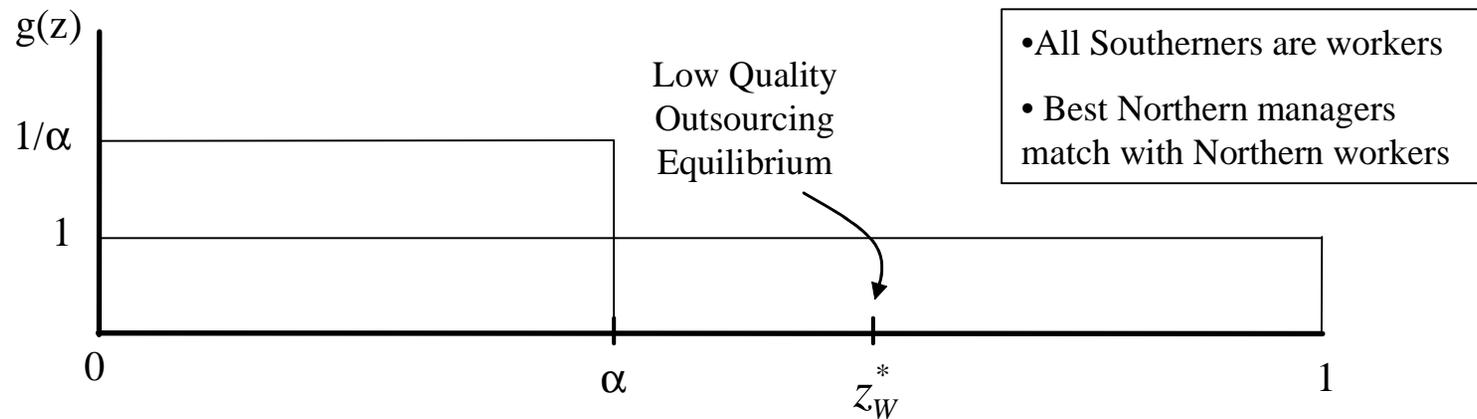
- Depending on the value of  $h$  and  $\alpha$  there are two types of equilibria in the world.

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# Equilibrium in the World Economy

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- *Low Quality Outsourcing Equilibrium (LQE):  $z_{WL}^* > \alpha$*



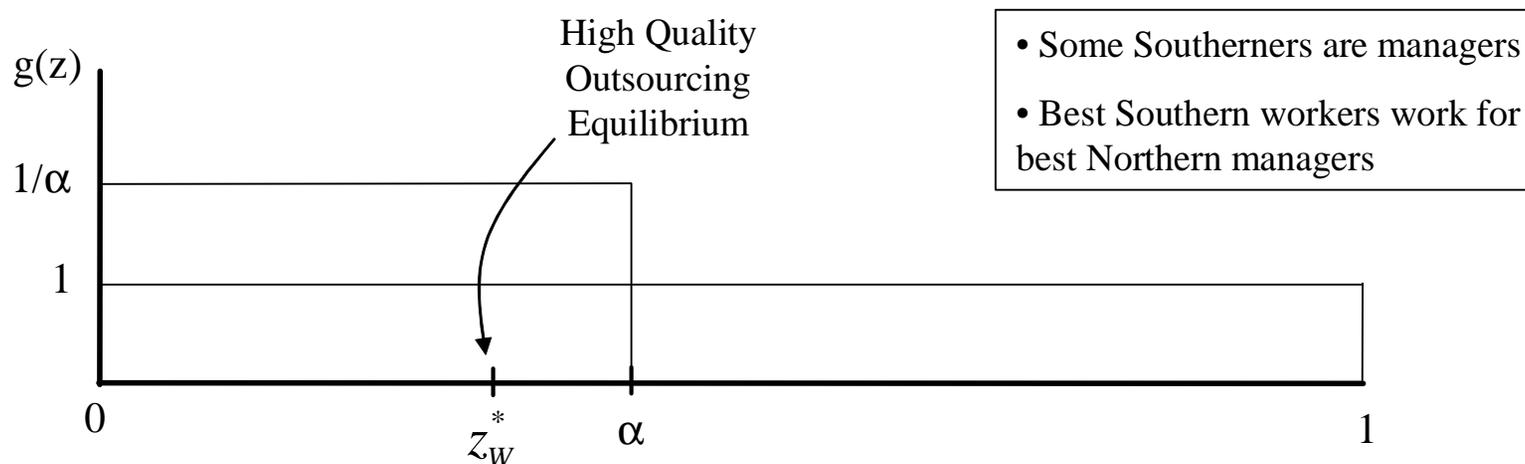
- International teams are associated with the worst managers in the world and therefore the smallest and less productive firms

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# Equilibrium in the World Economy

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- *High Quality Outsourcing Equilibrium (HQE):  $z_{WL}^* < \alpha$*

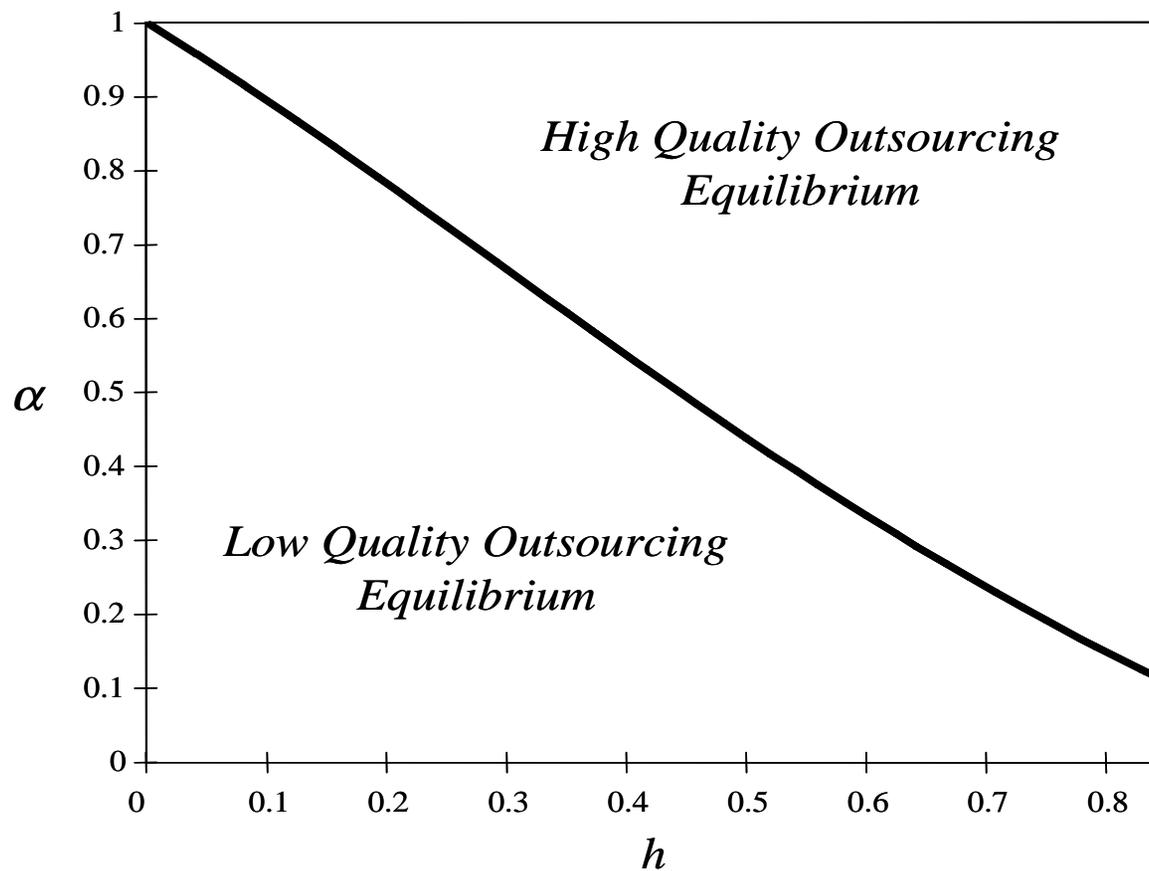


- Hence, international teams are associated with the best managers in the world and therefore the largest and most productive firms

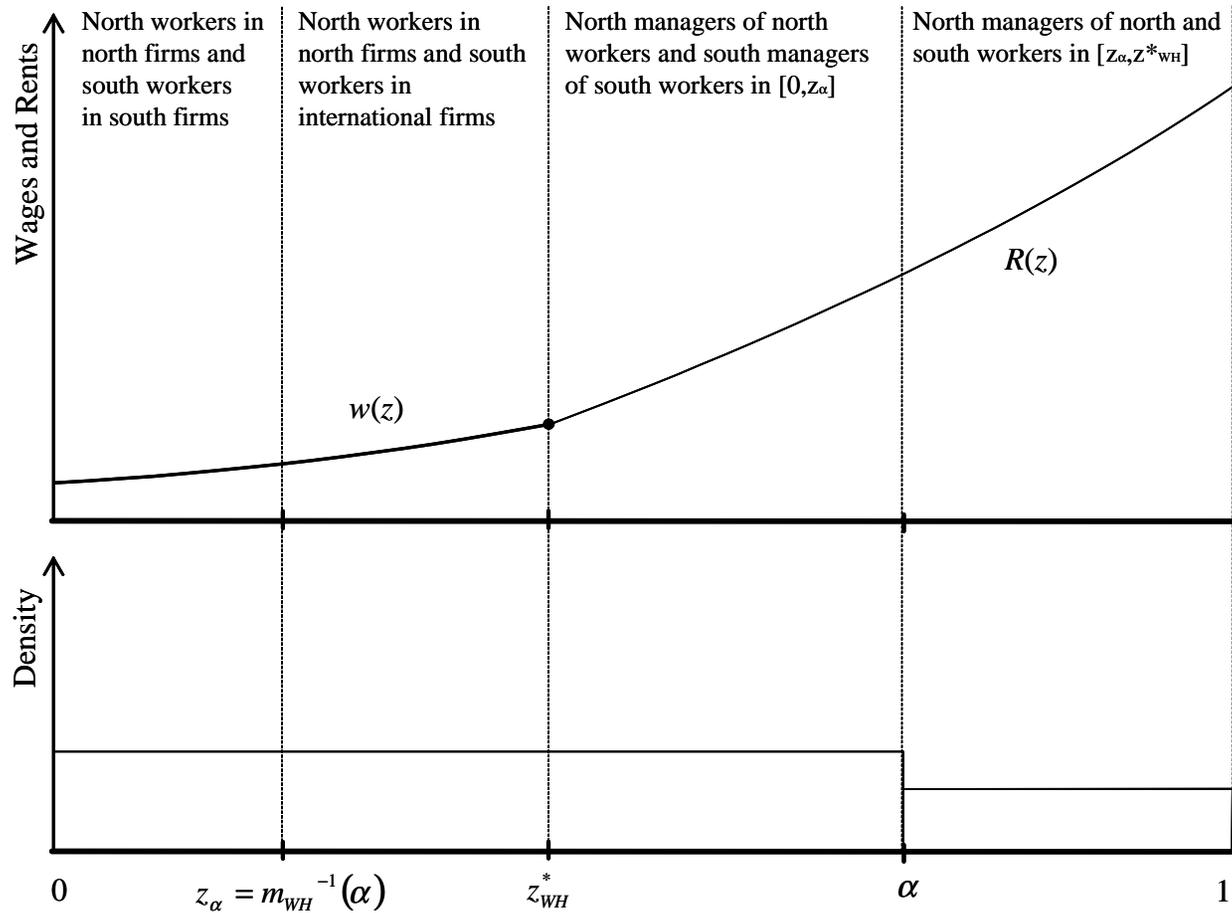
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# Equilibrium in the World Economy

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# High Quality Outsourcing Equilibrium

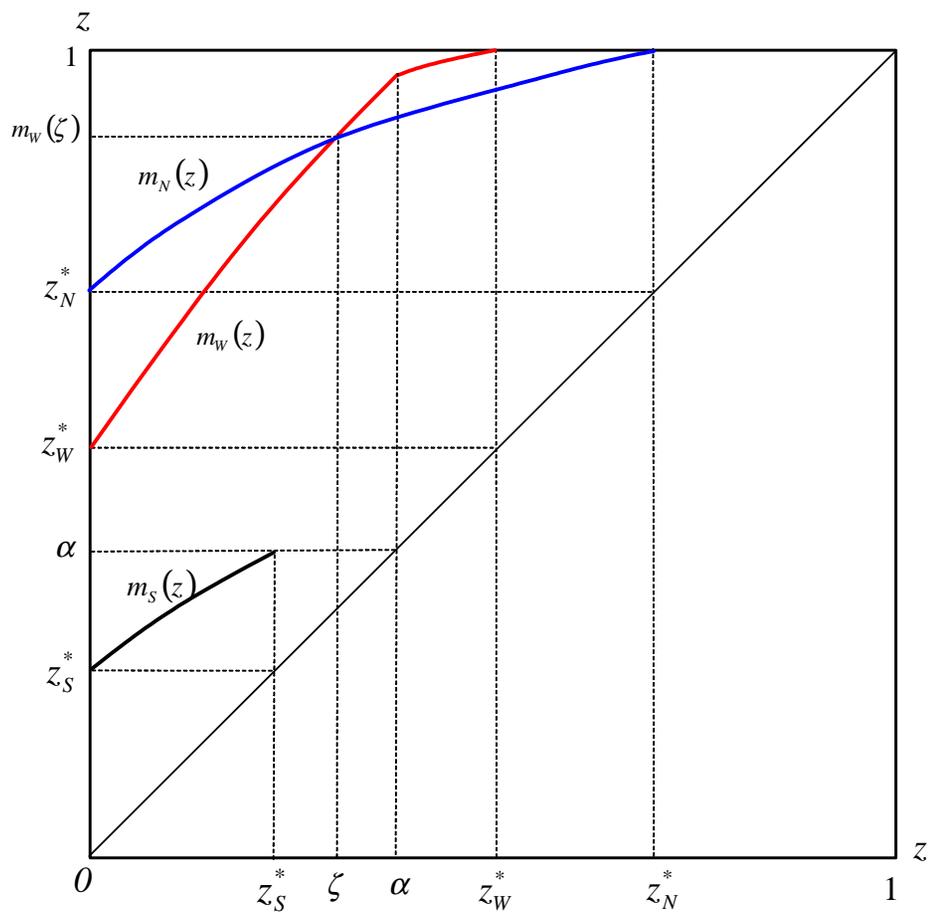


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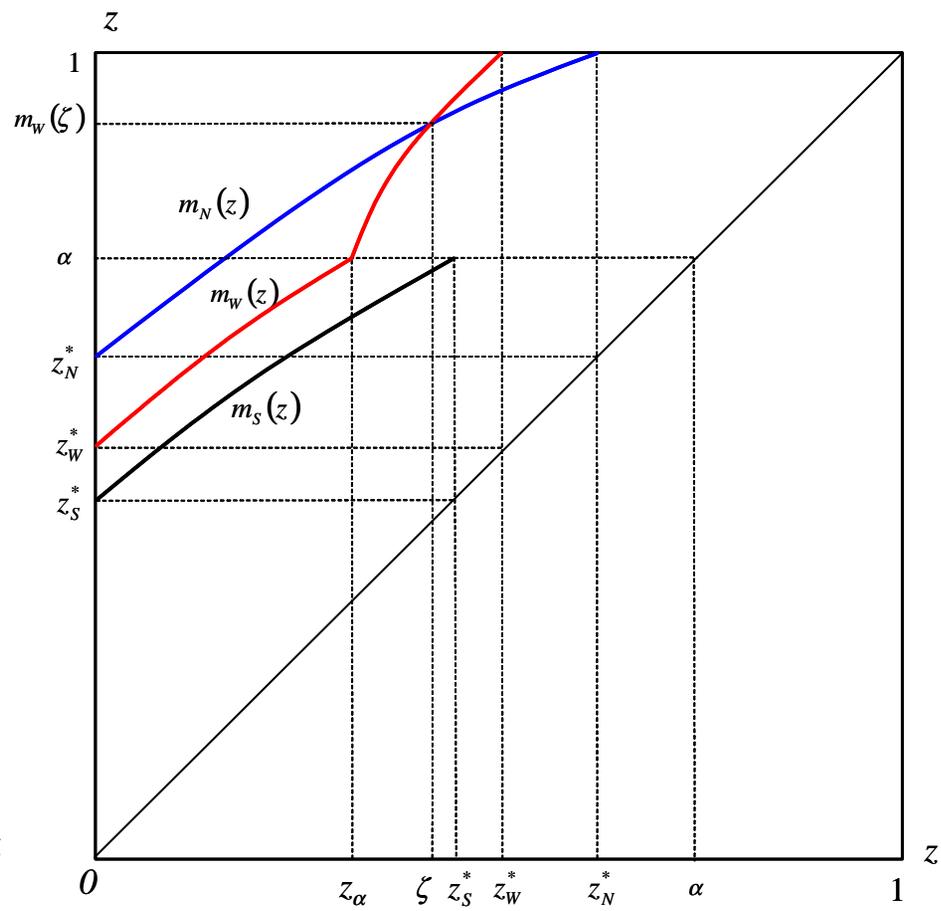
## Effects of Globalization: Matching

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- Compare autarky in North and South with the world equilibrium



LQE



HQE

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# Effects of Globalization: Matching

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**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*

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# Effects of Globalization: Organizations

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- The implications of globalization on matching lead to implications on organizations depends only on worker skills

**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*

- Positive sorting implies that best workers in the South are matched with good managers, who are in the North

**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*

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## Effects of Globalization: South Wage Inequality \_

- Throughout the paper we focus on three effects that we added result in the observed changes in wage inequality:
- *Occupational Choice Effect*: Changes in the skill set of agents that become workers
- *Competition Effect*: Changes in the baseline price of a unit of skill
- *Complementarity Effect*: Changes in the reward for agents that possess a certain number of units of skills
  - Because of the complementarity effect not all units of skill are command the same compensation

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## Effects of Globalization: South Wage Inequality \_

- Globalization increases wage inequality
  - (↑) Workers skills are relatively more scarce in the world economy than in the south: Competition effect ( $\sigma_{WL} > \sigma_S$  and  $\sigma_{WH} > \sigma_S$ )
  - (↑) More workers competing for the same manager so possessing more skills improves the assignment more: Complementarity effect
  - (↑) More agents become workers: 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*

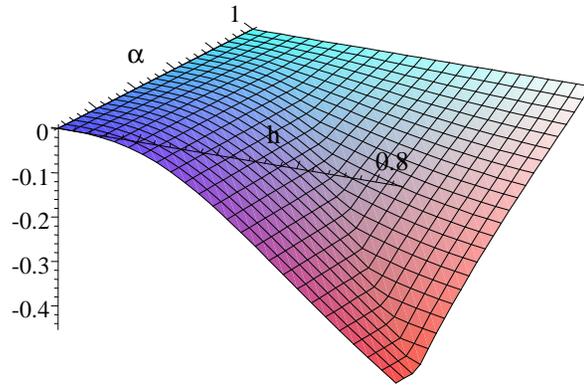
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## Effects of Globalization: North Wage Inequality \_

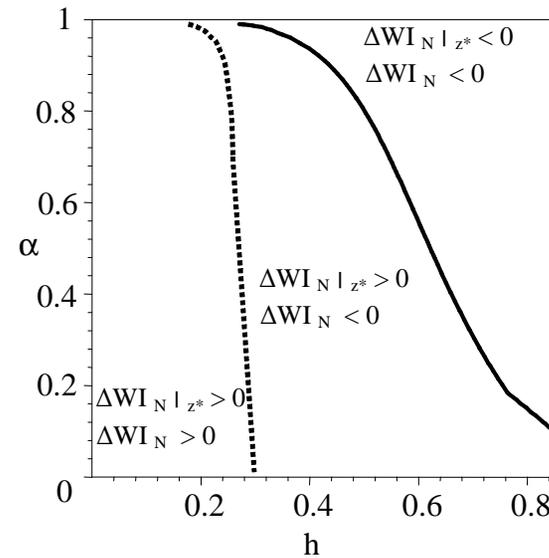
- Globalization increases wage inequality if  $h$  and  $\alpha$  low
  - ( $\downarrow$ ) Workers skills are relatively less scarce in the world than in the north: Competition effect
  - ( $\uparrow$ ) More workers competing for the same manager: Complementarity effect
  - ( $\downarrow$ ) Less agents become workers: Occupational choice effect

**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*

# Effects of Globalization: North Wage Inequality



Change in baseline wage per unit of skill



Change in wage inequality

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## Effects of Globalization: Manager Income

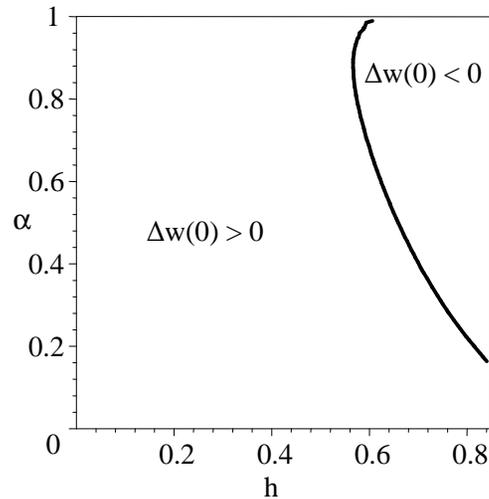
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- The marginal return to the skills of managers is given by the size of their team
- Managers in the South have smaller teams
- Best managers in the north have smaller teams
- But worst managers in the north before globalization have larger teams

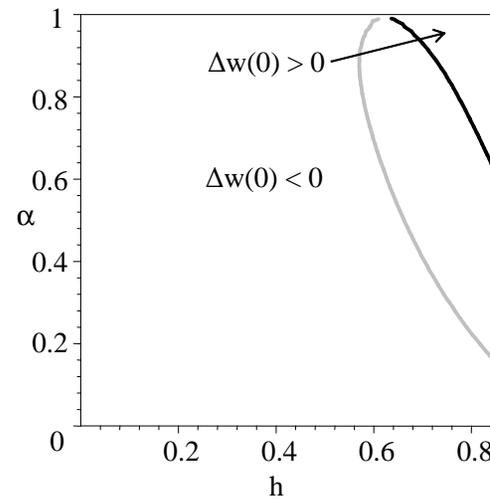
**Corollary 3:** *Globalization has the following effects on within-manager income inequality and on the marginal return to skill of managers:*

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

# Effects of Globalization: Winners and Losers



Effect on  $w(0)$  in the south



Effect on  $w(0)$  in the north

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

- (i) *Increases the wages of low skilled 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*

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## Effects of Globalization: Aggregates

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

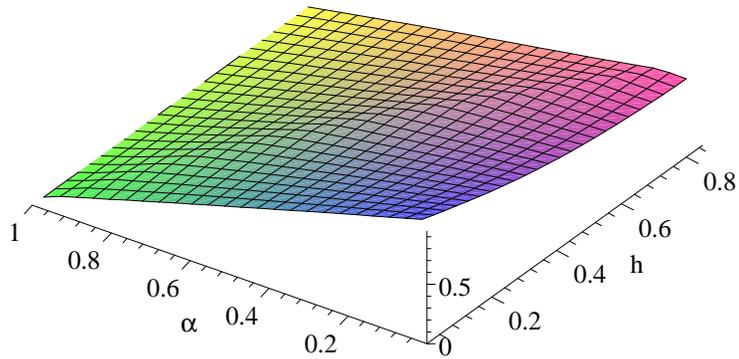
**Summary 3:** *Globalization has the following effects on manufacturing production, consumption, and the trade balance:*

- (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*

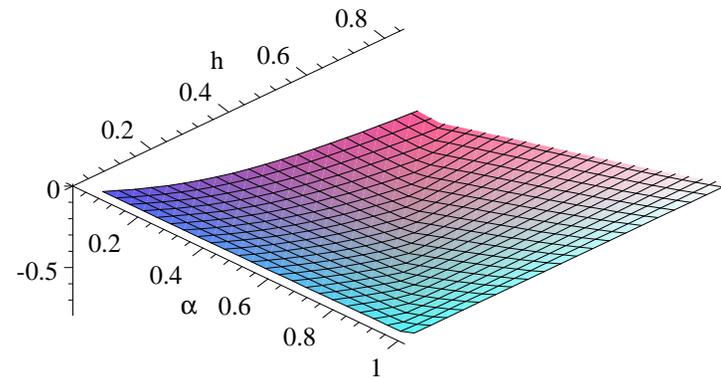
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# Effects of Globalization: Aggregates

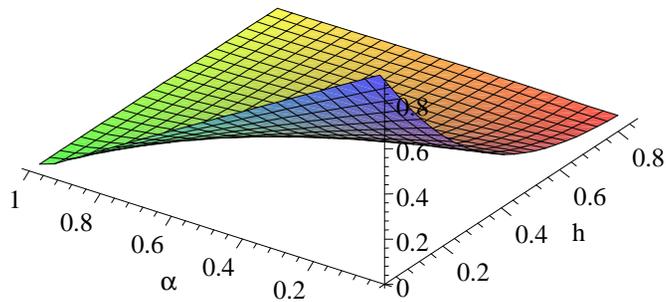
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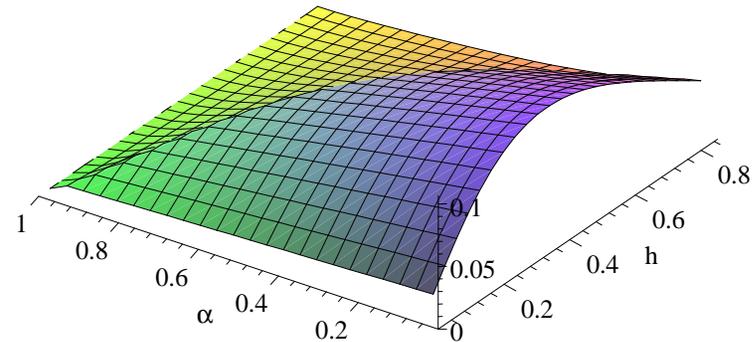
Change in southern output



Change in northern output



Change in southern consumption



Change in northern consumption

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## World Equilibrium and Communication Costs

- As communication costs decrease managers can deal with larger teams
- Wage of the best workers increases which incentivates the worst managers to become workers
- Managers can leverage their knowledge more so only the best agents become managers

**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  $h$ .*

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# World Equilibrium and Communication Costs

- Better communication technology implies that the smallest firms are managed by better managers
- However, the largest firms before the change have worse managers since some even larger firms are created

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

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

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## World Equilibrium and Communication Costs \_\_\_\_\_

- As communication technology improves only the best agents become managers and so there is more outsourcing
- We measure the *quantity of outsourcing* as the proportion of southern workers that work for international teams:

$$O_W = \begin{cases} 1 & \text{in a LQE} \\ \frac{z_W^* - z_\alpha}{z_W^*} & \text{in a HQE} \end{cases}$$

**Proposition 4:** *The quantity of international outsourcing is weakly decreasing in communication costs ( $h$ ). The number of workers engaged in outsourcing also decreases with  $h$*

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## World Equilibrium and Communication Costs \_\_\_\_\_

- The increase in the quantity of outsourcing implies that the average quality of the workers in international teams decreases
- We measure the *quality of outsourcing* as the proportion of southern workers that work for international teams:

$$Q_W = \begin{cases} 1 & \text{in a LQE} \\ \frac{z_W^* + z_\alpha}{z_W^*} & \text{in a HQE} \end{cases}$$

**Corollary 5:** *The quality of outsourcing is weakly increasing in communication costs ( $h$ )*

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## World Equilibrium and Skill Overlap

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- As the skill overlap increases the mass of agents with high skill increases
- Since some of them are workers, they work for large firms which increases the demand for workers and their number in equilibrium

**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  $\alpha$*

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# World Equilibrium and Skill Overlap

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- Since some managers become workers, better managers hire the worse workers and run smaller firms
- The best managers are matched with better workers and so run larger firms

**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*

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# World Equilibrium and Skill Overlap

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- As agents in the south become more skilled more of them decide to become managers, which decreases the share of workers in international teams

**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 decrease in quantity implies that international firms are more selective and the average quality of their workers increases

**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*

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## Conclusion

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- We have developed a theory of outsourcing in which agents with heterogeneous abilities sort into teams competitively
- We have interpreted globalization as a process that enables the formation of international teams
- 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 depend 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

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## Conclusion

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- Our model 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
  - The *occupational choice* effect: Globalization affects the dispersion of skills of managers and workers in each country
  - The *competition* effect: Globalization affects the relative supply of low skilled workers in each country
  - The *complementarity* effect: Globalization increases the difference in the manager assigned to a low and a high skill worker

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## Extensions and Future Research

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- Our theoretical framework has abstracted from central aspects of 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
  - Second, we have nothing to say about why the international exchange of knowledge will occur within firm boundaries

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## Low Quality Outsourcing Equilibrium: Matching

- $m(0) = z_{WL}^*$ ,  $m(z_{WL}^*) = 1$  and

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

imply

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

$$z_{WL}^* = \frac{1+h - \left(1+h^2(3-\alpha)\right)^{1/2}}{h}$$

- We need to guarantee that  $z_{WL}^* > \alpha$  so

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

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## Low Quality Outsourcing Equilibrium: Wages \_\_\_\_\_

- The wage function has to be continuous at  $\alpha$  and

$$w_{WL}(z_{WL}^*) = R_{WL}(z_{WL}^*)$$

- This implies

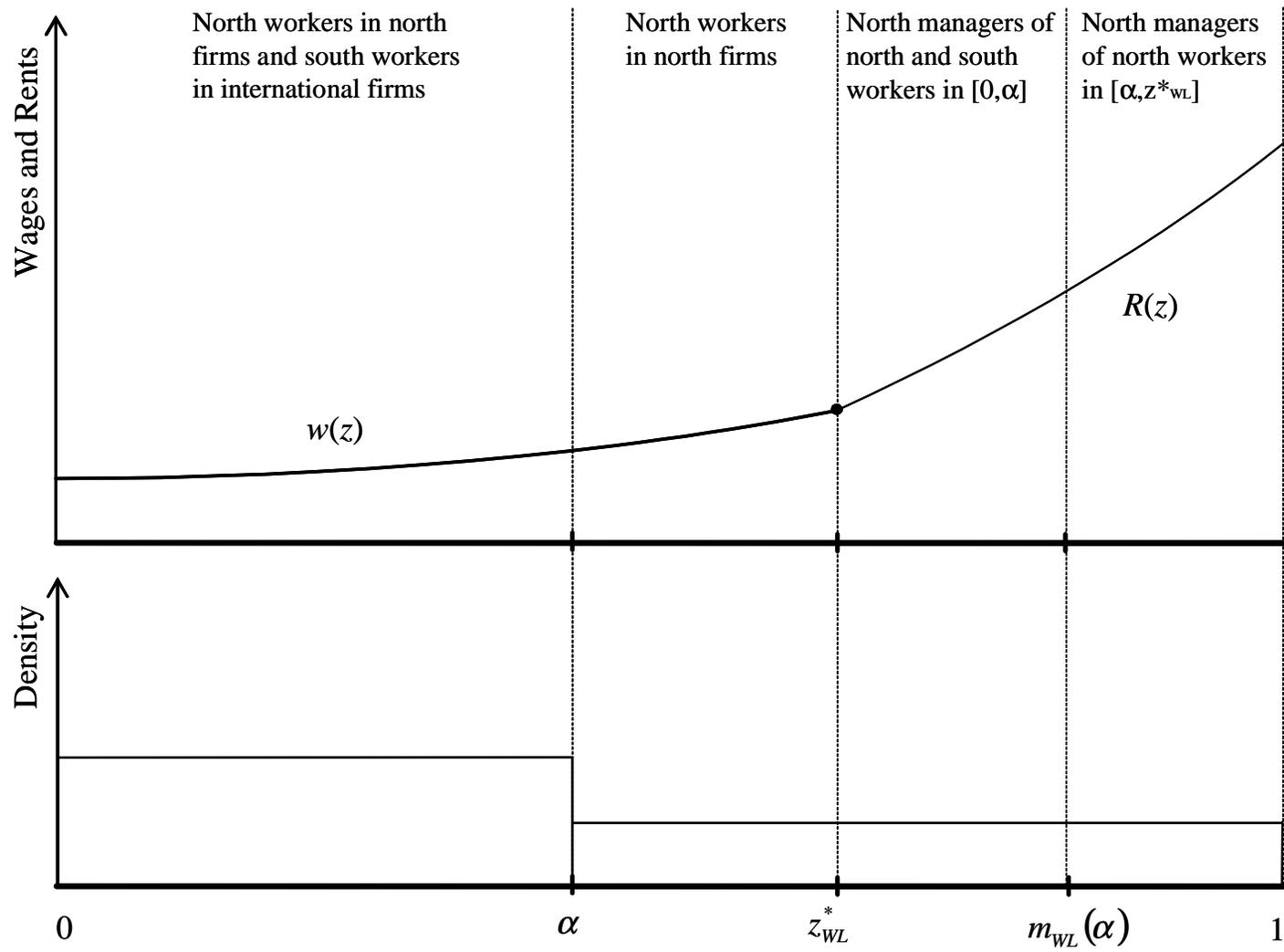
$$w_{WL}(z) = \begin{cases} z_{WL}^* - \sigma_{1L}(1-z) + \frac{1+\alpha}{2\alpha}hz^2 & \text{if } 0 < z < \alpha \\ z_{WL}^* + h\left(1 - \frac{1}{2}\alpha\right) - \sigma_{2L}(1-z) + \frac{h}{2}z^2 & \text{if } \alpha < z < z_{WL}^* \end{cases}$$

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

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## **Low Quality Outsourcing Equilibrium**

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# High Quality Outsourcing Equilibrium: Matching

- Define  $m(z_\alpha) = \alpha$
- $m(0) = z_{WL}^*$ ,  $m(z_{WL}^*) = 1$  and

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

imply

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

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

$$z_\alpha = 1 - \left(1 - 2 \left(\frac{\alpha - z_{WH}^*}{h}\right)\right)^{1/2}$$

# High Quality Outsourcing Equilibrium: Wages

- The wage function has to be continuous at  $z_\alpha$  and

$$w_{WL}(z_{WH}^*) = R_{WL}(z_{WH}^*)$$

- This implies

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

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

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