

Gersbach, Hans; Schmutzler, Armin

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Does globalization create superstars?

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University of Zurich

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Hans Gersbach and Armin Schmutzler

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Authors' addresses: Hans Gersbach
 E-mail: hgersbach@ethz.ch

 Armin Schmutzler
 E-mail: arminsch@soi.uzh.ch

Publisher Sozialökonomisches Institut
 Bibliothek (Working Paper)
 Rämistrasse 71
 CH-8006 Zürich
 Phone: +41-44-634 21 37
 Fax: +41-44-634 49 82
 URL: www.soi.uzh.ch
 E-mail: soilib@soi.uzh.ch

Does Globalization Create Superstars?*

Hans Gersbach

CER-ETH - Center of Economic Research
at ETH Zurich and CEPR
Zürichbergstrasse 18
8092 Zurich, Switerland
hgersbach@ethz.ch

Armin Schmutzler

Socioeconomic Institute and CEPR
University of Zurich
Blümlisalpstrasse 10
8006 Zurich, Switzerland
arminsch@soi.unizh.ch

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Abstract

To examine the impact of globalization on managerial compensation, we consider a matching model where a number of firms compete both in the product market and in the managerial market. We show that globalization, i.e. the simultaneous integration of product markets and managerial pools, leads to an increase in the heterogeneity of managerial salaries. Typically, while the most able managers obtain a wage increase, less able managers are faced with a reduction in wages. Hence our model can explain the increasing heterogeneity of CEO compensation that has been observed in the last few decades.

JEL Classification: D43, F15, J31, L13

Key Words: Globalization, manager remuneration, superstars

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1 Introduction

The salaries of top managers have recently received considerable public attention. According to Murphy and Zbojnik (2004), the average base salaries and bonuses of Forbes 800 CEOs increased from 700,000 U.S. dollars in 1970 to more than 2.2 million dollars in 2002.¹ This effect is even larger when stock options are taken into account. Similar observations have been reported in Europe (Murphy, 1999). Such figures cause particular concern when they are related to ordinary wages. The ratio between CEO cash compensation and average pay for production workers in the U.S. climbed from 25:1 in 1980 to 90:1 in 2000 (Murphy and Zbojnik, 2004). It is hardly surprising that this particular aspect of income redistribution has been highly controversial. Shareholders, labor unions, politicians and mass media have criticized both the level of managerial incomes and the tenuous connection between pay and performance. The discussion is by no means confined to the United States, as recent surveys in the Economist (Economist, 2007) and a reader in the Neue Zürcher Zeitung (NZZ, 2006) with 47 articles on the subject from 2001 to 2006 testify. In the United Kingdom, the discussions have led to the introduction of transparency rules for managerial pay (Severin, 2003).

Given the amount of public attention and the substantial academic research in this area, it is surprising that the causes of the recent salary increases are still imperfectly understood. In line with popular opinion, Bebchuk and Fried (2004) attribute the developments to managerial power. Shareholders, so the argument goes, have limited control over the wage-setting process, and the board often gives in to the interests of CEOs.

Murphy and Zbojnik (2004) take issue with such explanations. Without necessarily denying the existence of managerial rent-seeking activities, they argue that an explanation for recent salary increases on this basis would also require an increase in managerial power, which they find unconvincing. Instead, they propose the idea that the changes reflect an increasing demand for general, rather than firm-specific, managerial skills, “perhaps as a result of the steady progress in economics, management science, accounting, finance and other disciplines which, if mastered by a CEO, can

¹The figures are in 2002 dollars. The Forbes 800 list contains all companies ranked in the top 500 by assets, income, market capitalization or revenues. Typically, there are about 800 companies on the list.

substantially improve his ability to manage a company” (Murphy and Zabochnik, 2004, p.193). This results in an increasing tendency for outside hiring and a resulting competition for managers that drives up wages. Gabaix and Laudier (2006) argue that the increase in managerial pay can be attributed to an (exogenous) increase in firm size.²

In this paper, we provide an alternative explanation of recent trends that relates to informal arguments that are often advanced in popular accounts of the subject. Some observers regard increasing managerial wages as a by-product of globalization (Siegenthaler, 2003). To our knowledge, however, no attempt has been made to analyze the relation between globalization and managerial wages in a precise fashion. Our paper is an attempt to fill this gap.

We investigate how the simultaneous integration of product markets and managerial markets affects managerial wages. We consider a matching model where a number of firms compete both in the product market and in the managerial market. In the product market, they interact as oligopolists. In the managerial labor market, they compete for the services of managers with heterogeneous abilities, where the heterogeneity is reflected in the different marginal cost levels of the firms they manage. Globalization thus refers to the simultaneous integration of product markets and managerial pools.

The effects of globalization on managerial remuneration are subtle, because national markets are replaced by larger product markets with higher demands, more firms and a larger pool of managers. Nevertheless, we obtain a robust prediction about the effects of globalization on the distribution of managerial wages: Globalization leads to an increase in the heterogeneity of managerial salaries. Typically, while the most able managers obtain a wage increase, less able managers are faced with a reduction in wages. Hence our model can explain the increasing heterogeneity of CEO compensation that has been observed in the last few decades.

However, our model does not necessarily predict an increase in the *average* wage levels of managers. The reduction in wages for less competent managers may well offset the wage increases of the most competent managers. Nevertheless, our approach is consistent with the idea that globalization lies behind the increasing wages of *top* executives. Empirical results on *average* managerial salaries typically refer to the averages within a

²Baranchuk et al. (2006) also argue that increasing firm sizes play a role in the process, but they relate these size changes to underlying changes in demand.

fairly small group of top managers.³ As our model predicts pay rises for the best-paid managers due to globalization, such averages should also be expected to rise.

It is crucial for our results that the equilibrium wage differences between more and less competent managers reflect the differences in profits between more and less efficient firms. Understanding the effects of globalization on managerial wages therefore boils down to understanding how efficiency differences translate into profit differences. Intuitively, the more intense competition induced by globalization increases the payoff for being more efficient in the sense that the profit ratio between the most efficient firm and its less efficient competitors necessarily increases.

While we believe we have uncovered the critical link between globalization and managerial wages, we do not claim to have a full theory of managerial compensation. Most obviously, we abstract from problems of asymmetric information that loom large in the literature on the subject. In our model, managerial abilities can be observed, and providing incentives for managers to choose the right action is not an issue. Several existing papers (e.g. Schmidt, 1997 and Raith, 2003) deal with the effects of increasing competitive intensity on managerial compensation in the presence of asymmetric information. However, the relation between the concept of increasing competition and our more explicit notion of globalization as the integration of product and labor markets is vague. We have chosen to abstract from asymmetric information because this allows to identify the basic mechanism in the most transparent way - that globalization increases the payoff for being more efficient than competitors and therefore has a positive effect on wage spread. There is no reason to suppose that this effect would not survive in a richer model.

Our paper is related to the literature on superstars initiated by Rosen (1981), who shows how quality differences between agents lead to more than proportional differences in wages, turning agents with a fairly small quality advantage into “superstars” earning substantially more than the others. Our arguments show that globalization moves the market for managers closer to such a market for superstars.⁴ In the context of globalization, such superstar effects have for instance been discussed by Manasse and Turrini (2001), who also argue that globalization increases wage heterogeneity.

³Compare footnote 1.

⁴In addition, Baranchuk, MacDonalds and Yang (2006) consider effort choices for managers in this framework and derive implied ability distributions for the managers which are highly right-skewed.

Their analysis differs from ours in several important respects. First, they consider the differences in wages between skilled and unskilled workers rather than necessarily managers. Second, the channel through which decreasing trade costs operate is totally different: The increasing wage heterogeneity comes from redistribution of income between exporting and non-exporting firms whose skill-intensity differs.

The paper is organized as follows. Section 2 introduces the model. In Section 3, we characterize the equilibrium. Section 4 analyzes the effects of globalization as a comparative-statics exercise. Section 5 presents some extensions of the model which demonstrate the robustness of the argument. Section 6 concludes.

2 The Model

The model consists of a *wage-setting stage* followed by an *application stage* and a *product-market stage*. Firms $i = 1, \dots, I$ compete for managers $m = 1, \dots, M$ with $M \geq I$. Each firm has marginal costs c_0 , but can hire a manager to improve its operations. We model the effect of a manager by the level of marginal costs $c(m)$ that he can achieve in a firm. We index the managers by quality, that is,

$$c(1) \leq c(2) \leq \dots \leq c(M).$$

Manager 1 has the highest quality and can achieve the lowest marginal cost. Manager M has the lowest quality. As a normalization, we assume that he achieves no efficiency gains and thus produces with marginal costs c_0 . $\mathcal{M}^I \equiv \{1, \dots, I\}$ denotes the set of the best I managers.

At the *wage-setting stage*, all firms simultaneously make wage offers to all managers. We denote the offer of firm i to manager m as w_{im} .

In the *application stage*, after having observed the wage bids, managers decide which offer to accept. Outside options are normalized to zero. In the first round of the application stage, each manager accepts the highest non-negative offer.⁵ If several firms have offered the most attractive wage to a manager m , he will select one of these firms randomly. If only one manager accepts an offer from firm i , he will be employed. If two or more managers accept the offer, the firm will select one of them.

⁵As a tie-breaking rule, we thus assume that all managers choose to be employed as long as wages are non-negative, that is, at least as high as the outside option.

As a tie-breaking rule, we assume that a firm chooses the most competent manager if it is indifferent among several managers.⁶ In the second round of the application stage, the procedure is repeated with the rejected managers and the firms who have not yet filled their vacancy. The application process continues until each manager is either employed by a firm or rejected by all firms.

In the *product-market stage*, the I firms engage in oligopolistic competition, with marginal costs c_i given by the outcome of the application stage. Though several of our results are more general, we often specialize to a case where firms are Cournot competitors producing homogeneous goods facing an inverse demand function $p = a - bx$, where x is aggregate output, p is the price, and a, b are two positive numbers. We use m_i to denote the index of the manager hired by firm i , and \mathcal{M}_{-i}^I for the set of managers hired by its competitors if the best I managers are hired by the industry. Hence, *gross profits* Π_i of firm i can be written as $\Pi(m_i, \mathcal{M}_{-i}^I)$. In most oligopoly models, for any given distribution of managerial abilities in \mathcal{M}_{-i}^I (and thus implied marginal costs), profits are independent of the exact matching between competitors and managers in \mathcal{M}_{-i}^I . Finally, *net profits* (or *payoffs*) of firm i are $\Pi(m_i, \mathcal{M}_{-i}^I) - w_{i,m_i}$.

3 Equilibria

We now characterize the set of equilibria of the matching model just described, providing results that are not specific to the linear Cournot model we focus on later.

3.1 Symmetric Equilibria: Necessary Conditions

We first give a necessary condition for a symmetric equilibrium where the I most productive managers are employed.

Proposition 1 *A symmetric pure-strategy equilibrium in which managers \mathcal{M}^I are employed requires that for any i and k with $0 < k \leq I - i$*

$$w_{ii} - w_{i+k,i+k} = \Pi(i, \mathcal{M}_{-i}^I) - \Pi(i+k, \mathcal{M}_{-(i+k)}^I)$$

⁶This tie-breaking rule can be dispensed with by formulating that matching process as a dynamic game where firms approach managers in decreasing order of ability. Propositions 1 - 3 can still be derived in such a model with slightly more notational complexity.

The proof of Proposition 1 is given in the Appendix.

Proposition 1 implies that the wage differentials between managers reflect the additional gross profit that a firm achieves by replacing a less competent manager with a more competent manager at the expense of some competitor.

Note that in any equilibrium, we must have $w_{iM} = 0$ for all i , as manager M has no effect on costs.

3.2 Existence and Uniqueness of Symmetric Equilibria

Proposition 1 provides necessary conditions for the equilibrium wage differentials. We now show that an equilibrium with these wage differentials actually exists.

Proposition 2 *There exists a symmetric pure-strategy equilibrium in which the set \mathcal{M}^I is employed and each firm offers the wage scheme*

$$\begin{aligned} w_{im}^* &= 0 \text{ for } m \geq I \\ w_{im}^* &= \Pi(m, \mathcal{M}_{-m}^I) - \Pi(I, \mathcal{M}_{-I}^I) \text{ for } m < I. \end{aligned}$$

Firm i employs manager $m \in \mathcal{M}^I$ with probability $\frac{1}{I}$. All firms have identical net profits, $\Pi(I, \mathcal{M}_{-I}^I)$.

The proof of Proposition 2 can be found in the Appendix.

Intuitively, with the proposed wage w_{im}^* increases in gross profits from hiring better managers would be exactly offset by corresponding wage increases. Conversely, lower wages would be offset by losses in gross profits resulting from lower efficiency.⁷

We now show that no further equilibria exist in pure strategies.

Proposition 3 *There does not exist a symmetric pure-strategy equilibrium with*

$$w_{iI} > 0$$

⁷In the context of company worker training and technological spillovers it has been already observed that equilibrium wages of workers or R&D employees are given by their effects on firms profits (e.g., Gersbach and Schmutzler (2003)).

The proof of Proposition 3 is given in the Appendix.

Intuitively, in the proposed equilibrium a firm that deviates by offering the value of the outside option which is 0 to all managers would still be able to hire manager M and thus obtain net profits $\Pi(I, \mathcal{M}_{-I}^I)$ rather than $\Pi(I, \mathcal{M}_{-I}^I) - w_{iI}$.

4 The Impact of Globalization

We now consider the effects of integrating the product markets and the managerial labor markets of two identical countries. To this end, we focus on the Cournot specification of our model. We first derive explicit formulas for profits and wages for this model in the case of *autarky*. Then we derive the corresponding expressions for a *global economy* for which both the number of firms and the demand are twice as high as in the autarky case.

4.1 Autarky

Autarky is characterized by a set of I firms, inverse demand $p = a - bx$ ($b > 0$) and marginal costs (c_1, \dots, c_I) . The output of an individual firm i is denoted by x_i and $x = \sum_i x_i$ is the aggregate output. We use the standard result that profits in a Cournot oligopoly are

$$\Pi_i = \frac{1}{b(I+1)^2} \left(a - Ic_i + \sum_{j \neq i} c_j \right)^2. \quad (1)$$

The corresponding output levels are

$$x_i = \frac{1}{b(I+1)} \left(a - Ic_i + \sum_{j \neq i} c_j \right).$$

To guarantee that even the least efficient firm produces a nonnegative output, we assume

$$a - Ic_I + \sum_{j \neq I} c_j \geq 0. \quad (2)$$

We simplify notation by associating $\Pi(m, \mathcal{M}_{-m}^I)$ with Π_m and we label equilibrium profits and wages in the autarky case by Π_m^A and w_m^A , respectively. Π_m^A is given by (1), and w_m^A is given in the following lemma.

Lemma 1 *In the case of autarky, the equilibrium wage is given by*

$$w_m^A = \frac{c_I - c_m}{b(I+1)} \left(2 \left(a + \sum_{j \neq m, j \neq I} c_j \right) - (I-1)(c_I + c_m) \right).$$

The proof of Lemma 1 is given in the appendix.

4.2 Integration

We next consider integration by letting two countries of equal size and with an equal pool of managers integrate. Hence, we have only one product market with $2I$ firms, aggregate demand $p = a - \frac{b}{2} \cdot x$ and two managers of each quality $c(m)$.⁸ Equilibrium profits and wages under integration are denoted by Π_m^G and w_m^G , respectively, where m varies between 1 and I and each m stands for two firms that have the same marginal costs c_m .

Adapting (1) to the integration set-up yields

$$\Pi_m^G = \frac{2}{b(2I+1)^2} \left(a - 2Ic_m + \sum_{j \neq m} c_j + \sum_{j=1}^I c_j \right)^2.$$

In order to guarantee that the output of the least efficient firm under integration is nonnegative, we assume

$$a - 2Ic_I + 2 \sum_{j \neq I} c_j + c_I \geq 0 \quad (3)$$

This leads to a characterization of wages after integration.

Lemma 2 *In the integrated economy, the equilibrium wage is given by*

$$w_m^G = \frac{2(c_I - c_m)}{b(2I+1)} \left(2 \left(a + 2 \sum_{j \neq m, j \neq I} c_j \right) - (2I-3)(c_I + c_m) \right).$$

The proof of Lemma 2 is similar to the proof of Lemma 1 and thus omitted here.

⁸The demand function results from horizontal addition of the two identical autarky demand functions.

4.3 Comparison of Wages before and after Integration

In order to compare wages before and after integration, we have to make sure that firms operate under autarky and under integration. The following proposition ensures that Condition 3 is sufficient for profits of all firms to be positive before and after integration.

Proposition 4 *The set of parameters for which output and profits of the least efficient firm are at least zero under integration is contained in the set of parameters for which this is true under autarky.*

The proof of Proposition 4 is given in the Appendix.

Intuitively, while integration increases competition, it also increases demand. Proposition 4 says that the first effect dominates, so that it is easier for a firm to survive under autarky than under integration.

For the moment, we shall assume for simplicity that Condition 3 holds, so that all firms that operate under autarky survive under integration. Clearly, Proposition 4 suggests that firms that are marginal before autarky may well be driven out of the market after integration. In section 5, we therefore relax Condition 3. It will turn out that the conclusion we shall derive below will be reinforced if globalization leads to a consolidation of the market.

To compare the wage profiles under autarky and integration, we focus on the simple case of constant ability differences:

$$c_m = c_I - (I - m)\Delta, \quad m = 1, \dots, I, \quad \Delta > 0. \quad (4)$$

The following central result shows that integration increases the sensitivity of managerial wages to ability differences.

Proposition 5 *Assume that c_m is defined as in (4). Then*

$$w_m^G > w_m^A \text{ if and only if } m < m^{crit} \equiv \frac{2(a - c_I) + 2\Delta I(I + 2)}{(2I + 1)\Delta(I + 1)}.$$

The proof of Proposition 5 can be found in the Appendix.

Proposition 5 is our main result. It indicates that integration causes the wages of the most able managers to increase, while lower-quality managers suffer a pay cut. Integration increases the spread between the compensation of high-quality and low-quality managers. This increasing spread reflects the increase in the intensity of competition brought about by globalization. As it pays off more to have better managers, firms compensate efficiency differentials with higher wage differentials. When the heterogeneity between managers is small, the critical value m^{crit} is degenerate, so that integration will benefit all managers. This is captured in the following corollary:

Corollary 1

$$(i) \quad \frac{\partial m^{crit}}{\partial \Delta} < 0$$

$$(ii) \quad \lim_{\Delta \rightarrow 0} m^{crit} = \infty$$

Moreover, we obtain:

Corollary 2

$$(i) \quad \frac{\partial m^{crit}}{\partial a} > 0$$

$$(ii) \quad \frac{\partial m^{crit}}{\partial I} < 0 \quad \forall I \geq 2$$

The proof of Corollary 2 is tedious but straightforward and therefore omitted. Thus, as the demand captured by the parameter a increases under autarky, more managers will benefit from integration, whereas the converse statement holds for increases in the number of firms under autarky.

4.4 Numerical Examples

We have analyzed the model for several parameter values (see Table 1). The calculations suggest a number of insights beyond those already captured by the above results. First, the ratio between the profit of the most efficient firm and the profit of the second-best firm is higher under integration (Π_1^G/Π_2^G) than under autarky (Π_1^A/Π_2^A). Similar results also can be shown to hold for the ratio of the leader's profit and those of all other firms. Thus, integration increases competition in the sense proposed by Boone (2000).

		Scenarios				Results						
	I	Δ	a	b	c_I	$\frac{\Pi_1^A}{\Pi_2^A}$	$\frac{\Pi_1^G}{\Pi_2^G}$	$\sum_{i=1}^M \Pi_i^G$	$\sum_{i=1}^M \Pi_i^A$	$\sum_{i=1}^M w_i^A$	$\sum_{i=1}^M w_i^G$	m^{crit}
1.	5	10	300	1	100	1.47	1.78	7722	6000	6333	6000	1.66
2.	5	10	600	1	100	1.22	1.38	38556	24347	16333	16909	2.58
3.	5	10	1000	1	100	1.13	1.22	118556	71950	29667	31455	3.79
4.	5	10	1500	1	100	1.08	1.15	281056	168645	46333	49636	5.30

Table 1: Numerical results for $c_m = c_I - (I - m)\Delta$

Second, total profits under integration ($\sum \Pi_i^G$) are lower than under autarky ($\sum \Pi_i^A$). Again, this reflects increasing competition. Third, and most importantly, total managerial wages are not necessarily higher under integration ($\sum w_i^G$) than under autarky ($\sum w_i^A$). The perception that globalization benefits all managers may therefore be misleading. In view of our earlier results, it seems more likely that globalization generates an increasing spread of managerial wages, with increasing top salaries, but decreasing salaries for less efficient managers. However, as shown in Corollaries 1 and 2, for scenarios with a small number of firms and small cost differences (small heterogeneity), integration raises the wages of all managers, which is illustrated in the fourth scenario in Table 1.

We illustrate the impact of integration on the level and distribution of wages of managers for the four scenarios in Table 1 in Figures 1 - 4. These figures plot the equilibrium wages under autarky and integration, respectively. The figures illustrate how globalization increases the wage spread. They also show how an increase in market demand shifts the critical level in m^{crit} to the right, eventually leading to a situation where all managers benefit from globalization.

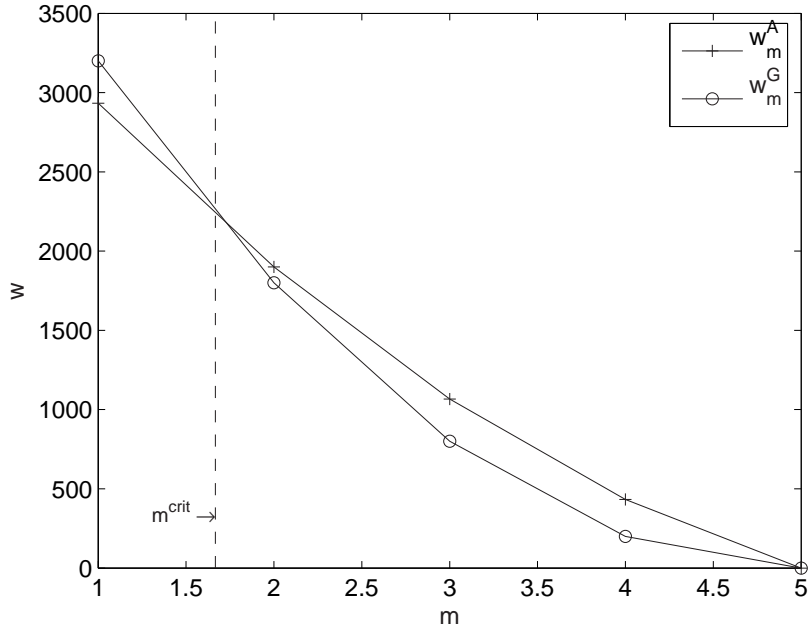


Figure 1:

I	Δ	a	b	c_I
5	10	300	1	100

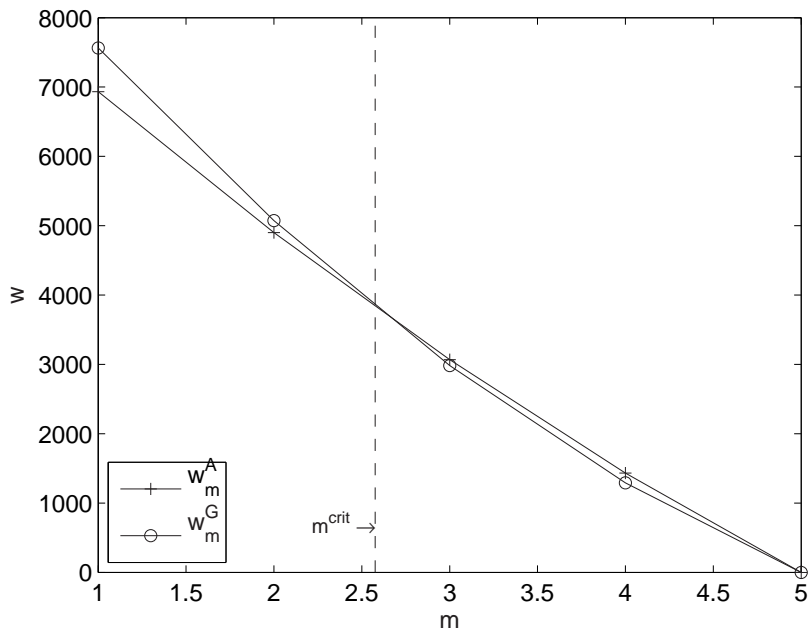


Figure 2:

I	Δ	a	b	c_I
5	10	600	1	100

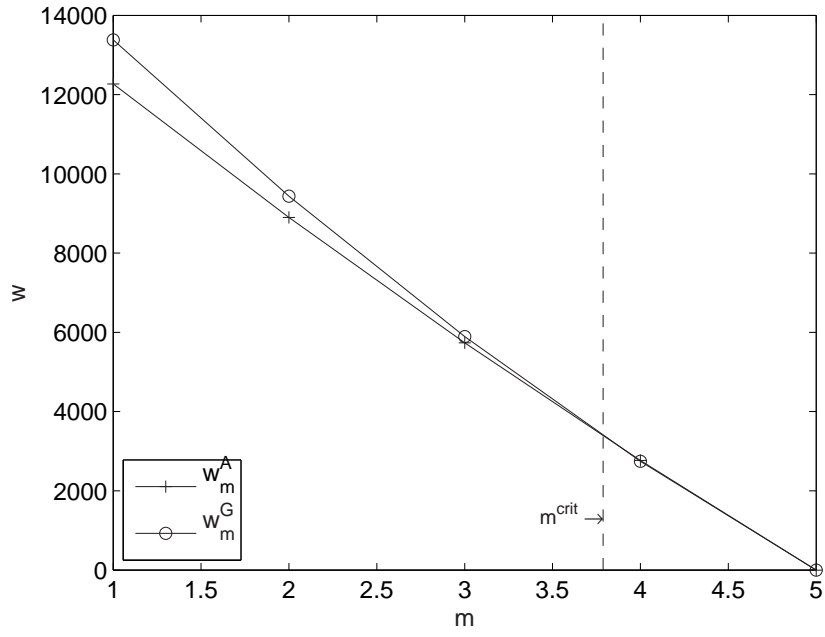


Figure 3:

I	Δ	a	b	c_I
5	10	1000	1	100

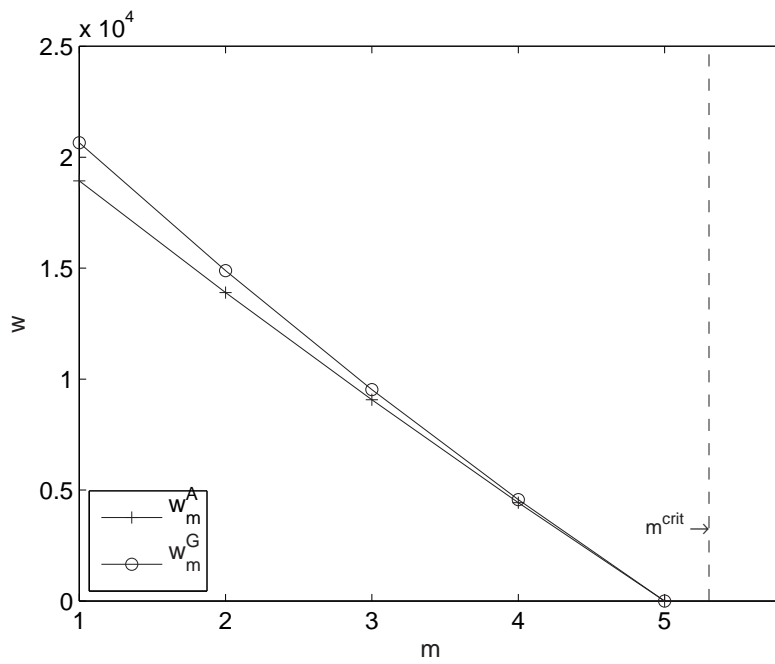


Figure 4:

I	Δ	a	b	c_I
5	10	1500	1	100

5 Robustness

To illustrate our effect in the most transparent way, we resorted to a number of simplifying assumptions. In the following, we will show that these simplifications are not crucial for the results.

5.1 Entry and Exit

Most obviously, we considered the number of firms as exogenous, not allowing for entry or exit. As in the monopolistic competition framework of Melitz (2003), globalization is likely to lead to the exit of inefficient firms in our model. We shall now demonstrate that our results are reinforced if we allow for this possibility.

To this end, we modify the model by assuming that there is a pool of potential firms that is so large that, at least the firms with relatively inefficient managers would optimally set outputs equal to zero. We then add an initial stage where firms decide whether they want to be in the market. After that, the game proceeds as before. We suppose that there are small, but positive fixed costs of being in the market.

The equilibrium structure will then be as follows. Under autarky, the number I of firms is determined so that the marginal firm earns non-negative profits, whereas any additional firm would earn negative profits if it entered the market. After integration, by Proposition 4, there cannot be net entry. More specifically, if condition (2) holds, but condition (3) does not, there will be net exit until the marginal firm has profits slightly above zero, so that the number of firms in the market will be smaller than $2I$.

Compared to the benchmark case without exit, that is, with $2I$ firms, the remaining non-marginal firms benefit from the exit of the competitors, so that their profits are higher than in the benchmark case. As a consequence, the profit differential between the best firm and the marginal firm increases, which immediately translates into an increase in the wage differential. Summing up, therefore, the increase in wage heterogeneity discussed in Section 4 is reinforced.

5.2 General Managerial Abilities

Another special aspect of our model is that managerial abilities are specific to one product market. Clearly, however, managerial talents are often more general. We will therefore show that our results are not affected when firms from different industries compete on the managerial labor market.

The simplest way to do so is to suppose that there is a finite number of copies of the product market described in Section 2 in each country, with firms from all industries competing for the same pool of managers. Thus, we go to the opposite extreme where managerial talent is fully general rather than specific to a particular industry. Globalization then corresponds to the simultaneous integration of all product markets and the managerial labor market. The equilibrium analysis parallels Section 3. In equilibrium, firms from all industries make wage offers to all managers. Wages are determined according to Propositions 1-3; with the obvious difference being that \mathcal{M}_{-i}^I now corresponds only to the subset of managers employed by the other firms in the same industry. As a result, the effects of globalization can be calculated in exactly the same way as in Section 4.

5.3 Alternative Cost Structures

While the general analysis up to and including Proposition 4 holds for arbitrary cost distributions, the numerical simulations were based on constant ability differences. Again, this simplification is not essential for our conclusion that globalization leads to increased wage heterogeneity. For instance, Proposition 5 holds for a flexible functional form for ability differences given by⁹:

$$c_m = c_I - \Delta \frac{1 - \gamma^{I-m}}{1 - \gamma}, \quad \gamma \in (0, 1) \quad (5)$$

Such a functional form captures decreasing ability differences. For γ approaching 1 we obtain constant ability differences which we used in our numerical exercise.

⁹Details are available upon request.

6 Conclusion

In this paper, we have examined how globalization affects the distribution of managerial wages. Our key insight is that globalization increases the heterogeneity of managerial salaries. Numerous issues deserve further scrutiny. For instance, incorporating asymmetric information and agency costs, or increasing demand for general rather than firm-specific managerial skills into our model suggests further insights into the structure of managerial compensation. Our paper may constitute a benchmark model for such research.

7 Appendix

Proof of Proposition 1

We consider the best-response conditions. Firm $i + k$ will not want to poach the higher quality manager $m = i$ from firm i by offering a higher wage if

$$\Pi(i + k, \mathcal{M}_{-(i+k)}^I) - w_{i+k, i+k} \geq \Pi(i, \mathcal{M}_{-i}^I) - w_{ii}$$

Firm i will not want to offer a higher wage to the lower-quality manager $m = i + k$ if

$$\Pi(i, \mathcal{M}_{-i}^I) - w_{ii} \geq \Pi(i + k, \mathcal{M}_{-(i+k)}^I) - w_{i+k, i+k}$$

Together, both inequalities imply the result. □

Proof of Proposition 2

Given wage offers w_{im}^* , managers are indifferent among all firms and choose each firm with probability $\frac{1}{I}$. The only reason for a firm to deviate by offering a higher wage to some manager would be to employ some $m < I$. However, by construction of w_{im}^* the required wage increase would exceed the increase in gross profits.

Now consider downward deviations of firm i . If the wage for some subset \mathcal{S} of managers is reduced, none of these managers will accept the offer of firm i in the first round. The managers in \mathcal{S} will randomize between the offers of firm i 's competitors, whereas the other managers will randomize between the offers of all firms. With positive probability, one of the managers in $\mathcal{M}^I \setminus \mathcal{S}$ will accept the offer of firm i in the first round, in which case payoffs remain unchanged. Also with positive probability, however, all those managers will accept the offer of some other firm. Then, by our tie-breaking rule that firms facing more than one application will choose the ablest manager, these other firms will hire all workers except manager I . This manager, however, will not accept any wage offer below w_{iI}^* because this is his outside option. □

Proof of Proposition 3

Suppose that $w_{iI} > 0$. According to Proposition 1 wage differences satisfy

$$w_{i+k,i+k} - w_{ii} = \Pi(i+k, \mathcal{M}_{-(i+k)}^I) - \Pi(i, \mathcal{M}_{-i}^I)$$

Hence, in the candidate equilibrium wages are given by

$$w_{im}^* = \Pi(m, \mathcal{M}_{-m}^I) - \Pi(I, \mathcal{M}_{-I}^I) + w_{iI} \text{ for } m < I$$

Equilibrium profits are given by

$$\Pi(I, \mathcal{M}_{-I}^I) - w_{iI}$$

Thus, a firm j could offer the wages $w_{jm} = 0$ for all m . According to our matching procedure, firm j would hire manager I and would obtain profits $\Pi(I, \mathcal{M}_{-I}^I)$. Hence, the deviation is profitable and the equilibrium does not exist. \square

Proof of Lemma 1

We calculate

$$\begin{aligned} w_m^A &= \Pi_m^A - \Pi_I^A \\ &= \frac{1}{b(I+1)^2} \left(a - Ic_m + \sum_{j \neq m} c_j \right)^2 - \frac{1}{b(I+1)^2} \left(a - Ic_I + \sum_{j \neq I} c_j \right)^2 \\ &= \frac{1}{b(I+1)^2} \left(a^2 - 2aIc_m + 2a \sum_{j \neq m} c_j + I^2 c_m^2 - 2Ic_m \sum_{j \neq m} c_j + \left(\sum_{j \neq m} c_j \right)^2 \right. \\ &\quad \left. - a^2 + 2aIc_I - 2a \sum_{j \neq I} c_j - I^2 c_I^2 + 2Ic_I \sum_{j \neq I} c_j - \left(\sum_{j \neq I} c_j \right)^2 \right) \\ &= \frac{1}{b(I+1)^2} \left(-2aIc_m + 2a(c_I + \sum_{j \neq m, j \neq I} c_j) + I^2 c_m^2 \right. \\ &\quad \left. - 2Ic_m(c_I + \sum_{j \neq m, j \neq I} c_j) + (c_I + \sum_{j \neq m, j \neq I} c_j)^2 + 2aIc_I \right. \\ &\quad \left. - 2a(c_m + \sum_{j \neq m, j \neq I} c_j) - I^2 c_I^2 + 2Ic_I(c_m + \sum_{j \neq m, j \neq I} c_j) - (c_m + \sum_{j \neq m, j \neq I} c_j)^2 \right) \end{aligned}$$

After some algebraic manipulations, we obtain

$$\begin{aligned}
w_m^A &= \\
&= \frac{1}{b(I+1)^2} \left(2a(I+1)(c_I - c_m) + (I^2 - 1)(c_m^2 - c_I^2) + 2(c_I - c_m)(I+1) \sum_{j \neq m, j \neq I} c_j \right) \\
&= \frac{c_I - c_m}{b(I+1)} \left(2(a + \sum_{j \neq m, j \neq I} c_j) - (I-1)(c_I + c_m) \right).
\end{aligned}$$

□

Proof of Proposition 4

The output of the least efficient firm under integration is nonnegative only if

$$a - 2Ic_I + 2 \sum_{j \neq I} c_j + c_I \geq 0.$$

However,

$$\begin{aligned}
a - 2Ic_I + 2 \sum_{j \neq I} c_j + c_I &= \left(a - Ic_I + \sum_{j \neq I} c_j \right) - (I-1)c_I + \sum_{j \neq I} c_j \\
&< a - Ic_I + \sum_{j \neq I} c_j.
\end{aligned}$$

Therefore, the critical condition for a positive output is easier to satisfy under autarky than under integration.

□

Proof of Proposition 5

With $c_m = c_I - (I - m)\Delta$, we get

$$\begin{aligned}
c_I - c_m &= (I - m)\Delta \\
c_I + c_m &= 2c_I - (I - m)\Delta \\
\sum_{j \neq m, j \neq I} c_j &= (I - 2)c_I - \frac{\Delta}{2}(I^2 - 3I + 2m)
\end{aligned}$$

Hence,

$$w_m^A = \frac{\Delta(I - m)}{b(I + 1)} \left(2(a - c_I) + \Delta(2I - m(I + 1)) \right)$$

and

$$w_m^G = \frac{2\Delta(I-m)}{b(2I+1)} \left(2(a-c_I) + \Delta(3I-m(2I+1)) \right).$$

To compare w_m^A and w_m^G , we calculate the difference $w_m^G - w_m^A$:

$$w_m^G - w_m^A = \underbrace{\frac{\Delta(I-m)}{b(I+1)(2I+1)}}_{(*)} \left(2(a-c_I) + \Delta(2I+1)(I-mI) + \Delta(3I-m(2I+1)) \right)$$

Since $(*) > 0$, $w_m^G - w_m^A > 0$ if and only if

$$2(a-c_I) + \Delta(2I+1)(I-mI) + \Delta(3I-m(2I+1)) > 0,$$

which is equivalent to

$$m < \frac{2(a-c_I) + 2\Delta I(I+2)}{\Delta(2I+1)(I+1)} =: m^{crit}.$$

□

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