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Managerial Incentives and Compensation in a Global Market

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Abstract
This paper embeds a principal-agent firm in an otherwise standard trade model a la Melitz (2003) to investigate the impact of globalization on the provision of managerial incentives and on the distribution of managerial compensation. Facing contractual frictions due to limited liability, firms with heterogeneous productivity endogenously sort into different pay structures to mitigate different levels of agency problems. More productive firms use a higher-powered incentive contract while less productive firms use a lowered- powered one. International trade within an industry enhances market competition, inducing resources reallocated from low productivity domestic firms to high productivity exporting .rms. The uneven effects of international trade on firms that differ in their exporting status and pay structure result in more prevalence of high-powered incentive pay, a larger wage gap between managers and production workers, and a higher level of wage inequality among managers.

Key Words: trade, heterogeneous firms, pay contracts, managerial incentives, managerial compensation, wage inequality
JEL Classification: D2, F1, J3, L1

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1 Introduction

Globalization affects the allocation of resources between countries, across industries and across firms. Naturally, firms respond by restructuring their organization of production. The mass media is replete with discussion about innovative management in the face of global competition. One hot debate is how to motivate and reward managers in a global context. Does globalization make managerial slack less tolerable and create a need to change the way managers are paid? Does globalization cause a surge of managerial compensation and increase wage inequality? Despite the real world relevance, systematic theoretical analysis to answer these questions is lacking. This paper provides a micro-founded theory to address the issue of how globalization affects the provision of incentives, the returns to managers and ultimately the distribution of wage.

My analysis encompasses three basic building blocks: the contractual frictions in the provision of managerial incentives inside firms, the sorting of pay structures across firms on the basis of productivity, and the impact of international trade on resource reallocation within industries. Because of contractual frictions, providing high-powered incentives is costly. Only when a manager's incentive makes a large difference to his employer will a high-powered but expensive pay scheme be used to motivate the manager. In an economy where the value of managerial incentive increases in firms' productivity, positive sorting of pay structures emerges: more productive firms adopt a high-powered pay contract while less productive firms use a low-powered one. International trade selects more productive firms into exporting, inducing resources to be reallocated from lower productivity domestic firms to higher productivity exporting firms. In response to global competition, the most productive firms strengthen the power of managerial pay; the least productive firms exit; intermediate firms adjust at the organizational margin. The uneven effects of globalization on firms that differ in their exporting status and pay structure result in more prevalence of high-powered incentive pay, an increase in the average managerial compensation, a wider wage gap between managers and production workers, and a higher level of inequality among managers.

Central in my analysis is the introduction of a modern managerial firm into an otherwise standard trade model a la Melitz (2003). First, managers differ from other workers. A manager can provide a local public-good type of service to affect a firm's productivity. However, the provision of managerial service requires managerial effort. Second, ownership and control rights are separate, and agency problems exist between the owner and the manager inside a firm. A manager may not provide sufficient service if his pay contract is not designed to induce proper incentive. Contractual frictions, for instance limited liability — the one that I model in this paper — make the provision of high-powered incentive costly, because a firm needs to sacrifice rent to compensate a manager's unwillingness to accept a severe punishment in a bad situation.

Based on the model developed by Wu (2011), I demonstrate a closed economy market equilibrium in which people with different managerial talent are sorted into different occu-

pations and pay structures. The least talented people become production workers. Mediocre people become managers in less productive firms. As the value of their managerial effort is not large enough, the optimal incentive contract is a low-powered fixed-bonus pay scheme. The most talented people are employed by the most productive firms, and it is optimal to offer them a high-powered equity-based pay scheme to induce managerial effort that is of great value. In a monopolistic competition framework with Dixit-Stiglitz preferences, I show that the sorting of pay structures generates a highly skewed wage distribution. Production workers receive a flat wage. Managers in less productive firms receive a fixed bonus, the amount of which is fixed in expectation. Managers in more productive firms share profits, and their pay level is amplified by the market value of firms. The top earning distribution therefore displays a strong convexity, analogous to the superstar effect discussed by Rosen (1981). The equity-based pay structure inside the firm and the scale-of-operations effect through the market constitute the source of a large wage gap between managers and production workers and the earning inequality within the managerial class.

I extend this closed economy model to an open economy with trade between two identical countries. Trade takes place within an industry because of the consumers' "love for varieties" preferences as in Krugman (1979). To have access to the foreign market, a firm needs to pay a fixed cost and a variable trade cost. Significant trade barriers prevent low productive firms from exporting. My model then features two types of sorting along the same dimension of firm productivity: firms are positively sorted by pay contract and by exporting status. More productive firms are more likely to use high-powered incentive pay, and are more likely to export. The two sorting mechanisms depend on and intertwine with one another, generating three main results that are of both theoretical and empirical significance.

The first main result concerns the impact of globalization on the provision of managerial incentives. As in Melitz (2003), the positive selection of firms into the international market induces resources reallocated from local firms, which suffer from tougher competition in the domestic market, to global firms, which gain from market enlargement. If the benefit from market enlargement dominates the loss because of tougher competition, a firm using the low-powered incentive structure is now willing to switch to the high-powered one. Conversely, if the market competition effect dominates, a firm may be forced to abandon the higher-powered but more costly pay structure. Globalization confronts firms with a trade-off between the enlargement in the new market and the shrinkage of the existing market. This is analogous to the trade-off between the business-stealing effect and the business-stolen effect in the literature on competition and managerial incentives (e.g., Hermalin 1992; Schmidt 1997; Raith 2003; Vives 2008). Compared with their homogeneous firm setting, what I highlight is the heterogeneous effect of market competition: globalization may cause an opposite impact on the pay structure and managerial incentives in firms with different productivity. Under certain conditions, globalization does discipline managerial slack, through crowding out the lower-powered incentive structure. At the average level, this implication is consistent with the

empirical finding that global competition enhances the power of incentive provisions inside firms (Cunat and Guadalupe 2005, 2009). But the heterogeneous effects of competition and the impact on the composition of pay structure call for further empirical examination.

The second result is that opening to trade increases the wage gap between managers and production workers, and the wage inequality among managers. This result is consistent with the empirical findings that trade liberalization tends to increase the wage inequality between skilled and unskilled labor (Goldberg and Pavcnick 2007 and the references therein), and the within-group wage inequality (e.g., Attanasio et al 2004; Menezes-Filho et al 2008). The general intuition stems from the across-firm resource allocation effect of trade, which in turn increases the dispersion of wages that are positively correlated with firm revenues.[1] The literature has widely discussed the wage premium due to firm size and the wage premium due to exporting. I introduce a new wage premium due to the pay structure that is derived from the optimal contractual design to mitigate agency problems inside firms. Only when the value of a worker's effort is large enough for a firm to use a sharing wage contract will firm size and exporting status become legitimate for a higher wage. Therefore the adjustment of firms at the organizational margin and the composition of pay structure in the market play a key role in determining the impact of trade on wage distribution. The introduction of this organizational feature distinguishes my research from the existing studies that emphasize matching between production technology and skills (Manasse and Turrini 2001; Yeaple 2005; Bustos 2011), competitive assignment (Ohnsorge and Trefler 2007; Costinot and Vogel 2010; Sampson 2010; Monte 2011), searching frictions in labor market (Helpman and Itskhoki 2010; Helpman et al 2010), and concerns of efficiency wage (Davis and Harrigan 2008) or fair wages (Egger and Kreickemeier 2009; Amiti and Davis 2011).

Related to the first two results, the third one demonstrates a non-monotonic relationship between wage inequality and trade openness. Moving from autarky to a low level, and then to a high level of trade openness, both the average level of managerial pay and the within-manager wage inequality first rise, and then decline. This result echoes the insight by Helpman et al (2010), who point out that the distribution of exporting wage premium varies with the level of trade openness. In my paper, the pay structure wage premium, together with the exporting wage premium, drives this non-monotonicity. The transmission mechanism is through firms' adjustments at both the entry and the organizational margins, and the resulting composition of pay structures in the market. Intuitively, when the level of trade openness is low, only a few highly productive firms play in the global market. Most firms, mixing with different pay structures, are confined in the domestic market. They suffer from import penetration without being compensated through exporting. At the entry margin, the least productive firms, together with their low-powered pay structures, exit. At the organizational margin, some firms cannot afford the equity-based pay structure and switch to

[1] Helpman et al (2009, 2010) provide a general framework to show that the result holds for a class of models satisfying reasonable conditions.

the low-powered pay structure. The two forces offset one another, leaving the composition of pay structures in the market barely changed. The managerial average compensation increases as a consequence of a small fraction of highly incentivized managers in global firms. When trade barriers decline so that firms with lower productivity can enter the international market, the advantage of the few exporting firms that were in the global market diminishes with the number of exporting firms. On the one hand, the selection effect at the entry margin is strengthened, as competition in the domestic market becomes more fierce. On the other hand, at the organizational margin, the adjustment from the high-powered to the low-powered pay structure slows down or even reverses, because more firms earn profits from sales in the foreign market. As a result, the fraction of firms that use the high-powered incentive structure increases. Transforming from a low level to a high level of trade openness, the average wage and the wage dispersion among managers who receive equity-based pay decrease. The higher average managerial compensation is driven by the composition of pay structures, rather than the level effect. When the level of trade openness is high enough for all firms to export, no firm is discriminated by its export status. The adjustment at the entry margin slows down, yielding a more balanced distribution of pay structure in the market. In consequence, both the average managerial pay and the within-manager wage inequality are reduced, although still higher than in autarky.

The current research contributes to the recent studies that attempt to open the black-box of firms in international trade. This literature has analyzed the boundary of firms (McLaren 2000; Antras 2003; Antras and Helpman 2004), organizational hierarchies (Antras et al 2005, 2008), delegation of power inside firms (Marin and Verdier 2008, 2010), and team matching (Sly 2011). However, the role of pay structure has received little attention in the trade literature, in sharp contrast with the wide application of optimal pay contract in other fields. With regard to the research on managerial incentives in international trade, my paper is closely related to Horn et al (1995), Grossman and Helpman (2004), and Vogel (2007). But none of these papers is intended to address the issue of managerial compensation. They do not specify a concrete managerial function, from which various pay structures are derived to reward different managers.

The rest of the paper is organized as follows. The next section sets up the basics of the model. Section 3 establishes the equilibrium in a closed economy, and characterizes the distribution of pay structure and pay level. Section 4 analyzes the impact of international trade, proceeding from a low level to a high level of trade openness. Section 5 concludes. All the proofs are relegated to the appendix.

2 The Model

In this section, I lay out the building blocks of the model. The specification of economic environments follows closely the standard treatment in the literature of trade with heteroge-

neous firms (Melitz 2003; Bernard et al 2007; Chaney 2008). For simplicity, I abstract from the dynamics of firm entry and exit. The specification of the organizational structure inside firms is a simplified version of Wu (2011).

2.1 Economic Environments

Endowment The economy has a continuum of people with a mass normalized to one. Each person is endowed with one unit of homogenous raw labour, and with heterogenous managerial talent whose distribution will be specified later. The managerial talent can be interpreted as entrepreneurship and general ability embodied in human capital, which is not industry specific and can be adapted to any technology. There exists a sufficiently large number of technologies in the economy. Each technology produces one variety of goods, and is owned by a firm.

Preferences A representative individual, independent of her ability and occupation, derives utility from a CES preference:

$$U = (\int_{\omega\in\Omega} q_\omega^\gamma d\omega)^{\frac{1}{\gamma}} \tag{1}$$

where q_ω is the consumption of one variety of differentiated goods ω from an endogenous continuum of bundles Ω. The parameter $\gamma \in [0,1]$ measures the degree of substitutability between any pair of differentiated varieties. The corresponding elasticity of substitution is $\sigma = \frac{1}{1-\gamma} > 1$. A larger γ or σ means that the varieties are more substitutable or less differentiated.

It is well known that the CES preference yields the demand for each variety ω : $q_\omega = Q(\frac{p_\omega}{P})^{-\sigma}$, where $Q = (\int_{\omega\in\Omega} q_\omega^\gamma d\omega)^{\frac{1}{\gamma}}$ can be regarded as an aggregate good and $P = (\int_{\omega\in\Omega} p_\omega^{1-\sigma} d\omega)^{\frac{1}{1-\sigma}}$ is an aggregate price index. Define aggregate spending $R \equiv PQ$. Then the expenditure (revenue) on a single variety can be expressed as $r_\omega = q_\omega p_\omega = R(\frac{p_\omega}{P})^{1-\sigma}$.

Production The only input in production is labor, provided by either a worker or a manager. A technology can be thought of as a stock of capital. The production features increasing returns to scale. A technology with productivity a produces q units of a final product at a cost $c(q) = \frac{q}{a} + F$ in terms of the homogenous raw labor. Here $\frac{1}{a}$ is the marginal cost, and F is the irreversible fixed cost such as overhead costs and distribution costs.

Product Market The structure of the product market is monopolistic competition. Given the above preferences and production technology, the pricing rule for each variety produced with productivity a is a constant mark-up over the marginal cost $p(a) = \frac{1}{\gamma a} = \frac{\sigma}{\sigma-1}\frac{1}{a}$. The corresponding demand and revenue are respectively

$$q(a) = Q(a\gamma P)^\sigma \text{ and } r(a) = R(a\gamma P)^{\sigma-1}.$$

The profit (net of the fixed cost) is

$$\pi(a) = \frac{r(a)}{\sigma} - F = \frac{R}{\sigma}(a\gamma P)^{\sigma-1} - F.$$

In the presence of heterogenous firms, the relative sales and relative revenues of two firms with different productivity can be explicitly expressed even without knowing the aggregates:

$$\frac{q(a_i)}{q(a_j)} = (\frac{a_i}{a_j})^{\sigma} \text{ and } \frac{r(a_i)}{r(a_j)} = (\frac{a_i}{a_j})^{\sigma-1}, \text{ for all } i,\ j \in \Omega. \tag{2}$$

These relations show that a more productive firm produces more output, earns more profits, and has a larger size (in terms of both employment of workers and sale revenues). I will, therefore, not distinguish a more productive firm from a larger firm.

2.2 The Firm

Now I start to open the black-box of a firm. The firm in this model departs from the neoclassical firm in two aspects: the existence of a functional manager and the separation of ownership and control rights.

2.2.1 The Function of Manager

The value of a manager for a firm comes from two factors: managerial talent and managerial effort. Managerial talent is an important source of firm productivity. For analytical simplicity, I makes the extreme assumption that a firm's initial productivity is determined solely by the talent of the manager it hires, following Lucas (1978) and Rosen (1982). Therefore the initial distribution of firm productivity is the distribution of managerial talent. [2] I assume that the managerial talent a is drawn from a continuous function $G(a)$ with well defined probability density $g(a)$ over the domain $(0, \infty)$.[3]

The margin of managerial talent is fixed by assumption. What's variable is managerial effort. A manager can adjust his effort to provide managerial service. The most important aspect of this managerial service is its local public good property. The core activities of a manager are to set up business strategies, to select profitable projects, to coordinate and motivate workers etc. All these activities will improve the total productivity of the whole workforce within a firm. Two types of cost are associated with the provision of managerial service. First, a manager needs to invest time and energy in all kinds of managerial activities. Second, the effect of managerial service on a firm is uncertain. Managerial failures abound. A simple way to fix the above ideas is as follows. A manager with talent a (in a firm with

[2] The qualitative result will be unchanged if I allow positive assignment between heterogenous talent and heterogenous firms as in Manasse and Turrini (2001), Costinot and Vogel (2010) and Monte (2011).

[3] I allow a person's managerial talent to reach an arbitrarily large upper bound for expository convenience. The results will not affected if we impose a finite upper bound on the domain of managerial talent.

initial productivity a) exerts effort e after incurring a cost $C(e)$ in terms of raw labor.[4] With probability e, the firm is in a good managerial state, and its total factor productivity will shift up to φa, $\varphi > 1$. With probability $1 - e$, the firm is in a bad managerial state, and its total factor productivity remains unchanged. Implicitly I assume that a manager's talent is specific to a single differentiated variety, and this limits his span of control.

If a manager owns a firm, he is the residual claimant and will always exert the first best level of effort to equate the marginal cost of his effort and the marginal value of social surplus. However, ownership and control rights are separate in most modern firms. Without being properly compensated, a manager is likely to shirk. This gives the crucial role of optimal pay structure.

2.2.2 Contracting with Limited Liability Constraints

The managerial labor market is potentially complicated because of searching, matching, competition, and turnovers. As my focus is on the internal pay structure, I abstract away from the complications in the external labor market. Searching is assumed to be prohibitively costly. After matching with each other, a pair of firm and manager will maintain their employer-employee relationship until one party chooses to exit the market.[5] This assumption pushes down the outside option of a manager, though heterogenous in talent, to the same minimum level, and allows the firms to retain positive rent.[6]

Specifically, a technology owner (the principal, she) posts a managerial vacancy in the labor market. After meeting a manager (the agent, he), the principal observes his managerial talent and makes a take-it-or-leave-it offer to the manager. If the offer is rejected, the principal will exit the market, and the manager will choose the alternative occupation as a production worker. If the offer is accepted, the manager converts his talent to the firm's productivity, production workers are employed, and production starts.

I introduce inside the firm a classic agency problem between the principal and the agent: moral hazard with limited liability. Two key assumptions are imposed. First, managerial effort is unobservable, and the principal and the agent can only contract on observable profits of the firm. Second, both parties are risk neutral, but the pay contract is subject to limited liability: the principal's ability to reward (punish) the manager is constrained by the latter's wealth.

The owner of a firm with productivity a maximizes her expected value by offering a wage

[4] Note that I model the cost of managerial effort as a managerial cost subtracted from the manager's income, following a broad interpretation of managerial efforts as investment in human capital. It would be equivalent to model the cost of managerial effort as disutility that is separable from income as in Grossman and Helpman (2004).

[5] It would be equivalent to assume random matching between firms and managers, and the firm productivity is match specific as in Helpman et al (2009, 2010).

[6] In this model, managerial talent is scarce while technologies are abundant. If searching is costless, all the rent will shift to the managers. As long as searching is imperfect, the qualitative results about pay structures in my model will remain similar, but the split of surplus will depend on a complex bargaining process.

profile $\{b(\varphi a), b(a), s(a)\}$, where $b(\varphi a)$ is the contingent payment (bonus) to the manager in a good managerial state when the firm's observed productivity is φa, $b(a)$ is the contingent payment in a bad managerial state when the productivity remains at the initial level a, and $s(a)$ is a non-contingent transfer (flat salary) from the owner to the manager. Given the economic environment in Section 2.1, a firm with productivity a will realize profits $\pi(a) = \frac{r(a)}{\sigma} - F$. Let the cost function of e take a quadratic form $\frac{1}{2k}e^2$ with $k > 0$, satisfying the regular convexity conditions. Then the firm faces the following constrained optimization problem:

$$\max_{b(.),\ s(.)} e[\pi(\varphi a) - b(\varphi a)] + (1-e)[\pi(a) - b(a)] - s(a) \tag{3}$$

subject to

$$\begin{aligned}
(PC) \quad &: \quad eb(\varphi a) + (1-e)b(a) - \frac{1}{2k}e^2 + s(a) \geq 1, \\
(IC) \quad &: \quad e \in \arg\max_{e'} e'b(\varphi a) + (1-e')b(a) - \frac{1}{2k}e'^2 + s(a), \\
(WC) \quad &: \quad \min\{b(\varphi a) + s(a), b(a) + s(a)\} \geq \underline{w} = 0.
\end{aligned}$$

Here PC is the participation constraint, meaning that the net return to the manager by working for the firm should be no less than his outside option as a production worker whose wage is normalized to one; IC is the incentive compatibility constraint, as a rational manager will maximize his expected payoffs; WC is the wealth constraint or limited liability constraint, saying that regardless of the managerial state, the owner cannot pay the manager less than $\underline{w}$, which is assumed to be zero.[7] I assume the existence of an interior solution for the managerial effort $e \in (0,1)$ to capture the idea that no matter how smart and diligent he is, the manager cannot ensure a hundred percent of success in a complex business world. This interior solution is guaranteed by a sufficiently small k.

2.2.3 Optimal Pay Contract

If there were no wealth constraint, the first best effort is achievable as the two parties are risk neutral. Even in the presence of the wealth constraint, the first best effort can be implemented by "selling the store" to the manager if his future income in any state is sufficient to "buy the store". This ownership transfer contract will result in a class of self-employed managers, as discussed in detail in Wu (2011). The main interest of the current paper is on the salaried managers employed by others. Therefore I rule out this type of contract by assuming that it is infeasible to transfer ownership without an up-front payment. Given the binding wealth constraint, only second best efforts are feasible.

Lemma 1 *Suppose that the wealth constraint is binding.*
1) When the participation constraint is binding (indicated by BP), the optimal contract takes

[7] For a genreal treatment of $\underline{w}$, see Wu (2011).

the form: $\{s(a)=0,\, b(a)=0,\, b^{BP}(\varphi a)=\sqrt{\frac{2}{k}}\}$*; the manager will exert a fixed level of effort* $e^{BP}(a)=\sqrt{2k}$.
2) When the participation constraint is relaxed (indicated by RP), the optimal contract is $\{s(a)=0, b(a)=0, b^{RP}(\varphi a)=\frac{1}{2}\frac{(\varphi^{\sigma-1}-1)}{\sigma}r(a)$*; the managerial effort is* $e^{RP}(a)=\frac{k}{2}\frac{(\varphi^{\sigma-1}-1)}{\sigma}r(a)$.

Proof. See the Appendix. ■

This lemma is intuitive. Because of unobservable managerial effort and uncertain outcomes, the principal tries to use a contingent performance pay scheme to induce managerial incentives by rewarding his good management and punishing his bad management. However, the binding wealth constraint limits the principal's ability to punish bad management. Thus the principal has to rely more on rewards to induce desirable managerial incentives. A high payment for good management encourages managerial effort, but leaves positive rent to the manager over his outside option. This trade-off between inducing managerial effort and giving up the limited liability rent depends on whether or not the participation constraint binds. A binding participation constraint implies that it is not worthwhile giving up the rent. Then the principal pays a fixed amount based on whether the productivity is improved, which will be referred to as a fixed-bonus contract. If the participation constraint is relaxed, the manager's pay is tied to the value of the firm, which I refer to as an equity-based contract.

Both types of pay scheme reflect the contractual frictions due to unobservable actions, and only yield second best managerial efforts. The fixed-bonus contract is a type of performance pay, but low-powered. A manager receives his pay based on a "local" performance indicator: a fixed bonus if and only if a task is implemented. The manager doesn't share the risk with the firm upon any shock in the market. This is a pay structure widely used for managers in small firms or low rank managers in large firms. By contrast, the equity-based contract is a high-powered performance pay. The managerial compensation is tied to a "global" performance indicator, and is sensitive to a firm's market value. This is a pay structure popular among CEOs and other senior managers in large firms.

2.3 Sorting of Pay Contract

According to the optimal contracts and managerial efforts in Lemma 1, the expected value of a firm with initial productivity a is

$$\begin{aligned} V_f^{Bonus}(a) &= [\sqrt{2k}(\varphi^{\sigma-1}-1)+1]\frac{r(a)}{\sigma}-(2+F); \\ V_f^{Equity}(a) &= \frac{k}{4}(\varphi^{\sigma-1}-1)^2[\frac{r(a)}{\sigma}]^2+\frac{r(a)}{\sigma}-F, \end{aligned} \tag{4}$$

where *Bonus* indicates the fixed-bonus contract, and *Equity* indicates the equity-based contract.

The expected pay net of the effort cost for a manager with talent a is

$$\begin{aligned} V_m^{Bonus}(a) &= 1; \\ V_m^{Equity}(a) &= \frac{k}{8}(\varphi^{\sigma-1}-1)^2[\frac{r(a)}{\sigma}]^2. \end{aligned} \tag{5}$$

It is straightforward to show that $V_f^{Equity}(a) \geq V_f^{Bonus}(a)$. From the firm's perspective, the high-powered equity-based contract is more efficient than the fixed-bonus contract, since it always yields more value to the firm. However, a manager does not always desire an equity-based pay scheme. When the surplus to be shared is small, the level of pay to the manager according to the optimally designed equity-based contract is not enough to induce participation into the employment relationship. Then the salary to the manager needs to be increased, which renders the firm's value below a level that it can obtain by using a fixed-bonus contract. In this sense, the equity-based pay structure is too expensive for small firms.

With the positive relation between a firm's productivity and its market value in Equation (2), managerial effort in a more productive firm creates a larger differential in the firm value between good and bad management. Firms sort into different pay structures, on the basis of their initial productivity.

Lemma 2 *There exists a unique threshold value a_* such that firms with initial productivity $a \leq a_*$will use the low-powered fixed-bonus contract to pay their managers, and firms with $a > a_*$ will adopt the high-powered equity-based contract to pay their managers. The threshold value a_*, at which both the firm and the manager are indifferent between the two pay schemes, is determined by $r(a_*) = \frac{2\sqrt{2}\sigma}{\sqrt{k}(\varphi^{\sigma-1}-1)}$.*

Proof. See the Appendix. ■

I will refer to the two types of firms as pay-by-bonus and pay-by-equity firms respectively.

3 Equilibrium in the Closed Economy

In this section, I establish the market equilibrium and characterize the distribution of both the pay structure and pay level in a closed economy. In equilibrium, the following conditions must be satisfied: 1) all manager-firm matches are stable; 2) pay contracts are optimally designed, and managers exert optimal efforts accordingly; 3) all the people optimally choose their occupations; 4) a firm is active if and only if it receives a non-negative expected payoff; 5) both the labor market and the product market clear.

From this section onwards, I assume that the distribution of managerial talent is subject to a Pareto distribution $G(a) = 1 - a^{-\lambda}$ over $(0, \infty)$, where λ governs the shape of the

distribution and the measure of talent inequality.[8] A larger λ means a flatter distribution and a lower level of inequality. To guarantee the existence of a meaningful solution to the economic system, I impose the restriction $\lambda > 2(\sigma - 1)$. The existence of equilibrium does not hinge on any specific distribution as shown in Wu(2011). The specification of the Pareto distribution, however, will facilitate the analysis, and is important for a clean characterization of wage distribution.

3.1 Market Entry and Stable Matching

The matching between firms and managers is bonded by different types of pay contract. Given the contracting environment and market conditions, the pay contracts are optimally designed by the firms, and the managers choose their optimal efforts. The stability of the matching is constructed by assumption, and is stable in the sense that given the contractual constraint, no manager/firm pair wishes to rematch with another firm/manager. From (4) and (5), both the value of the firms and the pay to managers increase in the managerial talent. The joint surplus created by a match strictly increases in a single exogenous factor representing both the manager's talent and the firm's initial productivity. The result is (second best) efficient given the limited liability constraint.

The managerial jobs are created by firms. A firm will enter the market if and only if its expected value is non-negative, that is, the expected profits net of the pay to the manager and workers should be large enough to cover the fixed cost F. Therefore the marginal firm/manager will be pinned down by the zero firm value condition: $V_f(\underline{a}) = 0$.[9] By Lemma 2, the least productive firms use the fixed-bonus pay structure. Then the marginal firm/manager is defined by

$$V_f^{Bonus}(a) = [\sqrt{2k}(\varphi^{\sigma-1} - 1) + 1]\frac{r(a)}{\sigma} - (2 + F) = 0. \tag{6}$$

3.2 Market Clearing

Clearing the labor market requires that every person in the economy is employed, either as a worker or as a manager. Unlike in Melitz (2003) where the supply of labor is fixed, labor supply in my model is endogenously determined by people's optimal choice of their occupations. Denote the number of employed managers $M \equiv \int_{\underline{a}}^{\infty} g(a)da$, which is also the number of active firms. The supply of raw labor is simply $1 - M$. The demand for raw

[8] The assumption that people's talent is Pareto distributed is standard in the literature on firm heterogeneity and trade, see for example Helpman et al 2010. Pareto distribution has been widely used to approximate the observed distribution of firm sizes (Axtell 2001), and the upper tail of wage distribution (Atkinson et al 2011 and the literature therein).

[9] Such $\underline{a}$ always exists since $V_f(a)$ is continuous in the domain $(0, \infty)$ with $\lim_{a\to 0} V_f(a) < 0$ and $\lim_{a\to\infty} V_f(a) = \infty$. Uniqueness is guaranteed by the monotonicity of $V_f(a)$.

labor is $M \cdot F + \int_{\underline{a}}^{\infty} \overline{\frac{q(a)}{a}} g(a)da$. The first term captures the raw labor required for each firm to bear the fixed cost; the second term captures the raw labor to bear the variable cost. $\overline{\frac{q(a)}{a}} = e(a)\frac{q(\varphi a)}{\varphi a} + [1 - e(a)]\frac{q(a)}{a}$ is an integrated term, indicating the expected variable raw labor demanded by a firm that has a probability $e(a)$ to improve productivity from a to φa. I assume that all the firms/managers work independently. Then by the law of large number, $e(a)$ can be regarded as the proportion of firms that successfully improve their productivity among the firms with initial productivity a.[10] In equilibrium, labor demand equals labor supply:

$$M \cdot F + \int_{\underline{a}}^{\infty} \overline{\frac{q(a)}{a}} g(a)da = 1 - M. \tag{7}$$

The aggregate income of the population includes the total wages paid to all workers and managers, and the dividend income for share holders.[11] Clearing the product market requires that the total expenditure (the total income) equals the total market value of output (the total revenues):

$$(1 - M) + \int_{\underline{a}}^{\infty} [V_m(a) + \frac{e(a)^2}{2k}]g(a)da + \int_{\underline{a}}^{\infty} V_f(a)g(a)da = R = \int_{\underline{a}}^{\infty} \overline{r}(a)g(a)da \tag{8}$$

where $\overline{r}(a) = e(a)r(\varphi a) + [1 - e(a)]r(a)$ is the expected revenue of a firm with initial productivity a. For any individual firm, the revenue $r(a)$ is exhausted by the payment to all the production workers, the managerial pay including the net value $V_m(a)$ and the compensation for the effort costs $\frac{e(a)^2}{2k}$, and the dividend payment to shareholders (the net firm value $V_f(a)$). Market clearing in the labor market and the product market boils down to the same condition, as the price of goods is related to the wage of production workers by the simple constant mark-up pricing rule.

Solving either (7) or (8) requires knowledge of $e(a)$ and $r(a)$, which are functions of the unknown aggregates R and P. Fortunately, the relationship between a firm's revenue and

[10] This is from an ex ante perspective. Alternatively, we can integrate the labour demand (or other variables) with an ex post productivity distribution $\mu(a)$ such that:

$\mu(a) = e(\frac{a}{\varphi})\frac{1}{\varphi}g(\frac{a}{\varphi}) + [1 - e(a)]g(a)$ if $a \geq \varphi\underline{a}$;

$= [1 - e(a)]g(a)$ if $\underline{a} \leq a \leq \varphi\underline{a}$.

The minimum productivity of a firm whose manager succeeds is $\varphi\underline{a}$. So firms with ex post productivity between $[\underline{a}, \varphi\underline{a}]$ are those whose managers have talents between this domain and do not succeed in improving productivity. The firms with ex post productivity $a > \varphi\underline{a}$ may come from two sources: the firms run by managers with talents $a > \varphi\underline{a}$ but fails to improve productivity and those run by less talented managers $\frac{a}{\varphi}$ but with successful management. This ex post approach will give the same result as the ex ante approach that I adopt in this paper.

[11] As the focus of this paper is wage incomes, I keep the distribution of dividen incomes in a black-box. They can be collected by the government or distributed to workers.

productivity (2) and that between a manager's effort and talent allow me to express $r(a)$ and $e(a)$ as follows:

$$r(a) = (\frac{a}{\underline{a}})^{\sigma-1} r(\underline{a}) = (\frac{a}{a_*})^{\sigma-1} r(a_*) \quad \text{for } a > \underline{a}_d; \tag{9}$$

and

$$\begin{aligned} e(a) &= \sqrt{2k} && \text{for } a \in [\underline{a}, a_*]; \\ e(a) &= (\frac{a}{a_*})^{\sigma-1}\sqrt{2k} && \text{for } a \in [a_*, \infty), \end{aligned} \tag{10}$$

where $r(\underline{a})$ is defined by (6), and $r(a_*)$ in *Lemma* 2, reproduced here as

$$\begin{aligned} \underline{r} &\equiv r(\underline{a}) = \frac{(2+F)\sigma}{\sqrt{2k}(\varphi^{\sigma-1}-1)+1}; \\ r_* &= r(a_*) = \frac{2\sqrt{2}\sigma}{\sqrt{k}(\varphi^{\sigma-1}-1)}. \end{aligned} \tag{11}$$

Then

$$a_* = [\frac{r(a_*)}{r(\underline{a})}]^{\frac{1}{\sigma-1}} \underline{a}. \tag{12}$$

The market clearing condition can be written in terms of a single unknown $\underline{a}$.

Lemma 3 *There exists a unique cutoff value $\underline{a}$ such that a firm will be active in the market if and only if its initial productivity exceeds $\underline{a}$.*

Proof. See Appendix. ■

The determination of the equilibrium $\underline{a}$ can be illustrated in Figure 1. As a larger $\underline{a}$ means fewer managers and more production workers, the raw labor supply curve LS is upward sloping in $\underline{a}$. From the demand side, an increase in $\underline{a}$ implies a tougher market. At the extensive margin, fewer firms remain. At the intensive margin, the remaining firms produce less and earn less profit, and the managers in the pay-by-equity firms adjust down their efforts. The demand for production workers declines at both margins, giving rise to a downward sloping demand curve LD. The intersection of the two curves pins down a unique $\underline{a}$. Then a_* and the equilibrium aggregates (M, R, P, Q) can be computed accordingly.

3.3 Occupational Stratification and Wage Distribution

Because of the one-to-one mapping between a firm's initial productivity and managerial talent, Lemma 2 and 3 together imply stratification of people on the basis of their talent.

Proposition 1 *In equilibrium, people with heterogenous talent sort into different occupations and pay structures in the following way: people with $a < \underline{a}$ become production workers, receiving a fixed wage; people with talent $a \in [\underline{a}, a_*)$ are managers in less productive firms, receiving a fixed-bonus pay scheme; people with $a \in [a_*, \infty)$ are managers in more productive firms, receiving an equity-based pay scheme.*

This proposition provides a new angle to look at the composition of labor force. One particular threshold value of talent creates a sharp division of labor between routine production and managerial matters. The least talented people will not enter the managerial labor market, and can never activate their managerial talent. Among the managerial class, mediocre ones manage small firms, and in expectation receive a flat salary; the more talented manage large firms, sharing both the profit and the risk with their employers. To distinguish the two types of managers, I will refer to the managers who are paid by fixed-bonus as salaried managers, and those paid by equity as equity-paid managers.

Under the specification of Pareto distribution of talent, the fractions of the salaried and the equity-paid managers among the managerial class are respectively:

$$\underline{\theta} = 1 - (\frac{a_*}{\underline{a}})^{-\lambda};\ \theta_* = (\frac{a_*}{\underline{a}})^{-\lambda}, \tag{13}$$

which can be calculated from (12).

A person's expected wage $W(a) = V_m(a) + \frac{e(a)^2}{2k}$ consists of two components: the net value of expected managerial pay and a compensation for managerial efforts. $W(a)$ is a step function of people's talent:

$$\begin{aligned} W_{PW}(a) &= 1 && \text{for } a \in (0, \underline{a})\ ; \\ W_{SM}(a) &= 2 && \text{for } a \in [\underline{a}, a_*); \\ W_{EM}(a) &= \frac{k}{4}\ \frac{(\varphi^{\sigma-1}-1)^2}{\sigma^2} r(a)^2 = 2(\frac{a}{a_*})^{2(\sigma-1)} && \text{for } a \in [a_*, \infty), \end{aligned} \tag{14}$$

where the subscripts PW, SM and EM indicate worker, salaried manager and equity-paid manager respectively. Figure 2 depicts the wage curve, combined with the stratification of occupations and pay structures. Production workers simply earn the unity wage. Mediocre managers receive a constant wage to compensate their outside option and the fixed amount of effort. They earn the same amount of wage due to their pay structure in spite of the heterogeneity in their generic talent. Finally, the earnings of the equity-paid managers increase rapidly in their talent, as they share the profits of the firms. Given the properties of the Pareto distribution, the wage of the equity-paid managers is also Pareto distributed with a shape parameter $\frac{\lambda}{2(\sigma-1)}$ and a minimum value 2. After the operations in the market, the wage distribution of the equity-paid managers becomes more skewed than the distribution of their generic talent, as the shape parameter λ is scaled down by a factor $\frac{1}{2(\sigma-1)}$. For a reasonable parameter value of σ, this market rescaling effect can transform a fairly even talent distribution into a substantially skewed wage distribution in favor of the top earnings.

Managerial Wage Premium The population is divided into two classes. The managerial class earns a premium over the working class, because they are talented enough to have opportunities to exert efforts (invest in human capital), and be rewarded through different

pay structures. The average managerial wage is

$$\widetilde{W}_M = \frac{\int_{\underline{a}}^{\infty} W(a)g(a)da}{1-G(\underline{a})} = \underline{\theta}\widetilde{W}_{SM} + \theta_*\widetilde{W}_{EM},$$

where the average pay to the salaried and the equity-paid managers are respectively

$$\widetilde{W}_{SM} = 2;\ \widetilde{W}_{EM} = \frac{2\lambda}{\lambda - 2(\sigma-1)}.$$

Collecting terms, the average managerial wage is

$$\widetilde{W}_M = 2 + \frac{4(\sigma-1)}{\lambda - 2(\sigma-1)}\theta_*. \tag{15}$$

Since I normalize the workers' wage to one, $\widetilde{W}_M$ is also a measure of the managerial wage premium.

Wage Inequality among Managers Being a manager does not necessarily yield a high wage income. The wage of the mediocre managers is constrained by their pay contract; their difference in talent does not result in a difference in pay. Only when a manager is talented enough to become an equity-paid manager will his pay be amplified by a large scale of market value. The equity-paid managers receive a premium due to the equity-based pay structure, which can be measured by $\frac{\widetilde{W}_{EM}}{\widetilde{W}_{SM}} = \frac{\lambda}{\lambda-2(\sigma-1)}$.

I construct a series of Theil indices to measure wage inequalities in different groups of people. With the convenience of Pareto distribution, the Theil index for the wage inequality among the equity-paid managers is$T_{EM} = \frac{2(\sigma-1)}{\lambda-2(\sigma-1)} - \ln\frac{\lambda}{\lambda-2(\sigma-1)}$.

The Theil index to measure the wage inequality within the managers then can be written as:

$$T_M = \ln 2 + \theta_* \frac{\frac{2\lambda}{\lambda-2(\sigma-1)}}{\widetilde{W}_M}\frac{2(\sigma-1)}{\lambda-2(\sigma-1)} - \ln\widetilde{W}_M, \tag{16}$$

an expression merely in terms of exogenous parameters in the economy.[12]

Wage Inequality in the Economy The average wage in the whole economy can be expressed as $\widetilde{W} = [1-(\underline{a})^{-\lambda}] + (\underline{a})^{-\lambda}\widetilde{W}_M$. The between-class Theil index is

$$\begin{aligned} T_{be} &= [1-(\underline{a})^{-\lambda}]\frac{1}{\widetilde{W}}\ln\frac{1}{\widetilde{W}} + (\underline{a})^{-\lambda}\frac{\widetilde{W}_M}{\widetilde{W}}\ln\frac{\widetilde{W}_M}{\widetilde{W}} \\ &= (\underline{a}_d)^{-\lambda}\frac{\widetilde{W}_M}{\widetilde{W}}\ln\widetilde{W}_M - \ln\widetilde{W}. \end{aligned} \tag{17}$$

[12]This within-manager Theil index can be decompoased as $T_M = T_{\frac{EM}{SM}} + \theta_*\frac{\frac{2\lambda}{\lambda-2(\sigma-1)}}{\widetilde{W}_M}T_{EM}$, where $T_{\frac{EM}{SM}} = \underline{\theta}\frac{\widetilde{W}_{SM}}{\widetilde{W}_M}\ln\frac{\widetilde{W}_{SM}}{\widetilde{W}_M} + \theta_*\frac{\widetilde{W}_{EM}}{\widetilde{W}_M}\ln\frac{\widetilde{W}_{EM}}{\widetilde{W}_M}$ is the Theil index measuring the wage inequality between the equity-paid managers and the salaried managers.

Finally the Theil index to characterize the overall wage inequality in the economy can be decomposed as

$$T = T_{be} + (\underline{a})^{-\lambda}\frac{\widetilde{W}_M}{\widetilde{W}}T_M, \tag{18}$$

where $(\underline{a})^{-\lambda}\frac{\widetilde{W}_M}{\widetilde{W}}$ is the wage bill share of the managers in the economy.

4 Trade Openness

In this section, I extend the framework in the closed economy to an open economy with international integration through trade of goods. Trade takes place within industries between countries with similar endowments because consumers love varieties as captured by the CES preferences. For expository convenience, I assume that the open economy consists of two identical countries, and thus it suffices to analyze the economic activities in the home country. Throughout the whole section, I will denote economic activities oriented for the domestic market with a subscript d and for the foreign market with x. The equilibrium variables in the closed economy presented in the last section will now be indexed with a superscript A for autarky.

4.1 Equilibrium in the Open Economy

The timing of the game for a representative firm in the open economy is as follows. A firm makes its market entry decision after meeting a manager in the labor market. Having known the managerial talent and decided to enter the market, the firm offers a pay contract to its manager, who has an outside option of being a production worker. Agreeing on the pay contract, the firm pays a fixed cost F_d to start production, and the manager exerts unobservable effort to improve the total factor productivity of the firm as in the closed economy. After observing the realized new productivity, the firm can decide whether to enter the international market. Access to the foreign market requires a firm to pay a fixed cost F_x to organize distribution networks and other costly activities. Moreover, a firm needs to ship $\tau > 1$ units of a good in order for one unit to reach the foreign destination because of the iceberg type of trade cost. After realizing profits in both markets, the firm will pay its manager according to the pay contract.

Formally a firm hiring a manager with talent a in the open economy faces the following objective function:

$$\begin{aligned} V_f(a) \quad = \quad & \max_{b(.),s(.),I_x} e(a)\{\frac{r_d(\varphi a)}{\sigma} + \mathbf{I}_x(\varphi a)[\frac{r_x(\varphi a)}{\sigma} - F_x] - b(\varphi a)\} \\ & +[1-e(a)]\{\frac{r_d(a)}{\sigma} + \mathbf{I}_x(a)[\frac{r_x(a)}{\sigma} - F_x] - b(a)\} - s(a) - F_d, \end{aligned} \tag{19}$$

where $r_d(a)$ and $r_x(a)$ are the revenues of a firm with (ex post) productivity a in the domestic

and foreign markets respectively, and $\mathbf{I}_x$ is an endogenous exporting status indicator, equal to one if a firm chooses to export and zero otherwise. The constraints faced by the firm are exactly the same as in the closed economy. A firm will choose its optimal pay contract according to *Lemma* 1 with reconsidering the surplus created by the managerial effort to improve productivity:

$$\pi(\varphi a) - \pi(a) = [\frac{r_d(\varphi a)}{\sigma} - \frac{r_d(a)}{\sigma}] + \mathbf{I}_x(\varphi a)[\frac{r_x(\varphi a)}{\sigma} - F_x] - \mathbf{I}_x(a)[\frac{r_x(a)}{\sigma} - F_x]. \tag{20}$$

Since a firm faces the same demand elasticity in both the domestic and the foreign markets, its exporting price is a constant multiplier of the domestic price adjusted by the variable trade cost: $p_x(a) = \tau^{1-\sigma} p_d(a) = \frac{\tau}{\gamma a}$. By the assumption of symmetric countries, the exporting revenue can be written as

$$r_x(a) = R_d(\tau a \gamma P_d)^{\sigma-1} = \tau^{1-\sigma} r_d(a).$$

A firm with realized productivity a will export if and only if its operating profit $\frac{r_x(a)}{\sigma}$ can cover the fixed cost F_x. As in Melitz (2003), I assume $\tau^{\sigma-1} F_x > F_d$ so that no firm can sell in the foreign market without serving the domestic consumers.

From an ex ante point of view, a firm, after entering the market, has three exporting options: 1) always stays in the home country; 2) exports only if in a good managerial state; 3) always exports regardless of its managerial state. I will refer to these three types of firms as local firms, conditional-exporting firms and global firms when distinction among them is necessary. Denote $\underline{a}_d$, $\underline{a}_c$, and $\underline{a}_x$ respectively the minimum productivity for a local firm, a conditional-exporting firm and a global firm, and $r_d(\underline{a}_d), r_d(\underline{a}_c)$ and $r_d(\underline{a}_x)$ the corresponding domestic revenues. Obviously $\underline{a}_c = \frac{\underline{a}_x}{\varphi} < \underline{a}_x$. The assumption $\tau^{\sigma-1} F_x > F_d$ implies that

$$\begin{aligned} r_d(\underline{a}_x) &= \max\{r_d(\underline{a}_d), \sigma\tau^{\sigma-1} F_x\}; \\ r_d(\underline{a}_c) &= \max\{r_d(\underline{a}_d), \sigma(\frac{\tau}{\varphi})^{\sigma-1} F_x\}. \end{aligned} \tag{21}$$

The possibility that $r_d(\underline{a}_d) \geq \sigma\tau^{\sigma-1} F_x$ arises in the current model because a firm needs to pay a manager to start production regardless of its exporting status. This managerial payment can be regarded as an fixed cost for market entry since the least productive firm pays a fixed expected wage to its manager . The following assumption will ensure that the least productive firms are active only in the domestic market.

Assumption 1 $\frac{2+F_d}{\sqrt{2k(\varphi^{\sigma-1}-1)+1}} < (\frac{\tau}{\varphi})^{\sigma-1} F_x$.

Under this assumption, the market entry condition is exactly the same as in the closed economy:

$$\underline{r}_d \equiv r_d(\underline{a}_d) = \frac{\sigma(2+F_d)}{\sqrt{2k}(\varphi^{\sigma-1}-1)+1}. \tag{22}$$

The equations in (21) become

$$\begin{aligned} \underline{r}_c &\equiv r_d(\underline{a}_c) = \sigma(\frac{\tau}{\varphi})^{\sigma-1} F_x \\ \underline{r}_x &\equiv r_d(\underline{a}_x) = \sigma F_x \tau^{\sigma-1}. \end{aligned} \tag{23}$$

The threshold values are linked by the relationship between relative productivity and relative domestic revenues in Equation (2).

The cutoff value for market entry $\underline{a}_d$ is the key to pin down the equilibrium in the global economy. Since the two countries are symmetric, $\underline{a}_d$ is determined by the labor market clearing condition in one country. The demand for raw labor in the home country is

$$\begin{aligned} &F_d M_d + \int_{\underline{a}_d}^{\infty} \{e(a)\frac{q_d(\varphi a)}{\varphi a} + [1-e(a)]\frac{q_d(a)}{a}\} dG(a) \\ &+F_x M_x + \int_{\underline{a}_d}^{\infty} \{e(a)\frac{I_x(\varphi a)\cdot \tau q_x(\varphi a)}{\varphi a} + [1-e(a)]\frac{I_x(a)\cdot \tau q_x(a)}{a}\} dG(a), \end{aligned} \tag{24}$$

where M_d is the total number of firms/managers, and M_x is the number of exporting firms in the home country. In addition to the demand for labor to bear the fixed and variable costs for the economic activities oriented to the domestic market (the terms in the first line of (24)), some firms also demand labor for the economic activities to export (the terms in the second line of (24)). Note that the exporting firms include global firms that always export and the conditional-exporting firms when they are in a good managerial state. Thus the number of exporting firms is $M_x = \int_{\underline{a}_c}^{\underline{a}_x} e(a)g(a)da + \int_{\underline{a}_x}^{\infty} g(a)da$. Similar to the analysis of the closed economy, managerial efforts and firm revenues in both the domestic and foreign markets can be written as relative to those of the marginal firm. Therefore the labor demand can be expressed as a downward sloping function of $\underline{a}_d$. The labor supply is $1 - M_d = 1 - \int_{\underline{a}_d}^{\infty} g(a)da$, increasing in $\underline{a}_d$. The intersection of the two curves pin down a unique cutoff value $\underline{a}_d$ in the open economy.

Lemma 4 *Under Assumption 1, there exists a unique triple of threshold productivity* $\underline{a}_d < \underline{a}_c < \underline{a}_x$ *in the open economy such that:*
1) A firm will be active if and only if its initial productivity is above $\underline{a}_d$*; Active firms will always sell in the domestic market.*
2) Firms with initial productivity between $\underline{a}_d$ *and* $\underline{a}_c$ *only serve the domestic market; Firms with initial productivity between* $\underline{a}_c$ *and* $\underline{a}_x$ *will export only in a good managerial state, and firms with initial productivity above* $\underline{a}_x$ *will always export.*
3) The threshold productivity for market entry is higher than in autarky, $\underline{a}_d > \underline{a}^A$.

Proof. See Appendix. ■

This lemma conveys two important messages. First, firms sort into different exporting status on the basis of their initial productivity. The least productive firms only serve the

local market, the intermediate firms are conditional exporters, and the most productive firms become global players. This positive sorting fits the stylized fact that exporting firms are more productive than domestic firms, as documented in Bernard and Jensen (1995) and Roberts and Tybout (1997) among others. Second, international trade triggers tougher competition and induces a selection effect at the entry margin. This second result can be illustrated graphically in Figure 1. Holding $\underline{a}_d = \underline{a}^A$, the number of active firms in the home country and thus the labor supply (LS) remain unchanged after trade. However, the exporting firms will increase their labor demand at the intensive margin. First, more production workers are demanded to bear both the fixed and variable costs in order to sell goods in the international market. Second, managers in the exporting firms will adjust their efforts in response to the enlargement of market share and profits. The increase in managerial efforts improves the productivity of the exporting firms and reinforces the demand for raw labor. As a result, the LD curves shift upwards to LD', intersecting with LS at a larger cutoff productivity for market entry. Intuitively, international trade drives out the least productive firms due to competition for labor, and resources are reallocated from smaller domestic firms to larger exporting firms. This is exactly the selection effect in Melitz (2003); the adjustment at the managerial margin enhances the selection and creates even more substantial resource reallocation.

I have shown that in the open economy, firms differ in two endogenous dimensions: pay structure and exporting status. The impact of trade will crucially depend on the level of trade openness. My analysis will proceed from a low level to a high level of trade openness, and finally to complete openness in which every firm exports.

4.2 Low Level of Trade Openness

In this subsection, trade barriers are so large that all the exporting firms operate on a large scale and adopt the equity-based pay scheme. Local firms are mixed with the two types of pay structure: pay-by-bonus and pay-by-equity. All the variables in the open economy, if necessary, will be indexed with a superscript L.

Denote a_*^L the initial productivity of the least productive firm that uses the equity-based pay structure. I consider the situation in which $a_*^L < \underline{a}_c$: the threshold (initial) productivity of becoming a pay-by-equity firm is lower than the minimum productivity of being a conditional-exporting firm. Since the least productive pay-by-equity firm will not export, its revenue is the same as in the closed economy:

$$r_*^L \equiv r_d^L(a_*^L) = \frac{2\sqrt{2}\sigma}{\sqrt{k}(\varphi^{\sigma-1}-1)}. \tag{25}$$

The domestic revenues of the least productive local, conditional-exporting, and global firms are defined in (22) and (23).

Assumption 2 *A low level of trade openness:* $\frac{2\sqrt{2}}{\sqrt{k}(\varphi^{\sigma-1}-1)} < (\frac{\tau}{\varphi})^{\sigma-1}F_x$.

This assumption is satisfied if trade barriers (F_x and/or τ) are sufficiently large. Note that Assumption 2 implies Assumption 1, given that $\frac{2\sqrt{2}}{\sqrt{k}(\varphi^{\sigma-1}-1)} \geq \frac{2+F_d}{\sqrt{2k}(\varphi^{\sigma-1}-1)+1}$, a condition assumed in the closed economy.

Under Assumption 2, managers together with their employers, are stratified by a series of threshold values in the order of $\underline{a}_d^L < a_*^L < a_c^L < a_x^L$. The least talented people, with talent below $\underline{a}_d^L$, are production workers; mediocre people with talent between $\underline{a}_d^L$ and a_*^L are salaried managers; and people with talent above a_*^L are equity-paid managers. Among the equity-paid managers, those with talent between a_*^L and a_c^L run the local firms; those with talent between a_c^L and a_x^L run the conditional-exporting firms; those with talent greater than a_x^L manage the global firms.

4.2.1 Composition of Pay Structures

As implied in *Lemma* 4, international trade has an asymmetric impact on firms with different exporting status. After trade openness, local firms face more fierce competition directly due to import penetration and indirectly due to higher labor demand by exporting firms; the least productive firms cannot survive. Given $\underline{r}_d^L = \underline{r}^A$ and $r_*^L = r_*^A$, the result $\underline{a}_d^L > \underline{a}^A$ in *Lemma* 4 implies $a_*^L > a_*^A$. The local pay-by-equity firms are not productive enough to enter the international market, and suffer from tougher competition in the home market without being compensated with sales in the foreign market. The managerial efforts in these firms are not as valuable as in the closed economy. The least productive ones cannot afford the equity-based pay structure any more, and switch to the fixed-bonus pay structure.

Interestingly, the fractions of the two types of firms are not affected by international trade. Let θ_*^L be the fraction of the pay-by-equity firms in the open economy. Under the specification of Pareto distribution,

$$\theta_*^L = (\frac{a_*^L}{\underline{a}_d^L})^{-\lambda} = (\frac{r_*^L}{\underline{r}_d})^{-\frac{\lambda}{\sigma-1}} = \theta_*^A. \tag{26}$$

The level of trade openness is so low that the local players are mixed with the pay-by-bonus and pay-by-equity firms. The two types of firms both bear the pressure of increasing domestic competition. The decrease in the number of the pay-by-equity firms is proportional to the total number of firms, leaving the fraction unchanged. The exact identity $\theta_*^L = \theta_*^A$ results from the Pareto distribution. But the intuition that the adjustments at the entry margin and at the organizational margin move in the same direction and balance one another is general.

4.2.2 Managerial Incentives and Compensation

In response to the optimal pay contracts offered by firms in the open economy, the managerial effort function is as follows:

$$\begin{aligned} e^L(a) &= \sqrt{2k} && for\ a \in [\underline{a}_d^L, a_*^L); \\ &= (\frac{a}{a_*^L})^{\sigma-1}\sqrt{2k} && for\ a \in [a_*^L, \underline{a}_c^L); \\ &= \frac{k[(\varphi^{\sigma-1} + (\frac{\varphi}{\tau})^{\sigma-1} - 1)\frac{r_d^L(a)}{\sigma} - F_x]}{2} && for\ a \in [\underline{a}_c^L, \underline{a}_x^L); \\ &= \frac{k(\varphi^{\sigma-1} - 1)(\tau^{1-\sigma} + 1)}{2}\frac{r_d^L(a)}{\sigma} && for\ a \in [\underline{a}_x^L, \infty). \end{aligned} \tag{27}$$

It can be shown that the managerial effort is continuous at all the threshold values, and thus the whole function is continuous in a. As in the closed economy, both the level and the slope of the managerial effort weakly increase in a.

Compare (10) with (27). The impact of trade on managerial incentives is uneven across managers in different types of firms. The salaried managers, if remaining in the market, are not responsive to trade at all, because the fixed-bonus pay shields them from the market changes faced by their employers. Among the equity-paid managers, all the ones working in local firms adjust their efforts downwards (recall $a_*^L > a_*^A$), with the least talented becoming salaried managers. The equity-paid managers in exporting firms may increase or decrease their efforts depending on the extent of global market competition. The following example illustrates the mechanism. Take a manager with talent $a > a_x^L$. His efforts before and after trade are related by

$$\frac{e^L(a)}{e^A(a)} = \underbrace{(1 + \tau^{1-\sigma})}_{>1} \cdot \underbrace{(\frac{\underline{a}_d^A}{\underline{a}_d^L})^{\sigma-1}}_{<1}. \tag{28}$$

Holding the adjustment at the entry margin constant, for instance in the short run, the manager's incentive improves by a factor $\tau^{1-\sigma}$. This is the market enlargement effect due to access to the foreign market. On the other hand, the entry of exporters enhance competition in both the domestic and the foreign markets. The magnitude of adjustment at the entry margin, captured in the second term of (28), reflects the extent of market competition. If the market is highly competitive, a wide range of less productive firms cannot survive in the global market ($\underline{a}_d^L$ is large relative to $\underline{a}_d^A$); the manager will not work as hard as he used to because his "excess" effort will not be rewarded since the market value of the firm declines. Only when the market enlargement effect dominates will the managerial effort increases. This trade-off between market enlargement (business stealing) and tougher competition (business stolen) is a central theme in the literature on competition and managerial incentives (e.g. Hermalin 1992; Schmidt 1997; Raith 2003; Vives 2008). But the existing studies only concern homogeneous firms in a partial equilibrium framework. Here the trade-off arises naturally

with international trade in a general equilibrium model with heterogenous firms. The uneven impact of global competition on managerial incentives across firms with different productivity is one main novelty of my model.

The wage function in the economy can be characterized as follows:

$$\begin{aligned}
W^L_{PW}(a) &= 1 && \text{if } a \in (0, a^L_d);\\
W^L_{d,SM}(a) &= 2 && \text{if } a \in [a^L_d, a^L_*);\\
W^L_{d,EM}(a) &= \frac{k(\varphi^{\sigma-1}-1)^2}{4}(\frac{a}{\underline{a}^L_d})^{2(\sigma-1)}\frac{\underline{r}^2_d}{\sigma^2} && \text{if } a \in [a^L_*, a^L_c);\\
W^L_{c,EM}(a) &= \frac{k}{4}\{[\varphi^{\sigma-1}+(\frac{\varphi}{\tau})^{\sigma-1}-1](\frac{a}{\underline{a}^L_d})^{\sigma-1}\frac{\underline{r}_d}{\sigma}-F_x\}^2 && \text{if } a \in [a^L_c, a^L_x),\\
W^L_{x,EM}(a) &= \frac{k(\varphi^{\sigma-1}-1)^2}{4}(1+\tau^{1-\sigma})^2(\frac{a}{\underline{a}^L_d})^{2(\sigma-1)}\frac{\underline{r}^2_d}{\sigma^2} && \text{if } a \in [a^L_x, \infty).
\end{aligned}$$

Here I use a composite subscript to indicate the type of manager based on pay structure and exporting status. Compared with the wage function (14), the wage function for the equity-paid managers in the open economy consists three segments, each for firms with different exporting status. Among them, the wage of the local managers, $W^L_{d,EM}(a)$, is subject to a truncated Pareto distribution, with a shape parameter $\frac{\lambda}{2(\sigma-1)}$ and bounded by 2 from below and by $2(\frac{r_c}{r^L_*})^2$ from above; the wage of the global managers, $W^L_{x,EM}(a)$, is Pareto distributed with a shape parameter $\frac{\lambda}{2(\sigma-1)}$ and with a minimum value $2(1+\tau^{1-\sigma})^2(\frac{r_x}{r^L_*})^2$. The wage distribution of the managers in the conditional-exporting firms, $W^L_{c,EM}(a)$, can be written as a combination of several different truncated Pareto distributions.

Figure 3A demonstrates the wage changes when a closed economy moves to a low level of trade openness. The least talented managers downgrade to production workers, and no longer receive compensation for their efforts. All the equity-paid managers in domestic firms receive lower wages due to the firms' loss in the domestic market; the least able ones become paid by a fixed bonus, and lose the chance to share rents with their employers. The impact of trade on the equity-paid managers in exporting firms is ambiguous depending on the trade-off between market enlargement and tougher competition. If the market enlargement effect dominates, the wage curve in the open economy will cut through some value between $\underline{a}^L_c$ and $\underline{a}^L_x$, and lie above the wage curve in the closed economy after the threshold (the red dashed line in Figure 3A). On the contrary, if the competition effect dominates, the whole wage curve in the open economy shifts to the right (the blue dotted line in Figure 3A). Regardless of this ambiguity, international trade increases the wage dispersion among the equity-paid managers. Consider two equity-paid managers, one in a local firm with talent $a' \in [a^L_*, \underline{a}^L_c)$, and the other in a global firm with $a'' \in [a^L_x, \infty)$. In the closed economy, their wage differential is $\frac{W^A(a'')}{W^A(a')} = (\frac{a''}{a'})^{2(\sigma-1)}$; in the open economy, their wage differential becomes $\frac{W^L(a'')}{W^L(a')} = (1+\tau^{1-\sigma})^2(\frac{a''}{a'})^{2(\sigma-1)}$. I will illustrate this point further.

4.2.3 Wage Inequality

International trade creates a wage wedge between managers in the domestic and exporting firms, even for those adopting the same pay structure. Using the properties of the Pareto distribution, the average wage of the (equity-paid) managers in exporting firms is

$$\widetilde{W}^L_{x,EM} = (1+\tau^{1-\sigma})^2(\frac{r_x}{r^L_*})^2\frac{2\lambda}{\lambda-2(\sigma-1)} > \frac{2\lambda}{\lambda-2(\sigma-1)} = \widetilde{W}^A_{EM}.$$

The average wage of the equity-paid managers in domestic firms is

$$\widetilde{W}^L_{d,EM} = \frac{1-(\frac{r_c}{r^L_*})^2(\frac{r_c}{r^L_*})^{-\frac{\lambda}{2(\sigma-1)}}}{1-(\frac{r_c}{r^L_*})^{-\frac{\lambda}{2(\sigma-1)}}}\frac{2\lambda}{\lambda-2(\sigma-1)} < \frac{2\lambda}{\lambda-2(\sigma-1)} = \widetilde{W}^A_{EM}.$$

The average wage of the managers in the conditional exporting firms lies between $\widetilde{W}^L_{d,EM}$ and $\widetilde{W}^L_{x,EM}$, and can be higher or lower than $\widetilde{W}^A_{EM}$.

Now I turn attention to the wage differential between the equity-paid managers and the salaried managers. The average wage of the equity-paid managers is

$$\widetilde{W}^L_{EM} = \frac{\int_{a^L_*}^{\underline{a}^L_c} W^L_{d,EM}(a)g(a)da + \int_{\underline{a}^L_c}^{\underline{a}^L_x} W^L_{c,EM}(a)g(a)da + \int_{\underline{a}^L_x}^{\infty} W^L_{x,EM}(a)g(a)da}{1-G(a^L_*)}.$$

Given that $W^L_{x,EM}(a) \geq W^L_{c,EM}(a) \geq W^L_{d,EM}$ with the first inequality being an equality at $\underline{a}^L_x$ and the second inequality being an equality at $\underline{a}^L_c$,

$$\widetilde{W}^L_{EM} > \frac{\int_{a^L_*}^{\infty} W^L_{d,EM}(a)g(a)da}{1-G(a^L_*)} = \widetilde{W}^A_{EM}. \tag{29}$$

The equality part of the above expression holds because the mean of a Pareto distributed variable only depends on the minimum value ($W^L_{d,EM}(a^L_*) = W^A_{EM}(a^A_*) = 2$) and the shape parameter ($\frac{\lambda}{2(\sigma-1)}$). The expected wage of the salaried managers remains constant due to the fixed-bonus pay structure. Therefore the wage gap between the two types of managers increases after trade, driven by the rise of average managerial pay in the global firms.

Since the fraction of each type of manager remains constant, the average wage of the managerial class increases:

$$\widetilde{W}^L_M = (1-\theta^L_*)2 + \theta^L_*\widetilde{W}^L_{equity} > \widetilde{W}^A_M.$$

It can be shown that the wage inequality between the equity-paid and the salaried managers is larger than that in the closed economy.[13]

[13] The Theil index between the equity-paid and the salaried managers is $T^L_{E/S} = (1-\theta^L_*)\frac{2}{\widetilde{W}^L_M}\ln 2 + \theta^L_*\frac{\widetilde{W}^L_{EM}}{\widetilde{W}^L_M}\ln\widetilde{W}^L_{EM} - \ln\widetilde{W}^L_M > T^A_{E/S}$, as $\frac{dT_{E/B}}{d\widetilde{W}_{EM}} = \frac{\theta_*}{(\widetilde{W}_M)^2}2(1-\theta_*)(\ln\widetilde{W}_{EM} - \ln 2) > 0$.

I summarize the main implications about the impact of trade openness on the distribution of pay structure and pay level as follows.

Proposition 2 *A low level of trade openness (Assumption 2 satisfied) leads to the following results in the home country:*
1) The total number of firms/managers decreases; both the numbers of the pay-by-bonus and the pay-by-equity firms/managers decrease, but the fraction of each type of firms/managers remains unchanged.
2) The average wage of the equity-paid managers increases.
3) The wage gap between managers and production workers increases.
4) Both the wage dispersion among the equity-paid managers and the wage inequality between the equity-paid and the salaried managers increase.

Consider two generations of identical people in a country. The first generation live in the closed economy, the second generation in the open economy. Compared to his ancestor, a person from the second generation is less likely to become a manager. Conditional on being a manager, his chance of receiving a high-powered equity-based pay scheme is exactly the same as his ancestor. As a pay-by-equity manager, he will on average receive a higher pay level than his counterpart in the previous generation, but it makes a big difference whether or not he works in an exporting firm. The level effect — a higher average wage of the equity-paid manager, in particular the pay to the managers in the global firms — is the main source of wage inequality in the economy. Taking the composition of all workers into account, the impact of trade on the wage inequality, measured by the Theil indices defined in (17) and (18), is ambiguous, because the wage distribution becomes more even at the bottom, although more skewed at the top.

4.3 High Level of Trade openness

If the two countries have already been integrated as described above, what happens if they continue to reduce trade barriers? Further trade liberalization will increase exchanges of goods across borders as well as global competition. On the one hand, the advantage of the previous global firms diminishes, as more firms export. On the other hand, the least productive firms suffer further from competition in the domestic market. These two forces will affect the adjustments of pay structure and managerial incentives, and significantly change the pattern of managerial compensation. In this subsection, I analyze a situation in which trade barriers are so low that some pay-by-bonus firms can enter the foreign market.[14] All the variables in the open economy with a high level of trade openness, if necessary, will be indicated with a superscript H.

[14]It may be possible that the level of trade integration permits co-existence of two types of conditional-exporting firms: pay-by-bonus and pay-by-equity. This special case will complicate the analysis without adding new insights, and is therefore neglected.

Denote $\underline{a}_d^H, \underline{a}_c^H$, $\underline{a}_x^H$ and a_*^H the threshold productivity/talent of entering the market, becoming a conditional exporter, being a global player, and becoming a pay-by-equity firm/manager respectively. If the least productive pay-by-equity firm exports, its domestic revenue is

$$r_*^H \equiv r_d^H(a_*^H) = \frac{2\sqrt{2}\sigma}{\sqrt{k}(\varphi^{\sigma-1}-1)} \frac{\tau^{\sigma-1}}{1+\tau^{\sigma-1}}. \tag{30}$$

Compared with (25), this threshold value is scaled down by a factor $\frac{\tau^{\sigma-1}}{1+\tau^{\sigma-1}} < 1$, because the value of managerial effort in an exporting firm is extended to the foreign market, and thus reduces the requirement of domestic revenues for a firm to adopt the equity-based incentive scheme. The following condition defines a high level of trade openness.

Assumption 3 *A high level of trade openness:* $F_x(1+\tau^{\sigma-1}) < \frac{2\sqrt{2}\sigma}{\sqrt{k}(\varphi^{\sigma-1}-1)}$

This assumption implies $\underline{r}_x < r_*^H$, and holds for a sufficiently small F_x and/or τ. Under Assumptions 1 and 3, firms are stratified by a series of threshold values in the order of $\underline{a}_d^H < \underline{a}_c^H < \underline{a}_x^H < a_*^H$. A range of pay-by-bonus firms are sorted by their exporting status: those initial productivity between $\underline{a}_d^H$ and $\underline{a}_c^H$ serve the local market; those between $\underline{a}_c^H$ and $\underline{a}_x^H$ export conditional on managerial success; those between $\underline{a}_x^H$ and a_*^H always export. The firms with productivity above a_*^H are global players that use the equity-based pay structure.

4.3.1 Composition of Pay Structures

As in the economy with low trade openness, international trade changes the mix of firms with different pay structures. The main difference is that now, the least productive pay-by-equity firms do not necessarily switch to the fixed-bonus structure. Combining (12) and (30), the change of the threshold productivity for adopting the equity-based pay is:

$$\frac{a_*^H}{a_*^A} = \underbrace{\frac{\underline{a}_d^H}{\underline{a}_d^A}}_{>1} \cdot \underbrace{\left(\frac{\tau^{\sigma-1}}{1+\tau^{\sigma-1}}\right)^{\frac{1}{\sigma-1}}}_{<1}. \tag{31}$$

In the case of a low level of openness, the second term is absent, and a_*^H is always greater than a_*^A. In the case of a high level of openness, a_*^H can be smaller than a_*^A if the market enlargement effect (the second term of (31)) dominates the competition effect (the first term of (31)). With sufficiently large market enlargement, the adjustment at the organizational margin reverses: the most productive pay-by-bonus firms will upgrade their pay structure to the higher-powered equity-based one in order to induce higher managerial efforts. In general, transforming from a low to a high level of trade openness, the adjustment from the high-power pay structure to the low-power one slows down, because the pay-by-equity firms are not discriminated by their exporting status. As a result, the fraction of the pay-by-equity firms among the surviving firms increases. Using the Pareto distribution, the fraction of the

pay-by-equity firms in the open economy is

$$\theta_*^H = (\frac{a_*^H}{\underline{a}_d^H})^{-\lambda} = (\tau^{1-\sigma}+1)^{\frac{\lambda}{\sigma-1}}\theta_*^A > \theta_*^A. \tag{32}$$

This implies that the fraction of the pay-by-bonus firms declines after trade. Since the total number of firms decreases, trade reduces the absolute number of the pay-by-bonus firms. Global competition crowds out the low-powered pay structure.

4.3.2 Managerial Incentives and Compensation

The optimal managerial effort in the highly integrated economy is

$$\begin{aligned} e(a) &= \sqrt{2k} && for\ a \in [\underline{a}_d^H, a_*^H); \\ e(a) &= \frac{k(\tau^{1-\sigma}+1)(\varphi^{\sigma-1}-1)}{2}\frac{r_d^H(a)}{\sigma} && for\ a \in [a_*^H, \infty) \\ &= \sqrt{2k}(\frac{a}{a_*^H})^{\sigma-1}. \end{aligned} \tag{33}$$

Whether an equity-paid manager increases or decreases his effort after trade entirely depends on the adjustment of a_*^H, which is a sufficient statistics for the trade-off between market enlargement and tougher competition.

Decompose the population into three groups: production workers, the salaried managers and the equity-paid managers. The wage function for each group in the open economy is analogous to that in the closed economy:

$$\begin{aligned} W_{PW}^H(a) &= 1 && \text{for} \quad a \in (0, \underline{a}_d^H); \\ W_{SM}^H(a) &= 2 && \text{for} \quad a \in (\underline{a}_d^H, a_*^H); \\ W_{EM}^H(a) &= 2(\frac{a}{a_*^H})^{2(\sigma-1)} && \text{for} \quad a \in [a_*^H, \infty). \end{aligned}$$

There is no variation in the wage level of production workers or the salaried managers. The wage of the equity-paid managers is subject to a Pareto distribution with a shape parameter $\frac{\lambda}{2(\sigma-1)}$ and a minimum value of 2, exactly the same as in the closed economy. I compare the wage curves in autarky and in trade openness in Figure 3B. The least talented managers downgrade to production workers. Provided that $\underline{a}_x^H \in (\underline{a}_d^H, a_*^H)$, a range of managers working in firms with different exporting status receive the same level of expected wage. The change in the wage of the equity-paid managers depends on a_*^H. If $a_*^H < a_*^A$, the wage curve of the equity-paid managers in the open economy lies above that in the closed economy; if $a_*^H > a_*^A$, an opposite pattern occurs.

4.3.3 Wage Inequality

The impact of trade openness on wage inequality is through the composition of people with different occupations and pay structures. Owing to the Pareto distribution, the average wage of the equity-paid managers remains unchanged: $\widetilde{W}_{EM}^H(a) = \frac{2\lambda}{\lambda-2(\sigma-1)}$. Since $\theta_*^H > \theta_*^A$, the average managerial pay in the open economy is:

$$\widetilde{W}_M^H = 2 + \frac{4(\sigma-1)}{\lambda-2(\sigma-1)}\theta_*^H > \widetilde{W}_M^A.$$

Using the Theil index defined in (16), the within-manager wage inequality in the open economy is:

$$T_M^H = \ln 2 + \theta_*^H \frac{\frac{2\lambda}{\lambda-2(\sigma-1)}}{\widetilde{W}_M^H} \frac{2(\sigma-1)}{\lambda-2(\sigma-1)} - \ln \widetilde{W}_M^H > T_M^A.^{15}$$

I summarize the basic results in this subsection as follows.

Proposition 3 *A high level of trade openness (Assumption 1 and 3 satisfied) leads to the following results in the home country:*
1) The total number of firms/managers decreases; both the number and the fraction of the pay-by-bonus firms/managers decrease; the fraction of pay-by-equity firms/managers increases.
2) The average wage of each of the three groups of people — production workers, the salaried managers and the equity-paid managers — remains the same as in autarky.
3) The wage gap between managers and production workers increases.
4) The within-manager wage inequality increases.

Revisit the example of two generations of identical people, the first generation living in the closed economy and the second generation in the open economy. A person from the second generation is less likely to become a manager. But conditional on being a manager, he has a better chance to be employed by a large firm and paid by the high-powered equity-based scheme. What may be striking for him is that when he enters any one of the three groups of labor force, he finds that on average he receives the same level of pay as his counterpart in the first generation. The wage distribution is more disperse in the second generation, merely because people are diverged towards the upper and lower groups without changing the average pay level in each group. People in the middle group, the salaried-managers, suffer most from trade openness because some of them are double "discriminated" in both export status and pay structure. The falling of this middle group is one source of the rising wage inequality among the managerial class. Again the impact of trade openness on the wage inequality in the overall economy is ambiguous, because the increasing average managerial pay is offset by the declining fraction of managers among all the whole population.

[15] It can be shown $\frac{dT_M}{d\theta_*} = \frac{1}{\widetilde{W}_M}\frac{4(\sigma-1)}{\lambda-2(\sigma-1)}[\frac{\frac{2\lambda}{\lambda-2(\sigma-1)}}{\widetilde{W}_M} - 1] > 0$.

Regardless of the level of openness, international trade always increases the average level of managerial pay and the wage gap between managers and production workers. Moreover, trade openness tends to increase the wage inequality among the managers. The difference that various levels of trade openness bring about is the channel through which trade impacts on the wage distribution. When the level of openness is low, it is the level effect — a higher wage level of the equity-paid managers in global firms — that drives up the wage inequality. When the level of openness is high, it is the composition effect — a larger fraction of pay-by-equity firms — that leads to more inequality. Interestingly, when an economy moves from a low to a high level of trade openness, both the average pay level and the wage dispersion among the equity-paid managers decline. This is simply because the equity-paid managers are no longer discriminated by their export status after the global market becomes highly integrated.

4.4 Complete Trade Openness

After an economy is highly integrated with the international market, it can be shown that a further trade liberalization (e.g. a smaller τ) will keep increasing the fraction of pay-by-equity firms/managers, the managerial wage premium, and the wage inequality within managers. What would happen if the level of trade openness is so high that all firms are able to export?

In such a fully integrated economy (indicated with a superscript F), *Assumption* 1 is violated. Suppose that the pay-by-bonus firms are able to survive as before. The market entry condition becomes

$$\frac{\sqrt{2k}(\varphi^{\sigma-1}-1)+1}{\sigma}(1+\tau^{1-\sigma})r_d^F(\underline{a}_d^F)-(2+F_d+F_x)=0,$$

or

$$\underline{r}_d^F \equiv r_d^F(\underline{a}_d^F)=\frac{(2+F_d+F_x)\sigma}{(1+\tau^{1-\sigma})[\sqrt{2k}(\varphi^{\sigma-1}-1)+1]}.$$

The domestic revenue of the least productive pay-by-equity firm is the same as in (11). Hence

$$(\frac{a_*^A}{\underline{a}_d^A})^{\sigma-1}>(\frac{a_*^F}{\underline{a}_d^F})^{\sigma-1}=\frac{r_*^F}{\underline{r}_d^F}>(\frac{a_*^H}{\underline{a}_d^H})^{\sigma-1}.$$[16]

This in turn implies

$$\theta_*^A<\theta_*^F=(\frac{a_*^F}{\underline{a}_d^F})^{-\frac{\lambda}{\sigma-1}}<\theta_*^H. \tag{34}$$

The fraction of the pay-by-equity firms is smaller in a fully integrated economy than in a highly integrated economy, although it is still larger than that in the closed economy. This

[16] It can be shown that $(\frac{a_*^F}{\underline{a}_d^F})^{\sigma-1}-(\frac{a_*^H}{\underline{a}_d^H})^{\sigma-1}=\frac{\frac{2\sqrt{2}}{\sqrt{k}(\varphi^{\sigma-1}-1)}}{\frac{2+F_d+F_x}{[\sqrt{2k}(\varphi^{\sigma-1}-1)+1]}}-\frac{\frac{2\sqrt{2}}{\sqrt{k}(\varphi^{\sigma-1}-1)}\frac{\tau^{\sigma-1}}{1+\tau^{\sigma-1}}}{\frac{2+F_d}{[\sqrt{2k}(\varphi^{\sigma-1}-1)+1]}}=\frac{2\sqrt{2}[\sqrt{2k}(\varphi^{\sigma-1}-1)+1](2+F_d-F_x\tau^{\sigma-1})}{\sqrt{k}(\varphi^{\sigma-1}-1)(2+F_d+F_x)(2+F_d)(1+\tau^{\sigma-1})}$, which is positive if Assumption 1 is violated.

is not totally surprising. With complete trade openness, no firm is discriminated by its export status. The adjustment at the entry margin slows down, yielding a more balanced distribution of pay structure among firms. Given the relationship between the fraction of pay structure and the average managerial pay (15), and the within-manager Theil index (16),

$$\widetilde{W}_M^A < \widetilde{W}_M^F < \widetilde{W}_M^H \text{ and } T_M^A < T_M^F < T_M^H.$$

Proposition 4 *A full level of trade openness (Assumption 1 violated) leads to the following results:*
1) The fraction of the pay-by-equity firms/managers is greater than in autarky, but is smaller than in the economy with high trade openness.
2) The average wage of each of the three groups of people — production workers, the salaried managers and the equity-paid managers — remains the same as in autarky.
3) The wage gap between managers and production workers is higher than in autarky, but is lower than in the economy with high trade openness.
4) The within-manager wage inequality is higher than in autarky, but is lower than in the economy with high trade openness.

Based on Proposition 2-4, I elicit three general implications about the impact of trade openness on the distribution of pay structure and pay level.

Result 1 *Relative to in autarky, trade openness always leads an economy to a higher level of managerial pay, a larger wage gap between managers and production workers, and greater wage inequality among the managerial class.*

The first set of results are in line with a number of recent studies of the impact of globalization on the wage inequality between skilled and unskilled labor, and on the wage inequality among the skilled labor (see the related references in Section 1). The underlying driving force is essentially the same: opening of trade increases the dispersion of firm revenue, which in turn increases the wage dispersion of workers whose pay is positively correlated with firm revenue. What's new in my paper is the economic mechanism that endogenizes the increasing correlation between a worker's pay level and firm revenue.

Result 2 *When an economy moves from autarky to a low level, then to a high level, and finally to a full level of trade openness, the average pay to the equity-paid managers first goes up, then moves down to the level in autarky after the high level of openness is achieved; in contrast, the fraction of the pay-by-equity firms/managers remains constant until the high level of openness is achieved, and then increases, but finally decreases after complete openness is achieved.*

Result 3 *When an economy moves from autarky to a high level, and then to a full level of trade openness, the wage gap between managers and production workers first increases, but then decreases; the within-manager wage inequality follows the same pattern.*

The last two sets of results display the non-monotonic effect of trade liberalization, as in Helpman et al (2010). The initial condition of international integration matters for the impact of trade liberalization on wage inequality. From Result 2 to Result 3, I demonstrate a channel to capture this non-monotonicity. It is precisely driven by the impact of trade on the margin of organizational adjustment. The degree of discrimination between the pay-by-equity firms with different export status affects the composition of pay structures and the distribution of managerial pay. Thus, organizational forms play an important role in transmitting the impact of trade liberalization.

5 Conclusion

This paper has brought a modern managerial firm into the study of international trade. Based on the total factor productivity shifting function of a manager and the contractual frictions due to limited liability, firms with heterogenous productivity optimally design different pay structures to mitigate different levels of agency problems with their managers. The sorting of firms in the dimension of pay structure generates a wage premium for managers who are paid by an equity-based sharing contract. The interaction between pay structures inside firms and intra-industrial trade enriches the analysis of a core economic issue: how does international trade affect the distribution of incomes across factors of production? Several interesting results regarding the heatedly debated consequences of globalization have been derived from the analysis.

One key result is that globalization affects the provision of managerial incentives inside firms. Integration into a global market confronts a firm with a trade-off between market enlargement and tougher competition. The value of managerial effort, resting on a firm's profitability, is affected accordingly. Firms in turn adjust their pay structures to induce greater managerial incentives (if the market enlargement effect dominates) or to reduce the power of incentive provision to avoid higher costs (if the competition effect dominates). The change in managerial incentives is an equilibrium outcome of the firms' adjustment of organizational structure in response to the changing market conditions. This is related to a long-standing debate about how market competition disciplines managerial slack. A country's openness to trade provides a natural setting to examine this issue. At the aggregate level, globalization may reduce managerial slack, but not because of the traditional wisdom that people work harder when facing greater competitive pressure; rather, the discipline is more impersonal: global competition crowds out the lower-powered incentive structure. What I have highlighted is the heterogenous effect of globalization on managerial incentives across firms with different exporting status and pay structures. This theoretical result provides a new angle for the empirical examination of the consequences of globalization on managerial incentives and compensation.

The effects of trade on firms' adjustment at the organizational margin and the resulting

changes in managerial effort ultimately lead to an impact on wage distribution. Since the sorting of firms into different exporting status and into pay structures with different incentive power are on the common basis of productivity, the firm size wage premium, the pay structure wage premium, and the exporting wage premium move in the same direction. The positive correlation between these three types of wage premium, not surprisingly, results in a higher level of managerial pay, a larger wage gap between managers and production workers, and greater inequality among managers in an economy with trade openness than in autarky. What I have emphasized is how the composition of pay structures in the market transmits the impact of international trade. In particular, when trade openness changes from a low to a high level, the composition effect replaces the level effect to become the driving force of higher managerial compensation. Moreover, the non-monotonic relationship between the composition of pay structures and the level of trade openness determines the non-monotonicity between wage inequality and trade openness. These results shed new light on the current debate about the surge of top incomes and the widening inequality between the working rich and working poor in a global context.

The current research has tried to bridge a gap between international trade and organizational economics. To highlight the effect of global competition in the product market, I have shut down trade channels due to comparative advantages or unequal distributions of factor endowment across countries. I also abstract away from other important kinds of international trade, for example, FDI and outsourcing. Future work will be devoted to extend the current framework to incorporate other channels and formats of trade. Focusing on the impact of globalization on managerial incentives and compensation, I have looked into the black-box of firms from an incentive perspective, and stressed the role of pay structure inside firms. However, firms may respond to globalization at various organizational margins. A new line of research is to build a richer firm structure, for example a combination of the incentive and the coordination views of firms, in the analysis of international trade.

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Appendix: Proof of Lemmas

A1. Lemma 1

Proof. Since IC is a concave function in e, we replace it with the first order condition

$$e = k[b(\varphi a) - s(a)] \qquad (IC').$$

Substitute this into the principal's objective function:

$$V_f(a) = e[\pi(\varphi a) - b(\varphi a)] + (1-e)[\pi(a) - b(a)] - s(a) - F,$$

which is decreasing in $b(a)$. So it is always optimal to set $b(a) = 0$.Then $s(a) = \underline{w} = 0$ by the binding WC.
Case 1) If PC is binding, $V_m^{Bonus}(a) = kb(\varphi a)^2 - \frac{1}{2k}k^2b(\varphi a)^2 = 1$, from which we solve $b^{BP}(\varphi a) = \sqrt{\frac{2}{k}}$ and $e^{BP}(a) = \sqrt{2k}$.
Case 2) If PC is relaxed, substituting IC', $b(a) = 0$, and $s(a) = 0$ into the objective function, we obtain $e^{RP}(a) = \frac{k(\varphi^{\sigma-1}-1)\pi(a)}{2}$ and $b^{RP}(\varphi a) = \frac{(\varphi^{\sigma-1}-1)\pi(a)}{2}$. Using $\pi(a) = \frac{r(a)}{\sigma}$, the results follow. ■

A2. Lemma 2

Proof. From (5),

$$\begin{aligned} V_f^{Equity}(a) - V_f^{Bonus}(a) &= \frac{k}{4}(\varphi^{\sigma-1}-1)^2[\frac{r(a)}{\sigma}]^2 - \sqrt{2k}(\varphi^{\sigma-1}-1)\frac{r(a)}{\sigma} + 2 \\ &= [\frac{\sqrt{k}}{2}(\varphi^{\sigma-1}-1)\frac{r(a)}{\sigma} - \sqrt{2}]^2. \end{aligned}$$

Obviously, the firm always prefers an equity-based pay contract. From (6), let $V_m^{Equity}(a) = V_m^{Bonus}(a)$, which determines $r(a_*) = \frac{2\sqrt{2}\sigma}{\sqrt{k}(\varphi^{\sigma-1}-1)}$. Therefore, a manager will accept an equity-based pay contract if $a > a_*$, accept a fixed-bonus pay contract if $a < a_*$, and is indifferent between the two contracts at $a = a_*$. Note $V_f^{Equity}(a) = V_f^{Bonus}(a)$ at a_*. ■

A3. Lemma 3

Proof. I prove this lemma with a general distribution of managerial talent. Rewrite the market clearing condition (7) as

$$\int_{\underline{a}}^{\infty} r(a)g(a)da + (\varphi^{\sigma-1}-1)\int_{\underline{a}}^{\infty} e(a)r(a)g(a)da = \frac{\sigma}{\sigma-1}[1 - M(1+F)]. \tag{A1}$$

Substituting (9) and (10) into (A1), the left hand side becomes

$$\underline{r}\int_{\underline{a}}^{\infty}(\frac{a}{\underline{a}})^{\sigma-1}g(a)da + (\varphi^{\sigma-1}-1)\sqrt{2k}\underline{r}[\int_{\underline{a}}^{a_*}(\frac{a}{\underline{a}})^{\sigma-1}g(a)da + \int_{a_*}^{\infty}(\frac{a}{\underline{a}})^{2(\sigma-1)}g(a)da].$$

The first term is decreasing in $\underline{a}$ since

$$\frac{d\int_{\underline{a}}^{\infty}(\frac{a}{\underline{a}})^{\sigma-1}g(a)da}{d\underline{a}} = -g(\underline{a}) - \frac{\sigma-1}{\underline{a}}\int_{\underline{a}}^{\infty}(\frac{a}{\underline{a}})^{\sigma}g(a)da < 0.$$

Let $\Phi(\underline{a}) = \int_{\underline{a}}^{a_*}(\frac{a}{\underline{a}})^{\sigma-1}g(a)da + \int_{a_*}^{\infty}(\frac{a}{\underline{a}})^{2(\sigma-1)}g(a)da$. Then

$$\Phi'(\underline{a}) = \frac{da_*}{d\underline{a}}(\frac{a_*}{\underline{a}})^{\sigma-1}g(a_*) - g(\underline{a}) - \frac{\sigma-1}{\underline{a}}\int_{\underline{a}}^{a_*}(\frac{a}{\underline{a}})^{\sigma-1}g(a)da$$

$$-\frac{da_*}{d\underline{a}}(\frac{a_*}{\underline{a}})^{2(\sigma-1)}g(a_*) - \frac{2(\sigma-1)}{\underline{a}}\int_{a_*}^{\infty}(\frac{a}{\underline{a}})^{2(\sigma-1)}g(a)da].$$

The terms

$$\begin{aligned} & \frac{da_*}{d\underline{a}}(\frac{a_*}{\underline{a}})^{\sigma-1}g(a_*) - \frac{da_*}{d\underline{a}}(\frac{a_*}{\underline{a}})^{2(\sigma-1)}g(a_*) \\ = \quad & \frac{da_*}{d\underline{a}}(\frac{a_*}{\underline{a}})^{\sigma-1}g(a_*)[1-(\frac{a_*}{\underline{a}})^{\sigma-1}] < 0, \end{aligned}$$

since $(\frac{a_*}{\underline{a}})^{\sigma-1} = \frac{r_*}{\underline{r}} > 1$. Then $\Phi'(\underline{a}) < 0$, and thus the demand curve is downward sloping. Obviously $M = \int_{\underline{a}}^{\infty}g(a)da$ decreases in $\underline{a}$, and the right hand side of (A1) increases in $\underline{a}$. Moreover, the difference between the left hand side and the right hand side is positive when $\underline{a} \to 0$, and the difference is negative when $\underline{a} \to \infty$. By the intermediate value theorem, the two sides intersect at a single interior point $\underline{a} \in (0, \infty)$.

Under the specification of Pareto distribution, A1 can be simplified as:

$$(\underline{a})^{\lambda} = (1+F) + \frac{\lambda(\sigma-1)}{\lambda-(\sigma-1)}(2+F) + \frac{4\lambda(\sigma-1)^2}{[\lambda-2(\sigma-1)][\lambda-(\sigma-1)]}(\frac{a_*}{\underline{a}})^{-\lambda}.$$

A unique $\underline{a}$ is determined immediately. ■

A4. Lemma 4.

Proof. The proof of the first part of Lemma 4 is similar to the proof of Lemma 3. The proof of the second part is implied when defining the threshold values. Here I only show the proof of the third part. Denote all variables in the closed economy with a superscript A, and in

the trade economy with T. The demand for raw labor in the close economy is

$$F_d \cdot M^A + \int_{\underline{a}^A}^{\infty} \{e^A(a)\frac{q^A(\varphi a)}{\varphi a} + [1 - e^A(a)]\frac{q^A(a)}{a}\} dG(a) \equiv LD.$$

By (24), the demand for raw labor in the open economy is decomposed into two parts:

$$\text{Domestic market:} \qquad F_d \cdot M_d^T + \int_{\underline{a}_d^T}^{\infty} \{e^T(a)\frac{q_d^T(\varphi a)}{\varphi a} + [1 - e^T(a)]\frac{q_d^T(a)}{a}\} dG(a) \equiv LDD$$

$$\text{Foreign Mark:} \qquad \int_{\underline{a}_d^T}^{\infty} \{e^T(a)\frac{I_x(\varphi a) \cdot \tau q_x^T(\varphi a)}{\varphi a} + [1 - e^T(a)]\frac{I_x(a) \cdot \tau q_x^T(a)}{a}\} dG(a) \equiv LDX.$$

Let a_*^A and a_*^T the threshold productivity of becoming a pay-by-equity firm in the closed economy and in the trade economy respectively. Rewrite the labor demand LD and LDD:

$$\begin{aligned} LD &= F_d \cdot \int_{\underline{a}^A}^{\infty} dG(a) + \int_{\underline{a}_d^T}^{\infty} \frac{q^A(a)}{a} dG(a) + \int_{\underline{a}^A}^{a_*^T} e(a)[\frac{q^A(\varphi a)}{\varphi a} - \frac{q^A(a)}{a}] dG(a) \\ &\quad + \int_{a_*^T}^{a_*^A} e(a)[\frac{q^A(\varphi a)}{\varphi a} - \frac{q^A(a)}{a}] dG(a) + \int_{a_*^A}^{\infty} \{e^A(a)[\frac{q^A(\varphi a)}{\varphi a} - \frac{q^A(a)}{a}] dG(a). \end{aligned}$$

and

$$\begin{aligned} LDD &= F_d \int_{\underline{a}_d^T}^{\infty} dG(a) + \int_{\underline{a}_d^T}^{\infty} \frac{q_d^T(a)}{a} dG(a) + \int_{\underline{a}_d^T}^{a_*^T} e^T(a)[\frac{q_d(\varphi a)}{\varphi a} - \frac{q_d(a)}{a}] dG(a) \\ &\quad + \int_{a_*^T}^{a_*^A} e^T(a)[\frac{q_d(\varphi a)}{\varphi a} - \frac{q_d(a)}{a}] dG(a) + \int_{a_*^A}^{\infty} e^T(a)[\frac{q_d(\varphi a)}{\varphi a} - \frac{q_d(a)}{a}] dG. \end{aligned}$$

By (2), $q^A(a) = (\frac{a}{\underline{a}^A})^\sigma q^A(\underline{a}^A)$ and $q_d^T(a) = (\frac{a}{\underline{a}_d^T})^\sigma q_d^T(\underline{a}_d^T)$. Since the market entry condition remains the same by Assumption 1, $q^A(\underline{a}^A) = q_d^T(\underline{a}_d^T)$. Suppose $\underline{a}^A = \underline{a}_d^T$. Then $q^A(a) = q_d^T(a)$ for all a. Because access to the foreign market increases the differential between good and bad management, and thus reduces the threshold productivity for a firm to adopt the equity-based pay structure, $\frac{a_*^T}{\underline{a}_d^T} \leq \frac{a_*^A}{\underline{a}^A}$. Hence $\underline{a}^A = \underline{a}_d^T$ implies $a_*^T \leq a_*^A$. Holding the threshold productivity for market entry constant,

$$\begin{aligned} LDD - LD &= \int_{a_*^T}^{a_*^A} [e^T(a) - \sqrt{2k}][\frac{q_d(\varphi a)}{\varphi a} - \frac{q_d(a)}{a}] dG(a) \\ &\quad + \int_{a_*^A}^{\infty} [e^T(a) - e^A(a)][\frac{q_d(\varphi a)}{\varphi a} - \frac{q_d(a)}{a}] dG. \end{aligned}$$

By Lemma 1,

$$\begin{aligned} e^T(a) &= (\frac{a}{a_*^T})^{\sigma-1}\sqrt{2k} > \sqrt{2k} \qquad\qquad \text{for } a \in (a_*^T, a_*^A] \\ e^T(a) &= (\frac{a}{a_*^T})^{\sigma-1}\sqrt{2k} \geq (\frac{a}{a_*^A})^{\sigma-1}\sqrt{2k} = e^A(a) \quad \text{for } a \in (a_*^A, \infty). \end{aligned}$$

Therefore $LDD > LD$, and $LDD + LDX > LD$ since $LDX > 0$. On the other hand, the supply of raw labor remains the same before and after trade given $\underline{a}^A = \underline{a}_d^T$. As a result, the labor demand curve shifts upwards after trade while the labor supply curve remains the same, implying $\underline{a}_d^T > \underline{a}^A$ as shown in Figure 1. ■

Figure 1: Demand and Supply Curves in the Labor Market

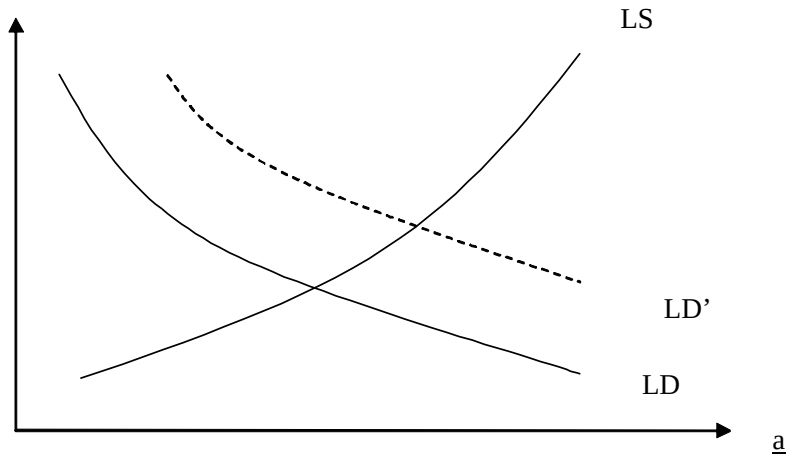


Figure 2: Distributions of Occupations, Pay Structures and Expected Wages

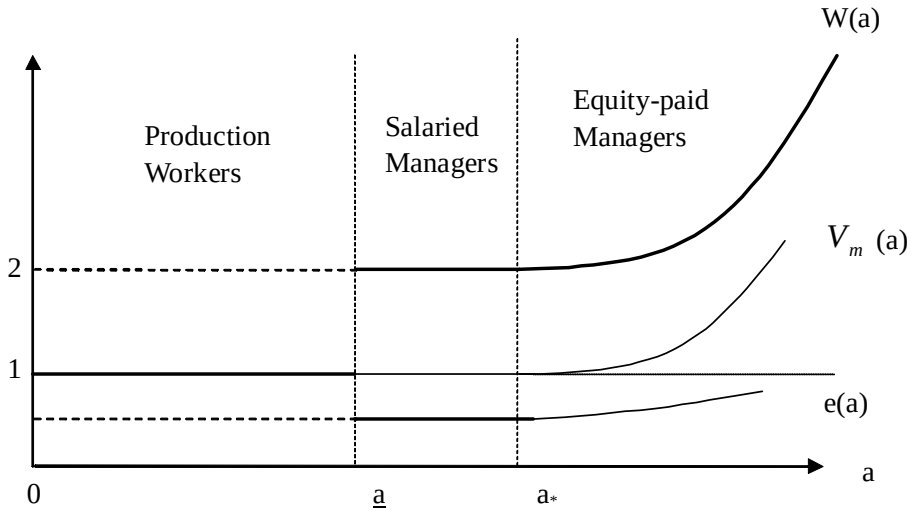
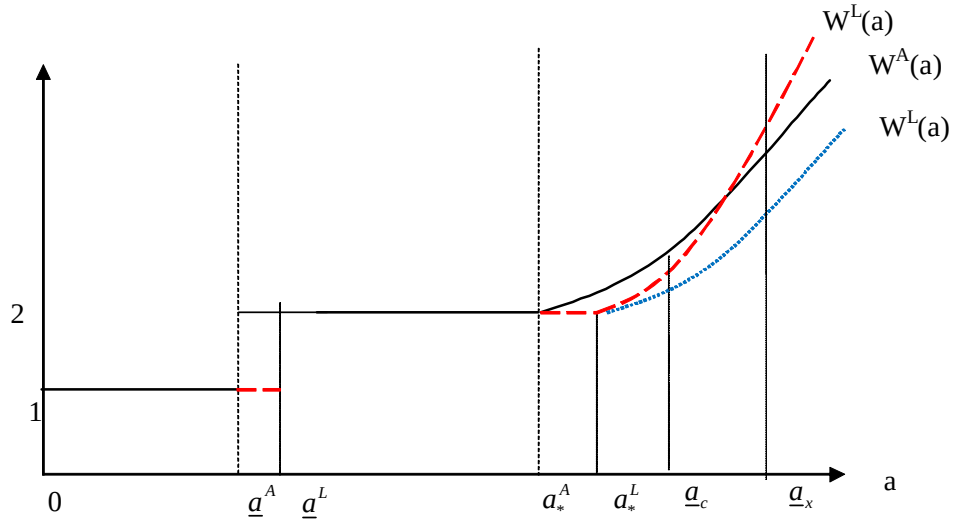
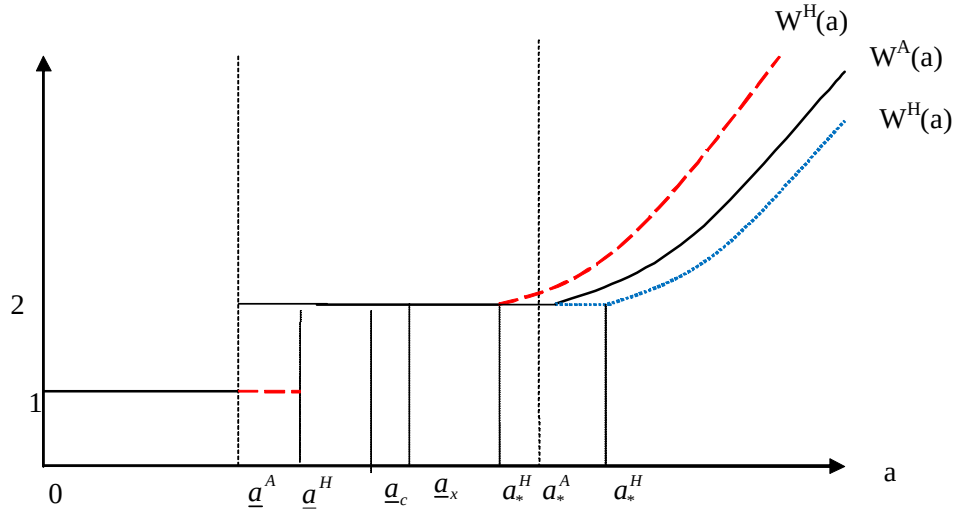


Figure 3: Impact of Trade on Wage Distribution

Case 1: Low Level of Trade Openness



Case 2: High Level of Trade Openness



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