

International Trade, Wages, and Unemployment

with Endogenous Firm Scope

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Abstract

Heterogeneous managers match and supervise production of multiple goods. Managerial skill improves labor productivity, so long as efficiency wages deter shirking. Trade liberalization eases the efficiency wage constraint, thereby raising total employment and labor wages. Trade rationalizes production in three ways. Firms become more specialized by dropping marginal product lines. Production is reallocated within industries toward the most efficient firms. Also trade rationalizes the matching behavior of managers, leading to improved team formation. Overall wage inequality rises as trade costs fall. There are workers who may benefit from trade even though workers with higher skill may lose.

1 Introduction

Two common assumptions in the trade literature are that firms produce a single product and use factors that are fully employed. Though such models have provided great insights about the nature of open economies, even casual observation leads to the conclusion that unemployment and multi-product firms are persistent features of any economy. While nearly all firms produce many differentiated products, they vary in both their product scope and productivity. These differences across firms are likely to result from endogenous choices made by rational economic agents.

Separate lines of literature have examined the impact of trade liberalization on firm scope and the effects trade has on unemployment in environments with heterogeneous firms. However, a link between features

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of structural unemployment and firm scope has been left unexplored. Here I consider how firms choose the number of products to manufacture given that unemployment persists because labor wages must be high enough to deter shirking. In addition I examine how the choice of skilled workers to match determines how firms within an industry initially organize, and shapes the distribution of firm productivity. Trade has a direct effect on the incentives of labor to shirk and the matching behavior of managers. In response to a change in the nature of worker supply after liberalization, firms adjust their product scope, hiring decisions and factor rewards. Moreover, managers rethink their pre-liberalization partnerships leading to changes in industrial organization.

Few firms produce only a single product and multi-product firms seem quite concerned with the specific portfolio of products that they offer. Firm behavior across product lines has been shown to respond to both internal and external influences. Bernard, Redding and Schott (2008) document the degree of product switching by multi-product firms and the share of production taking place at multi-product plants. Using 5-digit SIC classifications to identify different products they find that 87% of US manufacturing takes place at plants which produce multiple products, half of whom alter their product mix every five years. The decision to add or drop a product is often made for reasons particular to a firm/product pairing. Turning to external forces, Bernard, Jensen and Schott (2006) provide evidence that plants alter their product mix when exposed to foreign competition. Baldwin and Gu (2006) also find that lower tariffs cause plants to reduce the level of diversification in production but note that exporter plant size does not seem to respond to changes in tariffs.

Political discussions of international trade center on either unemployment or job quality. Trade can improve, or harm, the economic opportunities of workers in three ways. First, international market size could impact the probability that each worker is employed at all. Second, for those who are employed trade may alter the type of job they obtain. Third, even the workers who retain a certain job type will feel the effects of globalization if the rest of their employer's workforce responds to trade liberalization. These issues have been explored previously in Davidson, Martin and Matusz (1999), Itskhoki and Helpman (2007), Matusz (1986) and (1996), Davidson and Matusz (2004), Felbermayr, Prat, and Schmerer (2008), Davis and Harrigan (2007), and elsewhere.

Careful examination of the relationship between trade and labor market outcomes must account for the relationship that globalization has with both sides of the labor market: supply and demand. The emphasis of much of the literature falls on the effects of reduced trade costs on the organization of production, with labor market outcomes resulting from only changes in firm behavior. Worker behavior is left out of the analysis. This sort of "partial-partial equilibrium analysis" misses half of an economy's trade adjustment¹.

¹The term "partial-partial equilibrium" was coined by Rothschild (1973) as quoted by Davidson and Woodbury (2002)

Commodity prices and export opportunities are key determinants of worker supply. Endogenous worker responses to trade liberalization can play an important role in shaping firm organizational design, overall industrial organization and labor market outcomes.

Besides multi-product firms and unemployment, another key feature of any economy is heterogeneous production. Within narrowly defined sectors firms differ in the number of products that they offer (Bernard, Redding and Schott (2008)), in the types of workers that they hire, technologies that they employ (Doms, Dunne, and Troske (1997)), in productivity and in export status (Bernard and Jensen (1999)). Given the observed patterns of heterogeneity across each of these dimensions, I take the skill of managerial teams to be the underlying source of firm differences, as in Lucas (1978) and Rosen (1981). A key difference in the approach taken here is that, while the distribution of individual managerial talent is exogenous, the distribution of the skill of management teams available for hire is endogenous. Heterogeneity results from both endogenous matching behavior and exogenous skill differences².

In order to address the relationship between trade, worker supply, and the organization of production, I amend the model set forth in Matusz (1996). He incorporates efficiency wages into a monopolistic competition model with intraindustry trade. Laborers make a supply decision in the form of whether or not to shirk, as firms have imperfect monitoring abilities. In each economy a single final good is produced using the set of domestic and foreign intermediate products available. An increase in the number of available intermediates allows for greater specialization, and hence greater efficiency, in the production of the final good.

Heterogeneous intermediate firms have a core variety which they can modify to supply additional varieties to the market. Each firm is most productive in manufacturing its core variety. Labor efficiency suffers when producing additional varieties because of a greater need for modification. Given diminishing returns to scope, market demand, labor wages and management skill, each firm determines its scope endogenously.

Each economy is endowed with a set of managers who are heterogeneous with respect to their ability to improve labor productivity, given that shirking is deterred. Firms hire two managers and assign one to supervise labor in performing assembly tasks associated with developing the core variety and one to modification activities necessary to produce additional varieties. As managers cooperate in production of all the firms varieties, they share the firm's operating profits. Differences in the skill intensity of "scope tasks" and "scale tasks" lead to matches between heterogeneous managers, while complementarity leads to positive assortative matching. Given profit opportunities and the set of potential matches, skilled individuals form management teams endogenously.

²Davidson, Matusz and Shevchenko (forthcoming) contains a similar feature where heterogeneity obtains from endogenous technology choices and exogenous worker-firm matches. Also in Yeaple (2005) heterogeneity is the result of exogenous skill differences and endogenous technology choice.

Trade liberalization induces adjustments in production both across firms and within firms. The introduction of additional foreign intermediate varieties allows for greater efficiency in the production of the final good. This gain in efficiency increases real wages and relaxes the efficiency wage constraint. Slack in the efficiency wage constraint and better access to foreign markets encourages firms to hire additional labor. Additional labor demand bids up labor wages inducing a reallocation in production. In the face of higher labor costs the least productive firms are forced to exit and surviving firms shed marginal product lines. A greater share of production takes place at the firms with the best management teams, who concentrate on their core specialties, thereby increasing aggregate productivity.

This sort of marginalization of production across and within firms is similar to results obtained in Melitz (2003), Bernard, Redding and Schott (2006), Eckel and Neary (2008), and Nocke and Yeaple (2006). A significant difference being that changes in firm scope and industry organization come at the behest of both firm *and* worker response to trade liberalization. The most prominent departure from previous work is the role that international markets play on the manner in which firm management organizes initially.

Globalization induces adjustments in managerial matching. As the least efficient management teams exit, the highest skilled member of those pairs, who initially would only accept high skill intensity positions, now are willing to accept a less skill intensive position as opposed to unemployment. In light of a new group of managers who offer to take low skill jobs, every other manager rethinks her current partnership. Each manager vies for one of the relatively higher skilled managers willing to take a low skill intensity job. All surviving firms realize a change in management. Some individual managers feel the effect of trade via the type of job they acquire, and all feel its effects through the skill of the partner with whom they match in equilibrium.

When two managers attempt to match with a particular individual, the higher skilled of the two will always win the bidding contest. So as trade induces relatively higher skilled managers to begin accepting low skill intensity jobs, they will match with the best available partners. Adjustments in managerial matching due to trade lead to more positively assorted matches. Increased segregation generates productivity gains within the top firms, but losses among the bottom firms. The rationalization of matches at the largest firms may cause them to further diversify, despite the partial influence of trade to reduce product scope. The complete economic response to trade is the sum of the effects of matching, firm selection and product selection.

Both changes in production and changes managerial matching have consequences for total welfare. Even though trade reduces labor productivity partially through changes in management at smaller firms, in the aggregate these losses are dominated by the productivity gains from (1) the reallocation of production across firms toward larger firms, (2) the specialization within firms through decreased product scope, and

(3) increases in the quality of management at larger firms. Thus open economies enjoy greater economic welfare.

At a minimum globalization has a marginal impact on matching outcomes by forcing some managers to take low skill positions. But trade can have a drastic impact on the formation of management teams by inducing some managers to actually prefer low skill positions, if doing so guarantees the opportunity to export. Only the most efficient firms can penetrate foreign markets. So if there is a shift in matching behavior in order to secure export status, preferences will shift toward matching with higher skilled partners. Whether the result of changes in matching outcomes or overall matching behavior, trade causes matches between managers to be more positively assorted. The effects of shifts in matching behavior are magnifications of the effects due to marginal adjustments in matching outcomes.

The matching outcome in the manager market is crucial to the skilled wage distribution. For either job type, better partners result in better wages. More segregated matches after trade is liberalized increase the wages of the top managers but reduces the wages of the lower skilled. Real wage losses are more likely when matching preferences shift than when there are only marginal adjustments to matches.

Managerial wages also depend on market share and export status. Better trading opportunities benefit the best management teams through the reallocation of production; with heterogeneous matching the best teams are not composed entirely of the most able managers. The group of relatively low skill managers employed by exporting firms will benefit from trade, while some higher skilled managers with skill intensive positions at non-exporters will be harmed.

The combined effect of adjustments in the management and adjustments in production lead to an ambiguous effect of trade on the wages for all but the most skilled. The highest skilled workers always gain from trade and as a result overall wage inequality rises. The pattern of rising wage inequality that emerges post trade liberalization is one of less within-firm wage dispersion and more inequality across firms for workers with similar skill. These predictions are consistent with Dunne *et al.* (2004) who document the contributions of within-firm and across firm wage dispersion for production and non-production workers in the US. In addition moderately skilled workers may gain from trade, although the likelihood of benefiting from globalization is not necessarily increasing in skill.

Labor always benefits from trade. The introduction of foreign varieties and the rationalization of domestic production lowers prices thereby increasing the real wage. Increased labor demand further bids up nominal wages and raises total employment. Thus labor benefits from free trade because of better compensation while employed, and from shorter expected durations of unemployment.

The next section describes the model of labor and goods markets. Section 3 discusses the matching behavior of potential managers and derives an open economy equilibrium. Section 4 discusses the impact

of a reduction in trade costs on production, managerial matching and labor market outcomes. Section 5 concludes.

2 Model

2.1 Production

The world consists of two countries. Each economy produces a single final good Y using the set of available intermediate goods from domestic firms, χ , and exported by foreign firms, χ_{ex}^* . (An asterisk denotes a foreign variable.) Because firms produce multiple products the mass of varieties of intermediates available, χ , is greater than the mass of active firms determined below. The final good is assembled costlessly by combining intermediates according to the production function

$$Y = \left(\int_{\chi} x_j^\theta dj + \int_{\chi_{ex}^*} x_j^\theta dj \right)^{1/\theta}, \quad \theta \in (0, 1) . \quad (1)$$

Each intermediate good is produced by a firm, which may produce multiple intermediate varieties, using labor and managerial skill. There are two necessary tasks that must be performed by a firm producing any intermediate variety. First, labor must be used to assemble a "core" intermediate that represents the firm's base product in which it has the most expertise. This task is called an assembly activity. Each unit of output produced, of any variety, requires one efficiency unit of labor to perform the necessary assembly activities.

Second, if the firm produces multiple varieties additional labor must be used to alter the characteristics of its core intermediate to contribute to the production of Y . This task is called a modification activity. The further a particular intermediate variety is from a firm's core variety, the more labor that must be used in modification activities for that specific variety. For simplicity I assume that if a firm produces a mass of intermediates N , indexed by their distance from the core variety at $n = 1$, then the variety $n \in [1, N]$ requires n efficiency units of labor to perform the requisite modification tasks. Modification activities are particular to the characteristics of each specific intermediate good. Producing additional varieties has no effect on the efficiency of labor in the production of the firm's inframarginal varieties.

The labor pool has mass λ . The productivity of labor in performing both activities is normalized to unity. That is, each laborer supplies a single unit of efficiency labor of his own accord. Each economy is also endowed with a mass μ of heterogeneous agents who differ in their skill, s , for managing labor. A manager can improve the productivity of labor in performing either assembly or modification activities according to

her skill level³. While working under a manager of skill s each laborer supplies $m(s)$ efficiency units of labor to completing modification activities and $f(s)$ efficiency units of labor to performing assembly activities. More skilled managers are better at increasing the productivity of labor; $m'(s) > 0$ and $f'(s) > 0$. The distribution of managerial skill is given by $G(s)$ with support $(0, \bar{S}]$, and \bar{S} can be arbitrarily large.

Managerial tasks differ in their skill intensity. I assume, without loss of generality, that the assembly task is more skill intensive⁴; that is $\frac{\partial f(s)}{\partial s} \frac{1}{f(s)} > \frac{\partial m(s)}{\partial s} \frac{\tilde{N}}{m(s)}$. If a firm hires two managers of different skill⁵, then the optimal strategy will be to assign the more skilled manager to the more skill intensive task of improving labor productivity in completing assembly activities. The labor needed to produce one unit of variety n , which is a measure $n - 1$ from a firm's core competency, produced under the supervision of managers with skill s' and s'' , where $s' < s''$, is given by

$$l(n) = \left[\frac{n}{m(s')} + \frac{1}{f(s'')} \right]. \quad (2)$$

2.2 Demand

The composite final good Y is the numeraire. Combining intermediates according to (1) yields a cost function for Y given by

$$C(\vec{P}, Y) = \left(\int_{\mathcal{X}} P_j^{\frac{\theta}{\theta-1}} dj + \int_{\mathcal{X}_{ex}^*} P_j^{*\frac{\theta}{\theta-1}} dj \right)^{\frac{\theta-1}{\theta}} Y \quad (3)$$

The total sets of available intermediates from domestic and international firms are endogenously determined by the number of active domestic firms, foreign exporters, and the number of intermediates that each firm produces and exports. An intermediate firm faces a demand for each individual variety n of

$$D_n = Y \left(\int_{\mathcal{X}} P_j^{\frac{\theta}{\theta-1}} dj + \int_{\mathcal{X}_{ex}^*} P_j^{*\frac{\theta}{\theta-1}} dj \right)^{\frac{-1}{\theta}} p(n)^{\frac{1}{\theta-1}} + I(n) \left[Y^* \left(\int_{\mathcal{X}^*} P_j^{*\frac{\theta}{\theta-1}} dj + \int_{\mathcal{X}_{ex}} P_j^{\frac{\theta}{\theta-1}} dj \right)^{\frac{-1}{\theta}} p^*(n)^{\frac{1}{\theta-1}} \right].$$

The variable $I(n)$ is an indicator which equals 1 if the firm exports variety n and 0 if it does not.

³Production requires at least one manager to be hired. A single manager can apply her skills to only one production activity. In the absence of a manager specifically assigned to either task each laborer contributes his single efficiency unit of labor, i.e. $m(0) = f(0) = 1$.

⁴See the appendix for a discussion of skill intensity of the tasks.

⁵As will be shown, firms will always recruit managers of different skill in equilibrium.

2.3 Firm behavior

The gain in efficiency in producing the final good from having a greater mass of intermediate varieties guarantees that no firms will enter and produce the same intermediate goods. Also each firm is small relative the whole market and so takes the prices of other varieties as given. Similarly the firm can ignore the effect that its own additional production lines have on the demand for its inframarginal products. The profit function for an intermediate firm is equal to the revenues from all of its product lines (N), for all units of each variety sold ($x(n)$), less labor costs per unit of output of each variety (at labor wages ω), beachhead costs for the firm (β) and per product (γ) if the firm exports, and total wages paid to managers for services on all varieties (W_m and W_f). Implicitly defined for the skill of managers hired, the profit function is

$$\Pi = \int_1^N [p(n) - \omega l(n)] x(n) dn + \int_1^{N^*} I(n) \{ [p^*(n) - \omega l^*(n)] x^*(n) - \gamma \} dn - I(1) \beta - W_m - W_f$$

Managers perform identical tasks across all intermediate varieties produced by the firm, and so their compensation (described in detail below) does not affect firm behavior at the margin. Each firm maximizes profit by choosing the price it charges for each intermediate variety, and the total number of varieties to manufacture. Of course the optimal choice of scope and price depend on the skill the managers hired. The first order condition for the domestic price charged by a firm with managers of skill s' and s'' , with $s' < s''$, is

$$p(n) = \frac{\omega}{\theta} l(n) = \frac{\omega}{\theta} \left[\frac{n}{m(s')} + \frac{1}{f(s'')} \right]. \quad (4)$$

Each firm charges a fixed mark-up over marginal costs, which are a function of labor wages, ω , and labor productivity, the term in brackets. The first-order condition for the optimal firm scope shows that firms add production lines until the marginal intermediate variety yields zero additional profits.

$$[p(N(s', s'')) - \omega l(N(s', s''))] x(N(s', s'')) = 0 \quad (5)$$

Free entry guarantees that prices and scope are chosen optimally⁶ and that all revenues accrue to either labor or managers. Then using (4) and (5) the total labor demand of a firm with managers s' and s'' , with $s' < s''$, is

$$L(s', s'') = \int_1^{N(s', s'')} l(n) [x(n) + x^*(n)] dn$$

⁶Firms cannot strategically choose scope or price to attract a particular management team. Free entry means that managers who are not working for firms selecting price and scope based on (4) and (5) could be poached by entering firms that can offer better compensation.

Full labor employment in this economy would be $\int_x l_j dj = \lambda$, where the labor demand for all intermediates produced in each country required use of the entire labor pool. However the interest here is in equilibria where $\int_x l_j dj < \lambda$.

2.3.1 Export Choice

If an intermediate firm exports it must pay a fixed cost β to acclimate itself to foreign markets and γ to prepare each of its products for use in foreign production of the final good. In addition the firm must pay iceberg transportation costs on each unit of output exported. For a single unit of a specific variety to arrive in a foreign market an exporter must produce and ship $\tau > 1$ units. Fixed exporting costs have no effect on the marginal behavior of firms, and as a result a firm that charges a price p in the domestic market will charge τp in the foreign market.

Each intermediate firm must decide whether or not to export at all, and if so which products to sell overseas. Average fixed exporting costs are decreasing in the number of products exported because the firm must only make the investment to learn about foreign markets once. Because of the need for modification, each firm experiences diminishing returns to scope. The trade-off between reduced costs of market penetration and diminishing profits defines a firm's optimal export strategy. A firm that makes N intermediate varieties will be an exporter if, for at least one $n \in [1, N]$, the follow criterion is satisfied

$$\int_1^n [p^*(n) - \tau l(n)] x^*(n) \geq \beta + \gamma n \quad (6)$$

Upon entering a foreign market the firm must determine its extensive export margin. The firm chooses the number of products to export by comparing marginal operating profits from exporting an additional product and the marginal cost of adapting the product to the tastes of foreign consumers. So a firm will export the varieties $[1, N_{ex}]$, where N_{ex} satisfies

$$[p^*(N_{ex}) - \tau l(N_{ex})] x^*(N_{ex}) = \gamma. \quad (7)$$

Of course $N_{ex} \leq N$. Figure 1 shows the optimal scope and extensive export margin established in (6) and (7). Firms that do not export would have an operating profit curve that lies entirely below the line representing fixed exporting costs. As drawn the firm in Figure 1 would not choose to export only its core products, even though it produces them most efficiently. For this firm, decreasing average fixed costs to penetrate foreign markets is crucial in the decision of whether or not to export. The last thing to notice

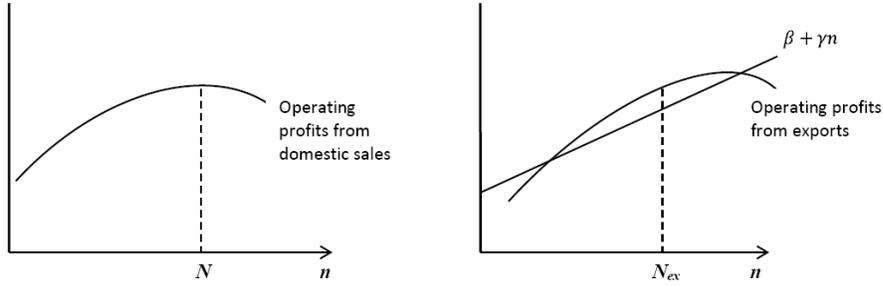


Figure 1: Firm scope and selection of exported products

about Figure 1 is that because managerial skill is relatively more important for intermediates that require more modification, firms with better management are more likely to export and will export a greater range of intermediate goods. That is, better management shifts the operating profits curve for a firm up. Also better management reduces the firm's incidence of diminishing returns to scope, which would be illustrated by less curvature in the operating profits curve.

2.4 Factor Markets

2.4.1 Efficiency Wages and Labor

Managerial skill improves labor productivity so long as labor is putting forth effort. Working on any task, at any level of productivity, is onerous so that each laborer has an incentive to shirk his duties while enjoying wages. Firms pay efficiency wages, ω , that are higher than the opportunity cost of effort and fire labor caught shirking. The benefit of higher wages and the threat of unemployment deter shirking in equilibrium.

The model of the labor market is set in continuous time. Labor who put forth effort still face the probability $b > 0$ that their employment will be terminated exogenously. Employees who shirk their duties are caught with probability $q > 0$. Note that these probabilities (particularly q) are not functions of managerial skill. The role of skill in this model is only to improve labor productivity in the performance of certain tasks. Regardless of skill in supervising modification activities or assembly activities, all managers can monitor labor with the same ability.

Labor can be in one of three possible states: employed and putting forth effort, employed and shirking, or unemployed. Laborers are risk neutral and find jobs at an endogenously determined rate e . All laborers discount the future at a rate $\rho > 0$, and the disutility of effort is $d > 0$. The asset value equations for being

in each state are

$$\begin{aligned}\rho V_e &= \omega - d + b(V_u - V_e) \\ \rho V_s &= \omega + (b + q)(V_u - V_s) \\ \rho V_u &= e(V_e - V_u)\end{aligned}$$

Shirking is avoided in equilibrium so long as the expected lifetime utility of shirking today is less than the expected utility associated with putting forth effort, that is $V_e \geq V_s$. Profit maximizing firms will pay efficiency wages just high enough to deter shirking so that $V_e = V_s$, or

$$\omega = d \left(\frac{\rho + b + q + e}{q} \right) \quad (8)$$

In a steady-state equilibrium the flows of labor into and out of employment are equal. Since shirking is deterred in equilibrium, the flow out of employment comes only from exogenous layoffs. A fraction b of the total number of workers employed, $\int_x l_j dj$, transition out of employment, while a fraction e of the pool of unemployed labor, $\lambda - \int_x l_j dj$ finds a job. Thus in a steady state

$$e = b \left(\frac{\int_x l_j dj}{\lambda - \int_x l_j dj} \right) \quad (9)$$

2.4.2 Managerial Earnings

Production occurs as managers cooperate in the performance of specific tasks, supervising either modification or assembly activities. Firms cannot capture any surplus generated from production because of free entry. Were any economic value retained by a firm, a competitor could poach the firm's management by offering marginally better pay. So total managerial earnings are the operating profits (revenues net labor costs and exporting costs if applicable) from all of the firm's varieties. Operating profits for a firm which employs managers with skill s' assigned to modification activities, skill s'' assigned to assembly activities, and produces

$N(s', s'')$ varieties of intermediate goods, are

$$\begin{aligned} \pi(s', s'') = & \int_1^{N(s', s'')} \left(p(n) - \omega \left[\frac{n}{m(s')} + \frac{1}{f(s'')} \right] \right) x(n) dn + \\ & \int_1^{N(s', s'')^*} I(n) \left[\left(\tau p(n) - \tau \omega \left[\frac{n}{m(s')} + \frac{1}{f(s'')} \right] \right) x^*(n) - \gamma \right] dn - I(1) \beta \end{aligned}$$

Note that the first argument in $\pi(\cdot)$ refers to the skill of the manager assigned to modification tasks, and the second argument to the manager assigned to assembly activities.

The coalition of managers must decide how to divide the sum of operating profits among themselves. Here I use the Shapley Value to determine the allocation of operating profits across the two managers. Each manager earns the average of her marginal contribution to the coalition. That is, each manager earns the average of operating profits when working with another skilled manager, and operating profits when her counterpart's labor activities are unsupervised.

When working alone, a manager of skill s' assigned to modification activities generates $\pi(s', 0)$ in operating profits, and an assembly manager of skill s'' generates $\pi(0, s'')$. Therefore a modification manager contributes $\pi(s', 0)$ to the coalition without a partner, and $\pi(s', s'') - \pi(0, s'')$ working with her partner. Then taking averages, managerial earnings for the modification manager and assembly manager (using a similar derivation) are respectively

$$W_m(s', s'') = \frac{1}{2} \{ \pi(s', 0) + \pi(s', s'') - \pi(0, s'') \} \quad (10)$$

$$W_f(s', s'') = \frac{1}{2} \{ \pi(0, s'') + \pi(s', s'') - \pi(s', 0) \} \quad (11)$$

3 Equilibrium

3.1 Managerial Matching

Two important features of the allocation of operating profits to management in (10) and (11) determine managerial matching behavior. First, as a manager's own skill level increases so does the opportunity cost of not cooperating with a second manager. Put another way, the managerial compensation functions are supermodular⁷. Each manager's earnings increases with the skill of her partner. As a result the equilibrium matching pattern is some type of positive assortative matching where, all else equal, each manager prefers a

⁷This is not the same condition as supermodularity of the profit function, even though it is a direct result of it.

relatively higher skilled partner.

Second, managerial compensation depends not only on the skills of the two managers but also the task to which each is assigned. Still assuming (WLOG) that the assembly task is more skill intensive, if two managers of the same skill match and cooperate in production, the manager assigned to supervise assembly activities will earn a strictly greater wage than the manager assigned to modification activities. In a homogeneous match the manager assigned to the less skill intensive task would prefer to match with a marginally less skilled worker to obtain a more lucrative skill intensive management position. Therefore, with a continuous distribution of skill, equilibrium matches will be heterogeneous⁸.

A tendency towards positive assortative matching leads to equilibria that are more segregated; managers matching with others who have similar skill. The returns from the skill of a partner encourage behavior that leads to segregated matches. On the other hand post-match task assignment across different skill intensities encourages behavior that leads to heterogeneous matches. The particular matching outcome sustained in equilibrium depends on the primitives of the model: the skill distribution, world market size, fixed exporting (beachhead) costs and variable trade costs. The interest here is on trade costs. An important distinction exists between shifts in the matching regime sustained in equilibrium, and marginal adjustments in matching outcomes within a particular regime, that occur at the behest of trade liberalization.

All matching regimes are characterized by a degree of segregation. Given the complementarity of managerial skill, a more diffuse skill distribution induces behavior that leads to a more segregated matching regime (see Kremer and Maskin (1996) and Legros and Newman (2002)). The reason being that a more diffuse distribution of skill means that *ceteris parabis* heterogeneous matches will occur between managers with greater differences in skill. Complementarity makes such matches less viable even when differences in the skill intensity of managerial tasks exist.

Larger international markets increase the opportunity costs of rejecting higher skilled partners (in order to obtain skill intensive jobs), especially when doing so excludes a manager from export opportunities. Trade costs have a similar effect as international market size on the equilibrium matching regime. Both beachhead and variable trade costs limit participation in foreign markets and lower the operating profits of exporting. Reduced trade costs increase the incentives of managers to overcome the expense of penetrating foreign markets; for some managers this may mean accepting less skill intensive jobs in order to match with partners that allow for profitable exports. Hence lower trade costs can lead to adjustments in matching regimes towards one which is more segregated.

Since there are many potential matching patterns, the procedure here will be to derive the effects of trade liberalization in the context of a particular matching regime. Then given the discussion above, describe the

⁸For a discussion of matching regimes see Legros and Newman (2002) and (2007).

new equilibria obtained after trade costs fall and the economy moves across matching regimes. I choose the most extreme form of heterogeneous matching where every manager strictly prefers to obtain the skill intensive position within her employing firm, regardless of export opportunities afforded at a given level of trade costs, and for all potential skill levels of partners. As each manager seeks the most skill intensive of the two available job types, the distribution of skill will be completely bifurcated with respect to task assignments. The top half of managers will obtain the most skill intensive jobs. The most skilled manager in the economy will attract the most skilled partner who takes a low skill intensity position; this must be the median worker⁹. Then as all managers vie for the best partners, matches are positively assorted across the median. This matching regime has been labelled *median matching*.

3.2 Median Matching Equilibrium

The next step is to derive the endogenous distribution of management skill employed in a median matching regime. The set of managers that are employed in equilibrium must be rational in terms of entry and consistent with median matching. The lowest skilled manager to find a job, S_L , will obtain a low skill intensity position supervising modification activities. In a median matching regime the S_L manager will be matched with a median-skilled manager, S_M , who performs assembly services. Entry by a firm which hires managers S_L and S_M must be rational given fixed entry costs F , and the exogenous probability that a firm breaks apart¹⁰, b . So,

$$V^{Entry} \equiv \int_0^{\infty} \exp(-bt)\Pi(S_L, S_M) dt - F \geq 0 \quad (12)$$

and in equilibrium (12) holds with equality.

A median-skilled manager could also obtain a job supervising modification activities while working with the highest skilled manager in the economy, \bar{S} . Therefore, in equilibrium the median worker must be indifferent between her compensation as a modification manager and an assembly manager.

$$W_m(S_M, \bar{S}) - W_f(S_L, S_M) \equiv 0 \quad (13)$$

The equilibrium conditions (12) and (13) can be plotted in a two dimensional skill space with the vertical axis representing the skill level of the manager assigned to the skill intensive task (assumed to be the assembly manager) and the horizontal axis representing the skill level of the manager assigned to the low skill intensity task. Both curves are monotonically decreasing; i.e. $\frac{dS_M}{dS_L} < 0$. Furthermore, the entry

⁹I assume an equal measure of workers on either side of the median, each including a median-skilled worker.

¹⁰Firm destruction leads to labor/firm break up. Labor takes this probability into account when making the decision whether or not to shirk. See the asset value equations for labor in the previous section.

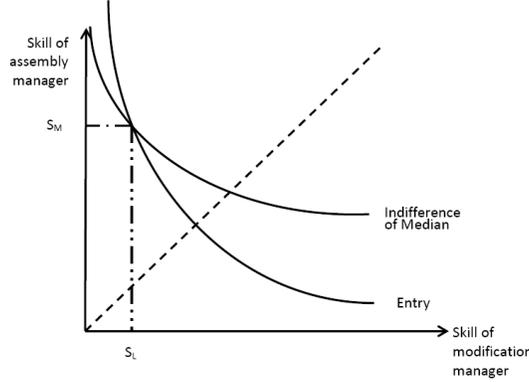


Figure 2: Determination of employed managers and task assignments in a Median Matching Regime

condition is everywhere steeper than the wage indifference condition (see appendix). Hence, these two determine a unique equilibrium pair S_L and S_M .

Since labor is identical across all firms, the distribution of managerial skill employed in equilibrium ($G(s)$ over $[S_L, \bar{S}]$), and the pattern matching between managers (median matching) completely describe the set of intermediate good firms active in equilibrium. From this point forward I simplify the notation by indexing each firm by its highest skilled manager so that the distribution of active firms is written $G(s)$ with the endogenously determined support $[S_M, \bar{S}]$. It should be understood that a firm of skill s refers to a firm with a modification manager of skill $\varphi(s)$ and an assembly manager with skill s where $\varphi(\cdot)$ is the one-to-one correspondence of matches across the median with $\varphi'(\cdot) > 0$.

3.3 Labor Market Equilibrium

A steady-state equilibrium in the labor market is characterized by an efficiency wage that deters shirking and a level of unemployment. Combining (8) and (9) the relationship between the efficiency wage and unemployment rate is given as a function of the set of intermediate firms active in the domestic country. Then denoting a representative domestic firm with management skill S_R , an equilibrium in the labor market must satisfy

$$\omega = d + \left(\frac{\rho}{q} + \frac{b}{qu(S_R)} \right) d. \quad (14)$$

The unemployment rate¹¹, $u(S_R) = (\lambda - \frac{\mu}{2}L(S_R)) / \lambda = \left(\lambda - \int_x l_j dj \right) / \lambda$, depends on both the number of firms and the representative skill level which determines firm size. The number of firms is increasing in the

¹¹Unemployment of managers is ignored as they are small relative to the entire workforce. The set of managers who are not employed is determined endogenously and is given by $\int_0^{S_L} \mu dG(s)$.

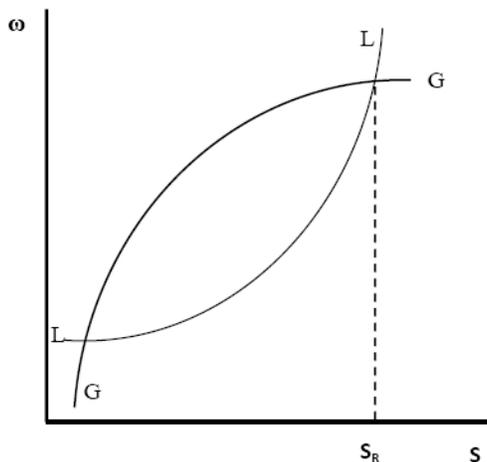


Figure 3: Labor wages and aggregate productivity with Labor and Goods market equilibria

mass of potential managers, μ , and the average size of firms in increasing in the skill level of the representative firm, S_R . And so the unemployment rate is decreasing in both μ and S_R . From (14) the efficiency wage paid to laborers is decreasing in the unemployment rate (increasing in μ and S_R) because longer spells of unemployment entail greater opportunity cost of shirking, diminishing the need for higher wages. The LL curve in Figure 3 traces the set of efficiency wage and representative firm skill pairs that are consistent with a steady-state equilibrium where shirking is deterred, given the distribution of firm productivity in a median matching regime.

3.4 Goods Markets Equilibria

An equilibrium in the final and intermediate goods markets consists of intermediate firms setting prices that satisfy (4) and choosing a scope of intermediates according to (5), equilibrium matching by managers determined by (12) and (13) in a median matching regime, and cost minimization in the Y sector according to (3). Substituting the individual firm prices into the cost function of Y in (3) gives the zero-profit condition for the Y sector.

$$1 = \left[\int_{\chi} \left(\frac{\omega l_j}{\theta} \right)^{\frac{\theta}{\theta-1}} dj + \int_{\chi_{e,x}^*} \left(\frac{\omega l_j}{\theta} \right)^{\frac{\theta}{\theta-1}} dj \right]^{\frac{\theta-1}{\theta}} \quad (15)$$

Instead of using the cost for each intermediate product, averaging the zero profit condition across all firms yields a simple expression for the relationship between labor wages and representative skill level of active management teams. The representative firm from the mass of $\frac{\mu}{2}$ management teams produces $N(S_R)$ varieties of intermediate goods which require an average of $\tilde{N}(S_R)$ efficiency units of labor for modification.

The firm sells its goods at an average price of $\frac{\omega}{\theta} l(\tilde{N}(S_R))$. Rewriting the zero profit condition for Y , given the optimal behavior of intermediate firms and the equilibrium distribution of active management teams, equilibrium in the goods market must satisfy

$$\omega = \frac{\mu}{2} \frac{1-\theta}{\theta} \left[\tilde{N}(S_R) l(\tilde{N}(S_R))^{\frac{\theta}{\theta-1}} + \tau^{\frac{\theta}{\theta-1}} \tilde{N}(S_R^*) l(\tilde{N}(S_R^*))^{\frac{\theta}{\theta-1}} \right]^{\frac{1-\theta}{\theta}}. \quad (16)$$

3.5 Full Equilibrium

The closed economy is in full equilibrium when both labor markets and goods markets are in equilibrium. A matching equilibrium occurs at the intersection of the entry condition in (12) and the median indifference condition in (13), as in Figure 2. Given the distribution of active firms and management teams the labor market and goods markets are in equilibrium when both (14) and (16) are satisfied. For given factor endowments λ and μ , an equilibrium is a unique efficiency wage, unemployment rate and a median skill level. The median skill level implies a certain profile of firms that can be summarized by a representative skill level. Figure 3 illustrates the equilibrium in the goods and labor markets.

4 Trade

4.1 Liberalization and Adjustment in Production

Regardless of the trading opportunities of an economy labor must be deterred from shirking in order for production to take place. Changes in trade costs have no impact on the labor market equilibrium conditions. However the equilibrium conditions for the intermediate product and final goods markets in (16) are dependent on the level of trade costs. Lower variable costs result in lower costs of imported intermediates and, because of selection into export markets, a greater number of foreign intermediates available for domestic production. Both act to lower production costs of the final good. Zero profits in the final good sector are restored only by an increase in labor wages. The shift in the goods market equilibrium condition resulting from trade liberalization is illustrated in the second diagram in Figure 4.

The new equilibrium occurs where the shifted GG curve and LL curve intersect. Holding managerial matches fixed liberalization increases the skill level of the management team at the representative firm. The increase in average labor productivity for a fixed set of employed managers has two potential sources: a greater share of production is taking place at firms who hire superior management teams, or firms have dropped fringe product lines which are produced less efficiently. In fact, both occur as a result of trade liberalization.

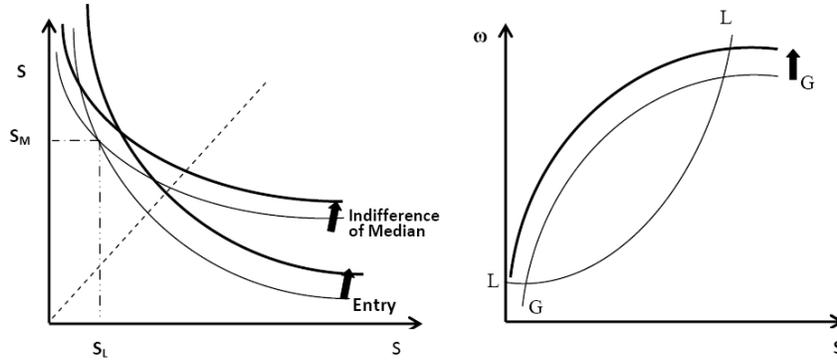


Figure 4: Effects of Trade Liberalization

Lower trade costs increase foreign demand for the varieties exported by domestic firms, causing these firms to expand the scale of production. The introduction of more foreign intermediates into the domestic market lowers the relative demand for the varieties produced by non-exporters, who respond by contracting the scale of production. Because the most efficient firms are those which export, the result is a larger share of production taking place at firms with better management.

Adjustments to production also occur within each firm, even without changes in management. Higher labor wages reduce the profitability of all product lines for both exporting and non-exporting firms. Non-exporters drop marginal varieties that are not profitable in the face of foreign competition and higher labor wages. Exporters are also induced to shed products in the face of higher labor costs, even though liberalization induces firms to export a larger fraction of the varieties it produces. As these firms drop the products that they make with the least efficiency, average labor productivity rises. The next proposition summarizes the findings on the effect of trade on the nature of production.

Proposition 1 *Holding fixed the set of managers employed, trade induces an increase in average productivity both across firms and within firms. After liberalization a larger share of production takes place at the most efficient firms and all firms devote a larger share of resources to the production of varieties in which they are most efficient.*

4.2 Liberalization and Labor Market Outcomes

Production of the final good is less costly in an open economy. An increase in the real wage eases the efficiency wage constraint, and together with the fact that a representative firm has greater productivity, firms demand more labor. Increased demand bids up nominal labor wages, further benefiting labor. Besides better compensation when working, spells of unemployment are shorter. At a higher real wage the opportunity cost

of being caught shirking is much higher. So firms can hire more labor and feel confident that laborers will exert themselves during production. Hence all laborers benefit from higher wages and lower unemployment, as in Matusz (1996).

4.3 Liberalization and Adjustment in Management

Trade Liberalization causes a reallocation of production towards firms which employ better managers. Smaller market shares and higher wages force the least productive management teams out of the industry altogether. The breakup of low skilled teams causes a change in the matching outcome in the entire manager market. The lowest skilled managers can no longer find partners and become unemployed. But their high-skilled counterparts seek out new matches, accepting low skill intensity positions if they must. The small group of managers now willing to accept low skill positions causes every other manager to rethink their current partnership.

Equilibrium in the manager market in a median matching regime occurs when entry is rational and the median manager is indifferent between a low-skill and high-skill intensity position given her potential matches. The equilibrium condition on entry shifts up when trade is liberalized because at higher wages better management is needed to survive. The level of trade costs also has an impact on the incentive compatibility constraint for the median skill level. Better export opportunities increase the operating profits from participating in international markets. Furthermore lower market shares for domestic firms reduce the incentive to accept low skill partners. Each of these incentives cause the equilibrium condition on the median manager in equation (13) to shift up. The size of the shift in the incentive compatibility constraint is larger than the shift in the entry condition because it accounts for both higher wages and better export opportunities. The first diagram in Figure 4 shows the unambiguous effect of trade on the matching outcome in a median matching regime.

Lower trading barriers cause matches to become more positively assorted. The managers with skill above the median level obtain partners ordered higher in the skill distribution, while lower skilled managers (if still employed) must accept partners lower in the skill ordering. Those with skill slightly above the initial median level obtain better partners, but switch to low skill intensity jobs, per the incentive compatibility constraint on the median manager. By accepting the low skill intensity job they gain access to foreign demand and avoid unemployment. The managers with the lowest skill continue to exit the industry and the remaining managers continue to reform teams until equilibrium is restored. The effect of trade on the median matching outcome is depicted in Figure 5.

Each manager's skill level is fixed, so when one firm shuts down the managers who remain above the

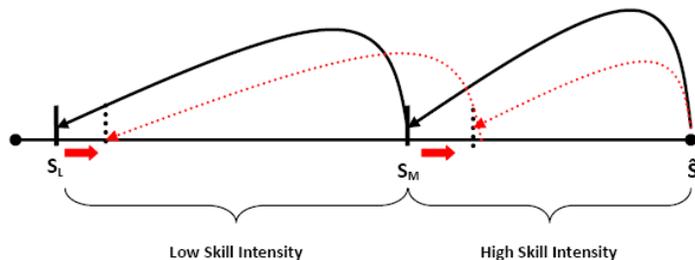


Figure 5: Changes in Matching Outcomes within a Median Matching Regime

median skill level obtain a partner who is the next highest in the ordering of skill to her initial partner. However the cardinal change in skill depends on the overall distribution of managerial ability. The next potential partner could have significantly more skill than the pre-liberalization partner, or could have exactly the same skill level if there are many identical managers. Because of complementarity of skill in production, more positively assorted matches result in higher average productivity.

In a peculiar case, where more than half of the set of managers have identical ability with at least some managers of greater skill, trade results in a change in matching outcomes that produces results akin to Melitz (2003). With endogenous matching, trade liberalization results in the top skilled managers finding partners that are ordered higher in the skill distribution. But if there is no difference in their partners' cardinal ability¹², then there is no change in the skill of the management teams which are active in equilibrium both pre- and post-liberalization. Yet trade improves overall productivity by driving the least efficient firms out of the industry and allowing the most efficient firms to expand production.

In the previous section the effect of trade liberalization on the share of production taking place at the most productive firms, and the level of diversification within firms, leads to an equilibrium in which the representative firm appears to be managed with greater skill. Now considering the general equilibrium adjustment to trade, all firms still operating are in reality managed by higher skilled teams. Endogenous adjustments to matching in the manager market, and the resulting distribution of firm productivity, might overturn previous conclusions about the effect of trade on firm scale and scope reported in Proposition 1, as well as in Bernard, Redding and Schott (2006), Nocke and Yeaple (2006) and Eckel and Neary (2008). The partial effect of trade is to rationalize production both across firms and within firms. However the change in the initial formation of firms causes matches to occur between partners with more similar skill levels. Better management leads to greater diversification, even when trade reduces the profitability of marginal product lines.

¹²For managers with the same cardinal ability the ordering is arbitrary.

To this point I have discussed the effect that trade has on the matching outcomes holding the behavior of managers constant. Specifically I have assumed that a median regime occurs in equilibrium because of every manager's preference to obtain a high-skill intensity position regardless of export opportunities. Depending on the skill distribution, lower trade costs might cause managers to reprioritize and seek participation in international markets, no matter the skill intensity of the job obtained. When the behavior of managers changes, the entire matching regime shifts.

Although the matching regime sustained in equilibrium depends on the underlying distribution of managerial skill, the impact of trade on the matching regime (if any) is clear. The firms that are able to export are those that have the best management teams. So if managers change their behavior, their preferences will always shift toward higher skilled partners, rather than skill intensive jobs. Managers will be more positively assorted and the complementarity of skill in production implies that the new regime will lead to a population of firms with higher average productivity. Davidson, Matusz and Shevchenko (2008) show in a search environment that free trade can change the behavior of workers so they begin to reject less efficient technologies. Their result is similar to shifts in matching preferences but only accounts for two worker types, rather than a continuum of skill levels.

To compare changes in matching outcomes within a regime to shifts across matching regimes consider how each affects the ordinal differences in the skill of the partner matched with the highest skilled manager, \bar{S} . Looking within a regime, the exit of a single firm allows her to match with the manager who has the next highest skill of her previous partner. But a change in preferences towards export opportunities increases the desire of others to match with a manager with high skills such as \bar{S} . The shift in preferences works to her advantage and she may be able to obtain a match with a manager ordered several places higher than her pre-liberalization match. Marginal adjustments in matching outcomes within a regime, and regime shifts due to matching behavior, have the same qualitative result: active management teams with higher average productivity. Although, changes in matching regimes induce a much greater reallocation of resources. The next proposition summarizes the effect of trade on the formation of management teams.

Proposition 2 *Lower trade costs cause management teams to be more positively assorted and thus raise aggregate productivity. The impact of trade is much larger if managers change their behavior and prioritize export opportunities over job type.*

The rationalization of matches between manager leads to changes in the distribution of firms that is consistent with the evidence. As demonstrated in Head and Ries (1999), the number of firms active after trade liberalization falls, and the remaining firms are larger on average. Furthermore Nocke and Yeaple (2006) show that the shape of the distribution of firm productivity changes as the world economy becomes

more integrated. Specifically they show that the distribution of firm sales within U.S. industries have become less skewed as trade costs have fallen, i.e. the largest firms do not lie as far ahead of their competitors when operating in industries with more trade exposure. Nocke and Yeaple also consider multi-product firms in their explanation of the "globalization-skewness puzzle". Yet their model predicts a negative correlation between a firm's scale and scope. Bernard, Redding and Schott (2006) find a positive relationship between a firm's extensive and intensive margins when looking at US manufacturing.

Adjustment in firm management across the industry has far reaching consequences for the distribution of firm productivity. Furthermore a reduction in the skewness of the productivity distribution is consistent with adjustments to matching outcomes in a median matching regime for many common skill distributions. When the median of the skill distribution lies near a mode, the top managers will match with a commonly occurring skill type. Globalization allows the top managers to begin matching with those ordered higher in the skill distribution. But with so many potential matches with similar skill levels, the top managers enjoy only modest gains in the cardinal ability of their partners.

The managers who lie above the median skill level, but not at the top of the skill distribution, will also match with managers ordered higher in the skill distribution. The increase in their partners' cardinal abilities will be much greater because they were matched with less commonly occurring skill types. The most productive firms are those that employ the best managers. Since these firms experience only modest gains in productivity from increases in matches, relative to less efficient firms, trade liberalization initiates a shift in the distribution of firm productivity that is less skewed, as in Nocke and Yeaple (2006).

4.4 Liberalization and Wage Inequality

4.4.1 Inequality across Skill Levels

There are two reasons that trade costs affect the income distribution within a particular matching regime. First, trade liberalization causes a reallocation of production towards the best management teams. The increase in the relative demand for the managers who export changes the distribution of income. Second, the formation of management teams is affected by trade costs. Each manager's compensation depends on the skill of her partner, so changes in matching outcomes also affect the income distribution. The full response of wages to trade depends on the joint responses along these two avenues.

Better export opportunities increase the operating profits for firms efficient enough to access foreign demand. However increased foreign competition reduces the relative demand for intermediates produced by non-exporters. The wages paid to the best management teams increase relative to wages paid to non-exporting teams. In a median matching regime teams are formed by heterogeneous managers. Thus

relatively higher wages paid to exporting teams are not concentrated among a conjoined skill group. The highest skilled workers above the median join with the highest skilled workers below the median and engage foreign markets. Holding matches constant, the least skilled managers who are still above the median (these are the managers with skill intensive positions at non-exporting firms) are harmed by trade, even though managers with less skill gain. The next lemma summarizes the effect that trade has on the income distribution via the reallocation of production across firms.

Lemma 1 *Trade causes a reallocation of production across firms. The effects on the income distribution is for some managers above the median skill level to lose, while some below the median will gain. Furthermore the most skilled managers, who obtain skill intensive positions at exporting firms, gain relative to all other managers.*

As some firms drop out of the industry each manager rethinks her current partnership and the result is a new matching outcome that is more positively assorted. Any manager who still obtains a high-skill intensity job after a reduction in trade costs will be matched with a higher skilled partner. Likewise, all managers with low-skill intensity jobs will have lower skilled matches than their pre-liberalization partner. The subsequent impact on wages is clear. Better matches result in better wages.

Lemma 2 *The effect of changes in the matching outcome due to trade liberalization is that the top of the skill distribution benefits from better matches, while the bottom half of the distribution loses.*

In order to describe the total impact of trade on the income distribution in a median matching regime there are four classes of skill to consider; managers are divided by the median skill level and a threshold separating non-exporters from exporters on either side of the median. Of course these partitions are determined endogenously, but considering the impact of trade within each class of skills is a convenient way to expose the impact of trade on wage inequality. The overall effect is derived from the combination of the previous two lemmas.

The most skilled workers, above the median and export threshold, benefit from trade because of both better matches and greater demand for their exported products. Those managers above the median skill level who do not export are harmed by foreign competition and decreased market share, but they do benefit from better matches. The net effect on the real wage of managers above the median who do not export is ambiguous. However, their wage definitely decreases relative to those at the top of the skill distribution.

Managers below the median have low skill intensity positions. If they are employed by an exporting firm, then greater export opportunities tend to increase their wages. However the rationalization of matches lowers their wages. Again, the net effect on the wages of exporting managers in low skill intensity positions is ambiguous; depending on trade-off between higher export profits and matching with a lower skilled partner.

Their wage decreases relative to the top of the skill distribution necessarily. Finally, the least skilled managers are harmed by trade both because of decreased demand for their products and because of worse matching outcomes. Trade harms the lowest skilled managers in terms of their real wage. Altogether the effect of trade on the income distribution is stated in the next proposition.

Proposition 3 *Trade increases overall income inequality. In terms of the real wage, the least skilled managers lose, the most skill managers gain, and the impact on those with moderate skills is ambiguous. Yet all managers lose relative to the top of the skill distribution.*

An interesting result is the likelihood that a manager benefits from trade is not necessarily increasing in her skill level. If adjustments in matching outcomes are small then managers with skill intensive jobs who do not export are likely to oppose trade liberalization, while some workers with less skill would support freer trade. Individual trade preferences depend on both the characteristics of the individual manager and with whom she works.

Clearly the response of matching behavior to trade liberalization is an important avenue for productivity gains and the shape of the skilled wage distribution. If trade initiates a shift in the matching regime towards one that is further segregated, wage inequality increases much more drastically. As higher managers begin to accept low skill positions, export profits are concentrated among only the highest skilled managers. Lower skilled managers are more likely to be excluded from export profits because of relatively lower skilled partners. Whether due to changes in matching outcomes or matching preferences, trade initiates a change in the skilled distribution toward one that is more unequal. Changes in the behavior of managers cause larger shifts.

4.4.2 Inequality within Firms

The previous discussion of wage inequality was concerned with wages across skill levels. Trade also causes changes in the relative wages within firms. As trade changes the operating profits of a particular firm, those gains and losses would be distributed across management teams. However the composition of managerial teams changes as trade costs are reduced. Within a particular matching regime globalization leads to matches which are more positively assorted. Furthermore, if trade induces a change in matching behavior, a new regime emerges in which all managers prefer higher skilled partners. In either case management teams form between managers with more similar skills. As a result within firm wage inequality falls. The impact of trade on the income distribution described here, with higher wage inequality across firms and skill levels within industries but less inequality within firms, is consistent with Dunne *et al.* (2004).

5 Conclusion

Worker behavior has far reaching consequences for production and labor market outcomes in general equilibrium. The choices of laborers to provide effort shape firm organizational design and lead to unemployment. The decision of managers to match is a key determinant of industry organization. With self-selection of firms into export markets, endogenous formation of management teams can be an important avenue for trade adjustment.

A reduction in transportation costs enlarges markets for only those firms productive enough overcome trade costs. As a result worker preferences for job type become secondary to securing export status. Even the managers who have no hope of engaging foreign consumers place less value on obtaining a particular job type, because the alternative may be unemployment.

Modeling worker behavior is challenging technically, but the implications of trade exposure for firms and workers may run opposite. Traditionally trade is thought to cause agents to lean down and become more competitive. For firms this may mean paring down the scope of activities that take place within its boundaries. For workers this means dropping low ability partners, leading to better performing teams. The partial incentive of firms to specialize may be eclipsed by improvements in team formation.

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Appendices

Appendix A-Task Assignment of Heterogeneous Managers

The optimal strategy of a firm that hires managers with two different skill levels is to assign the more skilled manager to the task that uses her skill most intensively. The function of each manager is to improve labor productivity in the performance of a specific production task. So the intensity with which a manager's skills are used depend on both the increase in each laborer's efficiency in performing the requisite task and the amount of labor benefiting from skilled oversight. I define the more skill intensive task to be the one that has the higher percentage increase in labor productivity from additional skill, weighted by the unit labor requirement. That is, the assembly task is more skill intensive for a firm that produces N varieties of intermediates, with an average requirement of \tilde{N} efficiency units of labor for modification activities, if

$$\frac{1}{f(s)} \frac{f'(s)}{f(s)} > \frac{\tilde{N}}{m(s)} \frac{m'(s)}{m(s)}. \quad (\text{A.1})$$

Note that the modification task is more likely to be skill intensive at a firm that produces a greater number of products (RHS is increasing in \tilde{N}). As intuition suggests, a firm that produces a greater range of products will devote more labor to modification activities. So, even if the modification task is relatively easy ($\frac{m'(s)}{m(s)}$ is low) there may be a large amount of labor that benefits from managerial skill. Another key feature of condition A.1 is that given the skill of each manager, product market characteristics influence task assignment; the reason being that N is chosen endogenously. As firms change their product scope and scale the ranking of the skill intensity of each task might reverse. Therefore a manager may be reassigned to different tasks when her employer adjusts its scope, even when the skill of her partner remains constant.

Given this definition of skill intensity it still remains to be shown that the optimal strategy of a firm is to assign the more able manager to the skill intensive task. To do this I will show that operating profits increase more from a marginal improvement in the skill of the manager assigned to the skill intensive task. Without loss of generality assume that the assembly task is more skill intensive given firm scope; this is the condition in A.1.

The operating profits of a firm that hires two managers of skill s are $\pi(s, s) = \int_1^{N(s,s)} [p(n) - \omega l(n)] x(n) dn$. Exporting profits are omitted without effect. After substituting the optimal price charged by firms and consumer demand, the increase in profits from a marginal increase in the skill of the assembly manager is

$$\pi_2(s, s) = \int_1^{N(s,s)} C(\vec{P}, Y) \omega^{\frac{\theta}{\theta-1}} \left[\frac{n}{m(s)} + \frac{1}{f(s)} \right]^{\frac{\theta}{\theta-1}-1} \frac{f'(s)}{f(s)^2} dn \quad (\text{A.2})$$

and the increase in operating profits from a marginally more skilled modification manager is

$$\pi_1(s, s) = \int_1^{N(s, s)} C(\vec{P}, Y) \omega^{\frac{\theta}{\theta-1}} \left[\frac{n}{m(s)} + \frac{1}{f(s)} \right]^{\frac{\theta}{\theta-1}-1} \frac{m'(s) n}{m(s)^2} dn. \quad (\text{A.3})$$

Firms will assign the more skilled worker to the skill intensive task (assembly task by assumption) if doing so generates more profits. Averaging across all product lines the criterion is

$$C(\vec{P}, Y) \omega^{\frac{\theta}{\theta-1}} \left[\frac{\tilde{N}}{m(s)} + \frac{1}{f(s)} \right]^{\frac{\theta}{\theta-1}-1} \frac{f'(s)}{f(s)^2} > C(\vec{P}, Y) \omega^{\frac{\theta}{\theta-1}} \left[\frac{\tilde{N}}{m(s)} + \frac{1}{f(s)} \right]^{\frac{\theta}{\theta-1}-1} \frac{m'(s) \tilde{N}}{m(s)^2}$$

or

$$\frac{1}{f(s)} \frac{f'(s)}{f(s)} > \frac{\tilde{N}}{m(s)} \frac{m'(s)}{m(s)}.$$

Q.E.D.

Appendix B-Equilibrium in a Median Matching Regime

A matching equilibrium occurs in a median matching regime when entry (Φ_1) is rational and the median manager's incentive compatibility constraint (Φ_2) is satisfied. The equilibrium conditions are

$$\begin{aligned} \Phi_1 &\equiv \int_0^{\infty} \exp(-bt) \Pi(S_L, S_M) dt - F = 0 \\ \Phi_2 &\equiv W_m(S_M, \bar{S}) - W_f(S_L, S_M) = 0 \end{aligned}$$

First, the implicit function theorem verifies that both conditions are downward sloping; $-\frac{\partial \Phi_1 / \partial S_M}{\partial \Phi_1 / \partial S_L} < 0$ and $-\frac{\partial \Phi_2 / \partial S_M}{\partial \Phi_2 / \partial S_L} < 0$. Then the equilibrium defined by Φ_1 and Φ_2 is unique only if one condition is everywhere steeper than the other. I will show that Φ_1 always more steeply sloped.

From Appendix A we know that

$$-\frac{\partial \Phi_1 / \partial S_L}{\partial \Phi_1 / \partial S_M} = -\frac{\pi_1(S_L, S_M)}{\pi_2(S_L, S_M)} > -1 \quad (\text{B.1})$$

Now substituting the managerial compensation function into condition Φ_2 we obtain

$$\Phi_2 = \frac{1}{2} \{ \pi(0, S_M) + \pi(S_L, S_M) - \pi(S_L, 0) \} - \frac{1}{2} \{ \pi(S_M, 0) + \pi(S_M, \bar{S}) - \pi(0, \bar{S}) \}. \quad (\text{B.2})$$

and using the implicit function theorem to derive the slope of Φ_2 we have

$$-\frac{\partial\Phi_2/\partial S_L}{\partial\Phi_2/\partial S_M} = \frac{-[\pi_1(S_L, S_M) - \pi_1(S_L, 0)]}{\pi_2(0, S_M) + \pi_2(S_L, S_M) - \pi_1(S_M, 0) - \pi_1(S_M, \bar{S})}. \quad (\text{B.3})$$

From B.1, Φ_1 is every where more steeply sloped than Φ_2 only if the equation in B.2 is greater than -1 , which is easily verified.

$$[\pi_1(S_L, S_M) - \pi_1(S_L, 0)] + [\pi_2(S_L, S_M) - \pi_2(0, S_M)] + [\pi_1(S_M, \bar{S}) - \pi_1(S_M, 0)] > 0.$$

Q.E.D.