Labor Matching Behavior in Open Economies and Trade Adjustment

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October 2008

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Abstract

This paper develops a model of costly trade and team production to examine the matching behavior of skilled workers in an open economy. Trade liberalization leads to a redistribution of rents across firms that differ in export status. When heterogeneous workers can bargain effectively and capture these rents, trade liberalization changes the supply of skilled production teams available for hire. Trade is shown to rationalize the matching behavior of workers, causing skill-upgrading within firms and infra-marginal improvements to firm-level productivity. Gains in productivity via skill-upgrading are distinct, and complementary, to the gains realized as low productivity firms exit and high productivity firms expand. All firms experience changes in skill composition, rather than just those on the margin of exit or exporting. Openness benefits those employed at exporting firms, however the likelihood of benefiting from trade is not necessarily increasing in skill. Wages in the open economy are tied to both worker skill and job type.

*I have benefited from many helpful discussions with Carl Davidson, Steven Matusz, Devashish Mitra, Priya Ranjan and Stephen Redding. Seminar presentations at Michigan State University, the Midwest International Economics Group meetings, the Workshop on Testing Trade Models with Labour Market Heterogeneity in Stockholm, Syracuse University and UC-Davis yielded many helpful comments for which I am thankful. I received comments from Anne van den Nouweland and Bruce Blonigen on early drafts. Any remaining errors are mine alone. E-mail: sly@uoregon.edu JEL Classifications: F16, C78, J24 Contact: *sly@uoregon.edu ph: 541.346.4661 address: 1285 University of Oregon, Eugene, OR 97405-1285.*

1 Introduction

Every country is populated by individuals that differ in their abilities and skills. One challenge for labor markets is to organize diverse workers into effective production teams, while the potential for wage bargaining inhibits economies from reaching the most productive allocation of the labor force. The consequences of bargaining among heterogeneous workers are likely to be pervasive in open economies. Frías et al. (2009) find that among exporters and non-exporters alike, wages determined at the firm-level are best described by non-neoclassical payment mechanisms. The previous attention on trade and wage bargaining has focused on settings with similarly skilled workers. For example, Abowd and Lemieux (1993) consider collective bargaining as the degree of foreign competition fluctuates and Helpman et al. (2010) examine how openness is related to firm incentives to further screen individuals that appear identical and bargain over wages[1]. Yet there is much evidence that the skill composition, or skill diversity, of a firm's workforce is integral to its behavior in global economies. The propensity of a firm to export (Bernard and Jensen (1999)), productivity growth as openness increases (Fernandes (2007)) and firm-level wages (Frías et al. (2009)) are all closely tied to the specific skills of workers hired.

The predominant view of trade and skill heterogeneity is that openness induces investments in skill-biased technologies as firms try to improve productivity and capture rents from abroad. That is, trade liberalization affects workers by changing the relative demand for skill at exporting firms[2]. Recent contributions by Bustos (forthcoming) and Bloom et al. (2009) have provided direct evidence of technological upgrading by establishments in response to more global competition. However, when workers can capture rents at the firm level, greater revenues from abroad can alter the supply of skilled workers available for hire, independent of other investment mechanisms.

Distinguishing between the forces that shift the organization of the labor force from the demand and supply side of the market is necessary to reconcile the endogeneity issue surrounding technology adoption. Just as trade has been linked to technology-upgrading, more intense foreign competition has been shown to induce skill-upgrading. When facing greater international competition, firms employ more "talented" managers (Cunat and Guadalupe (2009)) and hire additional skilled workers (Bernard and Jensen (1997) and Fernandes (2007)). In trying to explain skill-upgrading, Pavcnik (2003) finds that greater use of foreign

[1]Wage bargaining in Helpman et al. (2010) arises because of search frictions in the labor market; unmatched workers are imperfect substitutes for employed workers, allowing matched workers to negotiate wages within the firm. The authors examine an extension to the basic model where firms recruit *ex ante* heterogeneous workers from segmented labor markets. Thus workers with observable differences do not compete with one another for employment. Here I take the presence of wage bargaining as given to proved a more clear picture of the role of worker heterogeneity

[2]See Acemoglu (2003) Yeaple (2005) and Davidson et al. (2008). In addition to gaining market access, greater use of foreign intermediates may require a more skilled workforce. See Goldberg et al. (forthcoming) for evidence that international exposure increases the use of foreign intermediates by domestic firms. Also, international transfers of knowledge or technologies via goods trade, as in Grossman and Helpman (1991) or Eaton and Kortum (1999), may be better absorbed by more skilled workers.

intermediates, technological adoption, and investment have negligible impacts once accounting for firm-level unobservables. Moreover, Doms et al. (1997) find that US manufacturing firms which adopt more sophisticated technologies have a higher skilled workforce both prior to, and after, new production modes are in place. Skill composition appears more likely to shape firm investment behavior, rather than the other way around.

To examine skill composition and trade, separate from the influence of technology and labor demands, I consider team formation (i.e. matching) between heterogeneous workers who can bargain with firms competing in an open economy. The endogenous matching behavior of diverse workers determines the supply of skilled production teams available for hire, holding firm production methods fixed. As trading opportunities change I show that workers adjust their matching behavior, and consequently firms experience infra-marginal changes in skill composition and productivity.

In the framework developed below firms hire two managers to oversee production and a measure of homogeneous production workers. Managers differ in their abilities to supervise production and can each bargain with the firm over their wages[3]. While both managers improve firm-level productivity, the marginal return to their skill differs across the tasks to which they are assigned. Executive Managers contribute relatively more to production than do Middle Managers. During the wage bargaining process greater contributions to the firm's productivity lead to better wage outcomes. Thus the matching behavior of skilled workers is aimed at balancing a trade-off between a job as an Executive Manager to capture a large share of the rents generated during production, and a job as a Middle Manager with a partner whose skills increase the total amount of rents to be divided.

Trading opportunities weigh on worker matching behavior because of the distinct capability of exporting firms to earn revenues from abroad. By entering additional markets, exporting firms generate a relatively larger surplus over which workers can bargain. This gives rise to the well-known exporter premium[4]. When trading opportunities grow some managers seek better partners to capture surpluses earned abroad, sacrificing the potential of obtaining jobs as Executive Managers at their employing firm.

I present three key results about the consequences of trade liberalization with bargaining among heterogeneous workers. First, as trade barriers are reduced, workers form matches that are more segregated; high skilled workers match with relatively higher skilled workers, and low skilled matched with relatively lower skilled. Trade is shown to rationalize matching behavior in that more segregation among skilled workers is

[3]The assumption of only two managers is made for clarity as the model could incorporate teams of an arbitrary size at each firm. The exclusive ability of skilled managers to bargain and effectively extract rents corresponds to the findings of Cahuc et al. (2006): workers performing no managerial tasks extract very low rents, even in the French labor market where wage bargaining is pervasive. Effective wage bargaining in concentrated among supervisors and managers.

[4]See Bernard and Jensen (1999). Other reasons that workers may value employment at exporting firms include better survival and employment growth rates relative to their non-exporting counterparts.

a distinct source of gains from trade. Shifts in the organization of skilled workers in a more open economy obtain even when firms production techniques are fixed. In other words, changes in the skill composition of firms reflect the supply behavior of workers (via matching), rather than changing labor demands across firms. The potential of workers to bargain is integral in deriving this supply response as skilled workers internalize the effects of openness on the rents earned by their employer.

The second result describes infra-marginal changes in the skill composition. All firms experience changes in the relative skills of workers hired, not just those on the exit/entry margin or the margin of whether or not to export. More segregated matching outcomes lead to skill-upgrading, improving labor productivity within all surviving firms. The gains in productivity within establishments match the evidence for US manufacturing plants following tariff reductions provided by Bernard et al. (2006). Note that adoption of better technologies would only benefit those firms upgrading their production techniques, rather than all domestic and exporting firms. Hence the matching behavior of skilled workers has further reaching implications than the potential changes in technology and labor demands at marginal firms.

Finally, by initiating changes in skill composition of firms, trade openness is shown impact the distribution of income. The likelihood of a worker benefiting from trade is not necessarily increasing in skill. Some low skilled workers benefit from openness, while relatively higher skilled workers are harmed. Rising wage inequality occurs across firms, with workers who are employed at exporters gaining relative to those who are not. Because the changes in skill composition are infra-marginal, the distribution of wages within firms changes as well. Wage dispersion among skilled workers within firms is lower in an open economy, due to the more segregated matching outcomes. Production workers all earn competitive wages so that wage dispersion among these workers exhibits no trend in a globalizing economy. These predictions correspond closely to the experience of US manufacturing sectors reported by Dunne et al. (2004). Moreover, they find that rising overall wage dispersion is associated with rising dispersion over skill levels across plants, and within industries, consistent with intra-industry trading environment examined here.

Much of the trade literature with heterogeneous workers has focused on assignment problems of allocating workers to the appropriate industries, firms, technologies, or occupations: for open economy analyses of assigning workers to firms or technologies see Davidson et al. (1999), Yeaple (2005), Davidson et al. (2008) and Monte (2010), for heterogeneous workers to industries see Grossman and Maggi (2000), Ohnsorge and Trefler (2007) and Grossman (2004), or more generally in Roy-like assignment models see Costinot and Vogel (forthcoming)[5]. The role of team formation in open economies has concentrated on international team formation via offshoring; see Antràs et al. (2006) and Kremer and Maskin (2006). Here openness alters the

[5]See Davidson and Sly (2010) for a more extensive review of the trade literature with heterogeneous workers.

skill composition of firms hiring only from the domestic labor force, rather than improving access to foreign workers.

This analysis is also related to the literature examining trade, wages and the skill premium; see Manasse and Turrini (2001), Verhoogen (2008), Frías et al. (2009) and Burstein and Vogel (2009), in addition to the previously referenced works. The ability of workers to negotiate and extract quasi-rent by firms has been established by Abowd and Lemieux (1993), Abowd and Allain (1996) and Cahuc et al. (2006), among others. There are two results from this literature that I make use of here. First, the wage bargained by workers has been shown to respond to fluctuations in trading opportunities. Second, the size of the quasi-rent captured by workers varies across skill and job types. These facts suggest that trading opportunities and specific job opportunities are fundamental to the matching behavior of skilled workers.

A key result of this analysis is that better trading opportunities improve firm productivities by changing their skill composition. An alternative explanation for growth within existing establishments it the selection across product scope; firms can shed fringe product lines to improve their productivity as trade barriers fall. (See Eckel and Neary (2010) and Bernard et al. (2010).) Note that here, changes in skill composition occur regardless of the specific products or technology of the firm. In this sense, skill-upgrading and smaller product scope are complementary explanations for within-firm productivity growth, rather than competing hypotheses.

The next section describes production and the structure 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

The world economy consists of two identical countries. Firms in each country can enter foreign markets but must pay fixed and variable trade costs to do so. Each country is populated by a labor force with mass λ. Workers differ in their skill level s for managing production; the distribution of managerial skill is given by $G(s)$ with support $[0, \bar{S}]$, and $\bar{S}$ can be arbitrarily large. Firms hire labor to be production workers or to use their skills as managers. This section provides more details about production and the international trading environment.

2.1 Production

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_x^*. (An asterisk denotes a foreign variable.) The final good is assembled without cost by combining intermediates according to the production function

$$Y = \left(\int_{\chi} x(j)^{\theta} dj + \int_{\chi_x^*} x(j)^{\theta} dj \right)^{1/\theta}, \quad \theta \in (0,1). \tag{1}$$

Each intermediate good is produced by a firm using production workers and two managers[6]. A worker's skill only benefits the performance of managerial duties; regardless of their potential capabilities as managers, those hired as production workers supply a single efficiency unit of labor. The skill of each manager improves the productivity of all production workers hired by the firm.

Each firm hires a single Executive Manager and a single Middle Manager to supervise production workers. While working under an executive manager of skill s' each production worker supplies $e(s')$ efficiency units of labor, and working under a middle manager with skill s each production worker supplies and additional $m(s)$ efficiency units of labor. Thus the unit labor requirement for firm j, which recruits a middle manager with skill s and an executive manager of skill s', is given by

$$l(j) = \left[\frac{1}{m(s)} + \frac{1}{e(s')} \right]. \tag{2}$$

Increasing the skill of either manager improves labor productivity; $m'(s) > 0$ and $e'(s) > 0$ with $m(0) = e(0) = 1$. While the skill of both managers benefits labor efficiency, the skill of the executive manager contributes relatively more to productivity. The differential benefits of skill satisfy

$$\frac{\partial e(s)/\partial s}{e(s)} \frac{1}{e(s)} > \frac{\partial m(s)/\partial s}{m(s)} \frac{1}{m(s)} \tag{3}$$

The percentage increase in labor productivity from additional skill, per efficiency unit of labor, is larger when raising the skill of the executive manager of the firm. The final requirement on the production environment is that the unit labor requirement for a management team $(s, \bar{S})$ is less than the unit labor requirement for a management team $(0, s)$ for all s[7]. This simply assumes that team production benefits at least some firms

[6] See Garicano and Rossi-Hansberg (2006) for an endogenous determination of firm/management size in a knowledge economy. The assumption of two managers is made for simplicity as the model could be extended to an arbitrary number of managerial positions at each firm without effect to the qualitative results.

[7] The assumption about the benefits of team production is $\left[\frac{1}{m(0)} + \frac{1}{e(s)}\right] > \left[\frac{1}{m(s)} + \frac{1}{e(\bar{S})}\right]$ for all s.

in the economy, as is the case of interest here.

2.2 Demand

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

$$C(\vec{P}, Y) = Y\left(\int_{\chi} p(j)^{\frac{\theta}{\theta-1}}dj + \int_{\chi_x^*} p(j)^{*\frac{\theta}{\theta-1}}dj\right)^{(\theta-1)/\theta} \tag{4}$$

The variety of intermediates available from domestic and international firms is endogenously determined by the number of active domestic firms and foreign exporters. An intermediate firm faces demand in the domestic (D) and foreign markets (D^*) given by

$$\begin{aligned} D^T = D + D^* = Y\Bigg(\int_{\chi} p(j)^{\frac{\theta}{\theta-1}}dj + \int_{\chi_x^*} p(j)^{*\frac{\theta}{\theta-1}}dj\Bigg)^{-1/\theta} p(j)^{\frac{1}{\theta-1}} + \\ I(j)\left[Y^*\left(\int_{\chi^*} p(j)^{*\frac{\theta}{\theta-1}}dj + \int_{\chi_x} p(j)^{\frac{\theta}{\theta-1}}dj\right)^{-1/\theta} p^*(j)^{\frac{1}{\theta-1}}\right] \end{aligned} \tag{5}$$

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

2.3 Firm behavior

Production of the final good benefits from the availability of more varieties of intermediate goods. Hence all active firms will produce unique intermediates and take the prices of other firms as given. The profit function for an intermediate firm j is equal to the revenues from all units sold ($p(j)[x(j)+x^*(j)]$) , less labor wages (ω) for each worker hired ($l(j)$), beachhead costs (β) and transportation costs (τ) 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 total profit function of firm j is

$$\Pi(j) = p(j) - \omega l(j)x(j) + I(j)[p^*(j) - \tau\omega l(j)]x^*(j) - I(j)\beta - W_m - W_e$$

As is evident from the profit function above, managers capture rents for any volume of production and operating profits earned. More detail on the wage bargaining process is given below. For now the key point to recognize is that ability of managers to extract surplus does not influence firm behavior at the margin.

Firms chose prices which maximize profit given the cost of production workers and their efficiency during production. The optimal domestic price charged by a firm with managers of skill s and s' is

$$p(j) = \frac{\omega}{\theta} l(j) = \frac{\omega}{\theta} \left[\frac{1}{m(s)} + \frac{1}{e(s')} \right] \tag{6}$$

Each firm charges a fixed mark-up over marginal costs, which are a function of labor wages, ω, and labor productivity, represented by the term in brackets. Free entry guarantees that prices are chosen optimally; firms cannot strategically set prices to attract a particular management team because new firms can enter and raid the management of firms not setting prices according to (6). Finally the total demand for production workers is

$$L(j) = l(j)[x(j) + x^*(j)]$$

2.3.1 Export Choice

If an intermediate firm exports it must pay a fixed cost β to acclimate to foreign markets and prepare its variety 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 to arrive in a foreign market, the exporter must ship $\tau > 1$ units. Fixed exporting costs have no effect on the marginal behavior of firms. From (5), firms face iso-elastic demand in each country so that a firm which charges $p(j)$ in the domestic market will charge $\tau p(j)$ in the foreign market. Firms are willing to export if the following criterion is satisfied

$$\left[\tau p(j) - \tau \omega l(j)\right] x^*(j) \geq \beta \tag{7}$$

Values of the parameters representing trade costs are restricted to the interesting and empirically relevant case where only the most productive firms self-select into international markets. See Bernard and Jensen (1999) and Roberts and Tybout (1997).

2.4 Factor Markets

Firms use labor as production workers or hire them for their skills as mangers. Managerial skill is irrelevant when employed as a production workers. So all production workers earn the same competitive wage, ω. Managers differ according to their skill and have the ability to negotiate their individual wages with the firm. The sole ability of managers to extract rents from the firm matches the findings of Cahuc et al. (2006): workers who perform no managerial tasks extract "very low" rents, while managers can leverage

their talents and bargain effectively with the firm. The next section describes the bargaining outcomes for individual managers, and the matching market for management teams.

2.4.1 Wage Bargaining of Managers

Firm entry is undeterred so that all revenues in excess of trade costs must accrue to production workers or managers. The rents that managers can potentially extract are thus equal to the operating profits of the firm (revenues net labor costs, fixed and variable trade costs if applicable). For a firm j that employs a middle manager with skill s and an executive managers with skill level s', the operating profits are

$$\begin{aligned}\pi(s,s') = \left(p(j) - \omega\left[\frac{1}{m(s)} + \frac{1}{e(s')}\right]\right)x(j) + \\ I(j)\left\{\left(\tau p(j) - \tau\omega\left[\frac{1}{m(s)} + \frac{1}{e(s')}\right]\right)x^*(j) - \beta\right\}\end{aligned} \tag{8}$$

Note that the first argument in $\pi(\cdot)$ refers to the skill of the middle manager, and the second argument is the skill of the executive manger.

The coalition of managers must decide how to divide the whole of operating profits among themselves. Here I use the Shapley Value to determine the allocation of operating profits across the two managers. Each manager receives ex post payments equal to the average marginal contribution to the coalition. An executive manager with skill s', working with a middle manager of skill s, will generate $\pi(s,s')$ by cooperating, and will generate $\pi(0,s')$ by not cooperating with the middle manager. Then averaging across the potential contributions of each manager, the executive manger negotiates wages equal to

$$W_e(s,s') = \frac{1}{2}\{\pi(0,s') + \pi(s,s') - \pi(s,0)\} \tag{9}$$

and by similar construction the middle manager earns

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

Using the cooperative bargaining outcome to distribute surplus corresponds to an environment where managers can negotiate only with their employer and coworkers. Note that in many common settings where bargaining arises naturally, e.g, collective bargaining or search frictions, bargaining indeed occurs within firms. The cooperative bargaining mechanism here, with a solution found in the Shapley Value, allows for a tractable analysis with worker heterogeneity, taking multilateral bargaining within firms as given. Complications arise with worker heterogeneity when introducing the sorts of frictions that provide micro-

foundations for wage bargaining and would detract from the central thesis of this analysis: heterogeneous workers pursue specific employment opportunities given the ability to bargain and earn rents from abroad[8].

3 Equilibrium

A stable equilibrium in each economy is defined by a set of skill levels that are employed as middle managers, Σ^M, set of skills employed as executive managers, Σ^E, a matching function, $\mu(s) : \Sigma^E \to \Sigma^M$, that describes team formation between middle and executive managers, a wage paid to production workers, ω and a pair of skill cutoffs $(\mu(S^x), S^x)$ that define which managers are employed at exporting firms. Together these features of the economy describe the mass of intermediate goods available in each country and aggregate prices. This section derives a full equilibrium beginning with the market for managers.

3.1 Managerial Matching

Two important features of the division of operating profits between managers in (9) and (10) determine managerial matching behavior. First, individual compensation differs when an individual is employed as an executive manager or middle manager. The skills of the executive manager contribute more to production, and so executive wages are strictly greater than wages earned by middle managers, all else equal. Furthermore, the percentage difference in earnings across management positions are *relatively* increasing in skill; i.e. the payoff for any manager is log-supermodular in task and own skill. To see this formally note that following inequality holds for any own skill level $\dot{s}$ and potential partners s and s'.

$$\frac{\partial}{\partial \dot{s}} \left[W_e - W_m \right] = \frac{1}{2} \left[\pi_2(0, \dot{s}) + \pi_2(s, \dot{s}) - \pi_1(\dot{s}, 0) - \pi_1(\dot{s}, s') \right] > 0 \tag{11}$$

The inequality in (11) is sufficient for positive assignment of skilled workers across management positions. The highest skilled workers from the labor force will be hired as executive managers, and relatively lower skilled workers will be hired as middle managers. Consistent with positive assortment, in equilibrium there will be no worker hired as a middle manager that has skill greater that any executive manager: $\forall s \in \Sigma^M$ and $\forall s' \in \Sigma^E$ it must be that $s \leq s'$. Thus the set of skills assigned to each managerial position are defined

[8]In an extension of the basic model of trade with labor search frictions, Helpman et al. (2010) allow workers to differ in skill *ex ante*, but must assume that heterogeneous workers do not compete with one another for the same type of job, nor bargain with one another across occupation types, in order to close the model. Albrecht and Vroman (2002) and Davidson et al. (2008) also allow for worker heterogeneity and firm-level bargaining because of search frictions. However in these models firms hire only a single worker so that skill composition is fixed, even as trading opportunities change.

by two cutoff levels S_L and S_M such that

$$\Sigma^M = [S_L, S_M) \text{ and } \Sigma^E = [S_M, \bar{S}]. \tag{12}$$

The second key feature of managerial compensation describes the relative benefits of skill, and thus determines which executive and middle managers will match into teams. For both executive and middle managers, the negotiated compensations determined in (9) and (10) are relatively increasing in the skills of each manager. That is,

$$\frac{\partial^2 W_e(s,s')}{\partial s \partial s'} = \frac{\partial^2 W_m(s,s')}{\partial s \partial s'} = \frac{1}{2}\frac{\partial^2 \pi(s,s')}{\partial s \partial s'} > 0 \tag{13}$$

The inequality in (13) is sufficient for positive assortative matching to arise between executive and middle managers; e.g. the highest skilled executive will form a management team with the highest skilled middle manager, and the lowest skilled executive with the lowest skilled middle manager. More precisely the inequality in (13) is a sufficient condition for the matching function $\mu(s)$ to monotonically increasing and unique. Each team consists of exactly one middle and one executive managers so the the matching function $\mu(s)$ is defined implicitly for any $s \in \Sigma^E$ by

$$\int_{s}^{\bar{S}} dG(s) \equiv \int_{\mu(s)}^{S_M} dG(s) \tag{14}$$

The implications of wage bargaining across tasks and skills for team formation are summarized by the following proposition.

Proposition 1 *With a continuous and non-degenerate distribution of skill types, stable matches will exhibit positive assortative matching, but will not be perfectly segregated. Matches in any equilibrium will form between heterogeneous managers, with the more skilled of the pair hired as an executive manager.*

Proof. See the Appendix. ■

Proposition 1 points to the heart of this analysis. With complementarities between worker skills the most productive allocation of managers would be team formation between identical workers. (Note that the production and profits functions are supermodular in managerial skills.) When heterogeneous workers negotiate their wages across different management positions, they face a trade-off in their matching behavior between a large surplus to divide (which arises by capturing complementarities in production) and a relatively larger share of a surplus (from jobs with strong bargaining positions). Wage bargaining within firms causes any equilibrium allocation of managers to be segmented based on skill, and creates an avenue for trading

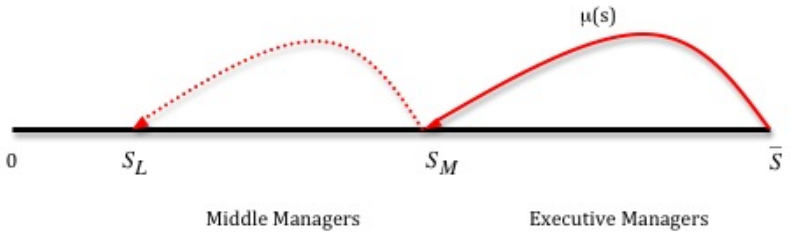

Figure 1: Equilibrium Assignment and Matching of Managers

opportunities in influence the supply of skilled teams available for hire.

Equilibrium in the matching market for managers is illustrated in Figure 1. The lower bound on skill needed to be hired as a manger is S_L. Workers with greater skill are divided evenly into middle and executive management positions. Given that there are two managerial tasks, the lower bound on skill for executive managers must be the median skill level between S_L and $\bar{S}$, which is denoted by S_M. The set of executive managers will form teams with middle managers having skill between S_L and S_M with positive assortment according to the matching function $\mu(s)$.

Proposition 1 guarantees that any equilibrium allocation of managers must assign the highest skilled workers to executive management positions, and the best executive and middle managers into the same team. Given the matching function, $\mu(s)$, equilibrium in the matching market is determined by the endogenous skill requirements S_L and S_M. So the next step is to pin down the assignment of skills to management positions.

There are three conditions which bind the managerial matching market. First, employment as a manager must be incentive compatible, given the option of each worker to earn a wage ω as a production worker. From the positive assortment of managers required by proposition 1, the lowest skilled worker employed as a manager will be a middle manager, and matched with the lowed skilled executive manager. Thus employment as a manager for a worker with skill S_L is incentive compatible across jobs and partners as long as the follow criterion is met

$$W_m(S_L, S_M) \geq \omega \tag{15}$$

Note that competition among skilled workers will push this condition toward equality in equilibrium.

All managers have a relative preferences for employment as an executive managers, holding the skill of their partner equal; see the inequality in (11). However, the positive assignment of workers across occupations implies that different management positions are associated necessarily with partners of different skill. A worker with skill level S_M can find employment as a middle manager while matched with an executive

manager having skill level $\bar{S}$, or employment as an executive manager while matched with a middle manager having skill level S_L. The second equilibrium condition requires that the matching behavior of a the manager S_M is incentive compatible across jobs and partners so that

$$W_e(S_L, S_M) - W_m(S_M, \bar{S}) \geq 0 \tag{16}$$

Note that the greater compensation associated with employment as an executive manager will push this condition toward equality in equilibrium.

The incentive compatibility constraints represent the competitive forces in the matching market which push the allocation of skilled workers towards a stable equilibrium. However there is an additional regularity condition that must also be satisfied. With team production at all firms, there must be an equal mass of workers performing each task; given two production tasks, exactly half of all employed managers must be performing either executive or middle management duties. Put simply, the median skill level separating executive and middle managers, S_M, must indeed be the median of the distribution of skilled workers employed, truncated at the lower bound, S_L. The regularity condition on a managerial matching equilibrium is

$$\int_{S_M}^{\bar{S}} dG(s) \equiv \int_{S_L}^{S_M} dG(s). \tag{17}$$

The equilibrium conditions for the matching market are illustrated in Figure 2. The lines representing the incentive compatibility conditions trace the pairs of skill levels where such that (15) and (16) hold with equality. The regularity condition intersects the vertical axis at the median of $G(\cdot)$ for the entire distribution of workers in the economy. The properties of these equilibrium conditions yield the following result.

Proposition 2 *An equilibrium with positive assignment of skilled workers to management positions, and positive assortment of managers into team exists and is unique.*

Proof. See the Appendix ■

Competition among workers for jobs as managers, and specifically for jobs as executive managers, ensure that an equilibrium must occur on the upper envelope of the incentive compatibility constraints, illustrated by the solid portions of each condition in figure 2. As is verified in the appendix, both incentive compatibility conditions are downward sloping, and everywhere haves different slopes. A worker just on the margin of obtaining a job as an executive manager has the potential to match with the highest skilled worker in the labor force and earn rents from abroad. Hence any marginal executive manager requires a relatively higher skilled partner, S_L, to remain indifferent to the possibility of earning an exporter premium. This is evident

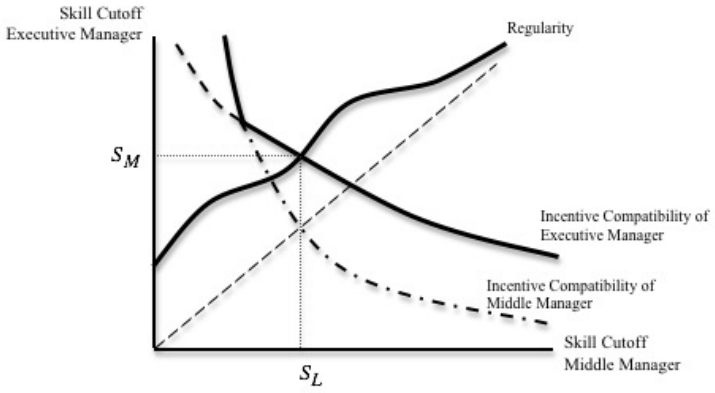

Figure 2: Determining Equilibrium in Manager Matching Market

in figure 2 by the fact that the incentive compatibility condition for the marginal executive manager is everywhere less steep than the constraint for the marginal middle manager. Equilibrium occurs where the regularity condition intersects the greater of the two incentive compatibility conditions.

3.2 Equilibrium in the Market for Production Workers

Equilibrium in the labor market occurs when total demand for production workers is equal to the supply of production workers at the prevailing market wage. The supply of production workers is the mass of workers with skills below the requisite level to find employment in management positions, S_L. Labor demand is strictly decreasing in the price of labor so that a unique equilibrium occurs at the wage ω which satisfies

$$\int_{\chi} L(j)dj = \int_{0}^{S_L} \lambda dG(s) \tag{18}$$

3.3 Equilibrium in Goods Markets

The set of intermediate goods traded between countries is determined endogenously according to profit maximization by firms, given the skill of their management. Only firms with the most skilled management teams can overcome fixed trade costs, β. So the mass of intermediates exported by each country is determined by a exporting skill cutoff, S^x, which satisfies

$$\left(\tau p - \tau\omega\left[\frac{1}{m\left(\mu\left(S^x\right)\right)} + \frac{1}{e\left(S^x\right)}\right]\right)x^* \equiv \beta \tag{19}$$

Given the set of domestic varieties available, and those imported, equilibrium in the market for the final good Y occurs when zero-profits are realized. Substituting individual firm prices into the cost function of Y from (3) gives the zero-profit condition for the final good sector

$$1 = \left[\int_{\chi} \left(\frac{\omega l(j)}{\theta} \right)^{\frac{\theta}{\theta-1}} dj + \int_{\chi^*_{ex}} \left(\frac{\omega \tau l(j)}{\theta} \right)^{\frac{\theta}{\theta-1}} dj \right]^{(\theta-1)/\theta}$$

Instead of using the cost for each intermediate firm, a weighted average of the labor productivity across all firms yields a simple expression for the relationship between labor wages and representative skill level of active management teams. Let $(\mu(S_R), S_R)$ be the management team at a representative firm such that its labor productivity is given by

$$\left[\frac{1}{m(\mu(S_R))} + \frac{1}{e(S_R)} \right]^{-1} = \left[\int_{S_M}^{\bar{S}} \left[\frac{1}{m(\mu(s))} + \frac{1}{e(s)} \right]^{\frac{\theta}{\theta-1}} dG(s) \right]^{\frac{1-\theta}{\theta}} \tag{20}$$

Then using the definition of the representative firm in (20), let $l(S_R)$ be the weighted-average unit labor requirements for the mass of $\frac{\lambda(1-G(S_L))}{2}$ active firms. Rewriting the zero-profit condition in final goods for the representative intermediate firm, an equilibrium in the market for Y must satisfy

$$\omega \equiv \left(\frac{\lambda(1-G(S_L))}{2} \right)^{\frac{1-\theta}{\theta}} \theta \left[l(S_R)^{\frac{\theta}{\theta-1}} + \tau^{\frac{\theta}{\theta-1}} l(S^*_R)^{\frac{\theta}{\theta-1}} \right]^{\frac{1-\theta}{\theta}} \tag{21}$$

3.4 Full Equilibrium

Each economy is in full equilibrium when both labor markets and goods markets are in equilibrium. To summarize this section, a matching equilibrium occurs for a matching function, $\mu(s)$, defined implicitly in (14). The sets of skills assigned to each management position, Σ^M and Σ^E, are determined by cutoffs S_L and S_M which lie on the intersection of the incentive compatibility and regularity conditions (15), (16), and (17). The mass of intermediates exported is defined by the skill level S^x given by (19). Wages for production workers are determined by (18). These endogenous variables determine a full equilibrium with a final goods market equilibrium characterized by (21).

4 Trade and Openness

Trade liberalization provides new opportunities for firms and workers to participate in international markets. This section first demonstrates how openness influences the distribution of rents across firms. Then given the ability of skilled workers to extract these rents from their employer, this section discusses how trade alters the supply of management teams available for hire. The reformation of matches between managers in an open economy is shown to change the skill composition within all firms, their productivity and the distribution of income.

4.1 Trade and the Distribution of Rents Across Firms

Lower transportation costs lead to an increase in foreign demand for exporters. As these firms expand, and more firms enter into export markets, demand for production workers rises. The consequence being that labor wages paid by all firms must also rise. Since all firms pass labor costs along to consumers via prices, they must all charge higher domestic prices in the new trade equilibrium. This mechanism of trade adjustment as firms take advantage of greater market access is similar to that of Melitz (2003) and Yeaple (2005) where the labor supply is held constant. The impact of openness on the market shares and operating profits for domestic and exporting firms, holding the matching behavior of managers fixed, is summarized in the following proposition.

Proposition 3 *When trade costs fall domestic firms reduce production and suffer losses in operating profits, while exporting firms expand production and enjoy relatively larger operating profits, all else equal.*

Proof. Differentiating the goods market clearing condition in (21) with respect to trade costs yields $-\frac{d\omega}{d\tau} > 0$; trade liberalization raises the equilibrium wage paid to production workers. The optimal price for any firm is a fixed markup over unit labor costs, equation (6). Thus for any skill level of management, firms charge a higher price in the domestic market. Given the downward sloping demand function for each firm in (5), and the fact that profits are strictly decreasing in labor wages, it must that liberalization reduces production and operating profits for all domestic firms.

Exporting firms similarly sell and earn less in the domestic market. However the foreign sales of exporting firms grow. Calculating from (21), $\left|\frac{\omega}{\tau}\frac{d\omega}{d\tau}\right| = \frac{l(S_R^*)^{\frac{\theta}{\theta-1}}\tau^{\frac{\theta}{\theta-1}}}{l(S_R)^{\frac{\theta}{\theta-1}}+l(S_R^*)^{\frac{\theta}{\theta-1}}\tau^{\frac{\theta}{\theta-1}}} < 1$. In absolute value, the percentage increase in labor wages per unit for any firm is less that the percentage decrease in per unit trade costs. The optimal price charged by any exporting firm in the foreign market is $\tau p(\cdot)$. As the percentage reduction in trade costs is larger that the percentage increase in the equilibrium wage rate, the price exporting firms

charge abroad necessarily falls. Given the downward sloping demand function for each firm in (5), it must that liberalization raises production and operating profits earned by all exporting firms. ■

These are the direct of effects of trade on the distribution of rents across firms. Fernandes (2007) and Pavcnik (2002) confirm that openness reallocates market shares across firms as described by proposition 3. For any given distribution of firms, those that export grow relative to non-exporters. When mangers can effectively bargain and capture rents earned by the firm, the reallocation of market shares must weigh of their matching behavior. The general equilibrium consequences of trade includes the reformation of managerial teams, and thus the supply of skilled workers available for hire.

4.2 Trade and Management Across Firms

By shifting rents across firms, trade liberalization alters the willingness and ability of skilled workers to obtain jobs as both middle and executive managers. The following proposition describes the equilibrium employment of skilled workers in more open economies.

Proposition 4 *As long as there are some firms that export and some firm that do not export in equilibrium, a fall in variable trade costs raises the skill requirement for employment as both a middle manager, S_L, and an executive manger, S_M.*

Proof. Recall that the requisite skill level to obtain a job as a middle manger, S_L, and an executive manger, S_M, are determined by the intersection of the incentive compatibility and regularity conditions. The regularity condition on the skill distribution for employed mangers is an immutable condition, unaffected by the level of trade costs. However both incentive compatibility conditions respond to changes in the trade costs.

Consider the marginal worker with skill S_L. As long as there non-exporting firms operating in equilibrium, a fall in trade costs reduces wages for the marginal worker: $\frac{dW_m}{-d\tau} < 0$ given that from (21) we have $\frac{d\omega}{-d\tau} > 0$. Incentive compatibility can only be upheld at a greater skill level S_L.

Next consider the incentive compatibility at the skill level S_M. As long as there are some firms that export in equilibrium, and some that do not, the reallocation of market shares from proposition 1 imply that $\frac{d}{d\tau}\left[W_e(S_L, S_M) - W_m(S_M, \bar{S})\right] < 0$. Incentive compatibility of the median manager can only be restored by and increase in S_L.

Both the free entry and incentive compatibility require a higher equilibrium skill level S_L for each value of S_M at lower trade costs. Given that the regularity condition is non-decreasing, its intersection of with either the entry or incentive compatibility condition occurs necessarily at a higher equilibrium values of S_L

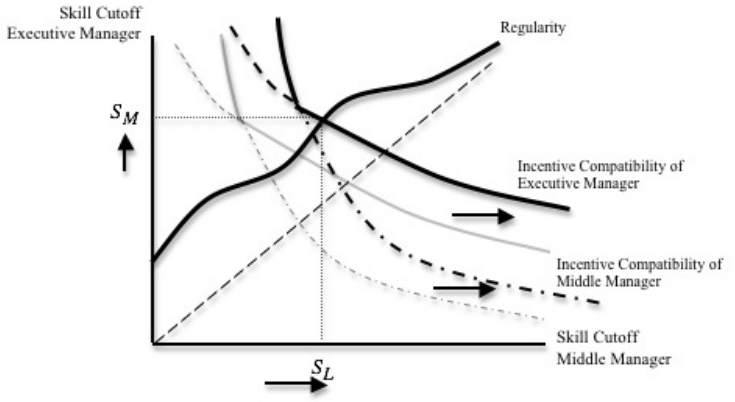

Figure 3: Trade and the Matching Market Equilibrium

and S_M. Thus the requisite skill levels for both management positions, S_L and S_M, must be greater in a more open economy. ■

Lower trade costs shift the upper envelope of skills requisites for managers outward. See Figure 3. The shift in the incentive compatibility condition for employment as a manager reflects the higher wages paid to production workers in an open economy. At higher wages, only those with greater skill benefit from employment as managers. The upward shift the the incentive compatibility condition for a manager with skill S_M reflects the change in wages earned at exporting versus non-exporting firms. According to proposition 3, exporting firms earn relatively greater profits as trade barriers fall. Facing the potential rents earn when matched with $\bar{S}$, the lower bound on the skills of middle managers must increase to keep the marginal executive manager indifferent between jobs at exporting and non-exporting firms.

The exclusion of relatively lower skilled workers from management positions has two consequences for the firms which survive in the more open economy. First, the need for mangers with higher skill necessarily reduces the number of domestic firms operating in equilibrium, and that the exit of firms is concentrated among low productivity firms. Second, a higher skill requirement for managers necessarily raises the average productivity of all firms that continues to operate following trade liberalization. To see this note the productivity of the representative firm in (20) is strictly increasing in the skill requirements for managers. Both of these consequences match the findings of Head and Ries (1999) for Canada, and of Bernard et al. (2006) for the US when firms face lower trade costs. An important finding of Bernard et al. (2006) is that productivity *within* surviving plants also grows following tariff reductions. To address this fact I turn next to trade and changes in the skill composition within firms.

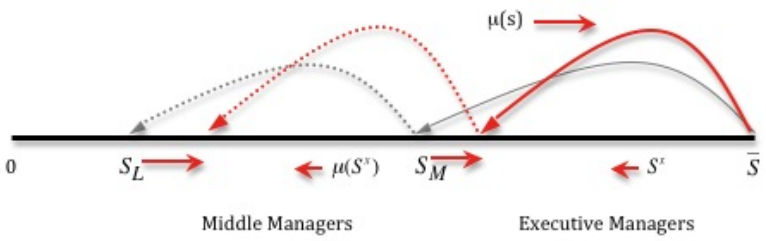

Figure 4: Trade and Skill Composition of Management

4.3 Trade and Management Within Firms

The last section established that trade raises the skill requirement, S_M, to obtain a job as an executive manager. The following proposition describes the adjustments in skill composition within firms by relating higher changes in S_M to changes in the equilibrium matching function $\mu(s)$.

Proposition 5 *Trade liberalization leads to skill-upgrading within firms. For any firm that hires an executive manager with skill s and a middle manager with skill $\mu(s)$, following trade liberalization an executive manager with skill s will be matched with a higher skilled middle manager, $\mu^*(s) > \mu(s)$.*

Proof. Proposition 4 guarantees that a reduction in trade costs will lead to an increase in the equilibrium value S_M. Then implicitly differentiating (14), for any skill level $s \in \Sigma^E$

$$\frac{d\mu(s)}{dS_M} = \frac{g(S_M)}{g(\mu(s))} > 0$$

■

Cunat and Guadalupe (2009) provide evidence of skill-upgrading within management as global competition intensifies. They find that lower tariff barriers cause US manufacturing firms to hire more "talented" individuals at the top management levels, and that these recruiting adjustments drive changes in the wage differentials between managers. Fernandes (2007) shows that skill-upgrading is key source of productivity growth among Columbian manufacturing firms after trade barriers were relaxed[9]. Furthermore Pavcnik (2003) demonstrated that skill-upgrading is not explained by greater use of foreign technologies or licensed patents. Consistent with proposition 5, skill-upgrading occurs separate from other firm investment mechanisms.

[9]Bernard and Jensen (1997) show that skill-deepening at US exporting plants account for a large portion of the wage and employment variation within US manufacturing industries. However their measure of skill-upgrading is at the extensive margin, measuring changes in the share of non-produciton workers hired. Here skill-upgrading is an improvement in the skills of non-produciton workers hired, holding the employment share fixed. In this sense proposition 5 can be interpreted as describing skill-upgrading at the intensive margin.

Proposition 5 indicates that skill-upgrading occurs for any skill level of executive managers. In other words, all firms realize improvements in team formation as the matching behavior of workers adjusts to the more open economy. Changing in skill composition and productivity are not limited to those that export, those that change export status, nor those on the margin of survival. The exit of some low productivity firms creates slack in the matching market so that even domestic firms employ more skilled management teams. The impact of trade liberalization on the organization of the skilled labor force is illustrated in Figure 4. From proposition 4, the skill requirements for both middle and executive managers increase. Subsequently the matching function, $\mu(s)$, shifts to the right so that surviving executives match with better middle managers per proposition 5. A reduction in trade costs reduces the skill requirements to export $\mu(S^x)$ and S^x.

Here skill-upgrading within firms is a consequence of workers pursuing rents from foreign sales. When workers can capture rents, openness alters the skill composition of firms directly. While changes in skill composition can arise solely because of wage bargaining, technology still appears to be an important margin of firm-level adjustment to trade. Pavcnik (2003), Bloom et al. (2009) and Bustos (forthcoming) all observe greater firm-level investments in technology as trade barriers fall. However the causal implications of trade for the adoption skill-biased labor demands are mitigated by proposition 6. The skill composition of a firm's workforce is more likely to cause investments in sophisticated technologies, rather than the other way around. See Doms et al. (1997). Put differently changes in the supply of skilled workers can alter firm demand for new technologies, rather than new technologies altering the relative demand for skill[10].

Another prominent reason for within-firm productivity growth as trade barriers fall is the selection across product lines. Firms can rationalize the scope of different products they offer in a more open economy and realize productivity gains as they concentrate on their core competency. These arguments have been put forth by Eckel and Neary (2010) and Bernard et al. (2010). Note that changes in skill composition here improve the marginal productivity of the firm, rather than only the average productivity of the firm. Put differently, the benefits of skill upgrading in a more open economy are realized even at the product level[11]. Hence skill-upgrading and reducing product scope should be viewed as complementary, rather than competing hypotheses, for within-firm productivity gains.

[10] At a more general level Acemoglu (2007) provides a detailed treatment of endogenously biased technologies as factor supplies change. The key point here is that the supply of skill available for hire is itself endogenous and depends on the openness of the economy.

[11] A previous version of this paper entitled "International Trade, Wages and Unemployment with Endogenous Firm Scope" showed that the rationalization of matches between managers acted as a countervailing effect to the rationalization of products. Firms shed products in a more open economy, but the incentives to do so are tempered by improvements in labor productivity via better skilled managers.

4.4 Trade and the Distribution of Income

The previous sections demonstrated that openness shifts the distribution of rents across firms and alters the equilibrium formation of managerial teams between skilled workers. Both of these trade adjustment mechanisms impact the distribution of income. As exporting firms gain better market access the wages they pay to their workforce also rise. Yet the rent-seeking behavior of skilled workers chasing positions as executive managers implies that the benefits of foreign market access are not captured exclusively by the highest skilled workers. Moreover, the expansion of exporting firms as trade barriers falls raises the demand for, and thus the wage of, production workers. The increase in labor costs cuts into the compensation retained by managers. In short, when heterogeneous workers can bargain effectively with their employer the impact of trade on the wage distribution across skills may not be uniform. The following proposition makes this point more clear.

Proposition 6 *The likelihood from gaining from trade is not necessarily increasing in skill.*

Proof. To avoid a taxonomy of cases I present one example of a relatively low skilled worker benefiting from trade liberalization, while a higher skilled worker is harmed. It has already been established that production workers benefit: $\frac{d\omega}{-d\tau} > 0$. Consider next a worker with skill s, who matched with an executive manager $\mu^{-1}(s)$, and remains employed as a middle manager at a non-exporting firm when trade barriers fall. The impact of liberalization on the wage of the middle manager s is given by

$$\frac{dW_m(s,\mu^{-1}(s))}{-d\tau} = \frac{1}{2}\Bigg\{\frac{d\pi(0,\mu^{-1}(s))}{d\omega}\frac{d\omega}{-d\tau} + \frac{d\pi(s,\mu^{-1}(s))}{d\omega}\frac{d\omega}{-d\tau} + \frac{d\pi(0,\mu^{-1}(s))}{d\omega}\frac{d\mu^{-1}(s)}{-d\tau} + \frac{d\pi(s,\mu_{-1}(s))}{d\omega}\frac{d\mu^{-1}(s)}{-d\tau}\Bigg\} < 0$$

The effect of trade on low skill production workers is $\frac{d\omega}{-d\tau} > 0$ while relatively higher skilled middle managers experience $\frac{dW_m(s,\mu^{-1}(s))}{-d\tau}$ when trade costs fall. This establishes the result. ■

All workers benefit from the reduction in prices that accompany a more open economy. However some workers incur losses in nominal wages as trading opportunities expand, with the possibility that these losses are real. The last proposition indicates that greater skill does not necessarily protect individuals from trade when they try to leverage that skill against their employer in wage negotiations.

The non-monotonic impact of trade on wages precludes direct calculations inequality across skills without a taxonomy of cases or a full parameterization of the model. However the matching behavior of skilled workers permits a clear examination of wage dispersion across and within firms. First consider production workers. Regardless of their employing firm all production workers are paid the same wage, and this wage increases

when trade is liberalized; recall from equation (21) $\frac{dw}{-d\tau} > 0$. In other words, the model predicts that wage dispersion among production workers exhibits no trend as the economy becomes more open, though their wage level rises.

Next consider the distribution of wages for managers in the more open economy. From proposition 5, trade liberalization will cause the managers within surviving firms to be more segregated with respect to skill. Calculating the change in the wage differential between the executive and median manager of the same firm reveals

$$-\frac{d}{d\tau}\left[W_e(\mu(s),s) - W_m(\mu(s),s)\right] = -\frac{\partial\pi(0,s)}{\partial\omega}\frac{d\omega}{d\tau} + \frac{\partial\pi(\mu(s),0)}{\partial\omega}\frac{d\omega}{d\tau} + \frac{\partial\pi(\mu(s),0)}{\partial\mu(s)}\frac{d\mu(s)}{d\tau} < 0 \tag{22}$$

Wage dispersion among non-production workers within the same firm falls as trade barriers are reduced. Greater segregation in matches causes the wages of management to converge.

Finally, as indicated by propositions 3 and 6, the impact of trade on skilled wages depends on whether managers are employed at exporting or non-exporting firms. It is a simple comparative statics exercise to verify that the wage of middle managers and executive managers at exporting firms both grow relative to the wages of their counterparts at non-exporting firms. Intuitively, foreign market access increases wage inequality for non-production workers across firms when trade costs exclude some of them from earning rents abroad. The changes in wage inequality following trade liberalization derived here are consistent with the findings of Dunne et al. (2004); among US manufacturing firms the decomposition of wage dispersion in recent decades is characterized by (1) a steady level of dispersion among production workers, (2) a declining level of dispersion among non-production (i.e. skilled) workers within firms, and (3) rising wage dispersion across firms participating in the same industry[12].

5 Gains from Trade and Matching

Up to this point the impact of trade on the matching behavior of skilled workers has been linked to within-firm productivity gains and changes in the distribution of income for individual workers. This section examines the aggregate impacts of worker matching behavior in open economies. The question remains whether or

[12]Dunne et al. (2004) argue that the across-plant component of rising wage dispersion is associated with rising computer investments, but note that their findings are also consistent with changing trade patterns (pg. 423). Given the evidence in Bustos (forthcoming) and Bloom et al. (2009), the investments in technology are plausibly endogenous responses to increases trade exposure. Of course the technology upgrades themselves may be caused by the skill-upgrading mechanism provided here. Unraveling the causal mechanism in between trade, skill composition and firm-level technology adoption is quite difficult. However evidence in favor of a causal story running from trade to skill composition to technology adoption can is found by looking at the within-firm component of wage dispersion: changes in the matching behavior of skilled workers are consistent with falling wage dispersion among non-production workers in the same firm.

not the reorganization of skilled workers improves the overall performance of the economy. That is, does trade rationalize the matching behavior of workers?

As trade barriers fall skilled managers seek partners that allow them to earn rents from abroad. Given that this adjustment is derived from the rent-seeking behavior of workers, it is not obvious that changes in team formation raise aggregate welfare. It is well known that the exclusion of low productivity firms, and the reallocation of production toward more productive firms, both represent real gains from trade. (See Melitz (2003) and Yeaple (2005).) The relevant question is whether or not changes in matching, $\mu(s)$, represent a distinct gain from trade. Note that the price index for the final good is strictly decreasing with respect to the labor productivity of the representative firm. Differentiating (20) with respect to $\mu(s)$, holding all else constant, we have

$$\frac{\partial \left[\frac{1}{m(\mu(S_R))} + \frac{1}{e(S_R)}\right]^{-1}}{\partial \mu(S_R)} = -\left[\frac{1}{m(\mu(S_R))} + \frac{1}{e(S_R)}\right]^{-2}\left[\frac{m'(\mu(S_R))}{m(\mu S_R)^2}\right] < 0 \tag{23}$$

From proposition 6, a fall in trade costs will improve the match, $\mu(\cdot)$, for any executive manager. Thus the inequality above demonstrates that trade rationalizes the matching behavior of skilled workers, reducing the price of the final consumption good. The pattern of team formation within firms in more open economies leads to higher welfare, in addition to the gains obtained by reallocation production across firms.

6 Discussion on Robustness

The matching behavior of skilled workers influences how an economy adjusts to trade primarily because workers can bargain with their employer, and their ability to negotiate effectively is tied to the specific job they perform within the firms. In deriving the implications of matching behavior in open economies I have assumed a cooperative bargaining environment within each firm, where the solution is given by the Shapley Value. The key feature of this bargaining process is that the specific share of rents captured by a manager is tied the relative performance of managers. Many alternative specifications, such as a tournament compensation scheme, would lead to similar conclusions as workers pursue jobs that help them be relatively more successful. However if the share of rents that workers could extract were not tied to relative performance and fixed exogenously, as would be the case with Nash Bargaining, workers would only pursue matches that generate the largest total surplus, regardless of trade costs. Evidence that the share of rents extracted varies across employment positions and skills can be found in Cahuc et al. (2006) suggesting the mechanisms

presented here are at work in the world economy[13].

In describing the relative performance of workers I have assumed that management positions at each firm exhibit strong differences in their complementarily with the skills of workers; specifically management positions are log-supermodular in skill so that executive managers improve labor productivity relatively more per worker hired. This form of complementarity ensures that the equilibrium assignment of workers derived above is obtained for any distribution of skills. No assumptions have been made here about the shape of the distribution of managerial talent. Costinot (2009) provides a detailed discussion on the the impact of log-supermodularity and comparative advantage with heterogenous workers and tasks. Weaker forms of complementarity could generate the same results derived here but only for certain skill distribution types.

7 Conclusion

When workers can bargain effectively, changes in trading opportunities alter the supply of skilled workers available for hire. The capability of workers to capture rents from their employer has been demonstrated in several countries and across different industries. Furthermore, evidence from Frías et al. (2009) demonstrate that exporters and non-exporters pay wages that differ from the standard competitive model. The pervasive use of negotiated wages suggests that the matching behavior of heterogeneous workers seeking rents can have a substantial impact on how economies respond to trade, independent of changes in the demands for skill.

I presented a model of firm level production with two management positions. Given the wage negotiations among skilled workers, differences in the return to skill across executive and middle management positions cause workers to pursue specific occupations, thereby sacrificing match quality at the margin. Trade liberalization was shown to rationalize matching behavior in that workers form more efficient management teams in an open economy.

Changes in matching behavior as economies become more open raise average productivity by forcing low productivity firms to exit. A novel feature here is that changes in the skill-composition of teams for hire lead to infra-marginal improvements in firm-level productivities. All surviving firms realize productivity gains via skill-upgrading, including those that do not change export status. The reorganization of the labor force alters the income distribution. Employees of exporting firms gain relative to their domestic counterparts. Changes in skill composition at all surviving firms reduce wage dispersion among skilled workers, and raise the income level of low skill production workers.

[13]See Helpman et al. (2010) and Acemoglu et al. (2007) for other applications of cooperative bargaining and the Shapley Value to the intra-firm bargaining process in open economies.

Appendices

Appendix A-Proof of Proposition 1

Proposition 1 states that any equilibrium allocation of managers exhibits positive assortative matching (PAM) between managers and positive assignment of skills to managerial positions. Since managerial compensation in (9) and (10) are weighted averages of operating profits earns, PAM can be established by showing that the profits are supermodular in the skills of each manager. Substituting optimal prices and demand into the firm profit function in (8) yields

$$\pi(s,s') = \left[\frac{1}{m(s)} + \frac{1}{e(s)}\right]^{\frac{1}{\theta-1}+1} \frac{\omega}{\theta}^{\frac{1}{\theta-1}+1}(1-\theta) \tag{A.1}$$

where exporting profits are suppressed without effect. Then computing the cross-partial.

$$\frac{\partial^2\pi(s,s')}{\partial s\partial s'} = \left[\frac{1}{m(s)} + \frac{1}{e(s)}\right]^{\frac{1}{\theta-1}-1} \frac{m'(s)}{m(s)^2}\frac{e'(s)}{e(s)^2}\left(\frac{\omega}{\theta}\right)^{\frac{1}{\theta-1}+1}(1-\theta) > 0$$

Using the well-known results from Legros and Newman (2007), the inequality above is sufficient for PAM between managers based on skill.

The next step is to show that equilibrium matches form between heterogeneous managers. This occurs if middle managers and executive managers are recruited from disjoint skill sets. As long as there is heterogeneity in skills, it is sufficient to show that there is positive assignment of skill to management positions. Calculating the inequality in (11), the the change in operating profits from a marginal increase in the skill of the executive manager is

$$\pi_2(s,s') = \omega^{\frac{\theta}{\theta-1}}\left[\frac{1}{m(s)} + \frac{1}{e(s')}\right]^{\frac{\theta}{\theta-1}-1}\frac{e'(s')}{e(s')^2} \tag{A.2}$$

and the increase in operating profits from additional skill for a middle manager is

$$\pi_1(s,s') = \omega^{\frac{\theta}{\theta-1}}\left[\frac{1}{m(s)} + \frac{1}{e(s')}\right]^{\frac{\theta}{\theta-1}-1}\frac{m'(s)}{m(s)^2} \tag{A.3}$$

Workers with greater skill will be assigned to executive positions if doing so generates more profits (and thus higher wages). The criterion is

$$\omega^{\frac{\theta}{\theta-1}}\left[\frac{1}{m(s)} + \frac{1}{e(s')}\right]^{\frac{\theta}{\theta-1}-1}\frac{e'(s')}{e(s')^2} > \omega^{\frac{\theta}{\theta-1}}\left[\frac{1}{m(s)} + \frac{1}{e(s')}\right]^{\frac{\theta}{\theta-1}-1}\frac{m'(s)}{m(s)^2}$$

which reduces to

$$\frac{1}{e(s')}\frac{e'(s')}{e(s')} > \frac{1}{m(s)}\frac{m'(s)}{m(s)}$$

This is the condition in (3) describing the relative skill intensity of executive and middle management positions.

The percentage difference in the improvements in labor productivity, per unit, that obtain from greater skill lead to positive assignment in competitive matching markets. Put differently, the fact that the negotiated wages are log-supermodular in positions and skill implies that high skill workers have comparative advantage as executive managers. See Costinot (2009) for a more detailed discussion of assignment of heterogeneous factors across multiple tasks and the role of log-supermodularity.

Appendix B-Proof of Proposition 2

First consider existence. An equilibrium in the matching market exists at skill levels S_L and S_M that satisfy both incentive compatibility conditions and the regularity condition. The equilibrium conditions are

indifference of S_L between employment as a production worker and middle managers

$$\Phi_1 \equiv \pi(S_L, 0) + \pi(S_L, S_M) - \pi(0, S_M) - \omega = 0$$

indifference of S_M between employment as a middle managers and executive manager

$$\Phi_2 \equiv W_m(S_M, \bar{S}) - W_f(S_L, S_M) = 0$$

and the regularity condition

$$\Phi_3 \equiv \int_{S_M}^{\bar{S}} dG(s) - \int_{S_L}^{S_M} dG(s) = 0$$

First, note that Φ_1 and Φ_2 are continuous non-negative functions. Moreover, the implicit function theorem verifies Φ_1 and Φ_2 are downward sloping; $-\frac{\partial\Phi_1/\partial S_M}{\partial\Phi_1/\partial S_L} < 0$ and $-\frac{\partial\Phi_2/\partial S_M}{\partial\Phi_2/\partial S_L} < 0$.

The regularity condition in Φ_3 traces the median skill levels for truncations of $G(\cdot)$ as the domain of skills employed as managers adjusts to changes in S_L. The regularity condition is thus continuous and increasing in the (s, s) skill space; $-\frac{\partial\Phi_3/\partial S_M}{\partial\Phi_3/\partial S_L} > 0$. Thus, Φ_3 must intersect both Φ_1 and Φ_2. An equilibrium must exist at the intersection of either Φ_1 or Φ_2, where pairing of skills (S_L, S_M) is greatest.

Next turn to uniqueness. The three equilibrium conditions potentially overidentify the equilibrium pairing (S_L, S_M). Given that Φ_1 and Φ_2 are strictly downward sloping, and that Φ_3 in non-decreasing, uniqueness can be established by showing that Φ_1 and Φ_2 everywhere have different slopes. (If the incentive conditions have different slopes for all skill levels, then all three conditions can only be satisfied with equality at a single equilibrium pairing (S_L, S_M), and thus avoiding overidentification.)

Computing the slopes of the incentive compatibility conditions we obtain

$$-\frac{\partial\Phi_1/\partial S_L}{\partial\Phi_1/\partial S_M} = -\frac{\pi_1(S_L, S_M) + \pi_1(S_L, 0)}{\pi_2(S_L, S_M) - \pi_2(0, S_M)} \tag{B.1}$$

Substituting the managerial compensation functions (9) and (10) into condition $\Phi_2$we obtain

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

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

$$-\frac{\partial\Phi_2/\partial S_L}{\partial\Phi_2/\partial S_M} = \frac{-\left[\pi_1(S_L, S_M) - \pi_1(S_L, 0)\right]}{\pi_2(0, S_M) + \pi_2(S_L, S_M) - \pi_1(S_M, 0) - \pi_1(S_M, \bar{S})} \tag{B.2}$$

Then using (B.1) and (B.2) and after some algebra, Φ_1 is everywhere more steeply sloped than Φ_2 if the following condition is satisfied:

$$-\frac{\pi_1(S_L, S_M) + \pi_1(S_L, 0)}{\pi_1(S_L, S_M) - \pi_1(S_L, 0)} < -\frac{\pi_2(S_L, S_M) - \pi_2(0, S_M)}{\pi_2(0, S_M) + \pi_2(S_L, S_M) - \pi_1(S_M, 0) - \pi_1(S_M, \bar{S})} \tag{B.3}$$

Note that the L.H.S. of (B.3) is strictly less that -1. Then difference in slope is established by showing that the R.H.S. of (B.3) is everywhere greater than -1. The requirement is

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

which is readily verified by substituting (A.2) and (A.3), and noting that team production is beneficial to at least some members of the economy - i.e. the unit labor requirement for any team $(s, \bar{S})$ is less than $(0, s)$ for all s as described in footnote 7. Q.E.D.

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