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Globalization and firm level adjustment with imperfect labor markets[☆]

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ABSTRACT

In a model with search generated unemployment and heterogeneity on both sides of the labor market, exporting firms are bigger and pay higher wages than other firms. Moreover, there is imperfect persistence in the decision to export and liberalization increases the wage gap between high- and low-skill workers. Openness can increase aggregate productivity in export-oriented markets while generating within-firm productivity *losses* for the weakest firms. In contrast, openness can lead to within-firm productivity gains for the weakest firms in import-competing industries.

1. Introduction

Even within narrowly defined industries, firms that produce similar products often use technologies with different levels of sophistication, employ different occupational mixes of workers and pay different wages. If one looks for patterns across firms, then recent findings suggest that firms that adopt more modern technologies tend to employ more highly-skilled workers and pay higher wages than their counterparts (Doms et al., 1997). The purpose of this paper is to show that by combining this insight with the fact that unemployed workers must search for jobs, we are able to develop a simple model of a product market that is consistent with a large number of the stylized facts about industry dynamics in open economies and the impact of openness on productivity and wages.

The stylized facts of interest can be found in two related strands of the literature. One strand consists of a firm and plant level studies that establish the existence of significant differences between firms that export and those that do not. Exporting firms are typically larger, more capital intensive, more productive and pay higher wages than their counterparts (Bernard and Jensen, 1999a). These studies also indicate that there is "imperfect persistence" in the export decision in that firms often change their export position from one period to the next (Roberts and Tybout, 1997; Bernard and Jensen, 1999a).[1]

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[1] These studies also find that firms typically export only a fraction of their output (Bernard and Jensen, 1999a). As will become evident, this feature is absent from our model due to our assumption of perfect competition in the product market. We could generate this outcome by allowing for monopolistic competition, but have chosen not to do so in order to keep the analysis tractable.

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Related studies have focused on the impact of openness on productivity at the firm and industry levels. One key finding in this strand of the literature is that openness tends to enhance productivity, although the mechanism is unclear.[2] At least three possible explanations have been offered. First, openness may allow exporting firms to take advantage of scale effects as they expand. Second, there may be increases in total factor productivity at the firm level, perhaps due to "learning-by-exporting." Third, since more efficient firms tend to export, liberalization may lead to a reallocation of market shares away from the least productive firms, resulting in higher aggregate productivity. Note that in the latter case, there are no within-firm productivity gains, only an increase in average productivity at the industry level.

Empirical studies do not offer much support for the scale effect explanation (Tybout, 2003), and provide mixed findings for the two other theories. Aggregate productivity gains in export-oriented industries are largely attributed to the fact that (1) it is the relatively efficient firms that choose to export; and (2) openness seems to trigger a reallocation in market shares in favor of these firms (Bernard and Jensen, 1999b; Pavcnik, 2002). It has been difficult to find evidence of within-firm productivity gains in export markets (Clerides et al., 1998; Bernard and Jensen, 1999a,b; Aw et al., 2004).[3] On the other hand, there is evidence of within-firm productivity gains in *import-competing* markets (Pavcnik, 2002; Fernandes, 2007; Topalova, 2007). Q1

Motivated by these stylized facts, we develop a model where the product market is perfectly competitive ~~product~~ but the labor market is beset by frictions. Specifically, our labor market is based on Albrecht and Vroman (2002) where workers with different skill levels search across firms for a job while initially identical firms must choose the type of technology to adopt. In equilibrium, some firms adopt a basic technology, employ relatively low-skilled workers and pay low wages, whereas others adopt a more advanced technology, employ high-skilled workers and pay high wages. One of the key features of the model is that if the revenues generated by the two different types of firms are sufficiently close, it is possible for underemployment to emerge in equilibrium. This occurs when high-skill workers, who are better suited for employment at high-tech firms, accept low-tech jobs because they happen to match with them first. Consistent with other models of firm heterogeneity, we show in the current setting that it is the largest, most productive firms paying the highest wages that face the strongest incentives to export. Moreover, we show that imperfect persistence may arise when equilibrium is characterized by underemployment. This occurs whenever low-tech firms that are matched with high-skill workers prefer to export their output while low-tech firms that are matched with low-skill workers prefer to sell their output domestically. Thus, our model predicts that the weakest firms in the industry may change their export position when the skill mix of its employee base changes.

When we turn to the impact of openness on productivity, we find that the relationship is complicated by the fact that there are two types of equilibria that are possible. Following Albrecht and Vroman, we define a "Cross-Skill Matching" (CSM) equilibrium as one in which high-skill workers will accept low-tech jobs (i.e., they are mismatched) and an "Ex-Post Segmentation" (EPS) equilibrium as one in which they are not willing to do so. If the economy starts in a CSM equilibrium and remains in one after liberalization, then we find that openness enhances productivity in export-oriented markets by reallocating market shares in favor of high-tech firms. However, within-firm productivity is unchanged. As for wages, since openness increases the surplus created by high-tech matches, high-skill workers employed by high-tech firms gain from liberalization. This increases the outside opportunities for high-skill workers with low-tech jobs, forcing the low-tech firms to increase the wages of these workers as well. On the other hand, since the number of low-tech firms shrinks, low-skill workers see their bargaining power eroded and may therefore lose from liberalization.

The fact that liberalization increases the spread between the revenues earned by the two types of firms opens up the possibility that it could cause the economy to move from a CSM equilibrium to an EPS equilibrium. When this occurs, liberalization's impact on productivity and wages is somewhat different. The main reason for this is that when high-skill workers start rejecting low-tech jobs, the number of low-tech firms falls dramatically. As a result, the aggregate productivity gains can be quite large and ~~the wages of low tech workers fall~~. In addition, since low-tech firms can now only attract low-skill workers, there are within-firm productivity *losses* for these firms. Thus, this case yields a surprising prediction: openness can dramatically increase aggregate productivity in export-oriented industries while generating within-firm productivity losses for the weakest firms.

In the latter part of the paper we examine the impact of openness on productivity in import-competing industries. Since import competition *reduces* the gap between the revenues earned by the two types of firms, it opens up the possibility that liberalization could shift the market from an EPS equilibrium to a CSM equilibrium. If so, then the fact that high-skill workers start to accept low-tech jobs means that import competition will generate within-firm productivity gains for low-tech firms.

Our model can be viewed as a contribution along the lines of Melitz (2003), Bernard et al. (2003) and Yeaple (2005). These papers attempt to explain why exporting firms are different from their counterparts, and generate aggregate productivity gains as the result of market share reallocations. In Melitz (2003) and Bernard et al. (2003), heterogeneity on the firm side is exogenous in that productivity is determined by a random draw. Firms make their exporting decision after learning their productivity, and, as in our setting, it is the high-productivity firms that choose to export. Openness then leads to a reallocation of market shares towards high-productivity firms and results in some low-productivity firms exiting the market. Yeaple (2005) generates endogenous heterogeneity across firms in the same manner that we do: initially identical firms make technology choices knowing that different choices allow them to employ different types of workers.[4] He shows that since the high-tech firms gain more from exporting, they

[2] For a survey of this literature see Tybout (2003).

[3] This is actually quite a complex issue. Many papers report increases in productivity just before a firm starts to export that persist and grow after exporting starts. Since the initial increase in productivity comes *before* the firm starts to export, papers such as those cited in the text, view this as something other than "learning-by-exporting." However, others such as Castellani (2002), Baldwin and Gu (2003, 2004), Blalock and Gertler (2004), Girma et al. (2004), Van Biesebroeck (2005) and Greenaway and Kneller (in press) point to the productivity gains *after* exporting begins and conclude that there evidence of learning-by-exporting.

[4] In our opinion, Yeaple's approach is more satisfying since the firm-side heterogeneity is a direct result of profit-maximizing decisions made by the firms.

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have an easier time covering the costs associated with doing so. Consequently, just as in Melitz (2003) and Bernard et al. (2003), high-tech firms self-select into exporting.

While these papers model the relationship between liberalization and industry-wide productivity, none are able to explain within-firm productivity gains due to changes in openness, nor do they address the issue of imperfect persistence.[5] In contrast, our model is able to generate both of these features due the unique manner in which the labor market is modeled. In addition, due to our labor market structure, our model and Yeaple's generate different predictions about the impact of openness on industry wage profiles, an issue we discuss at greater length in the text.

After formulating the model in the following section, we rank-order firms according to their incentive to export (Section 3) and show how the decision to export impinges on domestic supply (Section 4). Sections 5 and 6 illuminate the impact of liberalization on firms and the industry, respectively. We provide some numeric examples in Section 7 to assist in cementing intuition, and briefly conclude in Section 8.

2. The model

2.1. Technology

Our model is adapted from Albrecht and Vroman (2002) in which firms use capital and labor to produce a homogeneous good which is sold in a perfectly competitive product market with free entry. We assume that each firm requires a single manager to coordinate production and that the managerial labor market is characterized by frictions in that it takes time for unemployed managers and firms with vacancies to find each other. In this context, we use the term "manager" as a metaphor for all workers that cannot be found without search (this category would typically include non-production workers). By assuming one vacancy or manager per firm, as is standard in the search literature, we circumvent thorny issues dealing with returns to scale in the search process.

One of the key features of our model is that we allow for heterogeneity on both sides of the labor market. In this regard, we assume that there are two types of managers (high-skilled and low-skilled), where skills are assigned by nature. In contrast, firms are identical ex-ante, but make choices, described below, that result in ex-post heterogeneity.

We assume that firms undertake a series of decisions. The initial decision is whether to enter and create a vacancy and, if so, the type of technology to adopt. For simplicity, we assume that technology adoption is a binary choice, involving adoption of a basic (or "low-tech") technology or an advanced (or "high-tech") technology. The basic technology can be coordinated by managers of either skill level, whereas the advanced technology requires a high-skilled manager. Firms that adopt the advanced technology will pay higher wages and may end up searching longer for a manager, with these costs being offset by greater productivity once the vacancy is filled.

Once a vacancy is filled, the firm negotiates a wage with its manager, acquires all remaining inputs in perfectly competitive markets, and produces output. For simplicity, we treat all other inputs as a composite and call that composite capital. As we show below, firms will also make heterogeneous choices regarding production levels and the market (domestic or foreign) in which to sell that output.[6]

We assume a continuum of risk-neutral managers with a total measure of 1. A fraction q of these managers have low-skills, while the remainder have high-skills.[7]

The set of assumptions sketched here result in three possible types of firms: low-tech firms that employ low-skilled managers, low-tech firms that employ high-skilled managers, and high-tech firms that employ high-skilled managers. Notationally, we refer to these firms types as L, M, and H and define y_{ij} as the amount of output produced by a type-i firm for sale in market j. The skill level of a type-i manager is denoted by s_i (e.g., s_M is the skill level of a low-skill manager employed by a low-tech firm).

For concreteness, we assume that

$$y_{ij} = k_{ij}^{\alpha} s_i \quad i = L, M, H \quad j = d, f \tag{1}$$

where k_{ij} denotes the amount of capital rented by a type-i firm serving market j, d and f represent the domestic and foreign markets, $\alpha \in (0,1)$, and $s_H > s_M > s_L$.[8] Our assumption that $s_M > s_L$ indicates that a low-tech firm is more productive if coordinated by a

[5] There are a small number of papers that attempt to model within-firm productivity changes. Trindade (2004) explains the connection between openness and within-firm productivity gains as the result of a labor-leisure tradeoff decision made by managers of monopolistically-competitive firms. In his model, productivity is determined by managerial effort and managers, who are also consumers, value variety in consumption. By increasing the total variety of goods available, openness increases the rewards of working hard. As a result, liberalization inspires managers to work harder, resulting in higher productivity. Ederington and MacCalman (in press) explain productivity gains in import-competing industries as the result of technology diffusion. The issue of persistence is taken up by Das et al. (2007) who focus on the tradeoff between sunk costs that must be incurred each time a firm changes status from non-exporter to exporter, and the option value of a firm that continues to export.

[6] Except for knife-edge cases, each firm will find one market or the other to be more profitable, and therefore will choose to sell all of its output in a single market.

[7] The exogeneity of the size and composition of the labor force greatly simplifies the analysis and can be justified on empirical grounds in the short-to-medium run. For example, see Currie and Harrison (1997), Revenga (1997), Harrison and Hanson (1999), Topalova (2007), Pavcnik et al. (2004), Attanasio et al. (2004), and Wacziarg et al. (2004).

[8] We show below that a firm may be indifferent between serving the two markets. However, fixed costs rule out the possibility that a firm could earn higher profit from simultaneously serving both markets rather than concentrating on a single market.

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high-skilled manager than it would be if coordinated by a low-skilled manager.[9] Assuming that $s_H > s_M$ indicates that a high-skilled manager is more productive when paired with a high-tech firm than when paired with a low-tech firm.

Once a firm hires a manager (and observes her skill), it rents capital in a perfectly competitive market. We choose capital as numeraire, so the profit-maximizing amount of capital is

$$k_{ij} = p_j \alpha y_{ij} \quad \text{for} \quad i = L, M, H \quad j = d, f \tag{2}$$

where p_j is the price of the good in market j.

For future reference, we define $R_{ij} = p_j y_{ij} - k_{ij} - c_v - c_j$, which is revenue net of non-managerial costs generated by a type-i firm serving market j. Here, c_v represents the cost of creating and maintaining a vacancy, and c_j represents a composite of costs associated with serving market j (this may include maintenance of a distribution network, market research, advertising, and so on).[10] We make the natural assumption that $c_f > c_d$. Using Eq. (2), we have $R_{ij} = (1-\alpha) p_j y_{ij} - c_v - c_j$, which is the surplus that a type-i firm earns by serving market j. This is the surplus over which the manager and firm bargain.

2.2. Search and matching

Unemployed managers and firms with vacancies are randomly matched. Firms observe the skill of the manager with whom they are matched, and managers observe the technology that the firm has adopted. Both the manager and the firm can look forward and know which market (domestic or foreign) generates the higher surplus, and therefore know which market will be served by the firm.[11] The firm and manager then negotiate a wage based on this set of information.

Matches are created according to a function, $m(u,v)$, that exhibits constant returns to scale in unemployment (u) and vacancies (v). Following the standard approach, we define $\theta = v/u$ as our measure of market tightness. Then, with random matching, the arrival rate of vacancies for any manager is given by the ratio of new matches to the total measure of job seekers; or, $m(u,v)/u = m(\theta)$. By similar logic, the arrival rate of managers for any firm is $z(\theta) = m(u,v)/v = m(\theta)/\theta$. We assume that it becomes easier for managers to find a job and more difficult for firms to fill their vacancies as θ increases (i.e., $m'(\theta) > 0 > z'(\theta)$). Finally, we assume that jobs are destroyed at rate δ.[12]

2.3. Firms

As Albrecht and Vroman (2002) show, there are two types of equilibria in this model, depending on whether high-skill managers are willing to accept jobs at low-tech firms. If they are, then we have a "Cross-Skill-Matching Equilibrium" (CSM); whereas if they are not, we have an "Ex-Post Segmentation Equilibrium" (EPS). A CSM equilibrium typically exists if the wages that high-skill managers can expect to earn on the two types of jobs are not too different. Thus, whether these equilibria exist depends upon parameter values and expectations.[13] In some instances, the equilibria co-exist, whereas in other cases, the market equilibrium is unique. We provide more details on this issue below, but for now we assume that a CSM equilibrium exists. This means that high-skilled workers accept any job that is offered to them.

Continuing our description of firms, we use V_L to denote the expected value of present discounted income for a low-tech firm with a vacancy (the asset value of the firm), and V_H to denote the analogous value for a high-tech firm.[14] New firms enter the market as long as the expected discounted value of income is positive.[15] Moreover, entering firms choose the technology that generates the highest expected value of income. In this paper, we only consider steady-state equilibria where the economy is populated by low-tech and high-tech firms, implying the equilibrium condition $V_L = V_H = 0$. The first equality ensures that entering firms are indifferent with respect to the choice of technology, while the second equality ensures that the marginal firm is just indifferent with respect to the entry decision.

[9] Albrecht and Vroman (2002) assume that $s_M = s_L$, which ensures uniqueness of a given type of equilibrium. Our assumption allows for a richer set of results, but precludes us from making general statements about uniqueness.

[10] It is convenient to assume, as we do, that the cost of maintaining a vacancy is the same as the non-wage cost of employing a manager. Therefore c_v is a cost that firms carry even after the vacancy is filled. This assumption allows us to limit the number of parameters.

[11] The firm chooses to serve the market that generates the higher surplus. Both the manager and the firm have the same preferences concerning this decision since they split the surplus generated by the match.

[12] Of course, the job will also be destroyed if either party decides to voluntarily dissolve the match. This approach to modeling the labor market is due to Pissarides (2000) and Mortensen and Pissarides (1994).

[13] As mentioned in footnote 9, Albrecht and Vroman (2002) assume $s_L = s_M$, which ensures that there exists at most one equilibrium of each type. Given our assumption that $s_L < s_M$, we cannot rule out the possibility that there might exist a multiplicity of CSM or EPS equilibria for a given set of parameters. Our results apply to all equilibria.

[14] The derivation of V_k is provided in the Appendix.

[15] Our assumption that the firms make an irrevocable choice of technology implies, for example, that a low-tech firm cannot simply switch to the advanced technology if a shock pushes $V_L < 0 < V_H$. We could have alternatively assumed that an entering firm had to purchase some capital that was compatible with the initial choice of technology. A firm could then switch technology by switching the type of capital. However, this assumption adds complexity without insight. Firm exit is slightly more complicated. The discounted stream of income for a firm that has filled its vacancy is larger than a comparable firm with an open vacancy. A shock to the economy that pushes V_K below zero causes immediate exit of type-k firms with open vacancies. However, firms with filled vacancies have higher expected discounted income, and may therefore continue to produce if expected income remains above zero, only exiting after job separation. A sufficiently large shock can push expected income below zero even for firms with filled vacancies, in which case these firms exit immediately. These firm dynamics are standard in the search literature and consistent with Albrecht and Vroman (2002).

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We use J_{ij} to represent a firm's expected value of present discounted income once it hires a manager. That is, J_{ij} denotes the asset value of a type-i firm that has filled its vacancy and chosen to serve market j for $i=L,M,H$ and $j=d,f$. Using the Bellman equation and the fact that $V_k=0$, we have (where r is the discount rate and w_{ij} is the wage paid by a type-i firm serving market j):

$$rJ_{ij} = \{R_{ij} - w_{ij}\} - \delta J_{ij} \quad \text{for } i = L, M, H;\ j = d, f \tag{3}$$

The standard interpretation of Eq. (3) is that the flow value of the asset (rJ_{ij}) equals instantaneous profit ($R_{ij}-w_{ij}$) less the expected capital loss δJ_{ik}.

2.4. Managers

We now turn to the managers. Define N_{ij} to be the expected lifetime income earned by a manager who is currently employed by a type-i firm that sells its output in market j (for $i=L,M,H$ and $j=d,f$). We then have the following asset value equations for managers

$$rN_{ij} = w_{ij} - \delta\{N_{ij} - U_k\} \quad \text{for } i = L, M, H;\ j = d, f;\ k = L, H \tag{4}$$

and where the Bellman equations defining U_H and U_L are

$$rU_L = m(\theta)\phi_L\left\{\max_j N_{Lj} - U_L\right\} \quad \text{for } j = d, f \tag{5}$$

$$rU_H = m(\theta)\left\{\phi_L \max_j N_{Mj} + (1-\phi_L)\max_j N_{Hj} - U_H\right\} \quad \text{for } j = d, f \tag{6}$$

where ϕ_L represents the fraction of vacancies posted by low-tech firms. As with the firms, the right-hand-side is the sum of flow income and the expected capital gain (or loss) from changing labor market status. Unemployed managers earn no flow income, whereas employed managers collect wages. In Eqs. (5) and (6), note that the job acquisition rate for a high-skill manager is $m(\phi)$ (since they accept all jobs), whereas it is $\phi_L m(\theta)$ for low-skill managers (since they are only offered low-tech jobs). Moreover, an unemployed high-skill manager matches with a low-tech firm with probability $\phi_L m(\theta)$, in which case her capital gain is $\max_j N_{Mj} - U_H$; otherwise, she matches with a high-tech firm and gains $\max_j N_{Hj} - U_H$.

We assume that wages are negotiated with the outcome given by the Generalized Nash Bargaining Solution. If β denotes the bargaining power of managers and U_i denotes the expected lifetime income of a type-i unemployed manager, then wages are given by (see Albrecht and Vroman, 2002)

$$w_{ij} = \beta R_{ij} + (1-\beta)rU_k \quad \text{for } i = L, M, H;\ j = d, f;\ k = L, H. \tag{7}$$

In equilibrium, high-skill managers will be willing to accept low-tech jobs only if they can be paid a wage in excess of the flow value of remaining unemployed. Using Eq. (7), this means that

$$\max_j R_{Mj} - rU_H > 0 \tag{8}$$

which is the key condition that must be met for a CSM equilibrium to exist.

2.5. CSM equilibria

As noted above, a steady-state equilibrium populated by both low-tech and high-tech firms must be characterized by $V_L=V_H=0$. We derive the explicit functional forms for these variables in the Appendix, where we also demonstrate that both can be reduced to functions of θ and γ_L, where γ_L represents the share of low-skilled managers in the pool of unemployed.

In the steady-state equilibrium, it must be the case that the flows into and out of each employment state must be equal. For low-skilled managers this condition is given by

$$\delta(q - \gamma_L u) = \phi_L m(\theta)\gamma_L u, \tag{9}$$

with the analogous condition for high-skilled managers:

$$\delta\{(1-q) - (1-\gamma_L)u\} = m(\theta)(1-\gamma_L)u \tag{10}$$

The key to understanding Eqs. (9) and (10) is to recognize that there are $\gamma_L u$ unemployed low-skilled managers and $q-\gamma_L u$ low-skilled managers who are employed. Correspondingly, there are $(1-\gamma_L)u$ unemployed high-skilled managers and $(1-q)-(1-\gamma_L)u$ high-skilled managers who are employed. All employed managers become unemployed at rate δ, whereas the arrival rate of suitable jobs varies by manager type, with the arrival rate of jobs suitable for low-skilled managers being $\phi_L m(\theta)$ and the arrival rate of jobs for which high-skilled managers are suited being simply $m(\theta)$.

Finally, it must be the case that the product market clears. If we use $D_j(p_j)$ and $S_j(p_d,p_f)$ to denote demand and supply in market j, then

$$D_j(p_j) = S_j(p_d, p_f) \quad \text{for } j = d,f \tag{11}$$

This completes the description of the model when high-skill managers are willing to accept low-tech jobs.

2.6. EPS equilibria

We close this section by describing how the model would be altered in an EPS equilibrium. For this to be the case, the wage paid by low-tech firms cannot exceed the flow utility of unemployment for high-skilled managers (the inequality in Eq. (8) is reversed). Since high-skill managers would be unwilling to accept low-tech jobs, there would be no type-M firms — thus, Eqs. (1)–(5) and (7) would only apply to type-L and type-H firms. In addition, Eqs. (6) and (10) would have to be altered to reflect the fact that low-tech firms would only be able to hire low-skill workers. These equations would become:

$$rU_H = m(\theta)(1-\phi_L)\left\{\max_j N_{Hj} - U_H\right\} \quad \text{for } j = d,f \tag{6$'$}$$

$$\delta\{(1-q)-(1-\gamma_L)u\} = m(\theta)(1-\phi_L)(1-\gamma_L)u \tag{10$'$}$$

There are two factors that determine when CSM and EPS equilibria exist. First, a CSM equilibrium will not exist if low-tech firms cannot afford to pay high-skill managers enough to convince them to stop searching for a better job. This will occur if the revenue generated by a high-skilled manager at a low-tech firm *differs significantly* from the revenue generated if that manager were to be matched with a high-tech firm. This is important since, in the next section, we show that high-tech firms face a stronger incentive to export than low-tech firms. Thus, if liberalization results in high-tech firms exporting while low-tech firms do not, the increase in revenue generated when high-tech firms export can move the economy from a CSM equilibrium to an EPS equilibrium. The second important factor is expectations; and it is this factor that makes it possible to have CSM and EPS equilibria co-exist. To see this, note that if high-skill managers are willing to accept low-tech jobs, then the value from adopting the basic technology will be high and a large number of firms do so. This would make it hard for high-skilled managers to find high-tech jobs, making them more willing to match with low-tech firms. Thus, there are some situations in which self-fulfilling expectations support equilibria of each type for given parameters.

3. The export decision

We are now in position to discuss the firms' export decisions. Unless otherwise noted, we concentrate on CSM equilibria, although it should be clear that our basic message holds for all EPS equilibria as well. A type-i firm will export if the doing so maximizes its asset value — that is, if $J_{if}>J_{id}$. From Eqs. (3), (6), and (7) we have

$$J_{if} - J_{id} = \frac{1-\beta}{r+\delta}(R_{if} - R_{id}) \quad \text{for} \quad i = L,M,H. \tag{12}$$

Q2

Substitute Eq. (2) into Eq. (1) to solve for y_{ij} and then substitute this result into the definition of R_{ij}, and then substitute back into Eq. (12). Doing so yields (with $A = (1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}$)

$$J_{if} - J_{id} = \frac{1-\beta}{r+\delta}\left(A\left[p_f^{\frac{1}{1-\alpha}} - p_d^{\frac{1}{1-\alpha}}\right]s_i^{\frac{1}{1-\alpha}} - [c_f - c_d]\right) \quad \text{for} \quad i = L,M,H. \tag{13}$$

Given our assumption that $c_f>c_d$, it is evident that a firm exports only if $p_f>p_d$. A more interesting finding is that Eq. (13) is increasing in s_i, our measure of managerial skill, Thus we have,

Proposition 1. *If $p_f>p_d$ and $s_H>s_M>s_L$, then type-H firms face the strongest incentives to export while type-L firms face the weakest incentives to export. That is, $J_{Hf}-J_{Hd}>J_{Mf}-J_{Md}>J_{Lf}-J_{Ld}$.*

4. The domestic price

4.1. Autarky

We begin by assuming that the combination of p_f and c_f are such that $J_{if}<J_{id}$ for all firms, regardless of domestic price. A sufficient condition for this inequality to be satisfied can be obtained by evaluating Eq. (13) for a type-H firm when the domestic price is zero. The restriction on parameter values is then $c_f>A(p_f s_H)^{\frac{1}{1-\alpha}}+c_d$. In this case, no type-$H$ firm would choose to export even if the domestic price were to fall to zero. Since type-M and type-L firms derive even less benefit from exporting, no firm will export.

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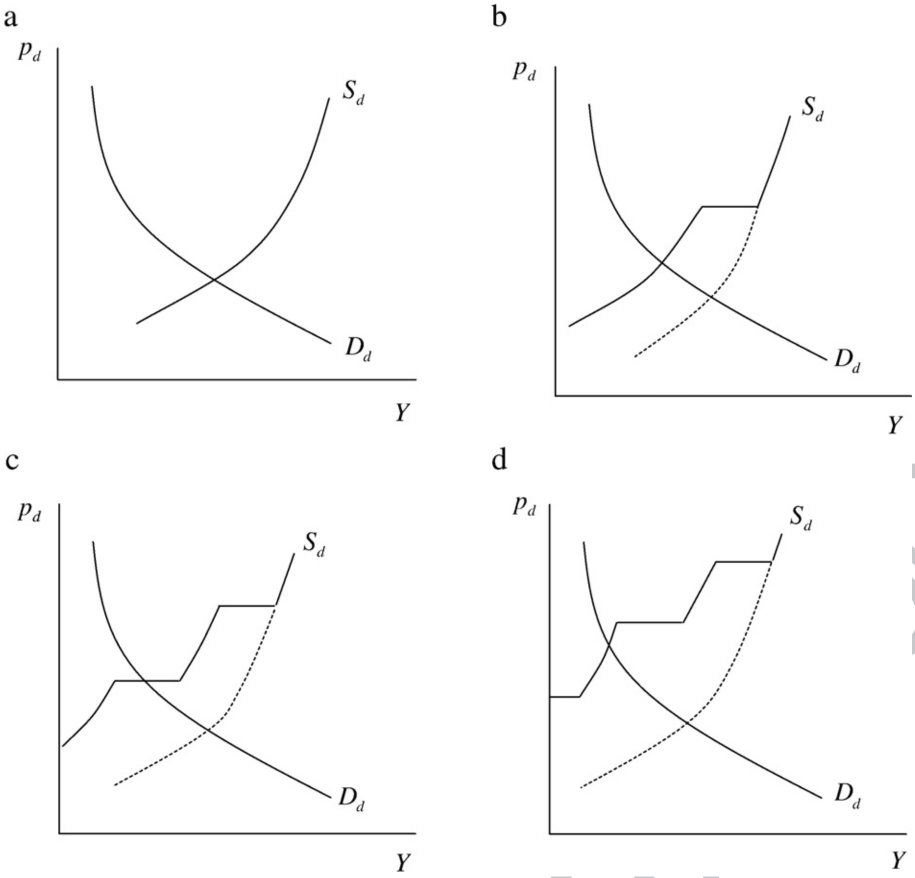

Fig. 1.

We can then solve for the autarkic domestic price.[16] After doing so, we can imagine that there is a reduction in the cost of serving the foreign market (or an increase in the foreign price) that is sufficient to induce at least some firms to start exporting. It is this latter case that we explore in the next subsection.

Each firm serving a given market produces more as the price increases. This is easily seen by substituting Eq. (2) into Eq. (1):

$$y_{ij} = (\alpha p_j)^{\frac{\alpha}{1-\alpha}} s_i^{\frac{1}{1-\alpha}} \quad \text{for} \quad i = L, M, H. \tag{14}$$

Moreover, the higher price of output creates incentive for more entry, further expanding supply. The autarky equilibrium is illustrated in Fig. 1.a.

4.2. Trade

Now suppose that there is a reduction in c_f. In particular, assume that c_f now satisfies $A(p_f s_H)^{\frac{1}{1-\alpha}} + c_d > c_f > A(p_f s_M)^{\frac{1}{1-\alpha}} + c_d$. In this case, type-$H$ firms would export rather than serve the domestic market for sufficiently low domestic prices. However, all other firms would continue to serve the domestic market, shifting the relevant portion of the supply curve leftward, as illustrated in Fig. 1.b.[17] The critical price below which type-H firms export is found by setting $J_{Hf} = J_{Hd}$:

$$p_d = \left(p_f^{\frac{1}{1-\alpha}} - \frac{c_f - c_d}{A s_H}\right)^{1-\alpha} \tag{15}$$

If the domestic price happens to equal this critical value, type-H firms are indifferent between serving either market. This is not a knife-edge result, as there exists a wide range of demand for which this critical price could be the domestic equilibrium. In the

[16] Here we concentrate on the case where this industry would be a net exporter if the cost of serving the foreign market is sufficiently low. We defer discussion of the possibility of imports to a later section.

[17] We are being somewhat informal here. Because of the fixed costs associated with creating and maintaining a vacancy, a sufficiently low domestic price will shut all firms out of the market, resulting in zero output.

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event that the demand curve cuts the supply curve on the step, a portion of type-H firms will serve the domestic market with the remaining firms exporting.[18]

If we continue to let the cost of serving the foreign market fall, we find a range of prices where type-H and type-M firms both prefer exports to serving the domestic market, and the supply curve has two "steps," as in Fig. 1.c. Finally, if the cost of exporting and the domestic price are both sufficiently low, all three types of firms would prefer to serve the foreign market. This is the case in Fig. 1.d. Note that reducing c_f adds additional steps to the supply curve and raises the height of each existing step.

5. Liberalization and firms

A sufficiently large reduction in the cost of serving the foreign market induces some firms to start exporting. Our purpose in this section is to show how the characteristics of these firms change as they switch from serving the domestic market to serving the foreign market, and how these firms compare with those that continue to serve the domestic market.

For illustrative purposes, we consider the case depicted in Fig. 1.c, where costs have fallen low enough so that type-M firms are indifferent between serving the domestic and foreign markets. In this equilibrium, all type-H firms serve the foreign market, while all type-L firms serve the domestic market.

Proposition 2. *Assume a CSM equilibrium in which type-L firms strictly prefer to export, type-H firms strictly prefer to sell their output domestically, and type-M firms are indifferent between exports and domestic sales. Compared with firms that serve the domestic market, exporting firms (a) are larger ($y_{Hf}>y_{Mf}>y_{Md}>y_{Ld}$); (b) employ more non-managerial inputs ($k_{Hf}>k_{Mf}>k_{Md}>k_{Ld}$); and (c) pay wages that are at least as high ($w_{Hf}>w_{Mf}=w_{Md}>w_{Ld}$).*

Proof. Assuming, as we have, that $c_f>c_d$, it follows that $p_f>p_d$ is a necessary condition for any firm to export. Combined with the assumption that $s_H>s_M>s_L$, (a) follows directly from Eq. (14). Part (b) then follows from Eq. (2). To prove part (c), note from the definition of R_{ij} that $R_{Hf}>R_{Mf}=R_{Md}>R_{Ld}$ Then from Eq. (7), we have $w_{Hf}-w_{Mf}=\beta(R_{Hf}-R_{Mf})>0$ and $w_{Mf}-w_{Md}=\beta(R_{Mf}-R_{Md})=0$. Furthermore, $w_{Md}-w_{Ld}=\beta(R_{Md}-R_{Ld})+(1-\beta)(rU_H-rU_L)$, which is positive if $rU_H>rU_L$. We show in the Appendix this last inequality holds, thereby completing the proof. #

Within firm type, exporters are larger than non-exporters because the price in the export market exceeds that in the import market. The higher price raises the value of the marginal product for variable inputs, so firms find it profitable to expand. Comparing different types of firms within the same market, type-H exporters are larger than type-M exporters because of superior technology, while type-M firms that serve the domestic market are larger than type-L firms (also serving the domestic market) because of more skilled management. Similarly, managers at type-H firms earn higher wages than at type-M firms (regardless of export status) because of superior technology, while those at type-M firms (again regardless of export status) earn higher wages than those at type-L firms because they are more skilled.

We specified Proposition 2 for a particular equilibrium configuration, but applications to other equilibria are transparent. For example, the equilibrium illustrated in Fig. 1.b is such that only type-H firms export, with type-M and type-L firms strictly preferring to serve the domestic market. In this case, it follows directly that type-H firms are larger, higher more inputs, and pay higher wages than type-M firms, which in turn are larger, hire more variable inputs, and pay higher wages than type-L firms.

The results of Proposition 2 emerge from complementary models as well.[19] In addition, our model provides a theoretical basis for the stylized fact that firms often change their export decision from one period to the next. That is, the model provides an explanation for the observation of imperfect persistence in the decision to export (see Das et al., 2007 for an alternative explanation).

To begin, we suppose that the equilibrium is qualitatively captured by Fig. 1.b, in which $J_{Hf}-J_{Hd}>0>J_{Mf}-J_{Md}>J_{Lf}-J_{Ld}$. In this case, all type-H firms export and all other firms serve the domestic market. In this case, there is perfect persistence — a firm that exports today always exports tomorrow, and no firm that serves the domestic market today exports tomorrow.[20]

We next turn to the case with $J_{Hf}-J_{Hd}>J_{Mf}-J_{Md}\geq 0>J_{Lf}-J_{Ld}$. The sub case in which $J_{Mf}-J_{Md}=0$ is depicted by Fig. 1.c, and the sub case with $J_{Mf}-J_{Md}>0>J_{Lf}-J_{Ld}$ in Fig. 1.d. In this case, type-H firms always export, and type-L firms always serve the domestic market. Some type-M firms export with the remainder serving the domestic market in the sub case $J_{Mf}-J_{Md}=0$, otherwise all choose to export when $J_{Mf}-J_{Md}>0$. But in the model, the distinguishing feature between type-L and type-M firms lies in the skill of the manager. A type-L firm that loses its low-skilled manager and finds a high-skilled replacement graduates to type-M status. Similarly, a type-M firm that finds only a low-skill manager to replace a lost high-skilled manager moves down to type-L status. In the context of the model, a change in export status is not driven by changes in market conditions, but by firm-level shocks.

If we use $\pi_S(i)$to represent the "export survival rate" for a type-i firm (defined to be the probability that firm exports next period conditional on exporting today), then it follows that $\pi_S(H)=1$ and $\pi_S(M)=(1-\delta)+\delta(1-\gamma_L)m(\theta)$.[21] Similarly, if we use $\pi_B(i)$to denote the "export birth rate" for a type-i firm (defined to be the probability that a firm starts exporting tomorrow given that it is currently not exporting), then we have $\pi_B(L)=\delta(1-\gamma_L)m(\theta)$.[22] Combining these results with Proposition 2, we have,

[18] Depending on parameter values, it is possible that these critical prices at which firms are indifferent between markets are lower than the minimum price consistent with a CSM equilibrium. In such situations, no firm would choose to export if a CSM equilibrium exists.

[19] For example, Bernard et al. (2003), Melitz (2003) and Yeaple (2005).

[20] Note that Fig. 1.a is also consistent with perfect persistence, as no firm would ever choose to export.

[21] Note that $\pi_S(L)$ is not defined.

[22] In this case, $\pi_B(H)$ and $\pi_B(M)$ are not defined.

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Table 1

Endogenous variables	$c_f > 25$	$c_f = 2$		
		$\eta = \infty$	$13.3 < \eta < 46.9$	$\eta < 6.4$
p_d	0.939	0.939	0.949	0.959
w_L	11.35	11.30	11.61	11.92
w_M	15.66	16.22	16.21	16.50
w_H	17.75	18.59	18.58	18.69
ϕ_L	0.714	0.666	0.672	0.686
MS_H	0.134	0.157	0.154	0.147
μ	0.049	0.052	0.051	0.049

Parameter values: $\alpha = 0.5$, $\beta = 0.5$, $\delta = 0.2$, $,r = 0.05$, $q = 2/3$, $s_H = 10$, $s_M = 9$, $s_L = 8$, $c_v = 2$, $c_d = 0$, $p_f = 1$, $c_f = 2$.

Proposition 3. *In any Cross-Skill Matching Equilibrium with Imperfect Persistence, the export survival rate is positively correlated with the wage the firm pays. The export birth rate is positive only for firms that pay the lowest wages in the industry.*

Proposition 3 is consistent with Bernard and Jensen's (2004) finding that the probability of exporting in period t given that a firm was an exporter in $t-1$ is increasing in the size and productivity of the firm.[23]

6. Liberalization and the industry

We now turn to a slightly different issue — what is the impact of liberalization on productivity and wages in export-oriented markets? To examine this, we begin by assuming that the cost of serving the foreign market is so high that no firms choose to export and equilibrium is characterized by Fig. 1.a. We then assume that the cost of serving the foreign market falls low enough so that type-*H* firms choose to export, while all other firms continue to serve the domestic market.[24] The latter equilibrium is illustrated in Fig. 1.b.

Clearly, the domestic price increases as the cost of exporting falls. Moreover, we must have $p_f > p_d$, otherwise no firms would export. Since all firms initially serve only the domestic market, we can conclude that type-*H* firms enjoy a larger increase in price compared with other firms. The price increase resulting from liberalization leads to expansion by existing firms and new entry. However, since type-*H* firms gain more than others, they expand by a greater amount and the overall fraction of firms using the advanced technology increases.

Since liberalization increases the prices received by firms, the surplus to be split between the firm and its worker increases. However, the increase in price is larger for firms that export; hence the increased surplus for type-*H* firms is higher than it is for others. The greater surplus induces new entry by both types of firms, with relatively more new entry by type-*H* firms. As a result, the share of vacancies posted by low-tech firms (ϕ_L) falls. Moreover, higher prices induce existing firms to expand by employing more non-managerial inputs, with type-*H* (exporting) firms expanding by a greater amount than those that serve only the domestic market. As a result of the reallocation of market shares towards type-*H* firms, measured productivity in the industry increases. But, at the firm level, all increased productivity can be fully attributed to the increased employment of non-managerial inputs, thus there are no within-firm increases in total factor productivity.[25]

As for wages, note that high-tech employees benefit from these changes since the surplus they share with their firm ~~has~~ increases (p_f is larger than the initial price) and their bargaining power increases (ϕ_L falls). Both effects work to increase w_H. The wages for low-skilled managers can rise or fall. On the one hand, the surplus created by low-tech firms increases (p_d is larger than the initial price), which works in favor of low-skilled managers. On the other hand, the fall in ϕ_L weakens their bargaining position, thereby putting downward pressure on their wage. Finally, consider the fate of high-skilled managers employed by low-tech firms. It should be clear that their wage, w_M, increases since the surplus created by these firms increases and the bargaining position improves for these workers. The latter is due to the decline in ϕ_L combined with better outside opportunities (i.e., the increase in w_H).

Of course, all of these results depend upon the assumption that high-skill managers are still willing to accept job offers from adopters of the basic technology — that is, we remain in a CSM equilibrium. We summarize these results in Proposition 4.

Proposition 4. *Suppose that the economy begins in a CSM equilibrium and that liberalization then results in a new CSM equilibrium. Then liberalization reallocates market shares in favor of type-H firms; thereby triggering an increase in productivity at the industry level. In addition, liberalization increases the wages earned by all high-skill managers; whereas the wages of low-skill managers might rise or fall. In either case, the gap in wages between what the highest paid and the lowest paid managers earn increases.*

Our predictions about the impact of openness on wage profiles differ significantly from Yeaple (2005). Although both models predict gains for high-skill workers from liberalization, Yeaple's model predicts nominal wage losses for workers earning *moderate*

[23] Using a different model of entry and exit behavior, Das et al. (2007) provide evidence for a sample of Colombian firms suggesting that the weakest firms within an industry are those that are most likely to be near the threshold of indifference between exporting or not.

[24] It is straight forward to extend the analysis to the case where type-*M* firms and then type-*L* firms choose to export.

[25] There is a bit of a semantic issue in our definition of a firm. For example, suppose that a low-tech firm exits and then chooses to re-enter after having adopted the advanced technology. Based on our terminology, an old firm has exited and a new one has entered, with no change in firm-level productivity. In practice, this would show up as a within-firm productivity gain due to an improvement in technology. But this firm would then be re-classified as a high-tech firm.

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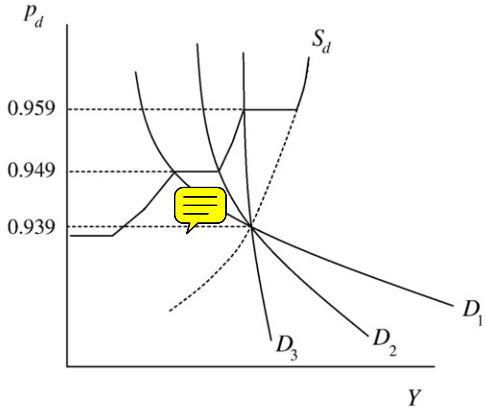

Fig. 2.

wages and no change in the wages earned by the least skilled workers in the economy. In contrast, our model predicts gains for workers earning high and moderate wages, with possible losses for those at the low end of the skill distribution. Our results are therefore consistent with recent empirical findings that (1) exporting is associated with increases in wage inequality between high-skill and low-skill workers, and (2) wages of the least skilled workers have declined over the last 30 years as markets have become more open (see, for example, Bernard and Jensen, 1997; Harrison and Hanson, 1999; Baldwin and Cain, 2000).

The fact that the wages paid by type-*H* firms rise faster than those paid by type-*L* firms opens up the possibility that after liberalization high-skill managers may no longer be willing to accept low-tech jobs. If this is the case, liberalization switches the economy to an EPS equilibrium. When this occurs, the wages of high-skill managers increase but the wages of low-skill managers fall. The reason for this is as follows. In the CSM equilibrium the wages of low-skill managers are propped up by the fact that high-skill managers are willing to match with low-tech firms. This means that it is easy for such firms to find a match and thus, a large number of vacancies are created by low-tech firms. This gives the low-skilled managers bargaining power and allows them to earn a relatively high wage. But, when liberalization causes the market to switch to a EPS equilibrium, it becomes much harder for low-tech firms to find a match, so fewer low-tech vacancies are created (or, alternatively, type-*L* and type-*M* firms exit upon loss of their manager). As a result, the bargaining power of low-skilled managers falls and so does their wage.

As for productivity, the reduction in the number of type-*L* and type-*M* firms coupled with the entry by new type-*H* firms results in a big reallocation of market shares in favor of type-*H* firms. This can result in large aggregate productivity gains. However, this gain would be somewhat moderated by within-firm productivity *losses* for low-tech firms. This follows from the fact that these firms would no longer be able to attract high-skilled managers and would have to rely on low-skilled managers.

7. Numeric examples

We offer some examples to highlight the impact of openness on market shares and wages and to demonstrate the richness of the model. We follow Albrecht and Vroman (2002) and use a matching function that is Cobb–Douglas in u and v so that $m(\theta)=2\sqrt{\theta}$. Our parameter values are specified in Table 1. For purposes of our first example, we assume that c_f, the cost of serving the foreign market, is initially too high for any domestic firm to export.[26] We then allow c_f to fall, creating the potential for some domestic firms to start exporting. The actual set of firms that export depends on the endogenously-determined domestic price compared with the exogenous foreign price and associated costs of serving the domestic and foreign markets. In turn, the endogenous p_d depends, in part, on domestic demand. We capture a range of cases by assuming that domestic demand is iso-elastic such that

$$D_d(p_d)=\Phi(p_d)^{-\eta}. \tag{16}$$

We vary Φ and η so that the demand curve rotates about an arbitrarily-chosen point on the autarky supply curve. The trading equilibrium then depends on the elasticity of demand (and the constant term), whereas the autarky equilibrium is independent of this elasticity. Key aspects of our example are displayed numerically in Table 1 and visually in Fig. 2.

Using Eq. (13), we solve for values of p_d at which the three types of firms are indifferent between domestic and foreign sales. These prices form the perfectly elastic portions of the domestic supply curve. For example, type-*H* firms strictly prefer to export if $p_d<0.959$, and strictly prefer to serve the domestic market if $p_d<0.959$.

[26] This value was calculated based on the condition given in the first paragraph of Section 4.1, which provides a sufficient condition for excluding domestic firms from foreign sales.

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We arbitrarily choose autarky equilibrium such that p_d = 0.939. We then allow c_f to fall. In the first scenario, we assume that domestic demand is infinitely elastic, so that the equilibrium domestic price remains unchanged. In this case, both type-*M* and type-*H* firms choose to export, while type-*L* firms serve only the domestic market.

The consequences for the three wages are illustrated in Table 1. The wage for low-skilled managers falls from 11.35 to 11.30, whereas w_M and w_H both increase, with the latter increasing proportionately more than the former. The wage falls for low-skilled managers because the surplus earned by their employing firms is unchanged (due to the unchanged market price) while their bargaining power erodes. The erosion of bargaining power follows from the fact that a smaller proportion of vacancies are created for low-skilled managers (ϕ_L falls). In turn, the reason that ϕ_L falls is that increased export opportunities for type-*M* and type-*H* firms causes these firms to expand while simultaneously providing stronger incentives for new entrants to adopt the advanced technology. The fall in ϕ_L is mirrored by an increase in MS_H, the market share of type-*H* firms.

Mismatched high-skilled managers see a small increase in their wage due to ~~the increase in the due to exporting,~~ their increased bargaining strength as more type-*H* firms enter the market~~,~~ and the fact that their outside options improve as w_H rises. Finally, high-skilled managers employed at type-*H* firms gain even more because of increased bargaining strength combined with the fact that the differential surplus earned by type-*H* firms vis-à-vis type-*M* firms is increasing in output price.

The reduction in c_f results in an increase in p_d for any finite elasticity of demand. The set of firms that choose to export is unchanged for any $\eta \in (46.9, \infty)$. Domestic price increases as demand becomes less elastic within this range. The higher domestic price increases the surplus earned by type-*L* firms without changing market conditions for type-*M* or type-*H* firms, both of which sell all output in the foreign market. More new entrants choose the basic technology, and existing type-*L* firms expand. Both effects reverse the initial fall (under an assumption of infinitely elastic demand) in ϕ_L. In turn, the wage for low-skilled managers begins to increase. For a sufficiently high domestic price, the wage for low-skilled managers surpasses its autarkic value.

For $\eta \in (13.3, 46.9)$, p_d equilibrates at the level for which type-*M* firms are indifferent between serving the two markets. Wages for high-skilled managers are higher at this equilibrium compared with autarky values, but very slightly lower compared with the case where low trade costs are coupled with perfectly elastic domestic demand. The reason for the slight decline is due to the very slight erosion in bargaining position resulting from the choice of more new entrants to adopt the basic technology.

The equilibrium p_d increases as the elasticity of demand falls below 13.3 and reaches its maximum value for $\eta < 6.4$, at which point type-*H* firms are indifferent between serving the two markets. As p_d increases above 0.949, type-*M* firms stop exporting and serve only the domestic market. Further increases in p_d therefore provide a benefit to type-*L* and type-*M* firms, but have no direct impact on type-*H* firms, which continue to export. The increased surplus for type-*L* and type-*M* firms creates relatively more low-tech firms, driving ϕ_L up and MS_H down. The bargaining power of low-skilled managers is therefore enhanced at the expense of the bargaining power of high-skilled managers.

Finally, we note in passing that the equilibrium unemployment rate is somewhat responsive to market conditions, but the degree of responsiveness is small. The initial set of assumptions regarding demand elasticity and trade costs results in higher unemployment compared with autarky because the number of vacancies available for low-skilled managers falls and these managers are in the majority. As demand parameters change and domestic price increases, more vacancies suitable for low-skilled managers are created and the unemployment rate is gradually reduced.

Table 2 shows what can happen when market conditions change sufficiently to push the economy from a CSM equilibrium to an EPS equilibrium. In constructing this example, we focus on the case where the elasticity of domestic demand is small enough so that it intersects with the top step of the domestic supply curve. All of the underlying parameters are the same as those used to generate Table 1 except for p_f, which we initially set equal to 1.110, then allow to increase to 1.111. From Eq. (18), the equilibrium domestic prices for the two scenarios are 1.073 and 1.074. Given the other parameters of the model, it can be shown that 1.073 is the highest domestic price consistent with a CSM equilibrium. The thought experiment in which the foreign price increases by less than one hundredth of a percent therefore concludes with the economy switching from a CSM equilibrium to an EPS equilibrium. Even if a high-skilled manager were offered the entire surplus generated by a low-tech firm, she would find it in her interest to turn down the job offer and continue searching for a high-tech firm. As Table 2 shows, the resulting equilibrium is dramatically different compared with the initial equilibrium. Because low-tech firms can no longer attract high-skilled managers, many fewer new entrants choose this route. This is seen by the significant reduction in ϕ_L. Because there are fewer vacancies for low-skilled managers, the bargaining power of this group erodes and their wage falls by nearly 1%. In contrast, high-skilled managers have a stronger bargaining position. Consequently, their wages increase dramatically. Managers who might have ~~formally~~ been mismatched have a wage increase in

Table 2

Endogenous variables	p_f = 1.110	p_f = 1.111
p_d	1.073	1.074
w_L	15.48	15.33
w_M	21.33	–
w_H	24.07	24.80
ϕ_L	0.66	0.528
MS_H	0.159	0.437
μ	0.045	0.063

Parameter values: α = 0.5, β = 0.5, δ = 0.2, r = 0.05, q = 2/3, s_H = 10, s_M = 9, s_L = 8, c_v = 2, c_d = 0, c_f = 2.

excess of 15%. Even those who would have been properly matched in the CSM equilibrium find a wage increase of 3%. These large changes were triggered by a change in price that is less than 0.01%.

Two other numbers reported in Table 2 deserve mention. First, the move to an EPS equilibrium results in a big increase in the market share of type-*H* firms. In turn, this triggers an increase in aggregate productivity despite the fact that low-tech firms become less productive. We note also that there is a fairly dramatic upswing in the unemployment rate. A small part of this change is due to the fact that there are fewer firms searching for low-skilled managers, and these managers are, in our parameterization, in the majority. The larger effect is that high-skill managers are now choosier about the jobs that they accept, therefore the average duration of unemployment increases for this group.

Although our main focus in this paper is on export-oriented industries, we close this section with a brief discussion of our model's predictions about the impact of openness on productivity in import-competing industries.[27] Our goal is to show that, consistent with the evidence, openness can increase within-firm measures of productivity by changing the job market preferences of high-skill workers.

When the model applies to an import-competing industry, liberalization lowers the price received by all firms. This reduction in price causes all firms to contract by utilizing fewer variable inputs, and narrows the gap between the revenues generated low-tech and high-tech firms. If high-skill managers are unwilling to accept low-tech jobs in the closed economy, then the may become willing to do so once trade is liberalized. If this occurs, then total factor productivity of the low-tech firms rises with liberalization.

Recall that Albrecht and Vroman showed that there exist parameterizations that could support both a CSM and an EPS equilibrium. In our model, our parameterizations are consistent with both types of equilibria for all $p_d \in (0.74, 1.11)$. We can then imagine that the economy begins at an EPS equilibrium at a price within this range, but then import competition pushes the domestic price lower. If the new price remains in this range, there are two possible outcomes. First, high-skilled managers may remain optimistic about finding jobs with high-tech firms, and these firms do not become worried that high-skilled managers will start to accept jobs at low-tech firms. Under these conditions, the economy will simply shift to a new EPS equilibrium at a lower output price.

However, it is perhaps easier to imagine newly unemployed high-skilled managers hearing news about an increase in import penetration in their industry and becoming pessimistic about their job prospects.[28] If so, they might begin to accept any job offer that comes along, and the economy could converge to a CSM equilibrium instead. This new equilibrium would then be characterized by low-tech firms that are, on average, more productive than they would have been in the closed economy. That is, type-*M* firms (which were non-existent in the initial equilibrium) are more productive than type-*L* firms. Thus, our model yields a fairly sharp prediction concerning within-firm productivity gains from liberalization in import-competing industries: these gains should tend to occur at the weakest firms in the industry and they should be negatively correlated with the firm's wage (in that low-wage firms are more likely to gain by matching with higher-skilled managers).[29]

We close this section with a brief discussion of whether the within-firm productivity changes predicted by our model provide an explanation of the productivity changes that have been uncovered in the empirical literature. It is clear that the researchers in this area are looking for a link between openness and total factor productivity (TFP); that is, they are *not* looking for productivity changes that can be explained by changes in the factors used in the production process as a result of trade liberalization. In an attempt to avoid such confusion, most researchers attempt to control for the factors used in production. For example, Pavcnik (2002), who provides perhaps the most complete and careful approach to this issue, controls for the skill mix of labor used in each plant. Thus, if the plants in her sample responded to changes in openness by changing the skill-intensity of the production process and if this led to changes in productivity, this would not show up in the data as a change in TFP.

In our model, within-firm productivity changes are driven by changes in the quality of workers that firms can attract. An econometrician who observes and controls for this quality change would therefore find that there is no change in TFP. One might be tempted to view this as just a change in the skill mix of labor and dismiss it as something already controlled for in Pavcnik's study. There is, however, a subtle but important distinction between the story that we are telling and one consistent with a change in the skill-intensity of production in Pavcnik's model. To see this, note that in Pavcnik's model plants are assumed to use Cobb–Douglas technologies with unskilled labor, skilled labor and capital as the primary inputs. So, for example, we can imagine a firm that combines non-production workers (managers, in our model) with production workers, capital, and raw materials (all part of the composite *k* in our model) to produce some final product. Suppose that liberalization leads the firm to substitute non-production workers for production workers and this substitution alters overall productivity. Pavcnik's approach would control for this change and would lead one to conclude that there is no change in TFP. Our story is somewhat different. In our model, there is heterogeneity

[27] As suggested by an anonymous referee, our lack of a general-equilibrium structure may overly simplify the analysis. In a multi-sector model where managers can flow between sectors, the degree of surplus in one sector may impinge on the type of equilibria possible in the other. While these concerns are certainly reasonable, refer back to footnote 7 where we provide references to recent evidence that between-sector flows in the short-to-medium run are quite small, suggesting that that our partial-equilibrium approach has merit.

[28] Recent survey research suggests that such a scenario is highly credible. For example, Scheve and Slaughter (2004) find that a significant portion of the US workforce fears that liberalization weakens job security.

[29] Fernandes (2007) finds that productivity gains due to liberalization are greater in larger plants, where larger plants are considered to be those with more than 50 employees prior to liberalization. According to note 30 in her paper, this correlation is robust to measuring plant size using market share. However, her explanation is that larger plants use more imported inputs (see her note 36). We do not consider this channel in our model. Using a sample of Indian firms, Topalova (2007) does not find any notable relationship between firm size and the effect of liberalization on productivity. In her analysis, large firms are in the top 1 percent of the sales distribution, medium firms have sales above the median (excluding firms already classified as large), and small firms are those with sales below the median. Topolova offers the suggestion that firm size may not be significant in her analysis because all firms in her sample (i.e., publicly listed firms) are substantially larger than the average Indian firm. Neither of these papers offers a clean test of our model.

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in terms of ability within each skill class of workers and openness alters the *quality* of non-production workers that firms can attract. Thus, it is as if openness alters the *effective* units of labor generated by the average worker hired by the firm. As far as we know, no empirical study has controlled for this. It follows that if openness triggers the types of within-firm productivity changes predicted by our model, they would show up in the residual in empirical studies — in other words, they would show up as changes in TFP.

8. Conclusion

We have presented a model based on Albrecht and Vroman (2002) in which managers differentiated by ability search over firms for jobs. Initially identical firms are ex-post heterogeneous as some adopt a basic technology and pay low wages, whereas others adopt a modern technology, employ high-skilled managers and pay high wages. As in Melitz (2003), Bernard et al. (2003), and Yeaple (2005), we find that exporting firms are typically larger, more productive, and pay higher wages than their counterparts. In addition, as in Yeaple (2005), the firm-side heterogeneity in our model arises endogenously as a natural outcome of profit-maximizing decisions.

Our paper departs from previous work in the manner in which the labor market is modeled. Building on the insights of Albrecht and Vroman (2002), we have shown that industry dynamics are largely determined by two factors: the types of firms different managers are *willing* to match with and the types of matches that *actually* occur. In particular, we have shown that when high-skilled managers are willing to accept low-tech jobs, imperfect persistence in the decision to export is a natural feature of equilibrium in that these firms will export when matched with high-skilled managers and sell their output domestically when matched with low-skilled managers. Thus, our model yields strong predictions about how the export survival and birth rates will vary with firm level measures of productivity and wages.

We have also shown that when high-skilled managers match with adopters of basic technology, openness enhances productivity in export markets by reallocating market shares in favor of the most productive firms. In this case, openness has no impact of within-firm measures of total factor productivity. While these two results can also be found in Melitz (2003), Bernard et al. (2003) and Yeaple (2005), a new possibility emerges in our model due to the fact that openness alters the spread between the revenues earned by firms that choose different technologies. In export markets, this spread is increased, causing the wages offered by the firms to diverge; whereas in import-competing markets the spread is decreased, causing the wage gap to contract. As a result, liberalization may alter the job-market preferences of the high-skilled managers. We have shown that in export markets, liberalization may cause high-skilled managers to reject job offers from firms that have adopted the basic technology. This then leads to large aggregate productivity gains due to market share reallocations and within-firm productivity *losses* for the weakest firms in the industry. In contrast, liberalization may cause high-skilled managers to start to accept these same jobs in import-competing industries. This would lead to within-firm productivity gains at this set of firms, an outcome that is consistent with recent empirical findings.

Our model also allows us to derive predictions that differ from Yeaple (2005) about the link between openness and the wage gap between skill groups. Since exporting increases the surplus generated by high-tech firms, high-skilled managers employed by these firms gain the most from liberalization. High-skilled managers employed by low-tech firms gain as well, since their outside opportunities are enhanced by the increase in wages paid by high-tech firms. Low-skilled managers, on the other hand, suffer nominal wage losses unless the domestic price rises sufficiently. The reason for this is that the shift in market shares away from low-tech firms (the only firms offering jobs to these workers) lowers the outside opportunities for low-skilled managers and weakens their bargaining power. These results are consistent with recent evidence that finds the wage gap between high-skilled and low-skilled rising as markets become more open.

There are a variety of ways to test the many predictions our model yields. We close by suggesting one test that we find particularly intriguing. In a paper closely related to Albrecht and Vroman (2002), Acemoglu (1999) presents a model of a labor market in which high-skilled and low-skilled workers search across (possibly) heterogeneous firms for jobs. He shows that two types of equilibria can exist. In the first, which he refers to as a "separating equilibrium," some firms create high-tech jobs and match only with high-skilled workers while other firms create low-tech jobs and match only with low-skilled workers (thus, this is similar to the EPS equilibrium in the Albrecht–Vroman model). In the other equilibrium, which he refers to as a "pooling equilibrium," all firms create the same type of jobs and match with both types of workers. Acemoglu refers to these jobs as "middling" and shows that middling jobs will be offered only when the relative productivity of high-skilled versus low-skilled workers is not too great; otherwise, equilibrium entails separation. In the latter part of his paper, Acemoglu (1999) offers a variety of evidence that in many industries middling jobs have been disappearing and have been replaced by the type of jobs that would be offered in a separating equilibrium. If we apply the logic presented in this paper to Acemoglu's model, the conclusion is that openness should cause middling jobs to *disappear* in export-oriented industries and *appear* in import-competing industries. This follows from the fact that exporting increases the spread between the revenues that the two types of workers can generate, while import competition decreases this spread. In his empirical analysis, Acemoglu does not separate his industries into groups based on their trade status. Our paper suggests that doing so might allow for a direct test of our model's prediction that openness can alter the nature of the labor market equilibrium.

9. Uncited reference

Q3

Hanson and Harrison, 1999

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Appendix A. Solution algorithm

The Bellman equations for unfilled vacancies can be written as:

$$rV_L = -c_v + z(\theta)\left\{\gamma_L \max_j J_{Lj} + (1-\gamma_L)\max_j J_{Mj} - V_L\right\} \qquad \text{for } j = d,f \tag{A.1}$$

$$rV_H = -c_v + z(\theta)(1-\gamma_L)\left\{\max_j J_{Hj} - V_H\right\} \qquad \text{for } j = d,f. \tag{A.2}$$

The right-hand sides of Eqs. (A.1) and (A.2) both incorporate the instantaneous flow cost of maintaining the vacancy plus the expected capital gain earned in the event that a match is made. In both Eqs. (A.1) and (A.2), the expected capital gain incorporates the firm's optimal export decision upon finding a match. Eq. (A.1) takes into account that a low-tech firm can employ managers of either skill level, whereas Eq. (A.2) recognizes that the marginal product of a low-skilled manager is zero when employed by a high-tech firm.

In a steady state, $V_H = 0 = V_L$. Moreover, we can use the definition of R_{ij} and Eqs. (3)–(7) to solve for J_{ij} a function of ϕ_L and θ. Therefore we have

$$c_v = \frac{z(\theta)\left\{\gamma_L \max_j J_{Lj}(\phi_L,\theta) + (1-\gamma_L)\max_j J_{Mj}(\phi_L,\theta)\right\}}{r + z(\theta)} \qquad \text{for } j = d,f \tag{A.3}$$

$$c_v = \frac{(1-\gamma_L)z(\theta)\max_j J_{Hj}(\phi_L,\theta)}{r + (1-\gamma_L)z(\theta)} \qquad \text{for } j = d,f \tag{A.4}$$

Eqs. (A.3) and (A.4) form a system of two equations in three unknown variables: θ, γ_L, *and* ϕ_L. We can use steady-state conditions (9) and (10) to solve for ϕ_L and u as functions of θ and γ_L. Substitution of $\phi_L(\theta, \gamma_L)$ allows us to then solve Eqs. (A.3) and (A.4) for θ and γ_L.

Appendix B. The value of search

The validity of Proposition 2.c requires $rU_H > rU_L$. From Eqs. (4)–(7):

$$rU_L = \frac{\beta\phi_L m(\theta)}{r + \delta + \beta\phi_L m(\theta)} R_{Lj} \qquad \text{for } j = d,f \tag{A.5}$$

$$rU_H = \frac{\beta m(\theta)}{r + \delta + \beta m(\theta)}\{\phi_L R_{Mj} + (1-\phi_L)R_{Hj}\} \qquad \text{for } j = d,f \tag{A.6}$$

From Eq. (A.6) and the requirement that $0 < \phi_L < 1$, we have

$$rU_H > \frac{\beta\phi_L m(\theta)}{r + \delta + \phi_L\beta m(\theta)}\{\phi_L R_{Mj} + (1-\phi_L)R_{Hj}\} \qquad \text{for } j = d,f. \tag{A.7}$$

Comparing Eq. (A.7) with Eq. (A.5), it follows directly that $rU_H > U_L$ if and only if

$$\phi_L R_{Mj} + (1-\phi_L)R_{Hj} > \phi_L R_{Lj} \qquad \text{for } j = d,f \tag{A.8}$$

This last inequality is satisfied by the fact that $R_{Hj} \geq R_{Hj} \geq R_{Lj}$ for $j = d,f$.

References

Acemoglu, D., 1999. Changes in unemployment and wage inequality: an alternative theory and some evidence. American Economic Review 89, 1259–1278.

Albrecht, J., Vroman, S., 2002. A matching model with endogenous skill requirements. International Economic Review 43, 282–305.

Attanasio, O., Goldberg, P., Pavcnik, N., 2004. Trade reforms and wage inequality in Colombia. Journal of Development Economics 74, 331–366.

Aw, B.Y., Chung, S., Roberts, M., 2004. Productivity and turnover in the export market: micro evidence from Taiwan and South Korea. World Bank Economic Review 14, 65–90.

Baldwin, J., Gu, W., 2003. Export market participation and productivity performance in Canadian manufacturing. Canadian Journal of Economics 36, 634–657.

Baldwin, J., Gu, W., 2004. Trade liberalization: export-market participation, productivity growth innovation. Oxford Review of Economic Policy 20, 372–392.

Baldwin, R., Cain, G., 2000. Shifts in US relative wages: the role of trade, technology, and factor endowments. Review of Economics and Statistics 92, 580–595.

Bernard, A., Jensen, J.B., 1997. Exporters, skill upgrading, and the wage gap. Journal of International Economics 42, 3–31.

Bernard, A., Jensen, J.B., 1999a. Exceptional exporter performance: cause, effect or both? Journal of International Economics 47, 1–25.

Bernard, A., Jensen, J.B., 1999b. Exporting and productivity. NBER Working Paper No. 7135.

Bernard, A., Jensen, J.B., 2004. Why some firms export. Review of Economics and Statistics 86, 561–569.

Bernard, A., Eaton, J., Jensen, J.B., Kortum, S., 2003. Plants and productivity in international trade. American Economic Review 94, 1265–1290.

Blalock, G., Gertler, P., 2004. Learning from exporting revisited in less developed settings. Journal of Development Economics 75, 397–416.

Castellani, D., 2002. Export behavior and productivity growth: evidence from Italian manufacturing firms. Weltwirtschaftliches Archiv 138, 605–628.

Clerides, S., Lach, S., Tybout, J., 1998. Is learning by exporting important? Micro-dynamic evidence from Columbia, Mexico, and Morocco. Quarterly Journal of Economics 113, 903–947.

Currie, J., Harrison, A., 1997. Trade reform and labor market adjustment in Morocco. Journal of Labor Economics 15, S44–S71.

Das, S., Roberts, M., Tybout, J., 2007. Market entry costs, producer heterogeneity, and export dynamics. Econometrica 75, 837–873.

Doms, M., Dunne, T., Troske, K., 1997. Wages, workers, and technology. Quarterly Journal of Economics 112, 252–290.

Ederington, J., MacCalman, P., in press. Endogenous firm heterogeneity and the dynamics of trade liberalization. Journal of International Economics. Q4

Fernandes, A., 2007. Trade policy, trade volumes and plant-level productivity in Columbian manufacturing industries. Journal of International Economics 71, 52–71.

Girma, S., Greenaway, G., Kellner, R., 2004. Does exporting increase productivity? A microeconomic analysis of matched firms. Review of International Economics, 12, 855–866.

Greenaway, D., Kneller, R., in press. Exporting, ~~agglomeration~~ and ~~productivity,~~ European Economic Review. Q5

Hanson, G., Harrison, A., 1999. Trade and wage inequality in Mexico. Industrial and Labor Relations Review 52, 271–288.

Harrison, A., Hanson, G., 1999. Who gains from trade reform? Some remaining puzzles. Journal of Development Economics 59, 125–154.

Melitz, M., 2003. The impact of trade on intra-industry reallocations and aggregate industry performance. Econometrica 71, 1695–1726.

Mortensen, D., Pissarides, C., 1994. Job creation and job destruction in the theory of unemployment. Review of Economic Studies 61, 397–415.

Pavcnik, N., 2002. Trade liberalization, exit, and productivity improvements: evidence from Chilean plants. Review of Economics Studies 69, 245–276.

Pavcnik, N., Blom, A., Goldberg, P., Schady, N., 2004. Trade policy and industry trade wage structure: evidence from Brazil. World Bank Economic Review 18, 319–344.

Pissarides, C., 2000. Equilibrium Unemployment Theory, 2nd ed. MIT Press, Cambridge, MA.

Revenga, A., 1997. Employment and wage effects of liberalization: the case of Mexican manufacturing. Journal of Labor Economics 15, S20–S43.

Roberts, M., Tybout, J., 1997. The decision to export in Columbia: an empirical model of entry with sunk costs. American Economic Review 87, 545–564.

Scheve, K., Slaughter, M., 2004. Economic insecurity and the globalization of production. American Journal of Political Science 48, 267–292.

Topalova, P., 2007. Trade liberalization and firm productivity: the case of India. IMF Working Paper.

Trindade, V., 2004. Openness and productivity: a model of trade and firm-owners' effort. Syracuse University Working Paper.

Tybout, J., 2003. Plant- and firm-level evidence on "new" trade theories. In: Choi, E.K., Harrigan, J. (Eds.), Handbook of International Trade. Blackwell Publishers, pp. 388–415.

Van Biesebroeck, J., 2005. Exporting raises productivity in sub-Saharan African manufacturing firms. Journal of International Economics 67, 373–391.

Wacziarg, R., Seddon-Wallack, J., 2004. Trade liberalization and intersectoral labor movements. Journal of International Economics 64, 411–439.

Yeaple, S., 2005. A simple model of firm heterogeneity, international trade and wages. Journal of International Economics 65, 1–20.

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