Trade and Labor Market Outcomes*

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Abstract

This paper reviews a new framework for analyzing the interrelationship between inequality, unemployment, labor market frictions, and foreign trade. This framework emphasizes firm heterogeneity and search and matching frictions in labor markets. It implies that the opening of trade may raise inequality and unemployment, but always raises welfare. Unilateral reductions in labor market frictions increase a country's welfare, can raise or reduce its unemployment rate, yet always hurt the country's trade partner. Unemployment benefits can alleviate the distortions in a country's labor market in some cases but not in others, but they can never implement the constrained Pareto optimal allocation. We characterize the set of optimal policies, which require interventions in product and labor markets.

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1 Introduction

For understanding the causes and consequences of international trade, recent research has increasingly focused on individual firms. While this research emphasizes reallocations of resources across heterogeneous firms, it typically assumes frictionless labor markets in which all workers are fully employed for a common wage. In reality, labor markets feature both unemployment and wage inequality, and labor market institutions are thought to play a prominent role in propagating the impact of external shocks. In this paper, we draw on recent research in Helpman and Itskhoki (2010) and Helpman, Itskhoki and Redding (2010), to discuss interdependence across countries.

This framework incorporates a number of features of product and labor markets. Firms are heterogeneous in productivity, which generates differences in revenue across firms. There are search and matching frictions in the labor market, which generate equilibrium unemployment, and give rise to multilateral bargaining between the firms and their workers. While workers are *ex ante* homogeneous, they draw a match-specific ability when matched with a firm, which is not directly observed by either the firm or the worker. Firms, however, can invest resources in screening their workers to obtain information about ability. Larger, more-productive firms, screen workers more intensively to exclude those with low-ability. As a result, they have workforces of higher average ability and they pay higher wages. These differences in firm characteristics are systematically related to export participation. Exporters are larger and more productive than nonexporters; they screen workers more intensively; and they pay higher wages in comparison to firms with similar productivity that do not export. The resulting framework highlights a new mechanism through which trade affects inequality, based on variation in wages across firms and the participation of only the most-productive firms in exporting.

We use a simplified version of this framework to examine interdependence across countries through labor market frictions. Cross-country differences in labor market characteristics shape patterns of comparative advantage. A reduction in a country's labor market frictions in the differentiated sector reduces unemployment within that sector and expands the share of workers searching for employment there, which affects aggregate unemployment through a change in sectoral composition. Depending on the relative values of unemployment rates across sectors, aggregate unemployment may rise or decline. The expansion in a home country's differentiated sector increases its welfare, but enhances the degree of product market competition faced by foreign firms, which leads to a contraction in the foreign country's differentiated sector and a reduction in its welfare. Unilateral labor market reforms, therefore, can have negative externalities across countries, whereas coordinated reductions in labor market frictions raise welfare in every country.

As well as providing a platform for analyzing the positive economic effects of trade and labor market characteristics, our framework can be used to address normative issues. We first examine the impact of unemployment benefits on resource allocation and welfare, and show that they raise welfare in some circumstances and reduce welfare in other. We also present new results on policies that implement a constrained Pareto optimum. When the Hosios (1990) condition is satisfied, these policies do not require intervention in the labor market. Otherwise, a combination of subsidies to the cost of posting vacancies/hiring, subsidies to output/employment, and a common subsidy to all fixed costs (entry, production and exporting) implement the constrained Pareto optimal allocation. These product market policies apply equally to exporting and nonexporting firms. Unemployment benefits can be part of the optimal policy package under some circumstances, but even then more direct interventions in the labor market are preferable on informational grounds.

The remainder of the paper is structured as follows. In Section 2 we discuss the motivation for our approach and some of the related literature. In Section 3 we use the framework of Helpman, Redding and Itskhoki (2010) to examine the relationship between inequality, unemployment and trade. In Section 4 we use a simplified version of this model from Helpman and Itskhoki (2010) to explore how changes in labor market frictions in one country affect its trade partners and how the removal of trade impediments affects countries with different labor market frictions. Section 5 extends the analysis to provide new results on the impact of unemployment benefits and on optimal policies. Section 6 concludes.

2 Background and Motivation

Traditional explanations of international trade have emphasized comparative advantage based on variation in technology across countries and industries (Ricardo 1817) or the interaction between cross-country differences in factor abundance and cross-industry differences in factor intensity (Heckscher 1919, Ohlin 1924, Jones 1965 and Samuelson 1948). In the 1980s, economies of scale and monopolistic competition were merged with factor proportions–based explanations for trade in Dixit and Norman (1980), Helpman (1981), Krugman (1981) and Lancaster (1980). While economies of scale and love of variety preferences together generated two-way trade within industries, as observed empirically, the assumption of a representative firm implied that all firms exported.

More recently, firm heterogeneity has been introduced into general equilibrium trade theory following Melitz (2003) and Bernard, Eaton, Jensen and Kortum (2003). The resulting models of firm heterogeneity and trade provide a natural explanation for empirical findings from micro data that only some firms within industries export and these exporters are larger and more productive than nonexporting firms. Table 1 reports some representative evidence on export participation from the World Trade Organization (2008). In each of the countries considered, only a minority of firms export. Furthermore, even within exporters, there is tremendous heterogeneity in productivity and size. As reported in Table 2, the top 1 percent of firms account for 81 percent of U.S. exports and a substantial percentage of exports in all countries.

Country	Year	Exporting firms, in percent
U.S.A.	2002	18.0
Norway	2003	39.2
France	1986	17.4
Japan	2000	20.0
Chile	1999	20.9
Colombia	1990	18.2

Table 1: Share of manufacturing firms that export, in percent (Source: WTO 2008, Table 5)

Country	Year	Top 1% of firms	Top 10% of firms
U.S.A.	2002	81	96
Belgium	2003	48	84
France	2003	44	84
Germany	2003	59	90
Norway	2003	53	91
U.K.	2003	42	80

Table 2: Share of exports of manufactures, in percent (Source: WTO 2008, Table 6)

This new theoretical literature on firm heterogeneity and trade emphasizes the self-selection of more-productive firms into exporting and foreign direct investment (FDI). As a result of this self-selection, reductions in trade costs have uneven effects across firms, as low-productivity firms exit and high-productivity firms expand to serve foreign markets. The resulting changes in industry composition raise aggregate productivity, consistent with empirical findings from trade liberalization episodes, as reported in Pavcnik (2002) and Trefler (2004). Firm heterogeneity and selection also influence cross-section patterns of trade and FDI. For example, the ratio of exports to foreign subsidiary sales depends not only on the trade-off between proximity and concentration, but also on the dispersion of firm productivity, as shown in Helpman, Melitz and Yeaple (2004) and Yeaple (2009). Similarly, the decision whether to offshore stages of production within or outside the boundaries of the firm is systematically related to firm productivity, as shown theoretically in Antràs and Helpman (2004) and empirically in Nunn and Trefler (2008) and Defever and Toubal (2010).

Although this theoretical literature emphasizes reallocations across firms, the modelling of the labor market has, until recently, been highly stylized. All workers are fully employed at a common wage and hence are affected symmetrically by the opening of trade. These model features sit uncomfortably with a large empirical literature that finds an employer-size wage premium (see the survey by Oi and Idson 1999) and with extensive evidence that exporters pay higher wages than nonexporters (see in particular Bernard and Jensen 1995, 1997). While this theoretical literature assumes no labor market frictions and costless reallocations across firms, search and matching frictions occupy a prominent position in macroeconomics (following Diamond 1982a,b, Mortensen 1970, Pissarides 1974, and Mortensen and Pissarides 1994). More generally, labor market institutions have been found to be influential in shaping the responses of European countries to external shocks (Blanchard and Wolfers 2000) and in understanding the evolution of unemployment rates in OECD countries over time (Nickell, Nunziata, Ochel and Quintini 2001).

Evidence on the magnitude of cross-country differences in labor market institutions is presented in Table 3. Even among countries at similar levels of economic development, such as OECD countries, there are substantial differences in the ease of hiring and firing workers and the rigidity of hours worked. In the European Union, member states have focused on labor market policies for more than a decade following the Luxembourg Extraordinary European Council Meeting on Employment in 1997. This meeting produced the European Employment Strategy, which was incorporated into the broader Lisbon Strategy, designed to turn Europe into a more competitive and dynamic economy. To address such policy issues, we require theoretical models that pay more than usual attention to features of labor markets. And the high levels of international integration in the contemporary world economy suggest the need for frameworks within which it is possible to examine interdependence in labor market outcomes across nations.

Country	Difficulty of Hiring	Rigidity of Hours	Difficulty of Redundancy
United States	0	0	0
Uganda	0	0	0
Rwanda	11	0	10
United Kingdom	11	20	0
Japan	11	7	30
OECD	**27**	**30**	**23**
Italy	33	40	40
Mexico	33	20	70
Russia	33	40	40
Germany	33	53	40
France	67	60	30
Spain	78	40	30
Morocco	89	40	50

Table 3: Cross-country Differences in Labor Market Frictions (Source: Botero et al. 2004). Downloaded from the World Bank's website http://www.doingbusiness.org/ExploreTopics/EmployingWorkers/ on September 25, 2009.

Our analysis builds on a long line of research on trade and labor market frictions. This literature has considered a number of different sources of labor market frictions, including minimum wages (Brecher 1974), implicit contracts (Matusz 1986), efficiency wages (Copeland 1989), fair wages (Agell and Lundborg 1995 and Kreickemeier and Nelson 2006), search and matching frictions (Davidson, Martin and Matusz 1988, 1999), and labor immobility and volatility (Cuñat and Melitz 2009). More recently, a surge of research has begun to incorporate labor market frictions into theories of firm heterogeneity and trade, including models of fair wages (Egger and Kreickemeier 2009, Amiti and Davis 2008), efficiency wages (Davis and Harrigan 2007), and search and matching frictions (Helpman and Itskhoki 2010, Helpman, Itskhoki and Redding 2010, Mitra and Ranjan 2010, and Felbermayr, Prat and Schmerer 2010).

Our analysis focuses on search frictions as the source of labor market imperfections and is based squarely in the new view of foreign trade that emphasizes firm heterogeneity in differentiated-product markets. The discussion of inequality, unemployment and trade in Section 3 draws on

Helpman, Itskhoki and Redding (2010), while the analysis of interdependence in labor market outcomes in Section 4 is based on Helpman and Itskhoki (2010). In Section 5, we present new results on the design of labor market policies in economies with firm heterogeneity and labor market frictions.[1]

3 Inequality

The traditional framework for examining the distributional consequences of trade liberalization is the Stolper-Samuelson Theorem of the Heckscher-Ohlin model. Recent research, however, has identified a need to rethink the links between trade and wage inequality. While the Stolper-Samuelson Theorem predicts that trade raises wage inequality in skilled-labor–abundant countries and reduces wage inequality in unskilled-labor–abundant countries, empirical studies of recent trade liberalization episodes typically find rising wage inequality in both developed and developing countries (see for example the survey by Goldberg and Pavcnik 2007).[2] Furthermore, whereas the Stolper-Samuelson Theorem emphasizes changes in the relative wages of skilled and unskilled workers, there is evidence of changes in within-group inequality for workers with the same observed characteristics in the aftermath of trade reforms, as in Attanasio, Goldberg and Pavcnik (2004) and Menezes-Filho, Muendler and Ramey (2008).

In this section we outline an alternative framework for examining the impact of trade on inequality from Helpman, Itskhoki and Redding (2010). In contrast to the Stolper-Samuelson Theorem's emphasis on reallocations of resources across sectors, the key predictions of this framework relate to the distribution of wages and employment across firms and workers within sectors. We derive these distributions from comparisons across firms that hold in sectoral equilibrium for *any* value of a worker's expected income outside the sector, i.e., his outside option. An important implication is that the predictions of our model for sectoral wage inequality hold regardless of general equilibrium effects. Throughout this section, all prices, revenues and costs are measured in terms of a numeraire, where the choice of this numeraire depends on how the sector is embedded in general equilibrium, as discussed further in Helpman, Itskhoki and Redding (2010).

[1] See also Itskhoki (2010) for an analysis of the optimal design of a tax system in an open economy with heterogeneous firms.

[2] See, however, Feenstra and Hanson (1996), Zhu and Trefler (2004), and Sampson (2010) for trade mechanisms that can raise inequality in rich and poor countries alike.

3.1 Model Setup

We consider a differentiated-product sector. Consumer preferences take the constant elasticity of substitution (CES) form, and the real consumption index for the sector (Q) is

$$Q = \left[\int_{j \in J} q(j)^{\beta} \mathrm{d}j \right]^{1/\beta}, \qquad 0 < \beta < 1, \tag{1}$$

where j indexes varieties; J is the set of varieties within the sector; $q(j)$ denotes consumption of variety j; and β controls the elasticity of substitution between varieties.

There is a competitive fringe of potential firms who can choose to enter this sector by incurring a sunk entry cost of $f_e > 0$. Once the sunk entry cost is paid, a firm observes its productivity θ, which is drawn from an independent Pareto distribution, $G_{\theta}(\theta) = 1 - (\theta_{\min}/\theta)^z$ for $\theta \geq \theta_{\min} > 0$ and $z > 1$. Once firms observe their productivity, they decide whether to exit, produce solely for the domestic market, or produce for both the domestic and export markets. Production involves a fixed cost of $f_d > 0$ units of the numeraire. Exporting involves an additional fixed cost of $f_x > 0$ units of the numeraire and an iceberg variable trade cost, such that $\tau > 1$ units of a variety must be exported in order for one unit to arrive in the foreign market.

There is a continuum of *ex ante* identical workers, who choose whether or not to search for employment in the sector. The labor market is subject to search and matching frictions. Workers draw a match-specific ability a when matched with a firm in the differentiated sector. This match-specific ability, which is observed neither by the worker nor the firm, is drawn from an independent Pareto distribution, $G_a(a) = 1 - (a_{\min}/a)^k$ for $a \geq a_{\min} > 0$ and $k > 1$.

The output of each firm variety (y) depends on the productivity of the firm (θ), the measure of workers hired (h), and the average ability of these workers ($\bar{a}$):

$$y = \theta h^{\gamma} \bar{a}, \qquad 0 < \gamma < 1, \tag{2}$$

where this production technology can be interpreted as capturing either human capital complementarities (e.g., production in teams where the productivity of a worker depends on the average productivity of her team) or a managerial time constraint (e.g., a manager with a fixed amount of time who needs to allocate some time to each worker). A key feature of this production technology is complementarities in worker ability, where the productivity of a worker is increasing in the abilities of other workers employed by the firm.

Search and matching frictions in the labor market are modelled following the standard Diamond-Mortensen-Pissarides approach. A firm that pays a *search cost* of bn units of the numeraire can randomly match with a measure of n workers, where the search cost b is endogenously determined by the tightness of the labor market x:

$$b = \zeta x^{\alpha}. \tag{3}$$

This search technology can be derived from a Cobb-Douglas matching function; ζ is a parameter that is increasing in the cost of posting vacancies and decreasing in the Hicks-neutral efficiency of the matching process; α is the ratio of the Cobb-Douglas coefficients on the number of workers searching for jobs and vacancies; and the tightness of the labor market, $x = N/L$, is the ratio of the measure of matched workers, N, to the measure of workers searching for employment in the differentiated sector, L.

Once matched with workers, firms can invest resources in screening them to obtain an imprecise signal of match-specific ability. By incurring a screening cost of ca_c^{δ}/δ, where $c > 0$ and $\delta > 1$, a firm can identify those workers with an ability below a_c, but cannot determine the abilities of the individual workers with any greater precision. We focus on interior equilibria in which c is sufficiently small that all firms screen their workers.

The timing of decisions is as follows. Firms and workers decide whether or not to enter the differentiated sector. The outside option of firms is zero. The outside option of workers is expected income in other employment, ω, where workers are assumed to be risk neutral and ω is determined in general equilibrium. After incurring the sunk entry cost for the differentiated sector, firms learn their productivity θ and choose whether to exit or produce. If firms choose to produce, they post a measure of vacancies and choose whether to serve only the domestic market or also export. Workers are next matched with firms. Unmatched workers become unemployed and receive unemployment benefits of zero. Firms screen their n matched workers by choosing a screening threshold a_c. Only workers with abilities above the screening threshold are hired and those with abilities below the screening threshold become unemployed. The firm and its h hired workers engage in multilateral bargaining over the division of the surplus from production as in Stole and Zwiebel (1996). Finally, output is produced and markets clear.

3.2 Firm's Problem

Given the specification of differentiated-sector demand, the equilibrium domestic-market revenue of a firm can be written as

$$r(j) = p(j)q(j) = Aq(j)^{\beta},$$

where A is a demand-shifter, that is increasing in total expenditure on varieties within the sector, E, and in the sector's ideal price index, P, which summarizes the prices of competing varieties.

If a firm exports, it allocates its output between the domestic and export markets to equate its marginal revenues in the two markets, so that total firm revenue can be expressed as

$$r(\theta) \equiv r_d(\theta) + r_x(\theta) = \Upsilon(\theta)^{1-\beta} Ay(\theta)^{\beta}, \tag{4}$$

where $r_d(\theta) \equiv Ay_d(\theta)^{\beta}$ is revenue from domestic sales; $r_x(\theta) \equiv A^{*}[y_x(\theta)/\tau]^{\beta}$ is revenue from exporting; $y_d(\theta)$ is output for the domestic market; $y_x(\theta)$ is output for the export market; and $y(\theta) = y_d(\theta) + y_x(\theta)$. The variable $\Upsilon(\theta)$ captures a firm's "market access," which depends on whether it chooses to serve both the domestic and foreign markets or only the domestic market:

$$\Upsilon(\theta) \equiv 1 + I_x(\theta)\,\tau^{-\frac{\beta}{1-\beta}}\left(\frac{A^{*}}{A}\right)^{\frac{1}{1-\beta}}, \tag{5}$$

where $I_x(\theta)$ is an indicator variable that equals one if the firm exports and zero otherwise.

The solution to the bargaining game implies that the firm receives a share $1/(1+\beta\gamma)$ of revenue, while each worker receives a wage equal to a constant share of revenue per worker:

$$w(\theta) = \frac{\beta\gamma}{1+\beta\gamma}\frac{r(\theta)}{h(\theta)}.$$

Anticipating this outcome of the bargaining game, a firm chooses the measure of workers to match with, n, the screening threshold, a_c, and whether or not to export to maximize its profits:

$$\pi(\theta) \equiv \tag{6}$$
$$\max_{\substack{n\geq 0,\\ a_c \geq a_{\min},\\ I_x \in \{0,1\}}} \left\{ \frac{1}{1+\beta\gamma} \left[1 + I_x \tau^{-\frac{\beta}{1-\beta}} \left(\frac{A^*}{A} \right)^{\frac{1}{1-\beta}} \right]^{1-\beta} A \left(\kappa_y \theta n^{\gamma} a_c^{1-\gamma k} \right)^{\beta} - bn - \frac{c}{\delta} a_c^{\delta} - f_d - I_x f_x \right\},$$

where κ_y is a derived parameter and we have used the properties of the Pareto distribution of worker ability. The latter implies that a firm choosing a screening threshold a_c hires a measure $h = n\left(a_{\min}/a_c\right)^k$ of workers with average ability $\bar{a} = ka_c/(k-1)$. Firms of all productivities have an incentive to screen for $0 < \gamma k < 1$ and sufficiently small values of c.

As a result of fixed costs of production and exporting, a firm's decision whether or not to produce and export takes a standard form. Only the most-productive firms with productivities $\theta \geq \theta_x$ export; firms with intermediate productivities $\theta \in [\theta_d, \theta_x)$ serve only the domestic market; and the least-productive firms with productivities $\theta < \theta_d$ exit. The firm's market-access variable is therefore determined as follows:

$$\Upsilon(\theta) = \begin{cases} 1, & \theta < \theta_x, \\ \Upsilon_x, & \theta \geq \theta_x, \end{cases} \qquad \Upsilon_x \equiv 1 + \tau^{-\frac{\beta}{1-\beta}} \left(\frac{A^*}{A} \right)^{\frac{1}{1-\beta}} > 1. \tag{7}$$

Using the first-order conditions to the firm's problem (6), closed-form solutions for all firm-specific variables can be derived:

$$\left. \begin{array}{ll} r(\theta) = \Upsilon(\theta)^{\frac{1-\beta}{\Gamma}} \cdot r_d \cdot \left(\frac{\theta}{\theta_d}\right)^{\frac{\beta}{\Gamma}}, & r_d \equiv \frac{1+\beta\gamma}{\Gamma} f_d, \\ n(\theta) = \Upsilon(\theta)^{\frac{1-\beta}{\Gamma}} \cdot n_d \cdot \left(\frac{\theta}{\theta_d}\right)^{\frac{\beta}{\Gamma}}, & n_d \equiv \frac{\beta\gamma}{\Gamma} \frac{f_d}{b}, \\ a_c(\theta) = \Upsilon(\theta)^{\frac{1-\beta}{\Gamma\delta}} \cdot a_d \cdot \left(\frac{\theta}{\theta_d}\right)^{\frac{\beta}{\delta\Gamma}}, & a_d \equiv \left[\frac{\beta(1-\gamma k)}{\Gamma} \frac{f_d}{c}\right]^{1/\delta}, \\ h(\theta) = \Upsilon(\theta)^{\frac{1-\beta}{\Gamma}(1-k/\delta)} \cdot h_d \cdot \left(\frac{\theta}{\theta_d}\right)^{\frac{\beta(1-k/\delta)}{\Gamma}}, & h_d \equiv \frac{\beta\gamma}{\Gamma} \frac{f_d}{b} \left[\frac{\beta(1-\gamma k)}{\Gamma} \frac{f_d}{c a_{\min}^{\delta}}\right]^{-k/\delta}, \\ w(\theta) = \Upsilon(\theta)^{\frac{(1-\beta)k}{\Gamma\delta}} \cdot w_d \cdot \left(\frac{\theta}{\theta_d}\right)^{\frac{\beta k}{\delta\Gamma}}, & w_d \equiv b\left[\frac{\beta(1-\gamma k)}{\Gamma} \frac{f_d}{c a_{\min}^{\delta}}\right]^{k/\delta}. \end{array} \right\} \tag{8}$$

More-productive firms have larger revenues, match with more workers, and screen to higher ability thresholds. As a result they have workforces of higher average ability and pay higher wages. As long as screening costs are sufficiently convex and worker ability is sufficiently dispersed, $\delta > k$,

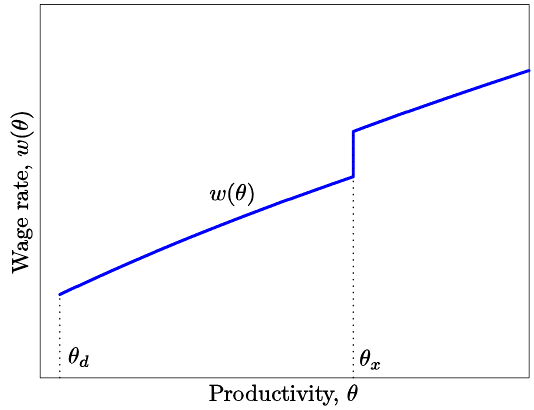

Figure 1: Wages as a function of firm productivity

more-productive firms also hire more workers, which implies that the model features the empirically-observed employer-size wage premium. The fixed costs of exporting imply that all firm variables, apart from profits, jump discretely at the productivity threshold for exporting, θ_x, where $\Upsilon(\theta)$ jumps from one to $\Upsilon_x > 1$. Exporting firms are, therefore, more productive, larger, have workforces of higher average ability, and pay higher wages, as found empirically using micro data on firms and plants (e.g. Bernard and Jensen 1995, 1997) and matched employer-employee datasets (e.g. Frías and Kaplan 2009).

The wage schedule as a function of productivity is illustrated for particular parameter values in Figure 1. Although more-productive firms pay higher wages, they also screen more intensively, which implies that they hire a smaller fraction of their matched workers. Using the solution to the bargaining game and the firm's first-order conditions, the higher wages of more-productive firms are exactly offset by the lower probability of being hired, since the Stole-Zwiebel bargaining solution implies that a firm's equilibrium wage is equal to its replacement cost for each worker. As a result, the expected wage conditional on being matched is the same across all firms:

$$\frac{w(\theta)h\left(\theta\right)}{n\left(\theta\right)} = b,$$

which implies that workers have no incentive to direct their search across firms of differing productivities.

3.3 Labor Market Equilibrium

Worker indifference across sectors requires that expected income in the differentiated sector is equal to workers' outside option, ω, where expected income in the differentiated sector equals the probability of being matched, x, times the expected wage conditional on being matched, b:

$$\omega = xb. \tag{9}$$

This indifference condition across sectors and the search technology (3) together determine the equilibrium tightness of the labor market and hiring costs as a function of workers' outside option:

$$b = \zeta^{\frac{1}{1+\alpha}} \omega^{\frac{\alpha}{1+\alpha}} \qquad \text{and} \qquad x = \left(\frac{\omega}{\zeta}\right)^{\frac{1}{1+\alpha}}, \tag{10}$$

where ω is determined in general equilibrium, as considered in Helpman, Itskhoki and Redding (2010).

3.4 Implications for Wage Inequality

Since wages and employment in (8) are power functions of productivity, which is Pareto distributed, we can solve in closed form for the wage distribution. The distribution of wages across all workers is a weighted average of the distributions of wages for workers employed by domestic firms and for workers employed by exporters, with weights equal to the shares of employment in the two groups of firms: $S_{h,d}$ representing the share of employment by nonexporters and $S_{h,x} = 1 - S_{h,d}$ representing the share of employment by exporters. The distribution of wages across workers employed by domestic firms is a truncated Pareto distribution while the distribution of wages across workers employed by exporters is an untruncated Pareto distribution, but these two wage distributions have the same shape parameter, $1 + 1/\mu$, where μ is defined as

$$\mu \equiv \frac{\beta k/\delta}{z\Gamma - \beta}, \quad \text{where } \Gamma \equiv 1 - \beta\gamma - \frac{\beta}{\delta}(1 - \gamma k),$$

and we require $0 < \mu < 1$ and hence $z\Gamma > 2\beta$ for the wage distribution to have a finite mean and variance.

In both the closed economy ($S_{h,d} \to 1$) and the open economy when all firms export ($S_{h,d} \to 0$), the distribution of wages across all workers is an untruncated Pareto distribution. One feature of an untruncated Pareto distribution is that all scale-invariant measures of inequality, such as the Coefficient of Variation, the Gini Coefficient and the Theil Index, depend solely on the distribution's shape parameter, which is a sufficient statistic for inequality. As this shape parameter is the same for workers employed by domestic firms and by exporters, it follows that the level of wage inequality in the open economy when all firms export is the same as in the closed economy. In contrast, when only some firms export, it can be shown that there is strictly greater wage inequality in the open economy than in the closed economy.

This result highlights a new mechanism for international trade to affect wage inequality: the participation of some but not all firms in exporting. This mechanism applies in any heterogeneous-firm model in which firm wages are related to firm revenue and there is selection into export markets. Our result holds whenever the following three conditions are satisfied: firm wages and employment are power functions of firm productivity, there is firm selection into export markets and exporting increases wages for a firm with a given productivity, and firm productivity is Pareto distributed. An important implication of this result, which applies for symmetric and asymmetric countries alike, is that the opening of trade can increase wage inequality in all countries. This result is therefore consistent with empirical findings of increased wage inequality in developing countries following trade liberalization. Similarly, our result is consistent with empirical evidence that much of the observed reallocation in the aftermath of trade liberalization occurs across firms within sectors and is accompanied by increases in within-group wage inequality.

Since sectoral wage inequality in an open economy in which all firms export is the same as in a closed economy, but sectoral wage inequality in an open economy in which only some firms export is higher than in a closed economy, it follows that the relationship between sectoral wage inequality and the fraction of exporters is at first increasing and later decreasing. The intuition for this result is that the increase in firm wages that occurs at the productivity threshold above which firms export is only present when some but not all firms export. When no firm exports, a small reduction in trade costs that induces some firms to start exporting raises sectoral wage inequality because of the higher wages paid by exporters. When all firms export, a small increase in trade costs that induces some firms to stop exporting raises sectoral wage inequality because of the lower wages paid by domestic firms.

3.5 Implications for Unemployment

While we have so far focused on the distribution of wages across employed workers, income inequality in this framework also depends on the unemployment rate. Workers can be unemployed either because they are not matched with a firm or because their match-specific ability draw is below the screening threshold of the firm with which they are matched. The sectoral unemployment rate u includes both of these components and can be written as one minus the product of the hiring rate σ and the tightness of the labor market x:

$$u = \frac{L - H}{L} = 1 - \frac{H}{N}\frac{N}{L} = 1 - \sigma x, \tag{11}$$

where $\sigma \equiv H/N$, H is the measure of hired workers, N is the measure of matched workers, and L is the measure of workers seeking employment in the sector.

As shown above, equilibrium labor market tightness, x, depends on worker's outside option, ω, which can either remain constant or rise following the opening of trade, depending on how the sector is embedded in general equilibrium (see Helpman, Itskhoki and Redding 2010). In contrast, the hiring rate, σ, is unambiguously lower in the open economy than in the closed economy, since the opening of trade reallocates employment within industries towards more-productive exporting firms, which screen more intensively and hire a smaller fraction of the workers with whom they are matched. Furthermore, this reduction in the hiring rate can dominate an increase in labor market tightness, so that the opening of trade not only increases wage inequality but also raises unemployment.

Although the opening of trade can increase both wage inequality and unemployment, it also reduces the CES ideal price index for the differentiated sector. Therefore, despite increasing social disparity, the opening of trade raises the expected welfare of risk-neutral workers.

3.6 Multiple Worker Types

Our main results on the impact of trade on wage inequality can be generalized to settings in which there are multiple types of workers with different observable characteristics. To illustrate, suppose that there are two types of workers, indexed by $\ell = 1, 2$. There are separate labor markets for each type of worker, which are modelled as above, where the magnitude of search frictions can vary across worker types. Within each group of workers there is heterogeneity in the match-specific ability, a_ℓ, which is not observable. As a result, workers of a given type ℓ are *ex ante* homogeneous but *ex post* heterogeneous, as for the case of a single type of worker discussed above.

Let the distribution of ability of type-ℓ workers be Pareto with shape parameter $k_\ell > 1$ for $\ell = 1, 2$, and let the production function be

$$y = \theta \left(\bar{a}_1 h_1^{\gamma_1} \right)^{\varkappa_1} \left(\bar{a}_2 h_2^{\gamma_2} \right)^{\varkappa_2}, \qquad \varkappa_1 + \varkappa_2 = 1.$$

Then Helpman, Itskhoki and Redding (2010) show that wage inequality is larger within each group of workers in an open economy in which only a fraction of firms export than in a closed economy. Moreover, for $k_1 < k_2$, more-productive firms employ relatively more workers of type-1—with the larger ability dispersion—and pay them relatively lower wages. The relatively larger number of type-1 workers in higher-productivity firms weakens these workers' relative bargaining power, which translates into relatively lower wages. As a result, there is less wage dispersion among type-1 workers.

Importantly, while trade raises wage inequality within every group of workers, it may raise or reduce wage inequality between the two groups. Yet even if trade reduces wage inequality between the groups, overall wage inequality may still rise as a result of the increase in wage inequality within each group of workers with similar observable characteristics.

4 Interdependence

Having examined the impact of trade on sectoral inequality and unemployment, we now discuss interdependence between trading countries in a simplified version of the framework from the previous section. As in Helpman and Itskhoki (2010), in the simplified framework there is no heterogeneity in match-specific ability and no worker screening. We address the following questions: How do labor market frictions impact interdependence across countries? And, in particular, what are the impacts of a country's labor market frictions on its trade partners?

4.1 Analytical Framework

For the purpose of addressing these questions, we consider a two-country world, say countries A and B, in which every country has the same technology in each one of two sectors. One sector produces varieties of a differentiated product while the other manufactures a homogeneous good. Preferences are quasi-linear, given by

$$\mathbb{U} = q_0 + \frac{1}{\eta} Q^{\eta}, \qquad \eta < \beta < 1, \tag{12}$$

where q_0 is consumption of the homogeneous good, Q is the real consumption index of the differentiated product, and we choose the homogeneous good as the numeraire. As before, β controls the elasticity of substitution across varieties, and the new parameter η controls the elasticity of substitution between the homogeneous good and the differentiated product. We think of $\mathbb{U}$ as the utility level of a family consisting of a continuum of workers of measure one. There exists a continuum of such families of measure $\bar{L}$. As a result, there are $\bar{L}$ workers in this economy. Each family chooses the allocation of family members across sectors to maximize family utility. Since the idiosyncratic risk faced by individual workers as a result of random search and matching is perfectly diversified across the continuum of workers within each family, each family behaves as if it is risk neutral.

The homogeneous good is produced according to a constant returns to scale technology, with one unit of labor required to produce one unit of output, and the homogeneous good is costlessly traded. The technology of the differentiated sector is a simplified version of the technology from the previous section, with no worker heterogeneity and no screening. In this case the production function of every variety is

$$y = \theta h,$$

where, as before, θ is the firm's productivity and h is its employment. Varieties in the differentiated sector are again subject to iceberg trade costs, where $\tau > 1$ units must be shipped in order for one unit to arrive in the other country.

There are labor market frictions in each sector, similar to the labor market frictions described in the previous section. In the homogeneous sector the cost of hiring is

$$b_0 = \zeta_0 x_0^{\alpha}.$$

The derived parameter ζ_0 is larger the higher the cost of vacancies is and the less efficient is the matching process in the homogeneous sector. Moreover, in equilibrium $w_0 = 1/(1+\lambda)$ and $b_0 = \lambda/(1+\lambda)$, where λ is the relative bargaining weight of the employer in the wage bargaining process (see Appendix).[3] As a result,

$$\zeta_0 x_0^{\alpha} = \frac{\lambda}{1+\lambda}, \tag{13}$$

and equilibrium tightness in the homogeneous sector's labor market, x_0, is decreasing in the level of labor market frictions in this sector, ζ_0. The cost of hiring in the differentiated sector is given by (3). The two countries, A and B, differ *only* in labor market frictions (ζ_0, ζ). That is, they differ either in the sectoral levels of the efficiency of matching or in the costs of posting vacancies, which determine the equilibrium levels of the frictions (ζ_0, ζ).

In equilibrium, workers are indifferent between searching for jobs in the homogeneous or the differentiated sector, which implies that their expected income is the same in each sector, $x_0 b_0 = xb$. Together with the search technology, this condition implies the following values of the wage rate, the cost of hiring, and labor market tightness in the differentiated sector in each country j, independently of the trade regime:

$$w_j = b_j = b_0 \left(\frac{\zeta_j}{\zeta_{0j}}\right)^{\frac{1}{1+\alpha}}, \qquad x_j = x_{0j} \left(\frac{\zeta_j}{\zeta_{0j}}\right)^{-\frac{1}{1+\alpha}}, \quad j = A, B. \tag{14}$$

For simplicity, and without loss of generality, we assume $\zeta_A/\zeta_{0A} > \zeta_B/\zeta_{0B}$, which implies $b_A > b_B$, i.e., labor market frictions in the differentiated sector are relatively larger in country A.

4.2 Trade and Welfare

Helpman and Itskhoki (2010) show that under these circumstances a larger fraction of differentiated-product firms export in country B, and that country B exports differentiated products on net and

[3] In Helpman and Itskhoki (2010) the bargaining weights are equal, as a result of which $\lambda = 1$ and $b_0 = 1/2$. We generalize this result in order to better characterize optimal policies in the next section.

imports homogeneous goods. Since the only difference between the two countries is in their labor market frictions, it follows that this pattern of trade is determined by differences in labor market frictions across countries; the country that has the relatively lower level of labor market frictions in the differentiated sector exports differentiated goods on net. Moreover, in this world economy the share of intra-industry trade is smaller the larger the gap in relative hiring costs b_A/b_B is.

Another interesting result is that both countries gain from trade, in the sense that a representative family's utility level $\mathbb{U}$ is higher in the trade equilibrium than in autarky. Since the idiosyncratic risk faced by individual workers is perfectly diversified within families, the expected utility of every worker is higher in the open economy than in autarky.

4.3 Interdependence in Labor Market Frictions

A key feature of the model is that international trade transmits the effects of labor market institutions across countries. In particular, each country loses from a lowering of labor market frictions in the differentiated sector of its trade partner. The intuition for this result comes from the relationship between labor market frictions and the size of each sector and the link between the size of each sector and welfare. A reduction in county j's labor market frictions in the differentiated sector reduces its costs in this sector relative to those of its trade partner. This change in relative competitiveness increases the real consumption index in the differentiated sector in country j and reduces the real consumption index in this sector in the other country. Under our assumption of quasi-linear utility, welfare equals income plus consumer surplus in the differentiated sector. Furthermore the pricing distortion associated with monopolistic competition in the differentiated sector implies that this sector is too small in the market equilibrium. Therefore, since the reduction in labor market frictions in the differentiated sector in country j expands this sector at home and contracts this sector abroad, it raises welfare at home and reduces welfare abroad.

A simultaneous proportional reduction of ζ_A and ζ_B raises welfare in both countries, because it expands the size of the differentiated sector in each one of them. On the other hand, a reduction in ζ_j and ζ_{0j} at a common rate (which does not change the hiring cost b_j) raises country j's welfare and does not affect the welfare level of its trade partner. This results from the fact that this type of reduction in labor market frictions does not impact competitiveness, yet it leads to higher aggregate utilization of resources in country j (see the discussion of unemployment below).

4.4 Trade Liberalization

Reductions of trade impediments, τ, raise welfare in both countries, because they also expand the size of the differentiated sector in each country. Unlike the welfare consequences of lower trade frictions, however, the effects on unemployment can differ across countries. A country's rate of unemployment equals a weighted average of its sectoral rates of unemployment—$(1 - x_{0j})$ in the homogeneous sector and $(1 - x_j)$ in the differentiated sector—with weights equal to the shares of workers seeking employment in these sectors. In other words, country j's rate of unemployment is

$$u_j = \frac{N_{0j}}{\bar{L}_j}(1 - x_{0j}) + \frac{N_j}{\bar{L}_j}(1 - x_j),$$

where N_{0j} is the measure of workers seeking employment in the homogeneous sector and N_j is the measure of workers seeking employment in the differentiated sector, with $N_{0j} + N_j = \bar{L}_j$. Since trade impediments do not impact sectoral rates of unemployment, because tightness in labor markets does not depend on trade frictions, the only channel through which reductions in τ can influence the rate of unemployment is through worker reallocation across industries. Therefore, if the rate of unemployment is higher in the differentiated sector than in the homogeneous sector, aggregate unemployment rises as a result of the expansion of the differentiated sector induced by lower trade frictions. And if unemployment is higher in the homogeneous sector than in the differentiated sector, aggregate unemployment declines as a result of the expansion of the differentiated sector induced by lower trade frictions. Moreover, (14) implies that the rate of unemployment is higher in the differentiated sector if and only if it has higher labor market frictions than the homogeneous sector, i.e., $\zeta_j > \zeta_{0j}$.

Helpman and Itskhoki (2010) show that lower trade frictions may impact the rates of unemployment in the two countries in the same direction or in opposite directions. Moreover, the rate of unemployment can be higher in country A for some levels of trade frictions and higher in country B for other levels of trade frictions. As a result, differences in aggregate levels of unemployment do not necessarily reflect differences in labor market frictions; a country with more rigid labor markets may have a higher or lower rate of unemployment. Finally, since lower trade frictions raise welfare in both countries, but may raise the rate of unemployment in both or only in one of them, it is evident that the impact of lower trade frictions on unemployment provides no information on their impact on welfare; welfare goes up in both countries even when their rates of unemployment increase.

4.5 Unemployment and Labor Market Frictions

Of special interest is the relationship between labor market frictions and rates of unemployment. This relationship is sharpest in the case of symmetric countries, which have the same levels of labor market frictions (ζ_0, ζ). In this case, Helpman and Itskhoki (2010) show that raising the common level of labor market frictions in the differentiated sector raises the rate of unemployment in both countries if and only if ζ/ζ_0 is smaller than a threshold that exceeds one. It follows that whenever $\zeta < \zeta_0$, i.e., labor market frictions are lower in the differentiated sector, this condition is satisfied and raising ζ increases the rate of unemployment. This increase in the rate of unemployment occurs for two reasons: first, the sectoral rate of unemployment rises in the differentiated sector; second, workers move from the differentiated sector to the homogeneous sector and the latter has a higher sectoral rate of unemployment. Alternatively, when $\zeta > \zeta_0$ but ζ/ζ_0 is smaller than the threshold, higher frictions in the differentiated sector raise the sectoral rate of unemployment which raises in turn the aggregate rate of unemployment. But now the movement of workers from the differentiated to the homogeneous sector reduces aggregate unemployment, because the homogeneous sector has a lower rate of unemployment than the differentiated sector. The former effect dominates, however, as long as ζ/ζ_0 is below the threshold. Above the threshold higher frictions in the differentiated sector's labor market reduce aggregate unemployment, because in this case the negative impact of worker reallocation across industries outweighs the positive impact of the rise in the rate of unemployment in the differentiated sector.[4]

When countries are not symmetric, the sectoral unemployment rate and labor force composition effects interact in complex ways. For example, starting with $\zeta > \zeta_0$ and raising labor market frictions in country A's differentiated sector can initially raise the rate of unemployment in both countries but eventually reduce it in country A, whereas it continues to raise the rate of unemployment in country B. As a result, A may have a higher rate of unemployment for low values of ζ_A but a lower rate of unemployment for high values of ζ_A, or it may have lower unemployment for all $\zeta_A > \zeta$. Again, we encounter a case in which knowledge of relative rates of unemployment across

[4] When ζ_0 and ζ increase proportionately, aggregate unemployment rises.

countries is not sufficient to draw inferences about their relative levels of labor market frictions.

5 Policy Implications

We now use the framework of Helpman and Itskhoki (2010) from the previous section to derive new results on economic policies. Two key features of this framework are that the cost of hiring is a sufficient condition for the size of the differentiated sector and that the differentiated sector is too small in the market equilibrium because of the pricing distortion associated with monopolistic competition in this sector. In the previous section we considered changes in the cost of hiring that were induced by changes in labor market frictions in the form of lower costs of vacancies or more efficient matching. In this section we examine how unemployment benefits—a prevalent labor market policy—affect the cost of hiring and welfare. Although it remains the case that lower hiring costs in the differentiated sector necessarily increase the size of this sector and welfare, unemployment benefits can either raise or reduce hiring costs in the differentiated sector, and hence can either increase or decrease welfare. Furthermore, a key difference between this policy-induced variation in the cost of hiring and the labor market frictions considered in the previous section is that unemployment benefits require financing through taxes. As a result, even if unemployment benefits reduce the cost of hiring in the differentiated sector, they can have a non-monotonic effect on welfare. In this case, the introduction of unemployment benefits can be welfare reducing, or it can be welfare improving up to a point and welfare reducing thereafter.

After discussing unemployment benefits in Sections 5.1 and 5.2, and the nature of the economy's distortions in Section 5.3, we examine in Section 5.4 policies that implement a constrained Pareto optimum. The focus on a constrained rather than an unconstrained optimal allocation stems from our desire to treat search and matching in the labor market as a constraint on economic activity that a social planner cannot remove, and she therefore cannot costlessly allocate workers to firms. We show that there exists a simple set of policies in labor and product markets that support such a constrained Pareto optimal allocation. This set of policies is not unique, because there exist alternative combinations of labor market and product market policies that can achieve the same end. One conclusion from this analysis is that there are cases in which unemployment benefits can play a useful role in the optimal policy design, but that there are also cases in which unemployment benefits are not congruent with efficiency. Another conclusion is that optimal policies do not discriminate between firms by export status; the same policies should be applied to exporters and nonexporters alike.

5.1 Unemployment Benefits

Unemployment benefits impact wages and the cost of hiring. Wages are affected directly when workers bargain with employers, because in the presence of unemployment benefits b_u—measured in units of the homogeneous numeraire good—the outside option of a worker in the bargaining game is b_u instead of zero (we drop the country index in what follows). In addition, unemployment benefits affect tightness in labor markets and thereby the incentives of workers to search for jobs in the homogeneous versus differentiated sectors.

In the homogeneous sector the wage rate is now

$$w_0 = b_u + \frac{1}{1+\lambda}\left(1 - b_u\right), \tag{15}$$

the cost of hiring is

$$b_0 = \left(1 - b_u\right)\frac{\lambda}{1+\lambda},$$

and tightness in the labor market (see Appendix for details) satisfies

$$\zeta_0 x_0^{\alpha} = \left(1 - b_u\right)\frac{\lambda}{1+\lambda}, \tag{16}$$

which is the same as (13) when the unemployment benefits are equal to zero. Evidently, in this case higher unemployment benefits reduce x_0 and raise the sectoral rate of unemployment. And, as before, higher frictions in the labor market reduce x_0. From (15) and (16) we obtain the expected income of a worker searching for employment in the homogeneous sector, $\omega = w_0 x_0 + b_u\left(1 - x_0\right)$, as a function of unemployment benefits. Moreover, ω is the outside option of workers searching for employment in the differentiated sector. Therefore, in an equilibrium with positive employment in both sectors, ω also equals the expected income of a worker searching for a job in the differentiated sector, and therefore $\omega = wx + b_u\left(1 - x\right)$.

In the differentiated sector bargaining over wages yields a wage rate equal to the fraction

$\beta/(\beta+\lambda)$ of revenue per worker plus $b_u\lambda/(\lambda+\lambda)$ (in the absence of unemployment benefits the second component equals zero). Accounting for the firm's profit-maximizing choice of employment and the requirement that the expected income of workers be the same in both sectors, we obtain

$$x = x_0 \left(\frac{\zeta_0}{\zeta}\right)^{\frac{1}{1+\alpha}}. \tag{17}$$

As a result, there is a proportional relationship between labor market tightness in the two sectors, and a change in unemployment benefits has the same proportional effect on labor market tightness in each sector. In particular, higher unemployment benefits reduce tightness in both labor markets. We also show in the Appendix that

$$b = \zeta x^{\alpha} + \frac{\lambda}{1+\lambda} b_u. \tag{18}$$

Therefore unemployment benefits, b_u, directly affect the cost of hiring in the differentiated sector and also have indirect effects through labor market tightness, x. Higher unemployment benefits raise b directly because they increase workers' outside option in wage bargaining. But higher unemployment benefits reduce b indirectly because they reduce tightness in the labor market, x. Equations (16)-(18) imply that higher unemployment benefits raise the cost of hiring, b, on net if and only if labor market frictions are higher in the homogeneous sector; that is, if and only if $\zeta_0 > \zeta$.[5] When labor market frictions are higher in the differentiated sector, the differentiated sector has a higher sectoral rate of unemployment than the homogeneous sector. Under these circumstances higher unemployment benefits reduce the hiring cost in the differentiated sector and lead to its expansion, as more workers choose to search for jobs in this industry. In other words, unemployment benefits have an uneven effect on sectoral employment, favoring the sector with higher unemployment. As a result, by raising unemployment benefits a country makes its differentiated sector more competitive on world markets if this sector has the higher sectoral rate of unemployment, in which case this policy hurts the country's trade partner. Alternatively, by

[5] Equations (16)-(18) can be used to derive a closed-form solution for the hiring rate:

$$b = \frac{\lambda}{1+\lambda}\left[b_u + (1-b_u)\left(\frac{\zeta}{\zeta_0}\right)^{1/(1+\alpha)}\right],$$

from which this result is transparent.

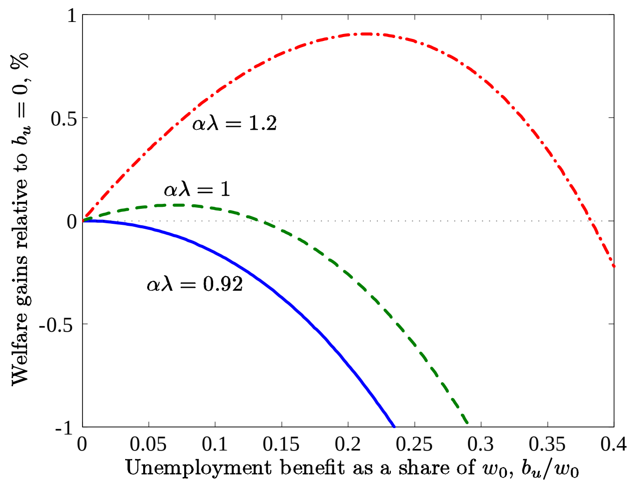

Figure 2: Welfare gains and losses from unemployment benefits

raising unemployment benefits a country benefits its trade partner when the country's labor market frictions are higher in the homogeneous sector.

5.2 Unemployment Benefits and Welfare

The next question is whether a country gains from raising its unemployment benefits. Figure 2 shows that the answer depends on structural features of the labor market. The figure depicts percentage changes in welfare, measured on the vertical axis, in response to changes in the level of unemployment benefits, measured as a replacement ratio of the homogeneous sector's wage rate, b_u/w_0. It describes simulations of a closed economy in which labor market frictions are higher in the differentiated sector.[6] In this case higher unemployment benefits always reduce the equilibrium cost of hiring in both sectors. Yet for high values of $\alpha\lambda$, welfare first rises in unemployment benefits and eventually declines, while for low values of $\alpha\lambda$, welfare always declines in unemployment benefits. It follows that when $\alpha\lambda$ is large welfare is maximized at a positive level of unemployment benefits, while the optimal level of unemployment benefits equals zero when $\alpha\lambda$ is small.

To gain further insight into these results, Figure 3 decomposes the changes in welfare that result from unemployment benefits for the case $\alpha\lambda = 1.2$. The North-Western panel describes the contribution of the differentiated sector to welfare, Q^{η}, and the contribution of income net

[6] The following parameters were used in the simulations described in Figures 2 and 3: $\lambda = 1.2$, $\alpha = 1$, $\beta = 2/3$, $\eta = 1/2$, $\zeta_0 = 0.6$, $\zeta = 0.66$, $f_d = 1$, $\bar{L} = 1.5$. In addition, f_e, $\theta_{\min}$ and z were chosen to yield $\theta_d = 1$.

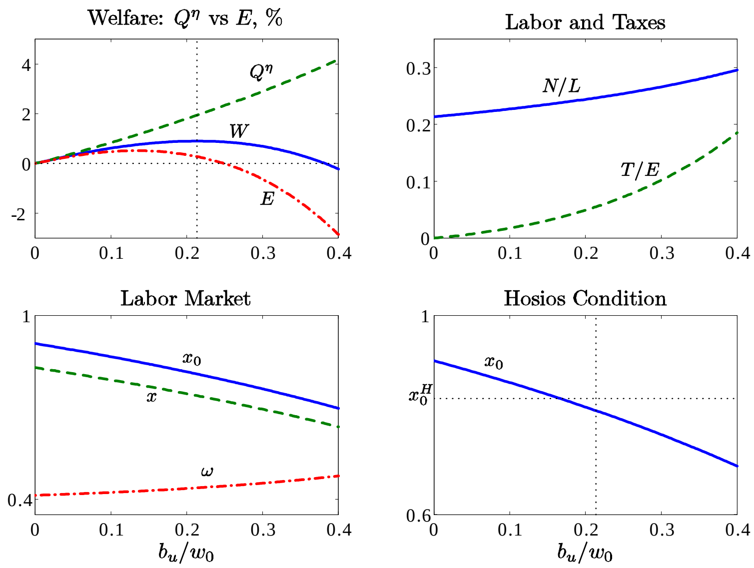

Figure 3: Changes resulting from unemployment benefits: $\alpha\lambda = 1.2$

of taxes, $E = \omega L - T$, as well as the total welfare level, W. As the cost of hiring declines with unemployment benefits, the contribution of the differentiated sector rises throughout. But net income rises initially as long as the rise in ωL is larger than the rise in taxes T needed to finance the unemployment benefits, and declines eventually. As a result, the welfare curve W has a hump shape. The North-East panel shows that not only do taxes rise with unemployment benefits, they also rise as a fraction of net income, T/E. In addition, the fraction of workers searching for jobs in the differentiated sector, N/L, rises. Finally, rising unemployment benefits reduce tightness in both sectors' labor markets, as shown in the South-West panel of the figure (which also shows the rise in ω).[7] As a result, higher unemployment benefits raise sectoral rates of unemployment. Since workers also move from the homogeneous to the differentiated sector, which is the higher unemployment rate sector, aggregate unemployment rises with unemployment benefits.

5.3 Product and Labor Market Distortions

An interesting implication of the example depicted in Figure 3 is that unemployment benefits are beneficial up to a point despite the fact that they raise unemployment. Yet if we were to reduce

[7] Our numerical example illustrates more general patterns. It can be shown analytically that wages and expected wages rise in both sectors with b_u while the levels of tightness in both sectors' labor markets decline with b_u. In addition, the hiring cost b decreases in b_u if and only if $\zeta > \zeta_0$, as we show in footnote 5. The only analytical ambiguity in the derivation of the optimal unemployment benefits stems from the response of $E = \omega L - T$.

$\alpha\lambda$ in this example to a sufficiently low level, we would find that unemployment benefits raise unemployment and reduce welfare. The question is *why*. To understand the answer, first note that in this type of economy there are multiple distortions. To begin with, the differentiated sector is too small, because it prices goods with a markup above marginal cost and there is too little entry into the industry. For this reason unemployment benefits that reduce the cost of hiring in the differentiated sector and induce a reallocation of workers from the homogeneous to the differentiated sector, benefit the economy. On the other side, in this example tightness in the labor market is too high initially and unemployment benefits bring it down. This is illustrated in the South-East panel of Figure 3 for the homogeneous sector, in which the horizontal dashed line x_0^H describes the optimal level of tightness, and the vertical dashed line shows the welfare-maximizing unemployment benefits policy. For low levels of unemployment benefits x_0 is too high, while for high levels of unemployment benefits it is too low. For this reason raising unemployment benefits from an initially low level reduces distortions in labor markets by reducing labor market tightness, and this raises welfare. But when initial unemployment benefits are high, the levels of tightness in the labor markets are too low and further increases in unemployment benefits aggravate the labor market distortions, which may reduce welfare.

There are no distortions in the labor market when the Hosios (1990) condition is satisfied, which in our case is $\alpha\lambda = 1$ (i.e., the elasticity of the matching function with respect to the number of vacancies equals the weight of employers in the bargaining game). While the Hosios condition was derived in models with linear revenue and single-job firms, we extend this condition to a model with monopolistic competition, multiple-job firms, and Sole and Zwiebel (1996) style multilateral bargaining. When the Hosios condition holds, or $\alpha\lambda \leq 1$, unemployment benefits always magnify the distortions in the labor markets, which reduces welfare. But because they reduce the distortion in the intersectoral allocation of labor (when they increase N), unemployment benefits may initially raise welfare on net. When $\alpha\lambda$ is very low, however, the distortions in the labor markets are so high that even small unemployment benefits reduce welfare on net.

To understand the link between the Hosios condition and labor market distortions in this model, consider the following experiment. Suppose we want to employ H workers in the differentiated sector, but we cannot allocate them directly to firms; all we can do is instruct N workers to search for jobs in the differentiated sector and the remaining $L - N$ workers to search for jobs in the homogeneous sector. How many vacancies do we need to open in each sector in order to secure the employment of H workers in the differentiated sector at minimum cost to the economy?

Instead of working directly with vacancies we can instead choose levels of tightness in the sectoral labor markets, x_0 and x. Naturally, in this case we need to send $N = H/x$ workers to search for jobs in the differentiated sector, which leaves $L - H/x$ workers searching for jobs in the homogeneous sector. However, only a fraction x_0 of the latter workers find employment in the homogeneous sector, producing $(L - H/x)\, x_0$ units of the homogeneous good. The cost of filling up $(L - H/x)\, x_0$ vacancies in the homogeneous sector is $(L - H/x)\, x_0 \zeta_0 x_0^{\alpha}$, because the cost of hiring is $\zeta_0 x_0^{\alpha}$ per worker. And the cost of filling up H vacancies in the differentiated sector is $H\zeta x^{\alpha}$, because the cost of hiring is ζx^{α} per worker in the differentiated sector. Consequently, the net output of homogeneous goods—which can be used for consumption or for entry of firms in the differentiated sector—equals[8]

$$(L - H/x)\, x_0 \left(1 - \zeta_0 x_0^{\alpha}\right) - H\zeta x^{\alpha}.$$

Given H, the optimal levels of x and x_0 maximize this measure of net output. The solution to this problem does not depend on H, however, and it can be characterized by

$$\zeta_0 x_0^{\alpha} = \frac{1}{1+\alpha} \tag{19}$$

and (17). When these conditions are satisfied, the ratio x/x_0 is at the optimal level independently of H or the level of unemployment benefits. Comparing (16) with (19), we see that levels of labor market tightness are optimal in the absence of unemployment benefits if and only if $\alpha\lambda = 1$. Moreover, if $\alpha\lambda < 1$, x_0 is too small without unemployment benefits and it moves further away from the optimal level the larger the unemployment benefits are. If, on the other hand, $\alpha\lambda > 1$, there exists a positive level of unemployment benefits at which the levels of tightness in the labor markets are optimal. In the South-East panel of Figure 3 this happens at the intersection point with the horizontal dashed line, where $x_0 = x_0^H$. However, the level of unemployment benefits that secures the optimal levels of labor market tightness does not maximize welfare, because it leaves distortions

[8] See the Appendix for more details.

in the allocation of labor across sectors (the optimal levels of unemployment benefits are depicted in this figure by the dashed vertical lines). If, for example, the differentiated sector has a higher rate of unemployment than the homogeneous sector, then it is optimal to raise b_u above the level that maximizes the net output of homogeneous goods, because this would attract more workers to the differentiated sector and thereby partially offset the monopolistic distortion that reduces the size of the differentiated sector[9]. Evidently, since this economy has multiple distortions, multiple instruments are needed to attain efficiency. These instruments are discussed in the next section.

5.4 Optimal Policies

We now consider policies that implement a constrained Pareto optimal allocation. The objective is to maximize the joint welfare of countries A and B, which—in view of the utility function (12)—is given by

$$\sum_{j=A,B}\left(q_{0j}+\frac{1}{\eta}Q_j^{\eta}\right).$$

The constraint is that the planner can allocate workers to industries but not to firms. However, the planner can post vacancies for every firm and thereby determine the probability with which vacancies are filled in every industry.

The Appendix contains an explicit formulation and solution to the planner's problem. This solution satisfies the labor market tightness conditions (17) and (19) in every country, for the reasons explained in the previous section. Therefore, if $\alpha\lambda = 1$, no intervention is required in the labor markets, despite the fact that the frictions ζ_0 and ζ differ across countries. If, however, $\alpha\lambda \neq 1$, then it is necessary to design labor market policies in the country in which the Hosios condition is not satisfied in order to implement the optimal allocation. Importantly, a country's optimal labor market policies depend only on its labor market parameters α and λ.[10] A direct policy that eliminates the labor market distortions is a subsidy or tax to the hiring cost, which is

[9] The impact of unemployment benefits on the relative size of sectors is similar in our case to Acemoglu and Shimer's (1999) analysis of policies that maximize output, except that in their case the distortion results from the reluctance of risk-averse workers to search for jobs in high-unemployment sectors. In their case aggregate output is too small without policy intervention, while unemployment benefits encourage workers to take the risk of searching for jobs thereby raising output. See also Acemoglu (2001), in which the composition of jobs in the market equilibrium is inefficient, and unemployment benefits and minimum wages can raise welfare through changing job composition.

[10] In the main text we assume that the relative bargaining weight λ is the same in both sectors, although it may vary across countries. In the Appendix we allow λ to vary across sectors also.

equivalent to a subsidy or tax to the cost of posting vacancies.[11] When the subsidy rate to hiring in the homogeneous sector is s_{b_0} (possibly negative), the resulting tightness in this labor market satisfies

$$\left(1 - s_{b_0}\right) \zeta_0 x_0^{\alpha} = \frac{\lambda}{1+\lambda}.$$

Comparing this condition to (19) we see that x_0 is optimal if and only if

$$s_{b_0} = \frac{1 - \alpha\lambda}{1+\lambda}.$$

Evidently, hiring has to be subsidized in the homogeneous sector when $\alpha\lambda < 1$ and taxed when $\alpha\lambda > 1$. For $\alpha\lambda < 1$, firms post too few vacancies and labor market tightness is too low. The required hiring subsidy is decreasing in the relative weight of job-seekers in the matching technology, α, and in the relative weight of the employer in wage bargaining, λ. For $\alpha\lambda > 1$, firms post too many vacancies and labor market tightness is too high, which implies that a hiring tax is required. In this latter case, optimal labor market tightness can also be achieved with unemployment benefits, but unemployment benefits cannot correct the labor market distortion when $\alpha\lambda < 1$.[12] A similar labor market policy is required in the differentiated sector, with the rate of subsidy the same in the two sectors: $s_b = s_{b_0}$.

With the optimal labor market subsidies in place, there are no remaining distortions in labor markets. But the relative size of the two sectors is not optimal. To correct the distortions in the relative size of the two sectors the planner can subsidize sales of the differentiated product. A subsidy of s_r per unit of sales in terms of the numeraire raises the revenue of every manufacturer, and the optimal subsidy is

$$s_r = \frac{1-\beta}{\beta}\frac{\lambda}{1+\lambda}.$$

The first term on the right hand side, $\left(1-\beta\right)/\beta$, represents the subsidy that offsets the distortion that results from the markup of price over the marginal cost (the monopolistic distortion), while the second term, $\lambda/\left(1+\lambda\right)$, represents the subsidy that offsets the distortion that results from wage bargaining. The total subsidy is increasing in the relative weight of employers in wage bargaining

[11] Note that a correction of this distortion requires a labor market policy that encourages job creation through lower costs of matching. For example, it cannot be a direct employment subsidy, because this policy does not reduce the matching costs to firms. Moreover, an employment subsidy is equivalent to a subsidy to the firms' revenues.

[12] In this case $b_u < 0$ is required, which means taxing the unemployed.

(λ) and decreasing in the elasticity of substitution between varieties of the differentiated product (β). A higher elasticity of substitution reduces the manufacturers' market power and thereby their markups above marginal costs, which leads to expansion of output and employment and implies that a lower subsidy to sales is required. The relative weight of employers in wage bargaining affects the value of the subsidy, because in the Stole-Zwiebel bargaining game firms have an incentive to hire more workers than is socially optimal in order to reduce the wage paid to infra-marginal workers, i.e., this bargaining mechanism leads to overemployment. This overemployment distortion partially offsets the effect of monopolistic pricing that makes the differentiated sector too small. The subsidy increases with the relative weight of employers in wage bargaining, because a larger value for this weight reduces the overhiring distortion, and hence reduces the size of the differentiated sector, which implies that a larger subsidy is required to restore the size of the differentiated sector to its socially optimal level.

In addition to the subsidy to sales, in the differentiated sector the fixed costs of production, export, and entry have to be subsidized at a common rate, equal to

$$s_f = \frac{1}{1+\lambda}.$$

This subsidy is decreasing in the relative weight of employers in wage bargaining (λ), because of the overhiring distortion in the Stole-Zwiebel bargaining game discussed above. Note that this subsidy does not depend on β, because the markup does not distort entry.

Importantly, the same optimal policies in the differentiated sector apply to all firms. In other words, they equally apply to low- and high-productivity firms, and to exporters and nonexporters alike. This means that the optimal policies do not discriminate between firms based on productivity, size, or export status.

We show in the Appendix that the optimal policies in product markets depend on whether subsidies or unemployment benefits are used in the labor market. If the social planner uses unemployment benefits in the labor market, which are feasible when $\alpha\lambda > 1$, then the subsidies to sales and to fixed plus entry costs in the differentiated sector depend not only on λ and β but also on the frictions in the labor markets, ζ_0 and ζ. For this reason, the optimal policies based on subsidies, discussed above, require less information than policies that rely on unemployment benefits.

6 Conclusion

The impact of trade liberalization on wage inequality and unemployment and the role of labor market institutions in shaping the effects of trade liberalization are areas of intense policy debate. Until recently, the ability of research in international trade to engage with this policy debate has been hampered by the widespread assumption of flexible labor markets and the associated prediction of full employment at a common wage.

In this paper, we have reviewed a new framework that combines firm heterogeneity in the product market with search and matching frictions in the labor market to examine the economy's response to trade. The resulting framework highlights a new mechanism for international trade to affect wage inequality: when only some firms export, the increase in wages that occurs at the productivity threshold for exporting raises wage inequality across firms. This mechanism accounts for the empirical findings of rising wage inequality in both developed and developing countries following trade liberalization and rationalizes rising wage inequality among groups of workers with the same observed characteristics. While the opening of trade can raise social disparity through both higher wage inequality and higher unemployment, expected welfare necessarily rises.

The introduction of labor market frictions into a general equilibrium model of trade permits the study of interdependence in labor market institutions across countries and the analysis of interactions between labor market institutions and trade liberalization. While labor market reforms that reduce search and matching frictions in the differentiated sector increase a country's own welfare, they reduce welfare in its trade partners. The aggregate unemployment rate depends on both the unemployment rate within each sector and the composition of the labor force across sectors. In consequence, policies that reduce the unemployment rate within the differentiated sector need not reduce aggregate unemployment if they also change the composition of the labor force across sectors. One important implication is that relative aggregate unemployment rates across countries are not, in general, fully informative about relative levels of labor market frictions.

In our setting with multiple product and labor market distortions, the market allocation is not constrained efficient. Only if the Hosios condition is satisfied, which requires the relative bargaining weight of employers to equal their relative weight in the matching technology, is the efficient level of labor market tightness attained. More generally, if the Hosios condition is not satisfied, subsidies to hiring costs or the costs of posting vacancies or unemployment benefits can be used to achieve the efficient level of labor market tightness. However, with several distortions in product and labor markets, unemployment benefits alone cannot achieve the constrained efficient allocation and their introduction can either raise or reduce welfare. To achieve the constrained efficient allocation requires a combination of these interventions in the labor market and subsidies to revenue and fixed costs in the product market. Notably, the efficient subsidies in the product market take the same value for both exporters and nonexporters. Finally, the use of direct subsidies or taxes to hiring requires less information than unemployment benefits and avoids the limitation that unemployment benefits have to be non-negative.

Appendix

This appendix sets up the model for Sections 4 and 5 and derives the results reported in the text; the model is based on Helpman and Itskhoki (2010), with the addition of policy instruments. We start by describing the decentralized equilibrium. We then set up the planner's problem and compare its solution with the decentralized allocation.

A Decentralized Equilibrium

We consider a decentralized equilibrium of the Helpman and Itskhoki (2010) model, allowing for nonsymmetric bargaining power of firms and workers, unemployment benefits, subsidies and taxes to hiring costs, entry costs, fixed production costs, and firm revenues in the differentiated sector.

A.1 Labor market equilibrium

In Helpman and Itskhoki (2010) we showed how a Cobb-Douglas matching function results in the following hiring cost function in the homogeneous-good sector:

$$b_0 = \zeta_0 x_0^{\alpha},$$

where ζ_0 is the ratio of vacancy costs to the productivity of the matching technology, x_0 is the endogenous labor market tightness (equal to the probability of a worker finding a job), and α is the ratio of the Cobb-Douglas parameters on unemployment and vacancies. In words, b_0 is the (expected) cost for a homogeneous-good producer of matching with (hiring) one worker. Similarly, the cost of matching in the differentiated sector is ζx^{α}, where we allow ζ to differ from ζ_0.

Consider the homogeneous-good sector. Upon matching, the firm and the worker produce one unit of the homogeneous good, which is our numeraire. They split this surplus via Nash bargaining. The outside option is zero for the firm and it equals unemployment benefits, $b_u < 1$, for the worker. In the process of bargaining, the surplus $(1 - b_u)$ is divided between the firm and the worker according to their relative bargaining power, which we denote by λ_0. This results in an operating profit level π_0 and a wage rate w_0:

$$\pi_0 = \frac{\lambda_0}{1+\lambda_0}(1-b_u) \qquad \text{and} \qquad w_0 = b_u + \frac{1}{1+\lambda_0}(1-b_u).$$

With free entry, equilibrium profits equal zero, and therefore the operating profits equal hiring costs. That is,

$$\pi_0 = (1-s_{b_0})b_0,$$

where s_{b_0} is the hiring-cost subsidy. Combining this with the previous expressions, we obtain

$$(1-s_{b_0})\zeta_0 x_0^{\alpha} = \frac{\lambda_0}{1+\lambda_0}(1-b_u), \tag{20}$$

which reduces to (16) when $s_{b_0} = b_u = 0$ and $\lambda = \lambda_0$. Finally, the expected income of workers in the homogeneous-good sector is given by

$$\begin{aligned}
\omega_0 &\equiv x_0 w_0 + (1-x_0)b_u \\
&= b_u + x_0\frac{1}{1+\lambda_0}(1-b_u) \\
&= b_u + \frac{1}{\lambda_0}(1-s_{b_0})\zeta_0 x_0^{1+\alpha}.
\end{aligned}$$

Next consider the differentiated sector. We show below that the equilibrium wage in this sector is

$$w = b_u + \frac{1}{\lambda}(1-s_b)\zeta x^{\alpha},$$

where λ is the relative bargaining power of firms in this sector, s_b is the sector-specific hiring-cost subsidy to firms, ζ is the sectoral labor market friction parameter (i.e., the ratio of vacancy costs to the productivity level of the matching technology), and x is the sector's labor market tightness (equal to the matching probability for workers). Therefore, a worker's expected income in the differentiated sector is

$$\omega \equiv xw + (1-x)b_u = b_u + \frac{1}{\lambda}(1-s_b)\zeta x^{1+\alpha}.$$

In equilibrium workers have to be indifferent between searching for jobs in the homogeneous or differentiated sectors, which requires $\omega_0 = \omega$. The latter implies

$$\frac{1}{\lambda_0}(1 - s_{b_0})\zeta_0 x_0^{1+\alpha} = \frac{1}{\lambda}(1 - s_b)\zeta x^{1+\alpha}. \tag{21}$$

Naturally, (17) is a special case of this condition, for $\lambda_0 = \lambda$ and no hiring subsidies. Also note that as long as unemployment benefits are common to the unemployed in both sectors, they do not affect relative labor market tightness in the two sectors. Conditions (20) and (21) pin down labor market tightness in the two sectors.

A.2 Product market equilibrium

In the differentiated sector firms solve the following maximization problem:

$$\pi(\Theta) = \max_{h\geq 0, I_x \in\{0,1\}} \Big\{(1 + s_r)R(h, \Theta) - w(h, \Theta)h - (1 - s_b)\zeta x^\alpha h - (1 - s_d)f_d - I_x(1 - s_x)f_x\Big\},$$

where h is employment, I_x is the firm's export status indicator, $\Theta \equiv \theta^{\beta/(1-\beta)}$ is a measure of the firm's productivity, s_r is the revenue subsidy rate, ζx^α is the hiring (matching) cost per worker, s_b is the subsidy rate to hiring costs, f_d is the fixed cost of production, f_x is the fixed cost of exporting, s_d is the subsidy rate to the fixed cost of production, and s_x is the subsidy rate to the fixed cost of exporting. As shown in Helpman and Itskhoki (2010), the revenue function of a firm in country j is

$$R(h, \Theta) = \left[Q^{-\frac{\beta-\eta}{1-\beta}} + I_x \cdot \tau^{-\frac{\beta}{1-\beta}} Q_{(-j)}^{-\frac{\beta-\eta}{1-\beta}}\right]^{1-\beta} \Theta^{1-\beta} h^\beta,$$

where $(-j)$ denotes the foreign country and we drop the subscript j from country j's variables. Importantly, revenue is a power function of employment.

Wages are set via bargaining over revenue between the firm and its workers. At the bargaining stage, entry costs, the export status, the fixed costs of production and export, and the hiring costs, are all sunk. We adopt Stole and Zweibel's (1996) bargaining game, which implies that the wage function satisfies the following differential equation:

$$\frac{\partial}{\partial h}\Big[(1 + s_r)R(h, \Theta) - w(h, \Theta)h\Big] = \lambda\big[w(h, \Theta) - b_u\big].$$

In words, the incremental surplus of the firm from an additional worker equals the surplus of the worker weighted by the firm's relative bargaining power. This differential equation has the following solution:

$$w(h,\Theta)=\frac{\beta}{\beta+\lambda}\frac{(1+s_r)R(h,\Theta)}{h}+\frac{\lambda}{1+\lambda}b_u.$$

Anticipating this bargaining outcome, the firm's profit maximization problem becomes

$$\pi(\Theta)=\max_{h\geq 0, I_x\in\{0,1\}}\left\{\frac{\lambda}{\beta+\lambda}(1+s_r)R(h,\Theta)-bh-(1-s_d)f_d-I_x(1-s_x)f_x\right\},$$

where its effective hiring cost is

$$b=(1-s_b)\zeta x^{\alpha}+\frac{\lambda}{1+\lambda}b_u.$$

The solution of the firm's problem can now be characterized in the following way. Optimal employment can be expressed as $h(\Theta)=h_d(\Theta)+I_x(\Theta)h_x(\Theta)$, where

$$h_d(\Theta)=\left(\frac{\beta\lambda}{\beta+\lambda}\right)^{\frac{1}{1-\beta}}(1+s_r)^{\frac{1}{1-\beta}}\left[(1-s_b)\zeta x^{\alpha}+\frac{\lambda}{1+\lambda}b_u\right]^{-\frac{1}{1-\beta}}Q^{-\frac{\beta-\eta}{1-\beta}}\Theta, \tag{22}$$

$$h_x(\Theta)=\left(\frac{\beta\lambda}{\beta+\lambda}\right)^{\frac{1}{1-\beta}}(1+s_r)^{\frac{1}{1-\beta}}\left[(1-s_b)\zeta x^{\alpha}+\frac{\lambda}{1+\lambda}b_u\right]^{-\frac{1}{1-\beta}}\tau^{\frac{-\beta}{1-\beta}}Q_{(-j)}^{-\frac{\beta-\eta}{1-\beta}}\Theta. \tag{23}$$

Here $h_d(\Theta)$ represents employment needed to supply the home market while $h_x(\Theta)$ represents employment needed to supply the foreign market. The profit level can be similarly decomposed into profits from domestic sales and profits from export sales, $\pi(\Theta)=\pi_d(\Theta)+I_x(\Theta)\pi_x(\Theta)$, where

$$\begin{aligned}\pi_d(\Theta)&=\frac{1-\beta}{\beta}\frac{\beta\lambda}{\beta+\lambda}(1+s_r)Q^{-(\beta-\eta)}\Theta^{1-\beta}h_d(\Theta)^{\beta}-(1-s_d)f_d,\\ \pi_x(\Theta)&=\frac{1-\beta}{\beta}\frac{\beta\lambda}{\beta+\lambda}(1+s_r)\tau^{-\beta}Q_{(-j)}^{-(\beta-\eta)}\Theta^{1-\beta}h_x(\Theta)^{\beta}-(1-s_x)f_x.\end{aligned}$$

See Helpman and Itskhoki (2010) for more detail. An immediate implication of (22)-(23) is that the solution to the wage-bargaining problem yields the equilibrium wage:

$$\begin{aligned} w &= \frac{1}{\lambda}b + \frac{\lambda}{1+\lambda}b_u \\ &= b_u + \frac{1}{\lambda}(1-s_b)\zeta x^{\alpha}, \end{aligned}$$

which is the same for all firms, independently of export status or productivity.

A firm's decisions as to whether to stay in the industry and whether to export can be characterized by two cutoff productivity levels Θ_d and Θ_x, which are implicitly defined by $\pi_d(\Theta_d) = 0$ and $\pi_x(\Theta_x) = 0$. That is, firms with productivity below Θ_d exit, firms with productivity $\Theta \in [\Theta_d, \Theta_x)$ serve the domestic market only, and firms with productivity above Θ_x serve both the domestic and export markets. The two conditions $\pi_d(\Theta_d) = 0$ and $\pi_x(\Theta_x) = 0$ can be expressed as

$$\frac{1-\beta}{\beta}\left(\frac{\beta\lambda}{\beta+\lambda}(1+s_r)\right)^{\frac{1}{1-\beta}}\left[(1-s_b)\zeta x^{\alpha} + \frac{\lambda}{1+\lambda}b_u\right]^{\frac{-\beta}{1-\beta}} Q^{-\frac{\beta-\eta}{1-\beta}}\Theta_d = (1-s_d)f_d, \tag{24}$$

$$\frac{1-\beta}{\beta}\left(\frac{\beta\lambda}{\beta+\lambda}(1+s_r)\right)^{\frac{1}{1-\beta}}\left[(1-s_b)\zeta x^{\alpha} + \frac{\lambda}{1+\lambda}b_u\right]^{\frac{-\beta}{1-\beta}} \tau^{\frac{-\beta}{1-\beta}} Q_{(-j)}^{-\frac{\beta-\eta}{1-\beta}}\Theta_x = (1-s_x)f_x. \tag{25}$$

Finally, free entry requires the entry cost net of the entry subsidy to equal expected profits from domestic and export sales:

$$\int_{\Theta_d}^{\infty}\pi_d(\Theta)\mathrm{d}G(\Theta) + \int_{\Theta_x}^{\infty}\pi_x(\Theta)\mathrm{d}G(\Theta) = (1-s_e)f_e.$$

Using the expressions for optimal profits and cutoffs, this condition can be expressed as

$$(1-s_d)f_d\int_{\Theta_d}^{\infty}\left(\frac{\Theta}{\Theta_d}-1\right)\mathrm{d}G(\Theta) + (1-s_x)f_x\int_{\Theta_d}^{\infty}\left(\frac{\Theta}{\Theta_x}-1\right)\mathrm{d}G(\Theta) = (1-s_e)f_e. \tag{26}$$

Conditions (24)-(26) characterize product market equilibrium in the home country. Specifically, given x and $Q_{(-j)}$, they allow us to solve for (Θ_d, Θ_x, Q) for country j (recall that we have dropped the index j from the home country's variables). Similar conditions describe the foreign country's product market equilibrium. Jointly, the two countries' equilibrium conditions allow us to solve the cutoffs and real consumption indexes $(\Theta_{dj}, \Theta_{xj}, Q_j)$ and $(\Theta_{d(-j)}, \Theta_{x(-j)}, Q_{(-j)})$.

Finally, conditions (20)-(26), together with the parallel conditions for the foreign country, describe the decentralized equilibrium allocation for the world economy, given labor and product market policies in the two countries. In this equilibrium the governments are assumed to have access to lump-sum taxes and transfers in order to finance their policies. Under the circumstances we need not worry about the government's budget constraint as long as there is positive consumption of the homogeneous good, which is assured when $\bar{L}$ is large enough.

B Optimal Policies

The world planner's problem—constrained by search frictions—can be formulated as follows:

$$\max_{\{x_{0j},x_j,\Theta_{dj},\Theta_{xj},M_j,h_{dj}(\cdot),h_{xj}(\cdot)\}_{j=A,B}} \sum_{j=A,B} \left(q_{0j} + \frac{1}{\eta} Q_j^{\eta} \right),$$

where

$$Q_j^{\beta} = M_j \int_{\Theta_{dj}}^{\infty} \Theta^{1-\beta} h_{dj}(\Theta)^{\beta} \mathrm{d}G(\Theta) + M_{(-j)} \int_{\Theta_{x(-j)}}^{\infty} \tau^{-\beta} \Theta^{1-\beta} h_{x(-j)}(\Theta)^{\beta} \mathrm{d}G(\Theta),$$

$$q_{0j} = x_{0j}(\bar{L}_j - H_j/x_j)(1 - \zeta_{0j} x_{0j}^{\alpha}) - \zeta_j x_j^{\alpha} H_j - M_j \left[f_e + f_d\big(1 - G(\Theta_{dj})\big) + f_x\big(1 - G(\Theta_{xj})\big)\right],$$

$$H_j = M_j \int_{\Theta_{dj}}^{\infty} h_{dj}(\Theta) \mathrm{d}G(\Theta) + M_j \int_{\Theta_{xj}}^{\infty} h_{xj}(\Theta) \mathrm{d}G(\Theta),$$

and M_j denotes the measure of differentiated product firms that enter in country j, and the other variables have been previously defined. The equation for Q_j comes from the CES aggregator once we notice that $\Theta^{1-\beta} h_{dj}(\Theta)^{\beta} = q_{dj}(\Theta)^{\beta}$, where $q_{dj}(\Theta)$ is consumption of a home variety produced in country j by a firm with productivity Θ, and similarly for imported varieties. The last term on the right hand side of the expression for q_{0j} represents total entry, production, and export fixed costs in terms of the homogeneous good, where $1 - G(\Theta_{dj})$ is the fraction of surviving firms and $1 - G(\Theta_{xj})$ is the fraction of exporting firms out of all entrants. The second term on the right hand side is the total hiring cost paid in the differentiated sector, where H_j is the total number of matches (employment) in this sector and $\zeta_j x_j^{\alpha}$ is the search cost per match. Finally, the first term is the output of homogeneous goods less search costs in the homogeneous-good sector (see the main text for a detailed discussion of the first two terms on the right hand side of the equation for q_{0j}).

Consider the planner's optimal allocation in a world of two symmetric countries (most of the following results generalize to a world of asymmetric countries). In this case we need to consider the optimality conditions for $\big(x_0, x, h_d(\cdot), h_x(\cdot), \Theta_d, \Theta_x, M\big)$, which are common to both countries. The first-order conditions for this problem yield[13]

$$\zeta_0 x_0^{\alpha} = \frac{1}{1+\alpha}, \tag{20^P}$$

$$\zeta x^{1+\alpha} = \zeta_0 x_0^{1+\alpha}, \tag{21^P}$$

$$h_d(\Theta) = \left(\frac{\zeta}{\zeta_0}\right)^{\frac{1}{1+\alpha}\frac{-1}{1-\beta}} Q^{-\frac{\beta-\eta}{1-\beta}}\Theta, \tag{22^P}$$

$$h_x(\Theta) = \left(\frac{\zeta}{\zeta_0}\right)^{\frac{1}{1+\alpha}\frac{-1}{1-\beta}} \tau^{\frac{-\beta}{1-\beta}} Q^{-\frac{\beta-\eta}{1-\beta}}\Theta, \tag{23^P}$$

$$\frac{1-\beta}{\beta}\left(\frac{\zeta}{\zeta_0}\right)^{\frac{1}{1+\alpha}\frac{-\beta}{1-\beta}} Q^{-\frac{\beta-\eta}{1-\beta}}\Theta_d = f_d, \tag{24^P}$$

$$\frac{1-\beta}{\beta}\left(\frac{\zeta}{\zeta_0}\right)^{\frac{1}{1+\alpha}\frac{-\beta}{1-\beta}} \tau^{\frac{-\beta}{1-\beta}} Q^{-\frac{\beta-\eta}{1-\beta}}\Theta_x = f_x, \tag{25^P}$$

$$f_d \int_{\Theta_d}^{\infty}\left(\frac{\Theta}{\Theta_d}-1\right)\mathrm{d}G(\Theta) + f_x \int_{\Theta_d}^{\infty}\left(\frac{\Theta}{\Theta_x}-1\right)\mathrm{d}G(\Theta) = f_e. \tag{26^P}$$

Equations (20^P)-(26^P) characterize the planner's allocation, and they are a direct counterpart to the decentralized equilibrium system (20)-(26). To characterize optimal policies, we simply need to find policy parameters $(b_u, s_{b_0}, s_b, s_r, s_d, s_x, s_e)$ that implement the planner's allocation $(x_0, x, h_d(\cdot), h_x(\cdot), \Theta_d, \Theta_x, Q)$ as a decentralized equilibrium, i.e., policies with which the solution of

[13] Equation (20^P) obtains from the first-order condition with respect to x_0; (21^P) obtains from the first-order condition with respect to x, combined with (20^P). Equations (22^P)-(23^P) obtain from the first-order conditions with respect to $h_d(\cdot)$ and $h_x(\cdot)$ after substituting in

$$\zeta x^{\alpha} + (1-\zeta_0 x_0^{\alpha})\frac{x_0}{x} = \left(\frac{\zeta}{\zeta_0}\right)^{\frac{1}{1+\alpha}},$$

which is implied by (20^P)-(21^P). We can use the above equation in similar fashion to derive the other conditions. Equations (24^P)-(25^P) obtain from the first-order conditions with respect to Θ_d and Θ_x after substituting in the expressions for $h_d(\Theta_d)$ and $h_x(\Theta_x)$ from (22^P)-(23^P). Equation (26^P) obtains through manipulation of the first-order condition with respect to M, which can be written as

$$\frac{1}{\beta}Q^{\eta} - \left(\frac{\zeta}{\zeta_0}\right)^{\frac{1}{1+\alpha}} H = M\left\{f_e + f_d\left[1-G(\Theta_d)\right] + f_x\left[1-G(\Theta_x)\right]\right\}.$$

Next substitute (22^P)-(23^P) into the definition of Q and H which implies

$$Q^{\eta} = \left(\frac{\zeta}{\zeta_0}\right)^{\frac{1}{1+\alpha}} H = M\left(\frac{\zeta}{\zeta_0}\right)^{\frac{1}{1+\alpha}\frac{-\beta}{1-\beta}} Q^{-\frac{\beta-\eta}{1-\beta}}\left[\int_{\Theta_d}^{\infty}\Theta\mathrm{d}G(\Theta) + \tau^{\frac{-\beta}{1-\beta}}\int_{\Theta_x}^{\infty}\Theta\mathrm{d}G(\Theta)\right].$$

Finally, combine the above two expressions with (24^P)-(25^P) to obtain (26^P).

(20)-(26) coincides with the solution of (20^P)-(26^P).[14]

B.1 Optimal policy with hiring-cost subsidies

We first consider the case without unemployment benefits ($b_u = 0$), but with hiring-cost subsidies (s_{b_0}, s_b) used to offset distortions in the labor market. Comparing (20)-(26) with (20^P)-(26^P), we obtain the following characterization of the optimal policy:

$$s_{b_0} = \frac{1-\alpha\lambda_0}{1+\lambda_0}, \qquad s_b = \frac{1-\alpha\lambda_0}{1+\lambda_0} - \frac{1+\alpha}{1+\lambda_0}(\lambda-\lambda_0),$$

$$s_r = \frac{1-\beta}{\beta}\frac{\lambda/\lambda_0-\beta}{1-\beta}\frac{\lambda_0}{1+\lambda_0}, \qquad s_d = s_x = s_e = \frac{1}{1+\lambda_0}.$$

The policies simplify when the firm's relative bargaining power is the same in the two sectors. In this case, we have

$$s_{b_0} = s_b = \frac{1-\alpha\lambda}{1+\lambda}, \qquad s_r = \frac{1-\beta}{\beta}\frac{\lambda}{1+\lambda}, \qquad s_d = s_x = \frac{1}{1+\lambda}.$$

This corresponds to the expression in Section 5.4 where we provide interpretation.

B.2 Optimal policy with unemployment benefits

We now consider the case when hiring-cost subsidies are unavailable, and the government uses unemployment benefits in order to offset labor market distortions. As long as unemployment benefits are common in the two sectors, it would be impossible to decentralize the planner's allocation when $\lambda \neq \lambda_0$. We therefore consider the case with $\lambda_0 = \lambda$. In this case the comparison of (20)-(26) and (20^P)-(26^P) yields the following optimal policies:

$$b_u = \frac{\alpha\lambda-1}{(1+\alpha)\lambda},$$

$$s_r = \frac{1-\beta}{\beta}\frac{\lambda}{1+\lambda} - \frac{\alpha\lambda-1}{(1+\alpha)\lambda}\frac{\beta+\lambda}{\beta(1+\lambda)}\left[1-\left(\frac{\zeta}{\zeta_0}\right)^{\frac{-1}{1+\alpha}}\right],$$

$$s_d = s_x = s_e = \frac{1}{1+\lambda} - \frac{\alpha\lambda-1}{(1+\alpha)(1+\lambda)}\left[1-\left(\frac{\zeta}{\zeta_0}\right)^{\frac{-1}{1+\alpha}}\right].$$

[14] We replace M with Q in the final equations, because it is simpler to discuss allocations in these terms.

In comparison to direct hiring subsidies, unemployment benefits attract more workers to the sector with the higher labor market frictions and therefore with the higher rate of unemployment. This effect needs then to be neutralized by the adjustment of the optimal product market policies, as the above equations demonstrate.

B.3 Single instrument: unemployment benefits

From the above discussion it is clear that the constrained efficient allocation is not feasible when the countries can use unemployment benefits as the only policy instruments. Therefore, the method used above to characterize optimal policies no longer applies. For this reason we directly search for the level of unemployment benefits that maximizes world welfare in a decentralized equilibrium.

Consider again a world of symmetric countries. The indirect utility function for a country is given by

$$\mathbb{V} = E + \frac{1-\eta}{\eta} Q^{\eta},$$

where E is disposable household income (for details see Helpman and Itskhoki, 2010). Unemployment benefits are financed by a lump-sum tax T on households, so that disposable income is

$$E = \omega_0 \bar{L} - T,$$

where $\omega_0 = x_0 b_0$ is expected income in the economy. Finally, the government budget constraint can be written as lump-sum taxes equal total spending on unemployment benefits, or

$$T = b_u \big[(1-x_0)(\bar{L}-N) + (1-x)N\big]. \tag{27}$$

Therefore, we numerically maximize welfare $\mathbb{V}$ with respect to b_u,

$$\max_{b_u} \left\{ x_0 b_0 \bar{L} - T + \frac{1-\eta}{\eta} Q^{\eta} \right\},$$

subject to the government budget constraint (27), and with (b_0, x_0, x, Q, N) determined as functions of b_u from the equilibrium system (20)-(26).[15]

[15] Note that $N = H/x$ and

$$H = \frac{\beta\lambda}{\beta+\lambda}\left(\zeta x^{\alpha} + \frac{\lambda}{1+\lambda}b_u\right)^{-1} Q^{\eta}.$$

To see this, note from (22)-(23) that $h(\Theta) = \frac{\beta\lambda}{\beta+\lambda}\left(\zeta x^{\alpha} + \frac{\lambda}{1+\lambda}b_u\right)^{-1} R(\Theta)$ when $s_r = s_b = 0$. Furthermore, aggregate revenue equals $Q^{\eta} = M\int R(\Theta)\mathrm{d}G(\Theta)$, and aggregate employment equals $H = M\int h(\Theta)\mathrm{d}G(\Theta)$. For more details see Helpman and Itskhoki (2010).

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Labour Market Rigidities, Trade and Unemployment

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We study a two-country, two-sector model of international trade in which one sector produces homogeneous products and the other produces differentiated products. Both sectors are subjected to search and matching frictions in the labour market and wage bargaining. As a result, some of the workers searching for jobs end up being unemployed. Countries are similar except for frictions in their labour markets, such as efficiency of matching and costs of posting vacancies, which can vary across the sectors. The differentiated-product industry has firm heterogeneity and monopolistic competition. We study the interaction of labour market rigidities and trade impediments in shaping welfare, trade flows, productivity, and unemployment. We show that both countries gain from trade. A country with relatively lower frictions in the differentiated-product industry exports differentiated products on net. A country benefits from lowering frictions in its differentiated sector's labour market, but this harms the country's trade partner. Alternatively, a simultaneous, proportional lowering of labour market frictions in the differentiated sectors of both countries benefits both of them. The opening to trade raises a country's rate of unemployment if its relative labour market frictions in the differentiated sector are low, and it reduces the rate of unemployment if its relative labour market frictions in the differentiated sector are high. Cross-country differences in rates of unemployment exhibit rich patterns. In particular, lower labour market frictions do not ensure lower unemployment, and unemployment and welfare can both rise in response to falling labour market frictions and falling trade costs.

1. INTRODUCTION

International trade and international capital flows link national economies. Although such links are considered to be beneficial for the most part, they produce an interdependence that occasionally has harmful effects. In particular, shocks that emanate in one country may negatively impact trade partners. On the trade side, links through terms-of-trade movements have been studied extensively, and it is now well understood that, say, capital accumulation or technological change can worsen a trade partner's terms of trade and reduce its welfare. On the macro side, the transmission of real business cycles has been widely studied, such as the impact of technology shocks in one country on income fluctuations in its trade partners.

Although a large literature addresses the relationship between trade and unemployment, we fall short of understanding how these links depend on labour market rigidities. Indeed, measures of labour market flexibility developed by Botero *et al.* (2004) differ greatly across countries.[1] The rigidity of employment index, which is an average of three other indexes—difficulty of hiring, difficulty of firing, and rigidity of hours—shows wide variation in its range between zero and 100 (where higher values represent larger rigidities). Importantly, countries with very different development levels may have similar labour market rigidities. For example, Chad, Morocco, and Spain have indexes of 60, 63, and 63, respectively, which are about twice the average for the OECD countries of 33.3 and higher than the average for sub-Saharan Africa. The United States has the lowest index, equal to zero, while Australia has an index of 3 and New Zealand has an index of 7, all significantly below the OECD average. Yet some of the much poorer countries also have very flexible labour markets, e.g. both Uganda and Togo have an index of 7.[2]

We develop in this paper a two-country model of international trade in order to study the effects of labour market frictions on trade flows, productivity, welfare, and unemployment. We are particularly interested in the impact of a country's labour market rigidities on its trade partner, and the differential impact of lower trade impediments on countries with different labour market rigidities. Blanchard and Wolfers (2000) emphasize the need to allow for interactions between shocks and differences in labour market characteristics in order to explain the evolution of unemployment in European economies. They show that these interactions are empirically important. On the other side, Nickell *et al.* (2003) emphasize changes over time in labour market characteristics as important determinants of the evolution of unemployment in OECD countries. We focus the analysis on search and matching frictions in Sections 2–5, and discuss in Section 6 how the results generalize to economies with firing costs and unemployment benefits.[3]

The literature on trade and unemployment is large and varied. One strand of this literature considers economies with minimum wages, of which Brecher (1974) represents an early contribution.[4] Another approach, due to Matusz (1986), uses implicit contracts. A third approach, exemplified by Copeland (1989), incorporates efficiency wages into trade models.[5] Yet another line of research uses fair wages. Agell and Lundborg (1995) and Kreickemeier and Nelson (2006) illustrate this approach. The final approach uses search and matching in labour markets. While two early studies extended the two-sector model of Jones (1965) to economies with this type of labour market friction,[6] Davidson, Martin, and Matusz (1999) provide a particularly valuable analysis of international trade with labour markets that are characterized by Diamond–Mortensen–Pissarides-type search and matching frictions.[7] In their model, differences in labour

1. Their original data has been updated by the World Bank and is now available at http://www.doingbusiness.org/ExploreTopics/EmployingWorkers. The numbers reported in the text come from this site, downloaded on 20 May 2007. Other measures of labour market characteristics are available for Organisation for Economic Co-operation and Development (OECD) countries; see Nickell (1997) and Blanchard and Wolfers (2000).

2. There is growing awareness that institutions affect comparative advantage and trade flows. Levchenko (2007), Nunn (2007) and Costinot (2009) provide evidence on the impact of legal institutions, while Cuñat and Melitz (2007) and Chor (2006) provide evidence on the impact of labour market rigidities.

3. While we use a static specification of labour market frictions, our analysis is consistent with a steady state of a dynamic model as we show in Helpman and Itskhoki (2009*b*).

4. His approach has been extended by Davis (1998) to study how wages are determined when two countries trade with each other, one with and one without a minimum wage.

5. See also Brecher (1992) and Hoon (2001).

6. See Davidson, Martin and Matusz (1988) and Hosios (1990).

7. See Pissarides (2000) for the theory of search and matching in labour markets.

market frictions, both across sectors and across countries, generate Ricardian-type comparative advantage.[8]

Our two-sector model incorporates Diamond–Mortensen–Pissarides-type frictions into both sectors: one producing homogeneous goods, the other producing differentiated products. In both sectors wages are determined by bargaining. There is perfect competition in homogeneous goods and monopolistic competition in differentiated products. In the differentiated-product sector, firms are heterogeneous, as in Melitz (2003). These firms exercise market power in the product market on the one hand and bargain with workers over wages on the other.[9] Moreover, there are fixed and variable trade costs in the differentiated sector. We focus the analysis on the differentiated sector and think about the homogeneous sector as the rest of the economy.[10]

We develop the model in stages. The next section describes demand, product markets, labour markets, and the determinants of wages and profits. In the following section, Section 3, we discuss the structure of equilibrium, focusing on the case in which both countries are incompletely specialized, and—as in Melitz (2003)—only a fraction of firms export in the differentiated-product industry and some entrants exit this industry. This is followed by an analysis of the impact of labour market frictions on trade, welfare, and productivity in Section 4. We allow the labour market frictions to vary across both countries and sectors. There we also study the differential impact of lower trade impediments on countries with different labour market frictions. Importantly, we show that both countries gain from trade in welfare terms and in terms of total factor productivity, independently of trade costs and differences in labour market rigidities. The lowering of labour market frictions in the differentiated sector of one country raises its welfare, but harms the trade partner. Nevertheless, both countries benefit from simultaneous proportional reductions of labour market frictions in the differentiated sector across the world.

By lowering frictions in its differentiated sector's labour market, a country gains a competitive advantage in this sector, which is reminiscent of a productivity improvement (but not identical). As a result, it attracts more firms into this sector while the foreign country attracts fewer firms. The entry and exit of firms overwhelms the terms of trade movement, leading to welfare gains in the country with improved labour market frictions and welfare losses in its trade partner.

In Section 4 we also show that labour market flexibility is a source of comparative advantage. The country with relatively lower labour market frictions in the differentiated sector (i.e. lower relative to the homogeneous sector) has a larger fraction of exporting firms and it exports differentiated products on net. Moreover, the share of intra-industry trade is smaller while the volume of trade is larger the larger is the difference in relative sectoral labour market rigidities across countries.

In Section 5 we take up unemployment. We show that the relationship between unemployment and labour market rigidity in the differentiated sector is hump-shaped when the countries are symmetric. A decline in labour market frictions in the differentiated sector decreases the

8. More work has followed this line of inquiry than the other approaches mentioned in the text. Recent examples include Davidson and Matusz (2006*a*, *b*) and Moore and Ranjan (2005).

9. A surge of papers has incorporated labour market frictions into models with heterogeneous firms. Egger and Kreickemeier (2009) examine trade liberalization in an environment with fair wages and Davis and Harrigan (2007) examine trade liberalization in an environment with efficiency wages; both papers focus on the wage dispersion of identical workers across heterogeneous firms in symmetric countries. Mitra and Ranjan (2007) examine offshoring in an environment with search and matching and Felbermayr, Prat and Schmerer (2008) study trade in a one-sector model with search and matching and symmetric countries.

10. The analysis can be generalized in a straightforward way to multiple differentiated sectors.

sectoral rate of unemployment and induces more workers to search for jobs in the differentiated-product sector. When the differentiated sector has the lower sectoral rate of unemployment, which happens when labour market frictions are relatively low in this sector, the reallocation of workers across sectors (i.e. the composition effect) reduces the aggregate rate of unemployment. Under these circumstances, the aggregate rate of unemployment declines, because both the shift in the sectoral rate of unemployment and the reallocation of workers across sectors reduce the aggregate rate of unemployment. On the other hand, when labour market frictions are higher in the differentiated sector, these two effects impact unemployment in opposite directions, with the composition effect dominating in a highly rigid labour market and the sectoral unemployment effect dominating in a mildly rigid labour market. As a result, unemployment initially increases and then decreases as labour market frictions decline, starting from high levels of rigidity.

We also discuss the transmission of shocks across asymmetric countries, using numerical examples to illustrate various patterns. In particular, we show that in the absence of unemployment in the homogeneous sector, if a single country reduces its labour market frictions in the differentiated sector, this reduces unemployment in the country's trading partner by inducing a labour reallocation from the differentiated-product sector to the homogeneous-product sector. We also show that lowering trade impediments can increase unemployment in one or both countries, despite its positive welfare effect, and that the interaction between trade impediments and labour market rigidities produces rich patterns of unemployment. Specifically, differences in rates of unemployment across countries do not necessarily reflect differences in labour market frictions; the more flexible country can have higher or lower unemployment, depending on the height of trade impediments and the levels of labour market frictions. In Section 6 we discuss the impacts of firing costs and unemployment benefits as additional sources of labour market frictions. In particular, we describe conditions under which the previous results remain valid, as well as how they change when these conditions are not satisfied. The last section summarizes some of the main insights from this analysis.

2. THE MODEL

We develop in this section the building blocks of our analytical model. They consist of a demand structure, technologies, product and labour market structures, and determinants of wages and profits. After describing these ingredients in some detail, we discuss in the next three sections equilibrium interactions in a two-country world. In order to focus on labour market rigidities, we assume that the two countries are identical except for labour market frictions. This means that the demand structure and the technologies are the same in both countries. They can differ in the size of their labour endowment, but this difference is not consequential for the type of equilibrium we discuss in the main text.

2.1. *Preferences and demand*

Every country has a representative agent who consumes a homogeneous product q_0 and a continuum of brands of a differentiated product whose real consumption index is Q. The real consumption index of the differentiated product is a constant elasticity of substitution aggregator:

$$Q = \left[\int_{\omega \in \Omega} q(\omega)^{\beta} d\omega \right]^{\frac{1}{\beta}}, \quad 0 < \beta < 1, \tag{1}$$

where $q(\omega)$ represents the consumption of variety ω, Ω represents the set of varieties available for consumption, and β is a parameter that controls the elasticity of substitution between brands.

Consumer preferences between the homogeneous product, q_0, and the real consumption index of the differentiated product, Q, are represented by the quasi-linear utility function[11]

$$\mathbb{U} = q_0 + \frac{1}{\zeta} Q^{\zeta}, \quad 0 < \zeta < \beta.$$

The restriction $\zeta < \beta$ ensures that varieties are better substitutes for each other than for the outside good q_0. We also assume that the consumer has a large enough income level to always consume positive quantities of the outside good, in which case it is convenient to choose the outside good as numeraire, so that its price equals 1, i.e. $p_0 = 1$. Under the circumstances $p(\omega)$, the price of brand ω, and P, the price index of the brands, are measured relative to the price of the homogeneous product.

The utility function $\mathbb{U}$ implies that a consumer with spending E who faces the price index P for the differentiated product chooses $Q = P^{-1/(1-\zeta)}$ and $q_0 = E - P^{-\zeta/(1-\zeta)}$.[12] As a result, the demand function for brand ω can be expressed as

$$q(\omega) = Q^{-\frac{\beta-\zeta}{1-\beta}} p(\omega)^{-\frac{1}{1-\beta}} \tag{2}$$

and the *indirect* utility function as

$$\mathbb{V} = E + \frac{1-\zeta}{\zeta} P^{-\frac{\zeta}{1-\zeta}} = E + \frac{1-\zeta}{\zeta} Q^{\zeta}. \tag{3}$$

As usual, the indirect utility function is increasing in spending and declining in price. A higher price index P reduces the demand for Q, and—holding expenditure E constant—reduces welfare. This decline in welfare results from the fact that consumer surplus, $(1-\zeta) P^{-\zeta/(1-\zeta)}/\zeta = (1-\zeta) Q^{\zeta}/\zeta$, declines as P rises and Q falls. In what follows, we characterize equilibrium values of Q, from which we infer welfare levels.

2.2. *Technologies and market structure*

All goods are produced with labour, which is the only factor of production. The market for the homogeneous product is competitive, and this good serves as numeraire. When a firm is matched with a worker, they produce one unit of the homogeneous good.

The market for brands of the differentiated product is monopolistically competitive. A firm that seeks to supply a brand ω bears an entry cost f_{e} in terms of the homogeneous good, which covers the technology cost and the cost of setting up shop in the industry. After bearing this cost, the firm learns how productive its technology is, as measured by θ; a θ-firm requires $1/\theta$ workers per unit output. In other words, if a θ-firm employs h workers, it produces θh units of output. Before entry, the firm expects θ to be drawn from a known cumulative distribution $G_\theta(\theta)$.

After entry, the firm has to bear a fixed production cost f_d in terms of the homogeneous good; without it no manufacturing is possible. Following Melitz (2003), we assume that the differentiated-product sector bears a fixed cost of exporting f_x in terms of the homogeneous

11. Alternatively, we could use a homothetic utility function in q_0 and Q; see Appendix for a discussion of this case.

12. The assumption that consumer spending on the outside good is positive is equivalent to assuming $E > P^{-\zeta/(1-\zeta)}$. Since $\zeta > 0$, the demand for Q is elastic and total spending PQ rises when P falls.

product. In addition, it bears a variable cost of exporting of the melting-iceberg type: $\tau > 1$ units have to be exported for one unit to arrive in the foreign country.[13]

We label the two countries A and B. If a country-j firm, $j = A, B$, with productivity θ hires h_j workers and chooses to serve only the domestic market, then (2) implies that its revenue equals

$$R_j = Q_j^{-(\beta-\zeta)} \Theta^{1-\beta} h_j^{\beta},$$

where $\Theta \equiv \theta^{\beta/(1-\beta)}$ is a transformed measure of productivity which is more convenient for our analysis. Higher Q_j implies tighter competition in the differentiated-product market of country j and proportionately reduces revenues for all firms serving this market.

If, instead, this firm chooses also to export, then it has to allocate output θh_j across the domestic and foreign markets, i.e. $\theta h_j = q_{dj} + q_{xj}$, where q_{dj} represents the quantity allocated to the domestic market and q_{xj} represents the quantity allocated to the export market.[14] With an optimal allocation of output across markets, the resulting total revenue is

$$R_j = \left[Q_j^{-\frac{\beta-\zeta}{1-\beta}} + \tau^{-\frac{\beta}{1-\beta}} Q_{(-j)}^{-\frac{\beta-\zeta}{1-\beta}} \right]^{1-\beta} \Theta^{1-\beta} h_j^{\beta},$$

where $(-j)$ is the index of the country other than j. In general, the revenue function of country-j firm with productivity θ can therefore be represented by

$$R_j\left(\Theta, h_j\right) = \left[Q_j^{-\frac{\beta-\zeta}{1-\beta}} + I_{xj}\left(\Theta\right) \tau^{-\frac{\beta}{1-\beta}} Q_{(-j)}^{-\frac{\beta-\zeta}{1-\beta}} \right]^{1-\beta} \Theta^{1-\beta} h_j^{\beta}, \tag{4}$$

where $I_{xj}(\Theta)$ is an indicator variable which equals 1 if the firm exports and zero otherwise.

2.3. *Wages and profits*

There are search-and-matching frictions in every sector and firms post vacancies in order to attract workers. The cost of posting vacancies and the matching process generate hiring costs. Moreover, search-and-matching frictions generate bilateral monopoly power between a worker and his firm, as a result of which they engage in wage bargaining.[15]

13. As is common in models with home market effects, we assume that there are no trade frictions in the homogeneous-product sector. We show in our working paper (Helpman and Itskhoki, 2009*a*) that adding trade costs to the homogeneous sector does not affect the results when these costs are not too large. In that paper there are no labour market frictions in the homogeneous sector, but the same arguments can be adapted to our framework.

14. From (2) these quantities have to satisfy

$$q_{dj} = Q_j^{-\frac{\beta-\zeta}{1-\beta}} p_{dj}^{-\frac{1}{1-\beta}} \quad \text{and} \quad q_{xj} = \tau Q_{(-j)}^{-\frac{\beta-\zeta}{1-\beta}} \left(\tau p_{xj}\right)^{-\frac{1}{1-\beta}}.$$

In this specification, p_{dj} and p_{xj} are producer prices of home and foreign sales, respectively. Note that when exports are priced at p_{xj}, consumers in the foreign country pay an effective price of τp_{xj} due to the variable export costs. Under the circumstances, they demand $Q_{(-j)}^{-(\beta-\zeta)/(1-\beta)} \left(\tau p_{xj}\right)^{-1/(1-\beta)}$ consumption units. To deliver these consumption units, the supplier has to manufacture q_{xj} units, as shown above. Such a producer maximizes total revenue when marginal revenues are equalized across markets. In the case of constant elasticity of demand functions, this requires equalization of producer prices, which implies that the optimal allocation of output satisfies

$$q_{xj}/q_{dj} = \tau^{-\frac{\beta}{1-\beta}} \left(Q_{(-j)}/Q_j\right)^{-\frac{\beta-\zeta}{1-\beta}}.$$

15. In the earlier working paper version (Helpman and Itskhoki, 2009*a*), we focused on the case in which there are no labour market frictions in the homogeneous-product sector. The current framework incorporates it as a special case (see footnote 20).

We assume that in the homogeneous-product sector every firm employs one worker. This assumption is common in the search and matching literature (see Pissarides, 2000) and in our case leads to no loss of generality. Since firms in this sector are homogeneous in terms of productivity and produce a homogeneous good, our analysis does not change if we allow firms to hire multiple workers, as long as they remain price takers.

When a firm and a worker match, they bargain over the surplus from the relationship. Since the outside option of each party equals zero at this stage, the surplus—which consists of the revenue from sales of one unit of the homogeneous product—equals 1. Assuming equal weights in the bargaining game then implies that the worker gets a wage $w_0 = 1/2$ and the firm gets a profit $\pi_0 = 1/2$, and these payoffs are the same in every country. We discuss additional details of the labour market equilibrium in this sector in the following section.

In the differentiated-product industry, firms are heterogeneous in terms of productivity but face the same cost of hiring in the labour market. A Θ-firm from country j that seeks to employ h_j workers bears the hiring cost $b_j h_j$ in terms of the homogeneous good, where b_j is exogenous to the firm yet it depends on sectoral labour market conditions, as we discuss below. It follows that a worker cannot be replaced without cost. Under these circumstances, a worker inside the firm is not interchangeable with a worker outside the firm, and workers have bargaining power after being hired. Workers exploit this bargaining power in the wage determination process.

We assume that the h_j workers and the firm engage in strategic wage bargaining with equal weights in the manner suggested by Stole and Zwiebel (1996*a*, *b*), which is a natural extension of Nash bargaining to the case of multiple workers. The revenue function (equation (4)) then implies that the firm gets a fraction $1/(1+\beta)$ of the revenue and the workers get a fraction $\beta/(1+\beta)$.[16] Recall that β determines the concavity of the revenue function in the number of workers; a lower β makes the revenue more concave and reduces the revenue loss from the departure of a marginal worker. Therefore, lower β reduces the equilibrium share of the workers in the division of revenue. This bargaining outcome is derived under the assumption that at the bargaining stage a worker's outside option is unemployment, and the value of unemployment is zero because there are no unemployment benefits and the model is static. In Section 6 we discuss unemployment benefits, and in Helpman and Itskhoki (2009*b*) we show that our bargaining solution carries over to the steady state of a dynamic model.

Anticipating the outcome of this bargaining game, a Θ-firm that wants to stay in the industry chooses an employment level, h_j, and whether to serve the foreign market, $I_{xj} \in \{0, 1\}$, that maximize profits. That is, it solves the following problem:

$$\pi_j(\Theta) \equiv \max_{\substack{I_{xj}\in\{0,1\},\\ h_j\geq 0.}} \left\{ \frac{1}{1+\beta}\left[Q_j^{-\frac{\beta-\zeta}{1-\beta}} + I_{xj}\tau^{-\frac{\beta}{1-\beta}} Q_{(-j)}^{-\frac{\beta-\zeta}{1-\beta}} \right]^{1-\beta} \Theta^{1-\beta} h_j^{\beta} - b_j h_j - f_d - I_{xj} f_x \right\}. \quad (5)$$

16. In the solution to the Stole and Zwiebel bargaining game, the firm and a worker equally divide the marginal surplus from their relationship, i.e.

$$\frac{\partial}{\partial h}\left[R_j(\Theta, h) - w_j(\Theta, h)h\right] = w_j(\Theta, h),$$

where $w_j(\Theta, h)$ is the bargained wage rate in a Θ-firm in country j which employs h workers. Therefore, the left-hand side represents the surplus of the firm from employing the marginal worker, accounting for the fact that his departure will impact the wage rate of the remaining workers. The wage on the right-hand side is the worker's surplus. Using the expression for revenue (equation (4)), the above condition represents a differential equation for the wage schedule which yields the solution $w_j(\Theta, h) = \beta/(1+\beta) \cdot R_j(\Theta, h)/h$.

The solution to this problem implies that the employment level of a Θ-firm in country j can be decomposed into

$$h_j(\Theta) = h_{dj}(\Theta) + I_{xj}(\Theta)\, h_{xj}(\Theta),$$

where $h_{dj}(\Theta)$ represents employment for domestic sales, $h_{xj}(\Theta)$ represents employment for export sales, and

$$\begin{aligned} h_{dj}(\Theta) &= \phi_1^{\frac{1}{\beta}} b_j^{-\frac{1}{1-\beta}} Q_j^{-\frac{\beta-\zeta}{1-\beta}} \Theta, \\ h_{xj}(\Theta) &= \phi_1^{\frac{1}{\beta}} b_j^{-\frac{1}{1-\beta}} \tau^{-\frac{\beta}{1-\beta}} Q_{(-j)}^{-\frac{\beta-\zeta}{1-\beta}} \Theta, \end{aligned} \tag{6}$$

where

$$\phi_1 = \left(\frac{\beta}{1+\beta}\right)^{\frac{\beta}{1-\beta}}.$$

Furthermore, a country-j firm with productivity Θ pays wages

$$w_j(\Theta) = \frac{\beta}{1+\beta} \frac{R_j(\Theta)}{h_j(\Theta)} = b_j, \tag{7}$$

where the first equality is the outcome of the bargaining game and the second equality follows from the optimal employment condition (6). Firms find it optimal to increase their employment up to the point at which the bargaining outcome is a wage rate equal to the cost of replacing a worker, b_j. Since this hiring cost is common across all firms, in equilibrium country-j firms of all productivity levels, exporters, and non-exporters alike, pay equal wages, $w_j = b_j$.[17]

Finally, the operating profits of a Θ-firm in country j are

$$\pi_j(\Theta) = \pi_{dj}(\Theta) + I_{xj}(\Theta)\, \pi_{xj}(\Theta),$$

where $\pi_{dj}(\Theta)$ represents operating profits from domestic sales, $\pi_{xj}(\Theta)$ represents operating profits from export sales, and

$$\begin{aligned} \pi_{dj}(\Theta) &= \phi_1 \phi_2 b_j^{-\frac{\beta}{1-\beta}} Q_j^{-\frac{\beta-\zeta}{1-\beta}} \Theta - f_d, \\ \pi_{xj}(\Theta) &= \phi_1 \phi_2 b_j^{-\frac{\beta}{1-\beta}} \tau^{-\frac{\beta}{1-\beta}} Q_{(-j)}^{-\frac{\beta-\zeta}{1-\beta}} \Theta - f_x, \end{aligned} \tag{8}$$

where

$$\phi_2 = \frac{1-\beta}{1+\beta}.$$

Note that higher labour market rigidity, reflected in a higher b_j, reduces proportionately gross operating profits (i.e. not accounting for fixed costs) in the domestic and foreign market.

17. This equilibrium outcome generalizes to other revenue functions and bargaining concepts as long as firms are allowed to vary their employment and the marginal hiring costs are equal across the firms. In the earlier working paper version (Helpman and Itskhoki, 2007), we generated size wage premium (i.e. higher wages paid by larger firms) and exporter wage premium (i.e. higher wages paid by exporters) by introducing convex hiring costs. Helpman, Itskhoki, and Redding (2009) develop a richer model, in which there is unobserved worker heterogeneity in addition to firm heterogeneity, wages are higher in more productive firms, and exporters pay a wage premium. Bernard and Jensen (1995) and Fariñas and Martín-Marcos (2007) provide evidence to the effect that exporting firms pay higher wages.

Therefore, an increase in b_j is similar to a proportional reduction in the productivity of all country-j firms.

The profit functions in (8) imply that exporting is profitable if and only if $\pi_{xj}(\Theta) \geq 0$, i.e. there exists a cutoff productivity level, Θ_{xj}, defined by

$$\pi_{xj}\left(\Theta_{xj}\right) = 0, \tag{9}$$

such that all firms with productivity above this cutoff export (provided they choose to stay in the industry) and all firms with productivity below it do not export. Firms with low productivity that do not export may nevertheless make money from supplying the domestic market. For this to be the case, their productivity has to be at least as high as Θ_{dj}, implicitly defined by

$$\pi_{dj}\left(\Theta_{dj}\right) = 0. \tag{10}$$

We shall consider equilibria in which $\Theta_{xj} > \Theta_{dj} > \Theta_{\min} \equiv \theta_{\min}^{\beta/(1-\beta)}$, where $\theta_{\min}$ is the lowest productivity level in the support of the distribution $G_\theta(\theta)$. That is, equilibria in which high-productivity firms profitably export and supply the domestic market, intermediate-productivity firms cannot profitably export but can profitably supply the domestic market, and low-productivity firms cannot make money and exit. Anticipating this outcome, a prospective firm enters the industry only if expected profits from entry are at least as high as the entry cost f_e. Therefore, the free-entry condition is

$$\int_{\Theta_{dj}}^{\infty} \pi_{dj}(\Theta)\, dG(\Theta) + \int_{\Theta_{xj}}^{\infty} \pi_{xj}(\Theta)\, dG(\Theta) = f_e, \tag{11}$$

where $G(\Theta)$ is the distribution of Θ induced by $G_\theta(\theta)$. The first integral represents expected profits from domestic sales, while the second integral represents expected profits from foreign sales. In equilibrium expected profits just equal entry costs.

2.4. *Labour market*

A country is populated by families. Each family has a fixed supply of L workers, and the family is the representative consumer whose preferences were described in Section 2.1. We assume that there is a continuum of identical families in every country, and the measure of these families equals 1 in every country.[18]

A family in country j allocates workers to sectors—N_j workers to the differentiated-product sector and $N_{0j} = L - N_j$ workers to the homogeneous-product sector—which determines in which sector every worker searches for work. Once committed to a sector, a worker cannot switch sectors. Thus, there is perfect intersectoral mobility *ex ante* and no mobility *ex post*.

Let the matching function in the homogeneous sector be Cobb–Douglas, so that $H_{0j} = m_{0j} V_{0j}^{\chi} N_{0j}^{1-\chi}$ is the number of matches when the number of vacancies in the sector equals V_{0j} and the number of workers searching for jobs in the sector equals N_{0j}, where $0 < \chi < 1$. We allow the efficiency of the matching process, as measured by m_{0j}, to vary across countries. It follows that output of homogeneous products equals H_{0j}, the probability of a worker finding a job in this sector equals $x_{0j} \equiv H_{0j}/N_{0j} = m_{0j}\left(V_{0j}/N_{0j}\right)^{\chi}$, and the probability of a firm finding

18. When preferences are homothetic rather than quasi-linear, the family interpretation is useful but not essential. See Appendix and Helpman, Itskhoki and Redding (2009) for a discussion of homothetic preferences, risk aversion, and *ex post* inequality.

a worker equals $H_{0j}/V_{0j} = m_{0j}\left(N_{0j}/V_{0j}\right)^{1-\chi} = m_{0j}^{1+\alpha}x_{0j}^{-\alpha}$, where $\alpha \equiv (1-\chi)/\chi > 0$.[19] We shall use x_{0j} as our measure of tightness in the sector's labour market.

Next assume that the cost of posting vacancies equals v_{0j} per worker in country j, measured in terms of the homogeneous good. Then a firm's entry cost into the industry equals v_{0j}. After paying this cost, the firm is matched with a worker with probability $m_{0j}^{1+\alpha}x_{0j}^{-\alpha}$ and not matched otherwise. When the firm is matched with a worker, they bargain over the surplus from the relationship, as described in the previous section; the worker gets a wage $w_0 = 1/2$ and the firm gets a profit $\pi_0 = 1/2$. Under these circumstances, the expected profits equal $m_{0j}^{1+\alpha}x_{0j}^{-\alpha}/2$ and firms enter up to the point at which these expected profits cover the entry cost v_{0j}. In other words, in equilibrium, tightness in the labour market equals[20]

$$x_{0j} = a_{0j}^{-1/\alpha}, \qquad a_{0j} \equiv \frac{2v_{0j}}{m_{0j}^{1+\alpha}} > 1. \tag{12}$$

The derived parameter a_{0j} summarizes labour market frictions in the homogeneous sector; it rises with the cost of vacancies and declines with the efficiency of the matching process. Evidently, tightness in the labour market declines with a_{0j}.

The expected income of a worker searching for a job in the homogeneous sector is $\omega_{0j} = x_{0j}w_{0j}$, which together with equation (12) yields

$$\omega_{0j} = \frac{1}{2}a_{0j}^{-1/\alpha}. \tag{13}$$

That is, the expected income of this worker rises with the efficacy of matching in the homogeneous sector and declines with the cost of vacancies. Finally, note that, as a result of free entry of firms, the cost of hiring per worker, $b_{0j} \equiv v_{0j}V_{0j}/H_{0j} = \left(v_{0j}/m_{0j}^{1+\alpha}\right)x_{0j}^{\alpha}$, equals one-half in the homogeneous sector in both countries:

$$b_{0j} = \frac{1}{2}a_{0j}x_{0j}^{\alpha} = \frac{1}{2}. \tag{14}$$

We now turn to the differentiated sector. Let H_j be aggregate employment in the differentiated sector. An individual searching for work in the differentiated-product sector expects to find a job with probability $x_j = H_j/N_j$, where x_j measures the degree of tightness in the sector's labour market. Conditional on finding a job, an individual expects to be paid a wage $w_j = b_j$ (see (7)). Therefore the expected income from searching for a job in the differentiated sector is x_jb_j.

A family allocates workers to sectors so as to maximize its aggregate income. A worker allocated to the homogeneous sector earns an expected income of ω_{0j}, given in equation (13). On the other hand, a worker allocated to the differentiated sector earns an expected income of x_jb_j. In an equilibrium with employment in both sectors, the two expected incomes have to be

19. Below we impose parameter restrictions which ensure that matching probabilities are between zero and 1. In a dynamic model with continuous time, these probabilities are replaced by hazard rates which can take arbitrary positive values including the limiting case of frictionless labour market. We show in Helpman and Itskhoki (2009*b*) that this type of dynamic specification yields steady-state outcomes which are similar to our static specification.

20. We assume that $m_{0j}^{1+\alpha} < 2v_{0j} < 1$, which ensures that the probability of a worker finding a job and the probability of a firm finding a worker are both smaller than 1. Alternatively, when $m_{0j}^{1+\alpha} = 2v_{0j} = 1$, workers and firms are matched with probability 1 and there is full employment in the homogeneous sector, as in Helpman and Itskhoki (2009*a*).

equal. That is, a family chooses $0 < N_j < L_j$ only if[21]

$$x_j b_j = \omega_{0j}. \tag{15}$$

Unemployment in the differentiated sector is an equilibrium outcome when $x_j < 1$. We provide below parameter restrictions that ensure this condition.

We now interpret the parameter b_j of the cost-of-hiring function $b_j h$; this variable is exogenous to the firm but endogenous to the industry. As in the homogeneous sector, workers in the differentiated sector are randomly matched with firms. The number of successful matches is $H_j = m_j V_j^{\chi} N_j^{1-\chi}$ in country j, where V_j is the number of vacancies and N_j is the number of individuals searching for jobs in this sector. Note that χ is the same here as in the matching function of the homogeneous sector, but m_j—which measures the efficiency of matching—is allowed to differ across countries and sectors. It follows that when the cost per vacancy is v_j in the differentiated sector of country j, then the cost of hiring is $b_j = v_j V_j / H_j$ per worker, and b_j can be related in a simple way to tightness in the labour market x_j:[22]

$$b_j = \frac{1}{2} a_j x_j^{\alpha}, \qquad a_j \equiv \frac{2v_j}{m_j^{1+\alpha}}, \tag{16}$$

where a_j is our measure of frictions in the differentiated sector's labour market, which is increasing in the cost of vacancies and decreasing in the productivity of matching. Note the symmetry in the modelling of hiring costs in the homogeneous and differentiated sectors (compare (16) with (14)).

Next note that equations (12)–(16) uniquely determine the hiring cost b_j and tightness in the labour market x_j:

$$\begin{aligned} x_j &= x_{0j} \left(\frac{a_{0j}}{a_j}\right)^{\frac{1}{1+\alpha}} = \left(\frac{1}{a_{0j}^{1/\alpha} a_j}\right)^{\frac{1}{1+\alpha}}, \\ w_j &= b_j = b_{0j} \left(\frac{a_j}{a_{0j}}\right)^{\frac{1}{1+\alpha}} = \frac{1}{2}\left(\frac{a_j}{a_{0j}}\right)^{\frac{1}{1+\alpha}}. \end{aligned} \tag{17}$$

Note that $x_j < 1$ and there is unemployment in the differentiated sector if and only if $a_{0j} a_j^{\alpha} > 1$, which we assume to be satisfied. It follows from this characterization that whenever a country has the same labour market frictions in both sectors, so that $a_{0j} = a_j$, it has the same labour market tightness in both sectors and the same cost of hiring in both sectors. Yet, while the cost of hiring is independent in this case of the common level of labour market frictions, because $b_{0j} = b_j = 1/2$, tightness in the sectoral labour markets declines with the level of frictions. This implies that when $a_{0j} = a_j$ in both countries, no country has comparative advantage in one of the sectors (see the discussion in the next section), even when the *level* of labour market frictions varies across countries. In Helpman and Itskhoki (2009*b*), we show that similar patterns arise in the steady state of a dynamic model.

In what follows we assume that $a_A/a_{0A} > a_B/a_{0B}$, so that country B has relatively lower labour market frictions in the differentiated sector. This implies $b_A > b_B$, i.e. country A has a larger hiring cost in the differentiated sector, and $x_A/x_{0A} < x_B/x_{0B}$, i.e. the sectoral labour

21. This is similar to the indifference between staying in the countryside and migrating to the city in the Harris and Todaro (1970) model. A similar condition holds in the Amiti and Pissarides (2005) model, which is otherwise quite different from ours.

22. See Blanchard and Galí (2008) for a similar specification.

market tightness is relatively lower in the differentiated sector of country A. Note, however, that our assumption on relative sectoral labour market frictions has no implications for whether the labour market is tighter in one sector or the other. When $a_j/a_{0j} > 1$ in both countries, sectoral tightness is higher in the homogeneous sector in both countries; when $a_j/a_{0j} < 1$ in both countries, sectoral tightness is higher in the differentiated sector in both countries; and when $a_A/a_{0A} > 1 > a_B/a_{0B}$, sectoral tightness is higher in the homogeneous sector in country A and higher in the differentiated sector in country B. Sectoral labour market frictions can differ because it may be more difficult to match workers with firms in some sectors than in others, and labour market frictions can differ across countries because of differences in matching efficiency or differences in costs of posting vacancies.[23] We allow these possibilities in order to accommodate variation in sectoral rates of unemployment, which feature in the data.[24]

Evidently, the model is bloc recursive, in the sense that the equilibrium wage rate and tightness in the labour market are uniquely determined by labour market frictions. We show in Section 6 that this property also holds with firing costs and unemployment benefits. The implication is that labour market frictions determine (b_j, x_j) in country j, and these in turn impact other endogenous variables, such as trade, welfare, and unemployment.

The sectoral rates of unemployment are $1 - x_{0j}$ in the homogeneous sector and $1 - x_j$ in the differentiated sector. As a result, the economy-wide rate of unemployment can be expressed as

$$u_j = \frac{N_{0j}}{L}\left(1 - x_{0j}\right) + \frac{N_j}{L}\left(1 - x_j\right), \tag{18}$$

which is a weighted average of the sectoral rates of unemployment, where the weights are the fractions of workers seeking jobs in every sector. It follows that the unemployment rate can rise either because it rises in one or both sectors or because more individuals search for work in the sector with a higher rate of unemployment.

3. EQUILIBRIUM STRUCTURE

We focus on equilibria with incomplete specialization, in which every country produces homogeneous and differentiated products. Conditions for incomplete specialization are described in the Appendix, and in our earlier working paper (Helpman and Itskhoki, 2007) we discuss properties of equilibria with complete specialization. This section is devoted to a description of equilibria and some of their properties. More substantive results, which build on this section, are developed and discussed in subsequent sections.

Equations (8)–(10) yield the following expressions for the domestic market and export cutoffs:

$$\begin{aligned} \Theta_{dj} &= \frac{1}{\phi_1\phi_2} f_d b_j^{\frac{\beta}{1-\beta}} Q_j^{\frac{\beta-\zeta}{1-\beta}}, \\ \Theta_{xj} &= \frac{1}{\phi_1\phi_2} f_x b_j^{\frac{\beta}{1-\beta}} \tau^{\frac{\beta}{1-\beta}} Q_{(-j)}^{\frac{\beta-\zeta}{1-\beta}}. \end{aligned} \tag{19}$$

23. In a dynamic model, sectors may differ in separation rates, which would be equivalent in the static framework to $b_{0j} \neq b_j$ (see Helpman and Itskhoki, 2009*b*). Specifically, we show that if the differentiated sector has a higher separation rate, it leads to greater turnover in this sector and a country with more efficient matching technology has a comparative advantage in this sector. Furthermore, policy differences can be a source of cross-country variation in labour market frictions, which we discuss in Section 6.

24. To illustrate, the BLS reports that in 2007 mining had an unemployment rate of 3.4%, construction had 7.4%, and manufacturing had 4.3% (see http://www.bls.gov/cps/cpsaat26.pdf, accessed on 25 April 2008).

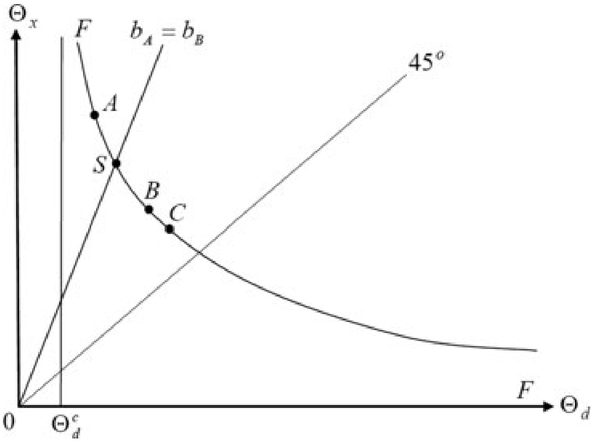

FIGURE 1

Cutoffs in a trading equilibrium

Now substitute these expressions into equations (8) and the resulting profit functions into the free-entry condition (11) to obtain

$$f_d \int_{\Theta_{dj}}^{\infty} \left(\frac{\Theta}{\Theta_{dj}} - 1 \right) dG(\Theta) + f_x \int_{\Theta_{xj}}^{\infty} \left(\frac{\Theta}{\Theta_{xj}} - 1 \right) dG(\Theta) = f_e, \quad j = A, B. \tag{20}$$

This form of the free-entry condition generates a curve in $(\Theta_{dj}, \Theta_{xj})$ space on which every country's cutoffs have to be located, because this curve depends only on the common cost variables and on the common distribution of productivity. Moreover, this curve is downward-sloping, as depicted by FF in Figure 1, and each country has to be located above the 45$^{\text{o}}$ line for the export cutoff to be higher than the domestic cutoff.[25]

Also note that, as the export cutoff goes to infinity, the domestic cutoff approaches the cutoff of a closed economy, which is represented by Θ_d^c in the figure. It therefore follows that if the cutoff Θ_d in the closed economy is larger than $\Theta_{\min}$, so is Θ_d in the open economy.[26] Finally, note that (19) yields

$$\frac{\Theta_{xj}}{\Theta_{d(-j)}} = \frac{f_x \tau^{\frac{\beta}{1-\beta}}}{f_d} \left(\frac{b_j}{b_{(-j)}} \right)^{\frac{\beta}{1-\beta}}, \quad j = A, B. \tag{21}$$

Equations (20) and (21) can be used for solving the four cutoffs as functions of labour market frictions and cost parameters, as illustrated in Figure 1. As is evident, the cutoffs do not depend

25. Note, from (19), in a symmetric equilibrium, in which $Q_j = Q_{(-j)}$, the export cutoff is higher if and only if $\tau^{\beta/(1-\beta)} f_x > f_d$, which is the condition required for exporters to be more productive in Melitz (2003). We assume for convenience that this condition is satisfied for all $\tau \geq 1$ which requires $f_x > f_d$.

26. The autarky production cutoff is the solution to

$$f_d \int_{\Theta_d^c}^{\infty} \left(\frac{\Theta}{\Theta_d^c} - 1 \right) dG(\Theta) = f_e,$$

which does not depend on labour market frictions. Note also that $\Theta_d^c > \Theta_{\min}$ if and only if $(\overline{\Theta}/\Theta_{\min}) > 1 + f_e/f_d$, where $\overline{\Theta}$ is the mean of Θ, which we assume to be satisfied. This results from the fact that the integral on the left-hand side of the above equation is decreasing in Θ_d^c and assumes its largest value of $(\overline{\Theta}/\Theta_{\min}) - 1$ when $\Theta_d^c = \Theta_{\min}$.

on the *levels* of the hiring costs b_j but only on their relative size. And once the cutoffs have been solved, they can be substituted into equation (19) to obtain solutions for the real consumption indexes Q_j.

Our primary interest is in the influence of trade and labour market frictions on the trading countries. We therefore use (20) and (21) to calculate the impact of these variables on the cutoffs, obtaining

$$\begin{aligned} \hat{\Theta}_{dj} &= \frac{\delta_{xj}}{\Delta}\left[-\left(\delta_{x(-j)}+\delta_{d(-j)}\right)\left(\hat{b}_j-\hat{b}_{(-j)}\right)-\left(\delta_{d(-j)}-\delta_{x(-j)}\right)\hat{\tau}\right], \\ \hat{\Theta}_{xj} &= \frac{\delta_{dj}}{\Delta}\left[\left(\delta_{x(-j)}+\delta_{d(-j)}\right)\left(\hat{b}_j-\hat{b}_{(-j)}\right)+\left(\delta_{d(-j)}-\delta_{x(-j)}\right)\hat{\tau}\right], \end{aligned} \tag{22}$$

where

$$\delta_{dj}=\frac{f_d}{\Theta_{dj}}\int_{\Theta_{dj}}^{\infty}\Theta dG(\Theta), \quad \delta_{xj}=\frac{f_x}{\Theta_{xj}}\int_{\Theta_{xj}}^{\infty}\Theta dG(\Theta), \quad \Delta=\frac{1-\beta}{\beta}\left(\delta_{dA}\delta_{dB}-\delta_{xA}\delta_{xB}\right).$$

Note that δ_{dj}/ϕ_2 is the average revenue per entering firm from domestic sales in country j and δ_{xj}/ϕ_2 is the average revenue per entering firm from export sales.[27] Moreover, δ_{dj} equals average gross operating profits (not accounting for fixed costs) per entering firm from domestic sales and δ_{xj} equals average gross operating profits per entering firm from exporting.

Building on these insights, we prove in the Appendix the following lemmas:

Lemma 1. *Let $b_A > b_B$. Then $\Theta_{dA} < \Theta_{dB}$ and $\Theta_{xA} > \Theta_{xB}$.*

Lemma 2. *An increase in τ raises the export cutoff Θ_{xj} and reduces the domestic cutoff Θ_{dj} in both countries.*

Lemma 3. *Let $b_A > b_B$. Then $Q_A < Q_B$.*

The first lemma shows that in the country with the relatively higher labour market frictions in the differentiated sector exporting requires higher productivity at the firm level and that firms with lower productivity at the bottom of the productivity distribution break even. The former result is quite intuitive; a disadvantage in labour costs needs to be compensated with a productivity advantage to make exporting profitable. The latter stems from the fact that in a country with higher b_j expected profits from exporting are lower at the entry stage, which has to be offset by higher expected profits from domestic sales in order for the free-entry condition to be satisfied. This implies that lower-productivity firms find it profitable to serve the domestic market. The second lemma just restates a well-known result from Melitz (2003) which also holds in our framework: higher variable trade costs cut into export profits, enabling only more productive firms to profitably export. Under the circumstances, lower-productivity firms need to survive entry in order to be able to cover the entry cost. The third lemma states that the

27. To see this, note that profit maximization (equation (5)) implies $\pi_{zj}(\Theta)=\phi_2 R_{zj}(\Theta)-f_z$ for $z=d,x$, where $R_{dj}(\Theta)$ is revenue from domestic sales and $R_{xj}(\Theta)$ is revenue from foreign sales. Then, from the zero profit conditions (9)–(10), we have $R_{zj}(\Theta)=f_z/\phi_2\cdot\Theta/\Theta_{zj}$. As a result, the average revenues per entering firm from domestic sales and exports equal

$$\int_{\Theta_{zj}}^{\infty}R_{zj}(\Theta)dG(\Theta)=\frac{f_z}{\phi_2\Theta_{zj}}\int_{\Theta_{zj}}^{\infty}\Theta dG(\Theta)=\frac{\delta_{zj}}{\phi_2}, \qquad z=d,x.$$

country with higher relative labour market frictions in the differentiated sector has lower real consumption of differentiated products. This stems from the home market effect. Due to the presence of trade costs, a country suffers a disadvantage in the local supply of differentiated products when its b_j is higher in the differentiated industry.

For our equations to describe an equilibrium with incomplete specialization, it is necessary to ensure positive entry of firms in both countries, i.e. $M_j > 0$ for $j = A, B$, where M_j is the number of firms that enter the differentiated sector in country j. This places restrictions on the permissible difference across countries in labour market rigidities. To derive the implications of these restrictions, first recall that $Q_j^{\zeta} = P_j Q_j$ is the total spending on differentiated products in country j, and $M_j \delta_{zj}/\phi_2$ is total revenue from domestic sales when $z = d$ and from foreign sales when $z = x$. Since aggregate spending has to equal aggregate revenue in market j, we have

$$Q_j^{\zeta} = M_j \frac{\delta_{dj}}{\phi_2} + M_{(-j)} \frac{\delta_{x(-j)}}{\phi_2},$$

where the first term on the right-hand side is revenues of domestic firms and the second term is revenues of foreign firms from sales in country j's market. Having solved for the cutoffs, which uniquely determine the δ_{zj}s and the real consumption indexes, Q_js, these equations for $j = A, B$ yield the following solutions for the number of entrants:

$$M_j = \frac{(1-\beta)\,\phi_2}{\beta \Delta} \left[\delta_{d(-j)} Q_j^{\zeta} - \delta_{x(-j)} Q_{(-j)}^{\zeta} \right]. \tag{23}$$

We show in the Appendix that they imply the following:

Lemma 4. *In an equilibrium with incomplete specialization: (i) $\delta_{dj} > \delta_{xj}$ in both countries; (ii) if $b_A > b_B$, then $\delta_{dA} > \delta_{dB}$ and $\delta_{xA} < \delta_{xB}$.*

Lemma 5. *Let $b_A > b_B$. Then $M_A < M_B$.*

Lemma 4 is a technical lemma, which describes conditions that hold in an equilibrium with incomplete specialization. The economic implication of part (i) is that average revenue per entering firm from domestic sales exceeds average revenue per entering firm from export sales in each one of the countries, and the economic implication of part (ii) is that in country A, which has the relatively high labour market frictions in the differentiated sector, average revenue per entering firm from domestic sales is higher and average revenue per entering firm from export sales is lower than in country B. And the last lemma states that there is less entry of firms in the differentiated-product industry in the country in which labour market frictions are relatively higher in this sector—a result which is quite intuitive.

Finally, consider the determinants of the number of workers searching for jobs in the differentiated sector, N_j, and aggregate employment in that sector, H_j. On the one hand, the wage bill in the differentiated sector, $w_j H_j$, equals $\omega_{0j} N_j$, because the wage rate is $w_j = b_j = \omega_{0j}/x_j$ (see (15)) and $x_j = H_j/N_j$ by definition. This implies that aggregate income equals $\omega_{0j} L$, where income $\omega_{0j} N_j$ is derived from the differentiated sector and income $\omega_{0j} N_0 = \omega_{0j} \left(L - N_j \right)$ is derived from the homogeneous sector. On the other hand, the wage bill in the differentiated sector equals the fraction $\beta/(1+\beta)$ of revenue (a result from the bargaining game). Therefore

$$\omega_{0j} N_j = \frac{\beta}{1+\beta} M_j \left(\frac{\delta_{dj}}{\phi_2} + \frac{\delta_{xj}}{\phi_2} \right), \tag{24}$$

where $M_j\left(\delta_{dj}+\delta_{xj}\right)/\phi_2$ is total revenue of country-j firms from domestic sales and exporting. It follows that, once the cutoffs and the numbers of firms are known, this equation determines the number of workers searching for jobs in the differentiated-product industry.[28] Having solved for N_j, aggregate employment in the differentiated sector is

$$H_j = x_j N_j. \tag{25}$$

The remaining $N_{0j} = L - N_j$ workers search for jobs in the homogeneous-good sector, with $H_{0j} = x_{0j} N_{0j}$ of them finding employment and generating H_{0j} units of output of the homogeneous good. This completes the description of an equilibrium with incomplete specialization.

4. TRADE, WELFARE, AND PRODUCTIVITY

In this section we explore channels through which the two countries are interdependent. For this purpose we organize the discussion around two main themes: the impact of a country's labour market frictions on its trade partner, and the differential effects of trade impediments on countries with different labour market frictions.

4.1. *Welfare*

We are interested in knowing how labour market rigidities and trade frictions affect welfare, and in particular their differential impact on the welfare of the two countries. Since aggregate spending in country j, E_j, equals aggregate income, and aggregate income equals $\omega_{0j}L = a_{0j}^{-1/\alpha}L/2$ (see equation (13)), the indirect utility function (3) implies that welfare is higher the larger the real consumption index of differentiated products Q_j is and the lower the friction in the homogeneous sector a_{0j} is. We have already shown that Q_j is higher in country B (see Lemma 3). It follows that welfare is also higher in B as long as the labour market friction in its homogeneous sector, a_{0B}, is not too high relative to that in country A, a_{0A}.

Now combine the formulas for change in the cutoffs (22) with the log-differential of the first equation in (19) to obtain

$$\frac{\beta-\zeta}{1-\beta}\hat{Q}_j = \frac{1}{\Delta}\left[-\delta_{d(-j)}\left(\delta_{xj}+\delta_{dj}\right)\hat{b}_j + \delta_{xj}\left(\delta_{x(-j)}+\delta_{d(-j)}\right)\hat{b}_{(-j)} - \delta_{xj}\left(\delta_{d(-j)}-\delta_{x(-j)}\right)\hat{\tau}\right]. \tag{26}$$

This equation has a number of implications. First, it shows that a reduction in a country's labour market frictions in the differentiated sector, i.e. a decline in a_j which reduces b_j (see (17)), raises its real consumption index Q_j and therefore its welfare, but it reduces the trade partner's welfare. On the other hand, a simultaneous reduction in labour market frictions in the differentiated sectors of both countries at a common rate $\hat{a}_A = \hat{a}_B$, which implies $\hat{b}_A = \hat{b}_B$, raises everybody's welfare.[29] Second, a reduction in a country's labour market frictions at a common rate in both sectors, i.e. a decline in a_{0j} and a_j such that $\hat{a}_{0j} = \hat{a}_j$, does not impact $\hat{b}_j$ and therefore does not impact its real consumption index Q_j nor the real consumption index of its trade partner $Q_{(-j)}$. As a result, the trade partner's welfare does not change, yet j's welfare rises because expected income of a worker, ω_0, rises (see equations (3) and (13), and recall

28. Recall that ω_{0j} is determined by labour market frictions in the homogeneous sector (see equation (13)).
29. This follows from the fact that $-\delta_{d(-j)}\left(\delta_{xj}+\delta_{dj}\right)+\delta_{xj}\left(\delta_{x(-j)}+\delta_{d(-j)}\right) = -\beta\Delta/(1-\beta) < 0$.

that expenditure equals income, $E_j = \omega_{0j}L$). Third, in view of Lemma 4, a reduction in trade impediments raises welfare in both countries. We summarize these findings in:[30]

Proposition 1. *(i) A reduction in labour market frictions in country j's differentiated sector raises its welfare and reduces the welfare of its trade partner. (ii) A simultaneous proportional reduction in labour market frictions in the differentiated sectors of both countries raises welfare in both of them. (iii) A reduction in labour market frictions in country j at a common rate in both sectors raises its welfare and does not affect the welfare of its trade partner. (iv) A reduction of trade impediments raises welfare in both countries and Q_j rises proportionately more in country B, which has relatively lower labour market frictions in the differentiated sector.*

The first part of this proposition is intriguing: it states that a country harms the trade partner by reducing its labour market frictions. Moreover, this happens despite the fact that the trade partner $(-j)$ enjoys better terms of trade as a result of improved labour market conditions in country j, because $(-j)$ pays lower prices for imported varieties from j and gets access to a larger set of foreign varieties. The reason for this result is that lower labour market frictions in country j's differentiated sector act like productivity improvements in this country, which makes foreign firms less competitive and therefore *crowds them out* from this sector. As a result, fewer foreign firms enter the industry. The entry of domestic firms does not fully compensate foreign consumers for the exit of foreign firms due to the home market effect, so that foreign welfare declines, and this negative welfare effect is larger than the welfare gain from improved terms of trade.[31]

The last part of this proposition establishes that both countries gain from trade, because autarky is attained when $\tau \to \infty$.[32] To emphasize this conclusion, we restate it in the following proposition.

Proposition 2. *Both countries gain from trade.*

This proposition is interesting because it is well known that gains from trade are not ensured in economies with non-convexities and distortions (see Helpman and Krugman, 1985), and in

30. The very last part of the proposition follows from the fact that (26) implies

$$\frac{\beta-\zeta}{1-\beta}\left[\hat{Q}_j-\hat{Q}_{(-j)}\right]=-\frac{1}{\Delta}\left[\left(\delta_{dj}+\delta_{xj}\right)\left(\delta_{d(-j)}+\delta_{x(-j)}\right)\left(\hat{b}_j-\hat{b}_{(-j)}\right)+\left(\delta_{d(-j)}\delta_{xj}-\delta_{x(-j)}\delta_{dj}\right)\hat{\tau}\right].$$

Under these circumstances, $\hat{Q}_j > \hat{Q}_{(-j)}$ in response to $\hat{\tau} < 0$, when $b_j < b_{(-j)}$ (by Lemma 4) .

31. Demidova (2008) studies a full employment model with exogenous differences in productivity distributions across countries and finds that (i) productivity improvements in one country hurt its trade partner; and (ii) falling trade costs benefit disproportionately the more productive country, and may even hurt the less productive country. Our results on labour market frictions are similar to these (except that in our case both countries necessarily gain from falling trade costs), because—not withstanding unemployment—labour market frictions have analogous effects to productivity. We stress that these effects are analogous but not identical, because our cross-country differences in relative labour market frictions are not identical to the differences in productivity in Demidova's paper.

32. The following is a direct proof of the gains-from-trade argument. We have seen that the domestic cutoff is higher in every country in the trading equilibrium than in autarky. The first equation in (19) then implies that Q_j is higher in every country in the trading equilibrium, because this equation also holds in autarky. In addition, in the earlier working paper Helpman and Itskhoki (2007), we show that both countries gain from trade when the difference in labour market institutions is large enough to cause the relatively rigid country to specialize in the production of the homogeneous good. Interestingly, in this case the gains from trade accrue disproportionately to the relatively rigid country, although its level of welfare is always lower than that of the relatively flexible country.

addition to the standard non-convexities and distortions that exist in models of monopolistic competition, our model contains frictions in labour markets. The intuition is that every country gains access to a larger variety choice and, in addition, the differentiated sector—which is too small relative to its first-best size—expands. Together, these effects of trade opening dominate the welfare outcome.

4.2. *Trade structure*

From Lemma 1 we know that the country with lower relative labour market frictions in the differentiated sector has a lower export cutoff and a higher domestic cutoff; therefore it also has a larger fraction of exporting firms in the differentiated-product sector. In addition, we know that exports per entering firm equal δ_{xj}/ϕ_2. Therefore exports of differentiated products from j to $(-j)$ are

$$X_j = M_j \frac{\delta_{xj}}{\phi_2}.$$

Lemma 4 states that country B has a larger δ_{xj} and Lemma 5 states that it has more firms. Therefore, $X_B > X_A$, which implies that B exports differentiated products on net. As a consequence, country A exports homogeneous goods.

As in the standard Helpman–Krugman model of trade in differentiated products, there is intra-industry trade. We can therefore decompose the volume of trade into intra-industry and inter-sectoral trade. Because trade is balanced, the total volume of trade equals $2X_B$, the volume of intra-industry trade equals $2X_A$, and the share of intra-industry trade equals

$$\frac{X_A}{X_B} = \frac{\delta_{xA} M_A}{\delta_{xB} M_B}.$$

Using this representation, we show in the Appendix that the share of intra-industry trade declines in b_A/b_B. These results are summarized in the following proposition.

Proposition 3. *Let $b_A > b_B$. Then: (i) A larger fraction of differentiated-sector firms export in country B. (ii) Country B exports differentiated products on net and imports homogeneous goods. (iii) The share of intra-industry trade is smaller the larger b_A/b_B is.*

That is, as in Davidson, Martin, and Matusz (1999), labour market frictions impact comparative advantage, and in our case they also impact the share of intra-industry trade. In addition, under Pareto-distributed productivity, the model also implies that the volume of trade is larger the larger the difference in relative hiring costs across countries, b_A/b_B, and the smaller the trade impediments (see Appendix). These are testable implications of our model.

4.3. *Productivity*

Alternative measures of total factor productivity (TFP) can be used to characterize the efficiency of production. We choose to focus on one such measure—the employment-weighted average of firm-level productivity—which is commonly used in the literature.[33] In the differentiated

33. This corresponds to the measure analysed by Melitz (2003) in the Appendix. Note that Melitz uses revenue to weight firm productivity levels. However, in equilibrium, revenue is proportional to employment, in which case his and our productivity indexes are the same.

sector, this measure is

$$TFP_j = \frac{M_j}{H_j}\left[\int_{\Theta_{dj}}^{\infty} \Theta^{\frac{1-\beta}{\beta}} h_{dj}(\Theta)dG(\Theta) + \int_{\Theta_{xj}}^{\infty} \Theta^{\frac{1-\beta}{\beta}} h_{xj}(\Theta)dG(\Theta)\right]. \tag{27}$$

Recall that $q_{zj}(\Theta) = \Theta^{(1-\beta)/\beta} h_{zj}(\Theta)$ for $z = d, x$. Therefore, TFP_j equals the output of differentiated products divided by employment in the differentiated sector.[34]

Using (6) and (8)–(10), we can express (27) as

$$TFP_j = \frac{\delta_{dj}\varphi_{dj} + \delta_{xj}\varphi_{xj}}{\delta_{dj} + \delta_{xj}} = \varpi_{dj}\varphi_{dj} + \varpi_{xj}\varphi_{xj}, \tag{28}$$

where $\varpi_{dj} = \delta_{dj}/(\delta_{dj} + \delta_{xj})$ is the share of domestic sales in revenue and ϖ_{xj} is the share of exports, i.e. $\varpi_{xj} = 1 - \varpi_{dj}$, $j = A, B$. Moreover,

$$\varphi_{zj} \equiv \varphi(\Theta_{zj}) = \frac{\int_{\Theta_{zj}}^{\infty} \Theta^{1/\beta} dG(\Theta)}{\int_{\Theta_{zj}}^{\infty} \Theta dG(\Theta)}, \quad z = d, x,$$

where φ_{dj} represents the average productivity of firms that serve the home market and φ_{xj} represents the average productivity of exporting firms. It follows that aggregate productivity equals the weighted average of the productivity of firms that serve the domestic market and the productivity of firms that export, with the revenue shares serving as weights. We show in the Appendix that $\varphi(\cdot)$ is an increasing function. Therefore average productivity is higher among exporters, i.e. $\varphi_{xj} > \varphi_{dj}$.

Expression (28) implies that the cutoffs $\{\Theta_{dj}, \Theta_{xj}\}$ uniquely determine the TFP_js, because ϖ_{zj} and φ_{zj} depend only on the cutoffs. Moreover, since the two cutoffs are linked by the free-entry condition (20), TFP_j can be expressed as a function of the domestic cutoff Θ_{dj}. This implies that in a closed economy TFP_j is not responsive to changes in labour market frictions, because Θ_d^c is uniquely determined by the fixed costs of entry and production and the *ex ante* productivity distribution.

Productivity TFP_j is higher in the trade equilibrium than in autarky, however, because $\varphi(\Theta_{xj}) > \varphi(\Theta_{dj}) > \varphi(\Theta_d^c)$, and in autarky $\varpi_x^c = 0$. That is, the average productivity of exporters and non-exporters alike is higher in the trade equilibrium than is the average productivity of firms in autarky. In addition, trade reallocates revenue to the exporting firms, which are on average more productive. For both these reasons, trade raises TFP_j. We summarize these results in the following proposition.

Proposition 4. *(i) In the closed economy, TFP_j does not depend on labour market frictions. (ii) TFP_j is higher in any trade equilibrium than in autarky.*

Next recall that in an open economy a reduction of trade costs raises the domestic cutoff and reduces the export cutoff. In addition, a reduction in country j's labour market frictions in the differentiated sector raises Θ_{dj} and $\Theta_{x(-j)}$ and reduces $\Theta_{d(-j)}$ and Θ_{xj}. Finally, a simultaneous

34. An alternative, and potentially more desirable, measure of productivity would divide output by the number of workers searching for jobs in the differentiated-product sector, N_j. This measure is always smaller than TFP_j by the factor x_j. It follows that labour market liberalization has an additional positive effect on this measure of productivity as compared to the measure used in the main text. Also note that TFP_j measures productivity in the differentiated-product sector only, rather than in the entire economy, and productivity in the homogeneous-product sector is constant given a_{0j}. We discuss in the Appendix a productivity measure that accounts for the compositional effects across sectors.

and proportional decline in both countries' labour market frictions in the differentiated sector (i.e. $\hat{b}_A = \hat{b}_B < 0$) leaves all these cutoffs unchanged (see (22)).

How do changes in labour market frictions impact productivity? In the case in which both countries' labour market frictions decline by the same factor of proportionality, the answer is simple: the TFP_js do not change. As long as productivity is measured with regard to the number of employed workers rather than the number of workers searching for jobs, measured sectoral productivity levels are not sensitive to the absolute levels of b_js; only the *relative* levels matter. This result points to a shortcoming of this TFP measure. We nevertheless continue the analysis with this measure, because it is commonly used in the literature.

A shock that raises the domestic cutoff Θ_{dj} and reduces the export cutoff Θ_{xj} affects TFP_j through three channels. First, the reallocation of revenue from firms that serve the home market to exporters raises the weight on the productivity of exporters, ϖ_{xj}, which raises in turn TFP_j. Second, some least efficient firms exit the industry, thereby raising the average productivity of firms that sell only in the home market, φ_{dj}, which raises TFP_j. Finally, some firms with productivity below Θ_{xj} begin to export, thereby reducing the average productivity of exporters, φ_{xj}, which reduces TFP_j.[35]

The presence of the third effect, which goes against the first two, does not enable us to sign the impact of single-country reductions of labour market frictions on productivity; in general, productivity may increase or decrease. The sharp result for the comparison of autarky to trade derives from the fact that, in a move from autarky to trade, the third effect is nil. In the Appendix, we provide sufficient conditions for productivity to be monotonically rising with Θ_{dj}, and therefore declining with b_j and τ and rising with $b_{(-j)}$. In this section, however, we limit our discussion to the case of Pareto-distributed productivity draws, which yields sharp predictions.

Under the assumption of Pareto-distributed productivity, that is, $G(\Theta) = 1 - (\Theta_{\min}/\Theta)^k$ for $\Theta \geq \Theta_{\min}$, (28) results in (see Appendix):

$$\widehat{TFP}_j = \frac{\delta_{dj}\left(\varphi_{xj} - \varphi_{dj}\right)\left(1 + k - 1/\beta\right)}{\delta_{dj}\varphi_{dj} + \delta_{xj}\varphi_{xj}}\hat{\Theta}_{dj}, \tag{29}$$

where $k > 1/\beta$ is required for TFP_j to be finite, and we therefore assume that it holds, and an increase in Θ_{dj} is accompanied by a corresponding decrease in Θ_{xj} in order to satisfy the free-entry condition. As a result, TFP_j is higher the higher Θ_{dj} is (and the lower Θ_{xj} is). It follows that productivity is higher in country B, and a reduction in a country's labour market frictions in the differentiated sector raises its productivity and reduces the productivity of its trade partner. An implication of this result is that the gap in productivity between countries B and A is increasing in b_A/b_B and therefore in a_A/a_B their relative labour market frictions in the differentiated sector. These results are summarized in the following proposition.

Proposition 5. *Let $b_A > b_B$ and let Θ be Pareto-distributed with shape parameter $k > 1/\beta$. Then: (i) TFP_j is higher in B; (ii) a decline in a_j raises TFP_j and reduces $TFP_{(-j)}$; (iii) a reduction of trade costs τ raises TFP_j in both countries.*

In other words, total factor productivity is higher in the country with relatively lower labour market frictions in the differentiated sector, and, while a reduction of labour market frictions in this sector in any country raises its own total factor productivity, this hurts the total factor productivity of the country's trade partner.

35. Formally, this decomposition can be represented as $\widehat{TFP}_j = \hat{\varpi}_{xj}(\varphi_{xj} - \varphi_{dj}) + (1 - \varpi_{xj})\hat{\varphi}_{dj} + \varpi_{xj}\hat{\varphi}_{xj}$ with $\hat{\varpi}_{xj} > 0$, $\hat{\varphi}_{dj} > 0$ and $\hat{\varphi}_{xj} < 0$.

5. UNEMPLOYMENT

Before discussing the variation of unemployment across countries with different labour market frictions in Section 5.2, we first examine the determinants of unemployment in a world of symmetric countries.

5.1. *Symmetric countries*

We study in this section countries with $a_{0A} = a_{0B} = a_0$ and $a_A = a_B = a$, so that $b_A = b_B = b$, in order to understand how changes in the common levels of labour market frictions and the common level of variable trade cost affect unemployment. In such equilibria, the cutoffs Θ_d and Θ_x, the consumption index Q, the number of entrants M, the number of individuals searching for jobs in the differentiated-product sector N, the number of workers employed in that sector H, and the rate of unemployment u are the same in both countries. We therefore drop the country index j for convenience. From Section 3 we know that two symmetric economies are at the same point on the FF curve in Figure 1 (point S), the location of this point is invariant to the common level of labour market frictions, and this point is higher the larger τ is (see (21)). Moreover, (26) implies that Q is lower the higher are either b or τ. When b is higher as a result of higher frictions in the labour market of the differentiated sector, welfare is lower because Q is lower while aggregate income $E = \omega_0 L$ is not affected (recall that welfare is given by equation (3)).

In order to assess the impact of labour market rigidities on unemployment, we need to know their quantitative impact on Q. For this reason, we use (26) to obtain

$$\hat{Q} = -\frac{\beta}{\beta - \zeta}\left(\hat{b} + \frac{\delta_x}{\delta_d + \delta_x}\hat{\tau}\right).$$

Next combine (23) and (24) to obtain $\omega_0 N = \beta Q^{\zeta}/(1+\beta)$, which together with the previous equation yields

$$\hat{N} = -\frac{\beta\zeta}{\beta - \zeta}\left(\hat{b} + \frac{\delta_x}{\delta_d + \delta_x}\hat{\tau}\right)$$

under the assumption that changes in b are driven by changes in a, which is our measure of labour market frictions in the differentiated sector. In other words, in this analysis we keep constant the level of labour market frictions in the homogeneous sector, a_0 (below we discuss the case of simultaneous reductions in labour market frictions in both sectors). Finally, from (17) and (18) together with the formula for $\hat{N}$ we obtain[36]

$$\operatorname{sign}\{\hat{u}\} = \operatorname{sign}\left\{\left[1 - (2b-1)\frac{\beta\zeta}{\beta - \zeta}\right]\hat{b} - (2b-1)\frac{\beta\zeta}{\beta - \zeta}\frac{\delta_x}{\delta_d + \delta_x}\hat{\tau}\right\}.$$

36. In this derivation we use $bx = b_0 x_0 = \omega_0$, where ω_0 is given in (13) and it does not vary with a, the measure of labour market frictions in the differentiated sector. Therefore, $\hat{b} = -\hat{x}$. Also note that $\hat{x}_0 = 0$ since $b_0 \equiv 1/2$. We have

$$uL\hat{u} = \mathrm{d}N(x_0 - x) - N\,\mathrm{d}x = xN\left[\left(\frac{x_0}{x} - 1\right)\hat{N} + \hat{b}\right].$$

From (17), $x_0/x = \left(a/a_0\right)^{1/(1+\alpha)} = 2b$. Finally, combining these results with the expression for $\hat{N}$, we obtain the result in the text.

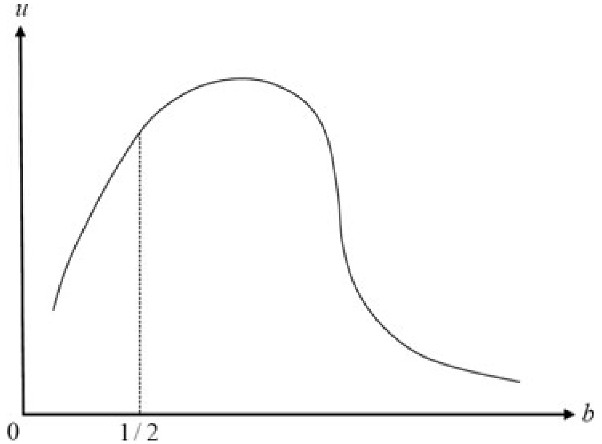

FIGURE 2

Unemployment in a world of symmetric countries

It is evident from this formula that lower frictions in the differentiated sector's labour market (lower b) reduce unemployment if and only if

$$2b = \left(\frac{a}{a_0}\right)^{\frac{1}{1+\alpha}} < 1 + \frac{\beta - \zeta}{\beta\zeta},$$

i.e. if and only if labour market frictions are low in this sector to begin with. This condition is always satisfied when labour market frictions are higher in the homogeneous sector, i.e. $a_0 > a$. If labour market frictions in the differentiated sector are high, however, and the above inequality is reversed, then a reduction in a—and hence in b—may raise the rate of unemployment. In fact, the relationship between b and the rate of unemployment has an inverted U shape as depicted in Figure 2.

To understand this result, note that changes in a impact unemployment through two channels: the rate of unemployment in the differentiated sector $1 - x$, and the fraction of individuals searching for jobs in this sector N/L. Reductions in these labour market frictions raise x and thereby reduce the sectoral rate of unemployment. On the other hand, such reductions attract more workers to the differentiated-product sector and thereby reduce the rate of unemployment if and only if the sectoral rate of unemployment is higher in the homogeneous sector (i.e. $x < x_0$). When $a_0 > a$, the sectoral rate of unemployment is higher in the homogeneous sector and both channels lead to a reduction in the rate of unemployment. On the other hand, when $a > a_0$, the two channels conflict, and the latter, i.e. the reallocation of labour toward the differentiated sector, dominates when labour market frictions are high.[37]

Next consider a proportional reduction in both sectors' labour market frictions, i.e. $\hat{a}_0 = \hat{a} < 0$. This has no effect on the search cost b and does not impact the real consumption index Q (see (17) and (26)). However, it raises the expected income ω_0: from equation (13), $\hat{\omega}_0 = -\hat{a}/\alpha$. It therefore follows from $\omega_0 N = \beta Q^{\zeta}/(1+\beta)$ that $\hat{N} = \hat{a}/\alpha$, and it follows from (17) that $\hat{x} = \hat{x}_0 = -\hat{a}/\alpha$. Using these expressions, and $N_0 + N = L$, the unemployment formula (18) implies that $\text{sign}\{\hat{u}\} = \text{sign}\{\hat{a}\}$. In other words, a reduction of labour market

37. It can also be shown that in the symmetric case lower a leads to increased entry of firms M, an increase in N proportionately to M, and a more than proportional increase in employment H.

frictions at a common rate in both sectors reduces the rate of unemployment. Note that this sort of change in labour market frictions impacts unemployment through two channels, which may operate in opposite directions. On one hand, it raises tightness in each sector's labour market, thereby reducing both sectoral rates of unemployment. On the other hand, it leads to a reallocation of workers from the differentiated to the homogeneous sector. If the sectoral rate of unemployment is higher in the differentiated sector, this reduces the rate of unemployment. But if the sectoral rate of unemployment is lower in the differentiated sector, this raises the rate of unemployment. Nevertheless, the composition effect is dominated by the sectoral effects.[38]

Finally, consider changes in trade impediments. As the formula for the sign of changes in the rate of unemployment shows, a lower trade cost τ *raises* the rate of unemployment if and only if $b > 1/2$ (i.e. $a > a_0$).[39] In this case, the impact on unemployment operates only through the reallocation of labour across sectors, because sectoral unemployment rates do not change. In particular, more workers search for jobs in the differentiated sector when τ declines, and therefore aggregate unemployment rises when the differentiated sector has higher sectoral unemployment and aggregate unemployment falls when the differentiated sector has lower sectoral unemployment. Since the lowering of trade costs raises welfare, this means that welfare and unemployment may respond in opposite directions to changes in trade costs.

We summarize the main findings of this section in the following proposition.

Proposition 6. *In a symmetric world economy: (i) reductions in labour market frictions in the differentiated sectors at the same rate in both countries reduce aggregate unemployment if and only if* $a < a_0 \cdot \left[1 + (\beta - \zeta)/\beta\zeta\right]^{1+\alpha}$*; (ii) reductions in labour market frictions at a common rate in both sectors and both countries reduce aggregate unemployment; (iii) reductions in trade impediments raise aggregate unemployment if and only if* $a > a_0$.

An intriguing result is that lower trade barriers may raise unemployment. Lower trade costs make exporting more profitable in the differentiated-product sector. Moreover, the tightness in its labour market is not affected by falling trade costs. This increases demand for labour in the differentiated sector and leads to reallocation of workers towards this sector. Under these circumstances, the sectoral unemployment rates remain the same, but the aggregate unemployment rate may increase or decrease due to the compositional effect across sectors.[40] The direction of this effect depends on whether the differentiated sector has a higher or lower unemployment rate.

Also note that unemployment can increase or decrease when welfare rises. That is, depending on the nature of the disturbance and the initial labour market frictions, unemployment and welfare can move in the same or in opposite directions. For this reason, changes in unemployment do not necessarily reflect changes in welfare. This results from the standard property of search and matching models, in which unemployment is a productive activity which leads to creation of productive matches. Under these circumstances, an expansion of the high-wage/high-unemployment sector results in higher unemployment, but may also raise welfare.

38. From (18) and $N_0 + N = L$, we obtain $uL\hat{u} = -N_0 x_0 \hat{x}_0 - N x \hat{x} + (x_0 - x) N \hat{N}$, where the first two expressions on the right-hand side represent the sectoral effects and the third represents the composition effect. Since $\hat{x} = \hat{x}_0 = -\hat{N} = -\hat{a}/\alpha$, the sectoral effects dominate.

39. The effect of a reduction in trade costs on unemployment is larger the larger is the share of trade in the sector's revenue, i.e. the larger is $\delta_{xj}/\left(\delta_{dj} + \delta_{xj}\right)$. When the economies are nearly closed, this effect is very small.

40. See Felbermayr, Prat, and Schmerer (2008) for a one-sector search model in which trade causes an increase in sectoral labour market tightness by reducing the real cost of vacancies, but naturally has no compositional effect.

5.2. *Asymmetric countries*

We address in this section the impact of trade and labour market frictions on unemployment when the two countries are not symmetric. We first discuss some analytical results and then turn to numerical examples to illustrate the key mechanisms and various special cases.

In our working paper, Helpman and Itskhoki (2007), we provide analytical results for countries that are nearly symmetric, in the sense that they have no labour market frictions in the homogeneous sector and the difference between their labour market frictions in the differentiated sector is very small. Under these circumstances, $b_A > b_B$ implies that: (i) a reduction in a country's labour market frictions reduces the rate of unemployment in its trade partner, yet it reduces home unemployment if and only if the initial levels of friction in the labour markets are low; and (ii) country B has a lower rate of unemployment if and only if the levels of labour market frictions are low to begin with. Evidently, a country's level of unemployment depends not only on its own labour market frictions but also on those of its trade partner. Moreover, lower domestic labour market frictions do not guarantee lower unemployment relative to the trade partner, unless the frictions in both labour markets are low. As a result, one cannot infer differences in labour market rigidities from observations of unemployment rates. Richer results obtain with large labour market frictions, as we show below.

For our numerical illustrations, we use a Pareto distribution of productivity levels,

$$G(\Theta) = 1 - \left(\frac{\Theta_{\min}}{\Theta}\right)^k, \quad \text{for } \Theta \geq \Theta_{\min}.$$

As is well known, the shape parameter k controls the dispersion of Θ, with smaller values of k representing more dispersion. It has to be larger than 2 for the variance of productivity to be finite. We show in the Appendix how the equilibrium conditions are simplified when productivity is distributed Pareto, and these equations are used to generate our numerical examples. One convenient implication of the Pareto assumption is that condition (11) implies $\delta_{dj} + \delta_{xj} = kf_e$, and therefore revenue of an average firm in the differentiated sector is independent of labour market frictions and is the same in both countries. For the simulations, we also assume that $a_{0A} = a_{0B} = a_0$, so that labour market frictions in the homogeneous sector are the same in both countries, as a result of which expected income of workers, ω_{0j}, is also the same in both countries, i.e. $\omega_{0A} = \omega_{0B} = \omega_0$. In addition, we assume that $a_A > a_B > a_0$, so that labour market frictions are larger in the differentiated sectors of both countries than in their homogeneous sectors, and particularly so in country A. This implies $b_A > b_B > 1/2$.

Combining equations (23) and (24), we obtain the following expression for global revenues generated in the differentiated sector:

$$Q_A^\zeta + Q_B^\zeta = \frac{1}{\phi_2}\left[M_A(\delta_{dA} + \delta_{xA}) + M_B(\delta_{dB} + \delta_{xB})\right] = \frac{1+\beta}{\beta}\omega_0(N_A + N_B).$$

Therefore, whenever $Q_A^\zeta + Q_B^\zeta$ rises, the world-wide allocation of workers to the differentiated sector, $N_A + N_B$, must also increase.[41] Next note that Proposition 1 establishes that a reduction in trade costs raises Q_j in both countries. Therefore, the above discussion implies that a

41. Note that this result does not rely on the Pareto assumption. Under the Pareto assumption, however, we additionally have $Q_A^\zeta + Q_B^\zeta = kf_e(M_A + M_B)/\phi_2$, so that the total number of entrants into the differentiated sector must also increase. Moreover, in the Appendix we show that in this case $\omega_0 N_j/M_j = \beta k f_e/(1-\beta)$. That is, the number of workers searching for jobs in the differentiated sector relative to the number of firms depends on expected income ω_0, but does not depend on the trade cost or labour market frictions in the differentiated sector.

reduction in trade costs increases $N_A + N_B$. In the Appendix we also show that N_A/N_B declines with reductions in τ when $b_A > b_B$. This then implies that N_B, the number of job-seekers in the differentiated sector of country B, necessarily increases. Since a fall in τ does not affect sectoral labour market tightness, we conclude that a reduction in trade costs increases unemployment in country B, which has lower labour market frictions in the differentiated sector. The effect on N_A and hence on the unemployment rate in country A is ambiguous, as we illustrate below.

The intuition behind this result is the following. Lower trade impediments increase the global size of the differentiated sector, which features increasing returns to scale and love of variety. As a result, the country with a more flexible labour market, which has a competitive edge in this sector, becomes more specialized in differentiated products. That is, the number of entering firms, employment, and the number of job-seekers in the differentiated sector, all increase in country B. This compositional shift leads to a higher rate of unemployment in this country because the sectoral rate of unemployment is higher in the differentiated sector. Finally, the reallocation of labour in country A may shift in either direction, depending on how strong the comparative advantage is (see below).

Figure 3 depicts the response of unemployment rates to variation in country A's labour market frictions a_A, which changes monotonically with b_A; the rising broken-line curve represents country B and the hump-shaped solid-line curve represents country A.[42] Country B has $b_B = 0.55 > 1/2$, and therefore the two countries have the same rate of unemployment when $b_A = 0.55$. As b_A rises, country A becomes more rigid. This raises initially the rate of unemployment in both countries, but B's rate of unemployment remains lower for a while. At some point, however, the rate of unemployment reaches a peak in country A, and it falls for further increases in b_A. As a result, the two rates of unemployment become equal again, after which further increases in rigidity in country A raise the rate of unemployment in country B and reduce it in country A, so that the rate of unemployment is higher in country B thereafter. The mechanism that operates here is that, once the labour market frictions become high enough in country A, the contraction of the differentiated-product sector leads to overall lower unemployment in A despite the fact that its sectoral unemployment rate is high. When b_A is very high, the sectoral unemployment rate is very high, but no individuals search for jobs in this sector, as a result of which there is no unemployment at all. This explains the hump in A's curve. Note that in the range in which the rate of unemployment falls in country A, the rate of unemployment keeps rising in country B. The reason is that there is no change in market tightness in country B and its differentiated-product sector becomes more competitive the more rigid the labour market becomes in A. As a result, the differentiated sector attracts more and more workers in country B, which raises its rate of unemployment. The monotonic impact of country A's labour market rigidities on the unemployment rate in B holds globally, and not only around the symmetric equilibrium.[43]

Figure 4 is similar to Figure 3, except that now the level of labour market frictions in country B is higher, i.e. $b_B = 0.65 > 1/2$, and therefore the two curves intersect at $b_A = 0.65$. Moreover, starting with a symmetric world that has these higher labour market rigidities, increases in b_A always raise unemployment in B and reduce unemployment in A. As a result, country A has lower unemployment when $b_A > b_B$ and higher unemployment when $b_A < b_B$.

42. In Figures 3–4 we use the following parameters: $m_0 = 2v_0 = 1, f_x = 3, f_d = 1, f_e = 0.5, k = 2.5, \beta = 0.75, \zeta = 0.5$, and $L = 0.1$.

43. In Figures 3–4, country A specializes in the homogeneous good when $b_A \geq b'$; in Figure 4, country B specializes in the homogeneous good when $b_A \leq b^o$; in Figure 3 country B specializes in the differentiated good for $b_A \geq b''$.

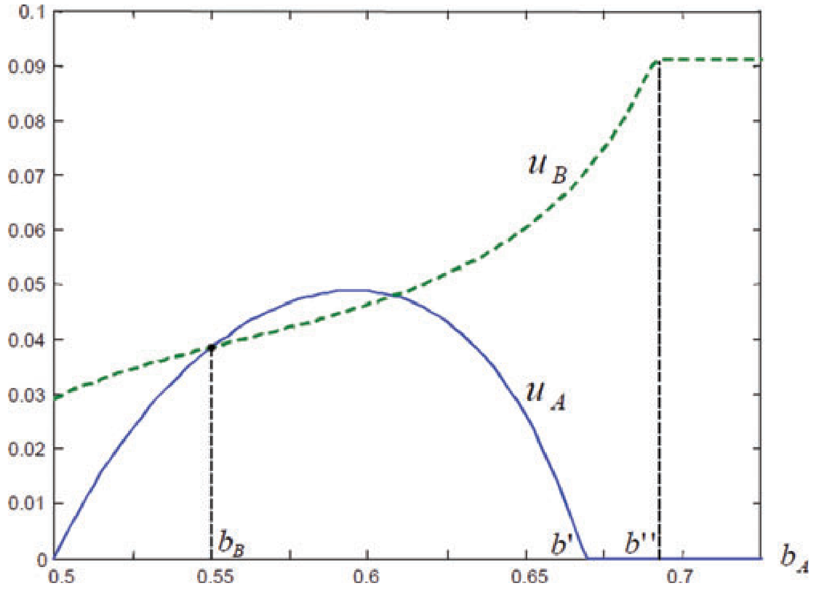

FIGURE 3

Unemployment as a function of b_A when b_B is low ($b_B = 0.55$ and $\tau = 1.1$)

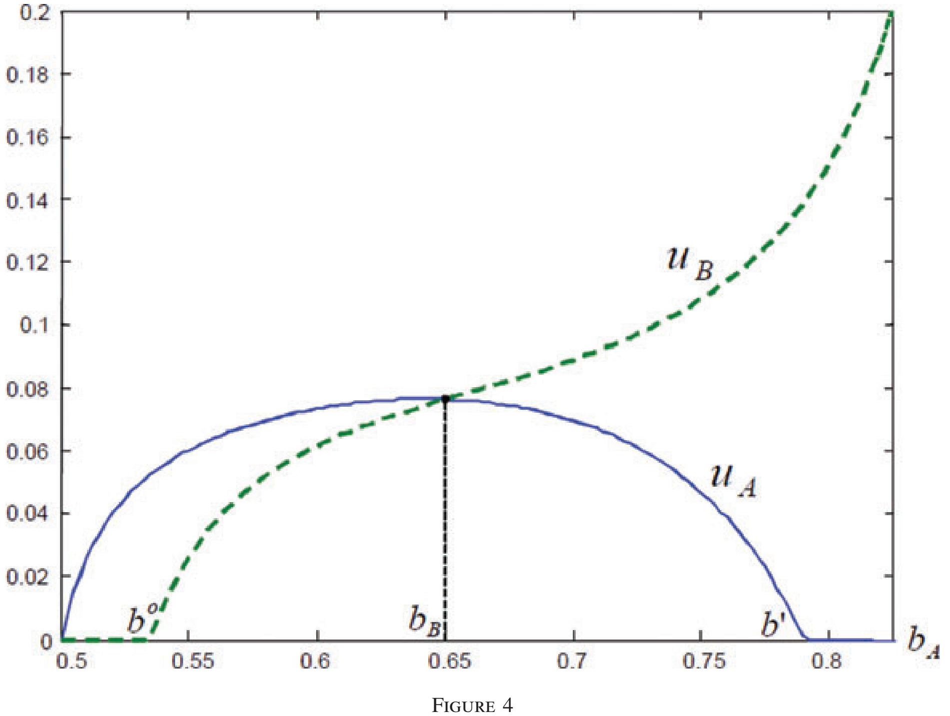

FIGURE 4

Unemployment as a function of b_A when b_B is high ($b_B = 0.65$ and $\tau = 1.1$)

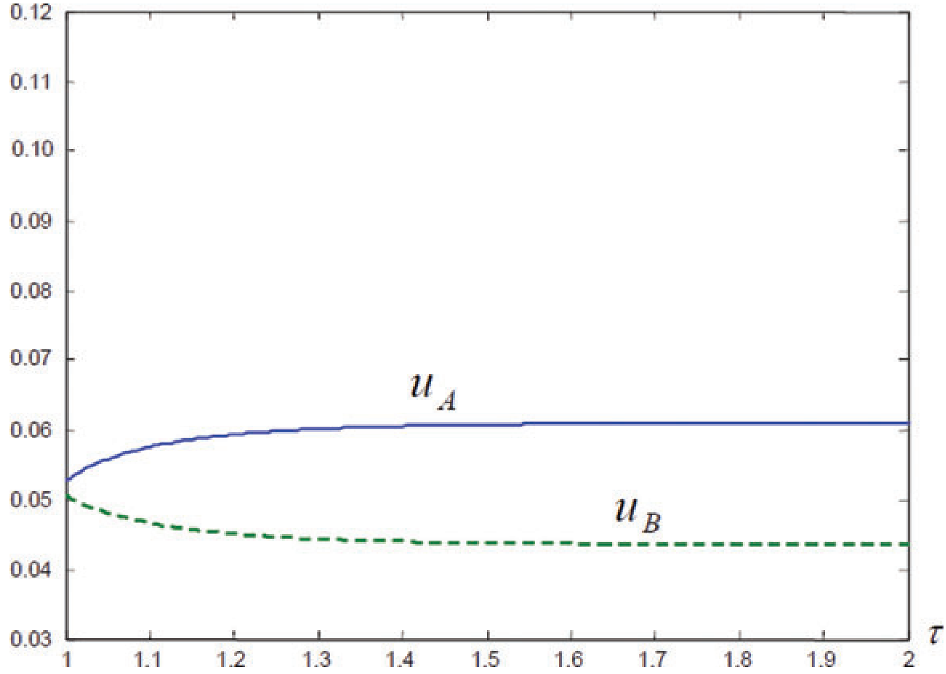

FIGURE 5

Unemployment as a function of τ when b_A and b_B are low ($b_A = 0.6$ and $b_B = 0.56$)

That is, in this case a more rigid country always has a lower unemployment rate when it specializes (incompletely) in the low-unemployment sector.

A comparison between Figures 3 and 4 demonstrates the importance of the overall level of labour market rigidities for unemployment outcomes. When labour market frictions are high, a relatively more flexible country always has a higher rate of unemployment. Moreover, the rates of unemployment in the two countries move in opposite directions as labour market frictions change in either of the countries. In contrast, when labour market rigidities are low and the difference in labour market frictions across countries is not large, the rate of unemployment is lower in a more flexible country and the rates of unemployment in both countries co-move in response to changes in labour market frictions.

The next three figures depict variations in unemployment in response to trade frictions, in the form of variable trade costs τ: Figure 5 for the case of low frictions in labour markets, Figure 6 for the case in which frictions are low in country B but high in A, and Figure 7 for the case in which frictions are high in both countries.[44] In all three cases, unemployment rises in B and falls in A when trade frictions decline.[45] Nevertheless, the rate of unemployment is not necessarily higher in A. In particular, unemployment is always higher in A when frictions in labour markets are low in both countries, yet unemployment is always higher in B when

44. In Figures 5–7 we use the following parameters: $m_0 = 2v_0 = 1$, $f_x = 5$, $f_d = 1$, $f_e = 0.5$, $k = 2.5$, $\beta = 0.75$, $\zeta = 0.5$, and $L = 0.1$.

45. This pattern is not general. As we know, in the symmetric case lower trade impediments raise unemployment in both countries, which is also the case when countries are nearly symmetric. We can also provide examples in which the rigid country has a hump in its rate of unemployment as trade frictions vary.

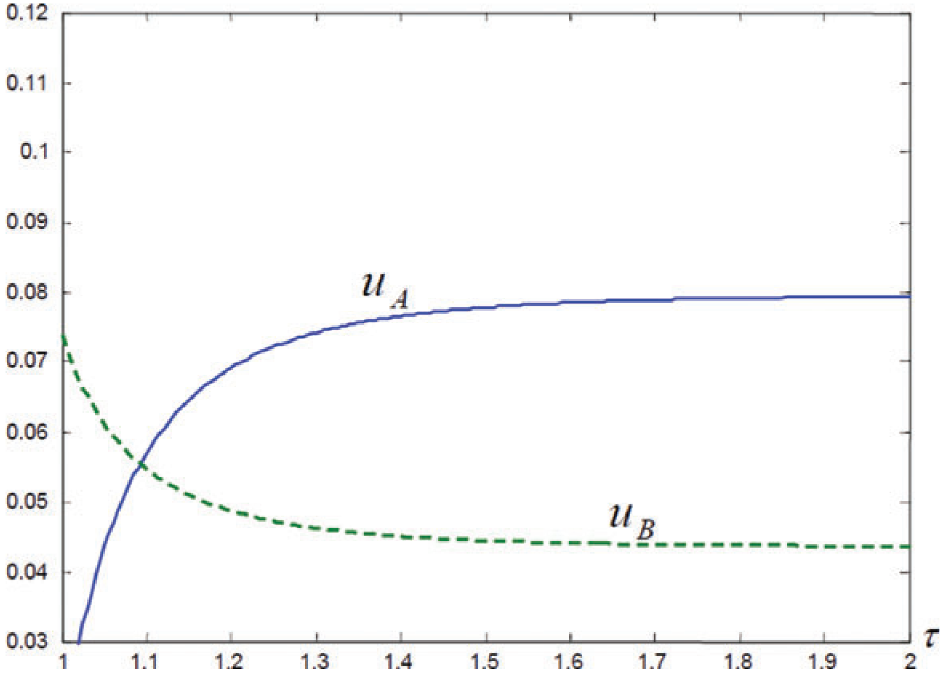

FIGURE 6

Unemployment as a function of τ when b_A is high and b_B is low ($b_A = 0.68$ and $b_B = 0.56$)

frictions in labour markets are high in both countries. In between, when labour market frictions are low in B and high in A, the relative rate of unemployment depends on trade impediments; it is lower in A when the trade frictions are low and lower in B when the trade frictions are high. This shows that labour market frictions interact with trade impediments in shaping unemployment.

6. FIRING COSTS AND UNEMPLOYMENT BENEFITS

Our analysis has focused on search and matching as the main frictions in labour markets, and we used $a_{0j} = 2v_{0j}/m_{0j}^{1+\alpha}$ and $a_j = 2v_j/m_j^{1+\alpha}$ as measures of labour market rigidity. Evidently, in this specification rigidity in a sector's labour market is higher if either it is more costly to post vacancies in this sector or the matching process is less efficient in it.

We can also incorporate firing costs and unemployment benefits as additional sources of labour market rigidity. These labour market policies are widespread and they differ greatly across countries. But note that governments can also influence search and matching costs by facilitating the flow of information about job vacancies and about unemployed workers. Moreover, in some countries there are government agencies that directly assign unemployed workers to firms, and workers need to try these jobs in order to be eligible for unemployment benefits. In other words, government policies can influence not only firing costs and unemployment benefits but also our measures of labour market frictions, a_{0j} and a_j, which were analysed above.

In order to save space, we briefly describe in this section results of a formal analysis conducted in our working paper (Helpman and Itskhoki, 2009*a*), under the simplifying assumption

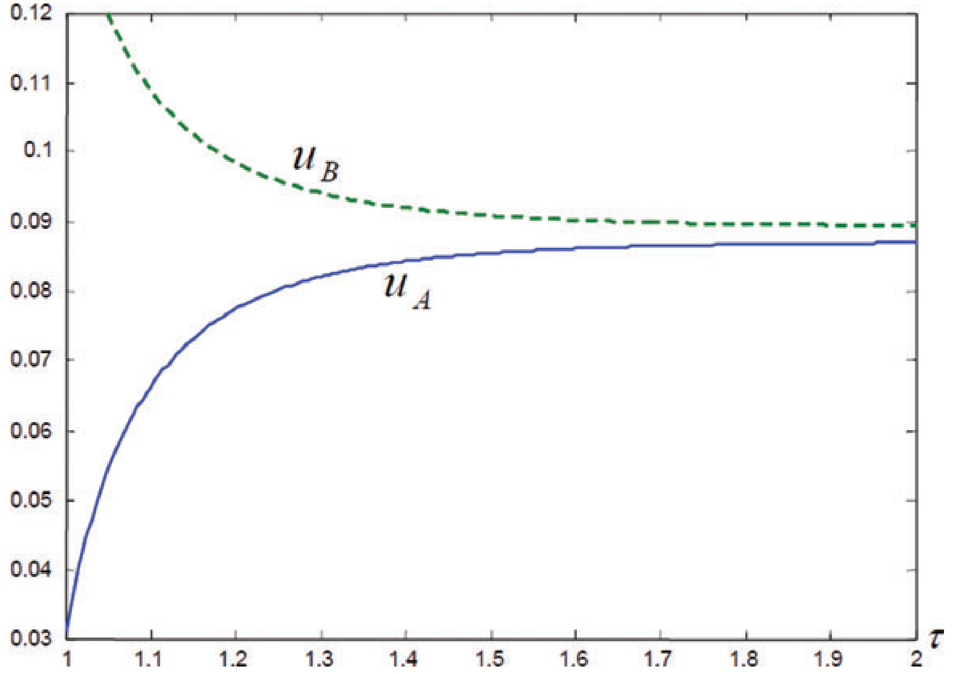

FIGURE 7

Unemployment as a function of τ when b_A and b_B are high ($b_A = 0.95$ and $b_B = 0.8$)

that there is full employment in the homogeneous sector. This analysis can be extended to allow for labour market frictions in the homogeneous-good sector, as in the earlier sections of the current paper.

With firing costs and unemployment benefits, (x_j, b_j) remains a sufficient statistic for labour market frictions, with b_j reinterpreted to represent the overall effective labour cost for a differentiated-sector firm, while the definition of x_j does not change; it remains the same measure of labour market tightness in the differentiated sector. Importantly, the effects of x_j and b_j on the equilibrium outcomes described in Sections 3–5 do not change, except for the qualification of welfare effects to be discussed below.

Firing costs operate similarly to matching frictions, yielding a type of equivalence between the hiring and firing costs. Specifically, higher firing costs reduce labour market tightness x_j and increase the effective labour cost b_j. Moreover, as long as unemployment benefits are not too high (see below), the effects of firing costs on welfare, trade patterns, productivity, and unemployment in trading economies, are the same as those of matching frictions. That is, all the earlier results of this paper extend to the case in which there are positive firing costs in addition to matching frictions.

Higher unemployment benefits always reduce equilibrium labour market tightness x_j, but they may increase or decrease the effective labour cost b_j. The intuition for this result is that unemployment benefits provide unemployment insurance to the workers on the one hand and a better outside option in the wage bargaining game on the other. Because higher unemployment benefits provide better unemployment insurance, workers are willing to search for jobs in a less tight labour market, with a higher sectoral rate of unemployment. This effect reduces the cost of hiring for firms. On the other side, the better outside option of workers at the wage bargaining stage improves their bargaining position and increases the effective cost of labour to firms. Either of these effects can dominate. Therefore, b_j may rise or decline in response to higher unemployment benefits. When b_j decreases, it leads to an expansion of the differentiated sector, which raises welfare. But because unemployment benefits need to be financed by (lump-sum) taxes, the additional taxes required to finance higher unemployment benefits reduce disposable income and hurt welfare. Therefore, on net welfare may rise or decline, but it definitely rises in response to a small rise in unemployment benefits which reduces b_j when the initial level of these benefits is small.[46]

We also show that firing costs and unemployment benefits notwithstanding, international trade may raise unemployment in both countries. The reason is that trade attracts more workers to the differentiated sector without affecting sectoral labour market tightness. Therefore, when this sector has the lower labour market tightness, trade increases aggregate unemployment.

7. CONCLUSION

We have studied the interdependence of countries that trade homogeneous and differentiated products, and whose labour markets are characterized by search and matching frictions. Variation in labour market frictions and the interactions between trade impediments and labour market rigidities generate rich patterns of unemployment. For example, lower frictions in a country's labour markets do not ensure lower unemployment, and unemployment and welfare can both rise in response to a policy change.

Contrary to the complex patterns regarding unemployment, the model yields sharp predictions about welfare. In particular, both countries gain from trade. Moreover, changes in one country's labour market frictions can differentially impact welfare of the trade partners. For example, reducing a country's frictions in the labour market of the differentiated sector raises competitiveness of its firms. This improves the foreign country's terms of trade, but also crowds out foreign firms from the differentiated-product sector. As a result, welfare rises at home and declines abroad, because the terms-of-trade improvement in the foreign country is outweighed by the decline in the competitiveness of its firms. Nevertheless, a common reduction in labour market frictions in the differentiated sectors raises welfare in both countries. These results contrast with the implications of models of pure comparative advantage, in which movements in the terms of trade dominate the outcomes.[47]

We also show that labour market frictions confer comparative advantage, and that differences in these labour market characteristics shape trade flows. In particular, the country with relatively lower labour market frictions in the differentiated sector exports differentiated products on net and imports homogeneous goods. Moreover, the larger the difference in these relative frictions, the lower the share of intra-industry trade. These are testable implications about trade flows and international patterns of specialization.

In addition, we show that trade raises total factor productivity in the differentiated-product sectors of both countries, while productivity does not change in the homogeneous sector. And productivity is higher in the country with relatively lower labour market frictions in the differentiated sector.

46. Severance pay affects labour costs similarly to unemployment benefits, except that it has no impact on disposable income.

47. See, for example, Brügemann (2003) and Alessandria and Delacroix (2008). The former examines the support for labour market rigidities in a Ricardian model in which the choice of regime impacts comparative advantage. The latter analyses a two-country model with two goods, in which every country specializes in a different product and governments impose firing taxes. The authors find that a coordinated elimination of these taxes yields welfare gains for both counties, yet no country on its own has an incentive to do it.

An important conclusion from our analysis is that simple one-sector macro models that ignore compositional effects may be inadequate for assessing labour market frictions, and especially so in a world of integrated economies. Moreover, a focus on terms-of-trade as the major channel of the international transmission of shocks misses the impact of competitiveness, which can dominate economic outcomes.

APPENDIX A

A.1. *An alternative specification with homothetic preferences*

We consider here an alternative specification of the model, with CRRA-CES preferences instead of quasi-linear preferences used in the main text, leaving the rest of the setup unchanged. The expected utility is $\mathbb{U} = \mathbb{E}\mathcal{C}^{1-\sigma}/(1-\sigma)$, where $\mathbb{E}$ is the expectations operator, $\sigma \in [0,1)$ is the relative risk aversion coefficient, and $\mathcal{C}$ is a CES bundle of homogeneous and differentiated goods:

$$\mathcal{C} = \left[\vartheta^{1-\zeta} q_0^{\zeta} + (1-\vartheta)^{1-\zeta} Q^{\zeta}\right]^{1/\zeta}, \qquad \zeta < \beta, \quad 0 < \vartheta < 1.$$

The ideal price index associated with this consumption bundle is

$$\mathcal{P} = \left[\vartheta + (1-\vartheta) P^{\frac{-\zeta}{1-\zeta}}\right]^{-\frac{1-\zeta}{\zeta}},$$

where the price of the homogeneous good p_0 is again normalized to 1 and P is the price of the differentiated product in terms of the homogeneous good.

The demand for homogeneous and differentiated goods is given by

$$q_0 = \vartheta \mathcal{P}^{\zeta/(1-\zeta)} E = \frac{\vartheta E}{\vartheta + (1-\vartheta) P^{\frac{-\zeta}{1-\zeta}}},$$

$$Q = (1-\vartheta)\left(\frac{P}{\mathcal{P}}\right)^{\frac{-1}{1-\zeta}} \frac{E}{\mathcal{P}} = \frac{(1-\vartheta) P^{\frac{-1}{1-\zeta}} E}{\vartheta + (1-\vartheta) P^{\frac{-\zeta}{1-\zeta}}},$$

where E is expenditure in units of the homogeneous good. Using these demand equations, we derive the indirect utility function

$$\mathbb{V} = \frac{1}{1-\sigma} \mathbb{E}\left(\frac{E}{\mathcal{P}}\right)^{1-\sigma}.$$

Since $\mathcal{P}$ is increasing in P, the indirect utility is falling in P for a given $\mathbb{E}E^{1-\sigma}$. Also Q is decreasing in P.

Next, the demand level for differentiated varieties is

$$D \equiv Q P^{\frac{1}{1-\beta}} = \frac{(1-\vartheta) P^{\frac{\beta-\zeta}{(1-\beta)(1-\zeta)}} E}{\vartheta + (1-\vartheta) P^{\frac{-\zeta}{1-\zeta}}},$$

which increases in P given $\beta > \zeta$. It proves useful to introduce the aggregate revenue variable

$$R \equiv PQ = D^{1-\beta} Q^{\beta} = \frac{(1-\vartheta) P^{\frac{-\zeta}{1-\zeta}} E}{\vartheta + (1-\vartheta) P^{\frac{-\zeta}{1-\zeta}}},$$

which, like Q and opposite to D, decreases in P. Note that with homothetic utility, demands and revenues are linear in income, E, which allows for simple aggregation. Specifically, in the expressions above, E can be interpreted as aggregate income equal to $E = \omega_0(L-N) + wxN$ and we normalize $L = 1$ since under homothetic demand it is without loss of generality.

Most of the remaining derivation of equilibrium conditions remains unchanged, with D replacing $Q^{-(\beta-\zeta)/(1-\beta)}$ in the text. Specifically, after this substitution the free-entry condition and zero-profit conditions are unchanged, which allows us to solve for equilibrium cutoffs and equilibrium Ds in the same manner as in the text. Qualitatively, all the relationships still hold, except that now instead of Q as the sufficient statistic for welfare and demand level it is more convenient to express all aggregate variables as functions of P. Additionally, $R = PQ$ replaces Q^{ζ} in the expressions for M and N.

One block of the equilibrium system that changes is the indifference conditions of workers between sectors which now becomes

$$x_0 w_0^{1-\sigma} = x w^{1-\sigma}.$$

The wage rate in the homogeneous sector is still $w_0 = b_0 = 1/2$ and equations characterizing x_0 and $\omega_0 = x_0 w_0$ (12) and (13) still hold. The wage rate in the differentiated sector is still $w = b$, where $b = ax^{\alpha}$ is the hiring cost (and similarly b_0). As a result, when $a = a_0$, we have $b = b_0 = 1/2$, $x = x_0$, and $w = w_0$ and $a > a_0$ implies $b > b_0 = 1/2$, $x < x_0$, and $w > w_0$. In the latter case, there is a risk premium for searching for a job in the differentiated sector so that $xw > \omega_0 = x_0 w_0$ with the size of risk premium depending on risk aversion σ. Finally, since all workers are indifferent between searching for a job in the two sectors, we have for every worker $\mathbb{E}E^{1-\sigma} = x_0 w_0^{1-\sigma} = x_0(1/2)^{1-\sigma}$, which is pinned down by the labour market friction in the homogeneous sector, a_0. Therefore, holding a_0 constant, the welfare in the economy depends only on the price level, $\mathcal{P}$, which in turn is determined by the price of the differentiated good, P.

Note that with homothetic preferences and $0 \leq \sigma < 1$, we have dropped the family interpretation. In this case, the structure of demand and indirect utility does not change if the worker becomes unemployed, and aggregation is straightforward.[48] As a result, this specification can be used to analyse issues such as the *ex post* income distribution and winners and losers from policy reforms.

Without showing the explicit derivation (which follows the same steps as in the text), we provide as an illustration a few comparative statics results for the symmetric open economies with homothetic preferences. Specifically, we consider proportional labour market deregulation in the differentiated sector of both countries (i.e. a decrease in a holding a_0 constant). We have $\hat{D} = \beta/(1-\beta)\hat{b}$, so that, as before, P decreases and Q and R increase as b falls. This also implies an increase in welfare.

As before, we can express the total wage bill in the differentiated sector as

$$bH = \frac{\beta}{1+\beta} R = \frac{\beta}{1+\beta} M(\delta_d + \delta_x)/\phi_2,$$

where the δ_zs are average revenues per entering firm as defined in the text. We still have $H = xN$. Using $xb^{1-\sigma} = x_0(1/2)^{1-\sigma}$, we have the expression for the number of workers searching for a job in the differentiated sector:

$$N = \frac{\beta}{1+\beta} \frac{R}{b^{\sigma} x_0 (1/2)^{1-\sigma}}$$

Since R is decreasing in b, we have that N decreases in b as before. As a result, there are still two opposing effects on the unemployment rate when $x < x_0$: $\text{sign}\{\hat{u}\} = \text{sign}\left\{(1-\sigma)\hat{b} + \left(x_0/x - 1\right)\hat{N}\right\}$. The change in the unemployment rate is again ambiguous: it still falls if the initial labour market friction is low enough and increases otherwise. These results are qualitatively the same as those derived in the text under quasi-linear preferences.

Additionally, we can discuss now *ex post* inequality. When $b > b_0$, a fall in b increases x and reduces w, which both lead to lower *ex post* inequality. At the same time it increases N, which may increase or reduce the inequality depending on the initial size of the differentiated sector. It follows that the comparative statics for inequality are ambiguous in the same way as those for the rate of unemployment. For discussion of these and other issues, see Helpman, Itskhoki, and Redding (2009) in a related but different model.

A.2. *Conditions for incomplete specialization*

We derive here a limit on b_A/b_B which secures an equilibrium in which both countries are incompletely specialized. When this condition is violated, the country with a relatively more rigid labour market (higher b) specializes in the production of the homogeneous good. Throughout we assume for concreteness that A is the relatively more rigid country, so that $b_A/b_B \geq 1$. We assume that L is large enough in both countries so that both countries always produce the homogeneous good. Following the main text, we analyse only equilibria with $\Theta_{xj} > \Theta_{dj} > \Theta_{\min}$, so that not all

48. In the case of $\sigma \geq 1$, we need to introduce unemployment benefits in order to dispense with the family risk-sharing.

producing firms export and there are also firms that exit. As shown in the text, this requires $f_x > f_d$ which we assume holds.

Given $b_A > b_B$, incomplete specialization implies that there is positive entry of firms in the differentiated sector of country A, i.e. $M_A > 0$. Equation (23) in the text implies that $M_A = 0$ whenever

$$\delta_{dB}\left(\frac{Q_A}{Q_B}\right)^{\zeta} \leq \delta_{xB}.$$

When this condition is satisfied with equality, we also find, using (19), that

$$\delta_{dB}\left[\frac{\Theta_{xB}}{\Theta_{dB}}\frac{f_d}{f_x}\tau^{\frac{-\beta}{1-\beta}}\right]^{\zeta\frac{1-\beta}{\beta-\zeta}} = \delta_{xB}. \tag{A1}$$

Note that this relationship is an upward-sloping (generally non-linear) curve in $(\Theta_{dB}, \Theta_{xB})$-space, lying between the 45°-line and $\Theta_{xB} = \Theta_{dB}\tau^{\beta/(1-\beta)}f_x/f_d$ (i.e. the equilibrium condition when $b_A = b_B$).[49]

We can now prove the following:

Lemma 6. *Let $\tau > 1$ and $b_A > b_B$. Then there exists a unique function $\overline{b}(\tau) > 1$, with $\overline{b}'(\tau) > 0$, such that* (A1) *holds for $b_A/b_B = \overline{b}(\tau)$. For $b_A/b_B < \overline{b}(\tau)$, there is incomplete specialization in equilibrium so that $M_A > 0$. For $b_A/b_B \geq \overline{b}(\tau)$, country A specializes in the homogeneous good so that $M_A = 0$.*

Proof. Recall that Θ_{dB} is decreasing and Θ_{xB} is increasing in τ. This implies that δ_{dB}/δ_{xB} is increasing in τ. Equation (22) implies that $\tau^{\frac{-\beta}{1-\beta}}\Theta_{xB}/\Theta_{dB}$ is increasing in τ. Next, Θ_{xB}/Θ_{dB} and δ_{dB}/δ_{xB} are decreasing in b_A/b_B. These considerations, together with (A1), imply that $\overline{b}(\tau)$ is unique and increasing in τ whenever it is finite.[50] Finally, Q_A/Q_B is decreasing in b_A/b_B. Therefore, from (23), $M_A > 0$ whenever $b_A/b_B < \overline{b}(\tau)$ and $M_A = 0$ whenever $b_A/b_B \geq \overline{b}(\tau)$. ‖

Evidently, Lemma 6 implies that there is an upper bound on how different the relative labour market frictions can be in the two countries for complete specialization not to occur in equilibrium. As we show in the numerical examples of Section 5.2, a wide range of $b_A/b_B > 1$ is consistent with incomplete specialization equilibrium. See the working paper version, Helpman and Itskhoki (2007), for the analysis of equilibria with complete specialization.

A.3. *Proof of Lemmas 1–5 and Proposition 3*

Proof of Lemma 1. This follows immediately from (22). First note that in equilibria with $\Theta_{dj} < \Theta_{xj}$, we have $\Delta = \frac{1-\beta}{\beta}\left(\delta_{dA}\delta_{dB} - \delta_{xA}\delta_{dB}\right) > 0$. Indeed, $\Theta_{dj} < \Theta_{xj}$ implies

$$\frac{\delta_{dj}}{\delta_{xj}} > \frac{f_d}{f_x}\frac{\Theta_{xj}}{\Theta_{dj}}.$$

Using these inequalities for $j = A, B$ together with (21) implies $\delta_{dA}\delta_{dB}/\left(\delta_{xA}\delta_{xB}\right) > \tau^{2\beta/(1-\beta)} > 1$, in which case $\Delta > 0$.[51] Then an increase in b_A/b_B reduces Θ_{dA} and Θ_{xB} and increases Θ_{dB} and Θ_{xA} (see (22)). Therefore, $b_A > b_B$ implies $\Theta_{dA} < \Theta_{dB}$ and $\Theta_{xA} > \Theta_{xB}$ since in a symmetric equilibrium these relationships hold with equality. ‖

Proof of Lemma 2. This also follows immediately from (22) and the fact that $\delta_{dj} > \delta_{xj}$, which we prove below (Lemma 4). ‖

Proof of Lemma 3. This follows from (19) and Lemma 1. Note that (19) implies:

$$\left(\frac{Q_A}{Q_B}\right)^{\frac{\beta-\zeta}{1-\beta}} = \frac{\Theta_{dA}}{\Theta_{dB}}\left(\frac{b_B}{b_A}\right)^{\frac{\beta}{1-\beta}}.$$

When $b_A > b_B$, Lemma 1 implies $\Theta_{dA} < \Theta_{dB}$ and hence we have $Q_A < Q_B$. ‖

49. In the special case of a Pareto distribution, (A1) is a ray through the origin.

50. Note that $\overline{b}(\tau) > 1$ by construction, since $\Theta_{xB} = \Theta_{dB}\tau^{\beta/(1-\beta)}f_x/f_d$ when $b_A = b_B$.

51. This also implies $\delta_{dj} > \delta_{xj}$ in at least one country and in both countries in the vicinity of a symmetric equilibrium.

Proof of Lemma 4. This follows from (23), the incomplete specialization requirement $M_j > 0$ and Lemmas 1 and 3. Specifically, when $b_A > b_B$, $M_A > 0$ together with (23) imply

$$\frac{\delta_{dB}}{\delta_{xB}} > \left(\frac{Q_B}{Q_A}\right)^{\zeta} > 1,$$

where the last inequality follows from Lemma 3. Lemma 1 implies that $\delta_{dA} > \delta_{dB}$ and $\delta_{xA} < \delta_{xB}$ since δ_{zj} is a decreasing function of Θ_{zj} $(z = d, x$ and $j = A, B)$. Therefore, $\delta_{dA}/\delta_{xA} > \delta_{dA}/\delta_{xA} > 1$. ‖

Proof of Lemma 5. This follows from (23) and Lemmas 3 and 4. Specifically, (23) implies

$$M_A - M_B = \frac{(1-\beta)\phi_2}{\beta\Delta}\left[\left(\delta_{dB} + \delta_{xA}\right)Q_A^{\zeta} - \left(\delta_{dA} + \delta_{xB}\right)Q_B^{\zeta}\right].$$

When $b_A > b_B$, Lemma 3 implies $Q_A < Q_B$ and Lemma 4 implies $\delta_{dA} > \delta_{dB} > \delta_{xB} > \delta_{xA}$. Therefore, in this case $M_A < M_B$. ‖

Proof of Proposition 3. This follows from Lemmas 1, 4, and 5 and the definition of intra-industry trade. When $b_A > b_B$, Lemma 1 states that $\Theta_{xA} > \Theta_{xB}$ and $\Theta_{dA} < \Theta_{dB}$, which implies that a larger fraction of firms export in country B: $\left[1 - G(\Theta_{xj})\right]/\left[1 - G(\Theta_{dj})\right]$ is greater in B.

In the text we show that exports of differentiated products is equal to $X_j = M_j\delta_{xj}/\phi_2$. When $b_A > b_B$, Lemma 4 states that $\delta_{xB} > \delta_{xA}$ and Lemma 5 states that $M_B > M_A$, which implies $X_B > X_A$; that is country B exports differentiated goods on net. Balanced trade implies that is has to import the homogeneous good.

In the text, the share of intra-industry trade is shown to equal $X_A/X_B = \delta_{xA}M_A/\left(\delta_{xB}M_B\right)$. Using equation (23), we have:

$$\frac{X_A}{X_B} = \frac{\frac{\delta_{dB}}{\delta_{xB}} - \left(\frac{Q_B}{Q_A}\right)^{\zeta}}{\frac{\delta_{dA}}{\delta_{xA}}\left(\frac{Q_B}{Q_A}\right)^{\zeta} - 1}.$$

From equations (22) and (26) and using Lemma 4, an increase in b_A/b_B leads to a decrease in δ_{dB}/δ_{xB} and to increases in δ_{dA}/δ_{xA} and Q_B/Q_A. Therefore, an increase in b_A/b_B reduces X_A/X_B. ‖

In Appendix A.5, we prove additionally that under Pareto-distributed productivity the total volume of trade increases in the proportional gap between relative labour market frictions, b_A/b_B.

A.4. *Derivation of results on productivity for Section 4.3*

We first show that $\varphi_{zj} = \varphi(\Theta_{zj})$ is monotonically increasing in Θ_{zj}. The log-derivative of $\varphi(\Theta_{zj})$ is

$$\hat{\varphi}_{zj} = \Theta_{zj}G'(\Theta_{zj})\left[\frac{\Theta_{zj}}{\int_{\Theta_{zj}}^{\infty}\Theta dG(\Theta)} - \frac{\Theta_{zj}^{1/\beta}}{\int_{\Theta_{zj}}^{\infty}\Theta^{1/\beta}dG(\Theta)}\right]\hat{\Theta}_{zj} \qquad \text{for } z = d, x.$$

The term in the square brackets is positive since

$$\frac{\Theta_{zj}^{1/\beta}}{\int_{\Theta_{zj}}^{\infty}\Theta^{1/\beta}\frac{dG(\Theta)}{1-G(\Theta_{zj})}} < \left(\frac{\Theta_{zj}}{\int_{\Theta_{zj}}^{\infty}\Theta\frac{dG(\Theta)}{1-G(\Theta_{zj})}}\right)^{1/\beta} < \frac{\Theta_{zj}}{\int_{\Theta_{zj}}^{\infty}\Theta^{1/\beta}\frac{dG(\Theta)}{1-G(\Theta_{zj})}},$$

where the first inequality follows from Jensen's inequality and the second inequality comes from the fact that $\beta < 1$ and $\Theta_{zj} < \int_{\Theta_{zj}}^{\infty}\Theta\frac{dG(\Theta)}{1-G(\Theta_{zj})}$.

Next we provide the general expression for a log-change in aggregate productivity:

$$\widehat{TFP}_j = \left\{1 + \frac{\kappa_{dj}}{\varphi_{xj} - \varphi_{dj}}\left[\frac{\kappa_{xj}}{\kappa_{dj}}\left(\Theta_{xj}^{\frac{1-\beta}{\beta}} - TFP_j\right) + \left(TFP_j - \Theta_{dj}^{\frac{1-\beta}{\beta}}\right)\right]\right\}\frac{\delta_{dj}(\varphi_{xj} - \varphi_{dj})}{\delta_{dj}\varphi_{dj} + \delta_{xj}\varphi_{xj}}\hat{\Theta}_{dj}, \qquad \text{(A2)}$$

where

$$\kappa_{zj} \equiv \kappa(\Theta_{zj}) = \frac{f_z \Theta_{zj} G'(\Theta_{zj})}{\delta_{zj}} = \frac{\Theta_{zj} G'(\Theta_{zj})}{\frac{1}{\Theta_{zj}} \int_{\Theta_{zj}}^{\infty} \Theta dG(\Theta)}.$$

A series of sufficient conditions can be suggested for the terms in curly brackets to be positive. Since $TFP_j \geqslant \Theta_{dj}^{(1-\beta)/\beta}$ is always true, it is sufficient to require that

$$TFP_j \leqslant \Theta_{xj}^{(1-\beta)/\beta},$$

which holds for large enough Θ_{xj}, i.e. when the economy is relatively closed. However, this inequality fails to hold when Θ_{xj} approaches Θ_{dj}. Tighter but less intuitive sufficient conditions are provided in the working paper version (Helpman and Itskhoki, 2007).

Now we provide the derivation of equation (29) under the assumption of Pareto-distributed productivity draws. When Θ is distributed Pareto with the shape parameter $k > 1/\beta$, there is a straightforward way of computing the change in TFP_j. Taking the log derivative of equation (28), we have

$$\widehat{TFP}_j = \left[\frac{\delta_{dj}\varphi_{dj}\hat{\delta}_{dj} + \delta_{xj}\varphi_{xj}\hat{\delta}_{xj}}{\delta_{dj}\varphi_{dj} + \delta_{xj}\varphi_{xj}} - \frac{\delta_{dj}\hat{\delta}_{dj} + \delta_{xj}\hat{\delta}_{xj}}{\delta_{dj} + \delta_{xj}} \right] + \frac{\delta_{dj}\varphi_{dj}\hat{\varphi}_{dj} + \delta_{xj}\varphi_{xj}\hat{\varphi}_{xj}}{\delta_{dj}\varphi_{dj} + \delta_{xj}\varphi_{xj}}.$$

Under the Pareto assumption, the free-entry condition (20) can be written as $\delta_{dj} + \delta_{xj} = kf_{\mathrm{e}}$, which implies $\delta_{dj}\hat{\delta}_{dj} + \delta_{xj}\hat{\delta}_{xj} = 0$. We use this to simplify

$$\widehat{TFP}_j = \frac{\delta_{dj}\varphi_{dj}\left(\hat{\delta}_{dj} + \hat{\varphi}_{dj}\right) + \delta_{xj}\varphi_{xj}\left(\hat{\delta}_{xj} + \hat{\varphi}_{xj}\right)}{\delta_{dj}\varphi_{dj}}.$$

Next note that $\delta_{zj} = f_z \frac{k}{k-1}(\Theta_{\min}/\Theta_{zj})^k$ so that $\hat{\delta}_{zj} = -k\hat{\Theta}_{zj}$ and $\varphi_{zj} = \frac{k-1}{k-1/\beta}\Theta_{zj}^{(1-\beta)/\beta}$, implying $\hat{\varphi}_{zj} = (1-\beta)/\beta\hat{\Theta}_{zj}$. Thus, the log-derivative of the free-entry condition can also be written as $\delta_{dj}\hat{\Theta}_{dj} + \delta_{xj}\hat{\Theta}_{xj} = 0$. Therefore,

$$\delta_{dj}\left(\hat{\delta}_{dj} + \hat{\varphi}_{dj}\right) = -\delta_{xj}\left(\hat{\delta}_{xj} + \hat{\varphi}_{xj}\right) = -\left[k - (1-\beta)/\beta\right]\delta_{dj}\hat{\Theta}_{dj}.$$

Using this, we obtain our result (29) in the text.

Finally, we discuss an alternative measure of productivity which takes into account the sectoral composition of resource allocation:

$$TFP'_j = \frac{L - N_j}{L}\frac{H_{0j}}{N_{0j}} + \frac{N_j}{L}\frac{H_j}{N_j}TFP_j,$$

which is a weighted average of $x_{0j} = H_{0j}/N_{0j}$ (the productivity in the homogeneous sector) and $TFP''_j \equiv x_j \cdot TFP_j$ (productivity in the differentiated-product sector). The weights are the respective fractions of the two sectors in the labour force. Note that both sectoral productivity measures take into account unemployment of labour. Further, note that $\widehat{TFP''_j} = \widehat{TFP}_j + \hat{x}_j$. If $TFP''_j > x_{0j}$, an increase in the size of the differentiated sector improves productivity. Reduction in trade costs or labour market frictions in the differentiated sector (decreases in a_j/a_{0j}) shifts resources towards the differentiated sector by increasing N_j. Moreover, decreases in labour market frictions improve sectoral labour market tightness and hence increase productivity. These are the additional effects captured by this alternative measure of aggregate productivity.

A.5. *Solution under Pareto assumption for Section 5.2*

We characterize here the solution of the model under the assumption that productivity draws Θ are distributed Pareto with the shape parameter k. That is, $G(\Theta) = 1 - (\Theta_{\min}/\Theta)^k$ defined for $\Theta \geq \Theta_{\min}$. We use this characterization in Section 5.2 in order to solve numerically for the equilibrium response of unemployment to different shocks. In the end of this appendix, we provide some analytical results under Pareto-distributed productivity referred to in the text.

Pareto-distributed productivity leads to the following useful functional relationship:

$$\delta_{zj} \equiv \frac{f_z}{\Theta_{zj}} \int_{\Theta_{zj}}^{\infty} \Theta dG(\Theta) = f_z \frac{k}{k-1}\left(\frac{\Theta_{\min}}{\Theta_{zj}}\right)^k, \qquad z = d, x,$$

so that $\hat{\delta}_{zj} = -k\hat{\Theta}_{dj}$. As a result, we can rewrite the free entry condition (20) as

$$f_d \Theta_{dj}^{-k} + f_x \Theta_{xj}^{-k} = (k-1) f_e \Theta_{\min}^{-k} \qquad \Leftrightarrow \qquad \delta_{dj} + \delta_{xj} = k f_e.$$

Manipulating cutoff conditions (19) and the free entry condition above, one can obtain two equations linear in Θ_{dj}^{-k} and Θ_{xj}^{-k}. This allows us to solve for all equilibrium variables in closed form. We provide these solutions in the working paper version (Helpman and Itskhoki, 2007).

Using the Pareto assumption and the equation for M_j (23), we get

$$M_j = \phi_2 \frac{k-1}{k} \Theta_{\min}^{-k} \frac{f_d Q_j^{\zeta} \Theta_{d(-j)}^{-k} - f_x Q_{(-j)}^{\zeta} \Theta_{x(-j)}^{-k}}{f_d^2 \Theta_{dA}^{-k} \Theta_{dB}^{-k} - f_x^2 \Theta_{xA}^{-k} \Theta_{xB}^{-k}}. \tag{A3}$$

Finally, using the condition for N_j (24) and the free entry condition under the Pareto assumption, we get:

$$\omega_{0j} N_j = \phi_1^{\frac{1-\beta}{\beta}} \phi_2^{-1} M_j \left[\delta_{dj} + \delta_{xj}\right] = \phi_1^{\frac{1-\beta}{\beta}} k f_e M_j.$$

That is, under the Pareto assumption, N_j is always proportional to M_j.

Volume of trade (remark for Section 4.3). Under the Pareto assumption we can get a simple prediction about the response of the trade volume to τ, b_A, and b_B. Recall that the total volume of trade (when $b_A > b_B$) equals $2X_B$, where we have

$$X_B = \phi_2^{-1} M_B \delta_{xB} = \frac{\frac{\delta_{dA}}{\delta_{xA}} Q_B^{\zeta} - Q_A^{\zeta}}{\frac{\delta_{dA}\delta_{dB}}{\delta_{xA}\delta_{xB}} - 1} = \frac{\frac{f_d}{f_x}\left(\frac{\Theta_{xA}}{\Theta_{dA}}\right)^k Q_B^{\zeta} - Q_A^{\zeta}}{\frac{f_d^2}{f_x^2}\left(\frac{\Theta_{xA}\Theta_{xB}}{\Theta_{dA}\Theta_{dB}}\right)^k - 1} = \frac{\frac{f_d}{f_x}\left(\frac{\Theta_{xA}}{\Theta_{dA}}\right)^k Q_B^{\zeta} - Q_A^{\zeta}}{\tau^{\frac{2\beta k}{1-\beta}}\left(\frac{f_x}{f_d}\right)^{2(k-1)} - 1}.$$

As b_A increases or b_B falls, the denominator remains unchanged while Θ_{xA}/Θ_{dA} and Q_B increase and Q_A decreases. As a result, the volume of trade unambiguously rises. Finally, one can also show that X_B decreases in τ. Substitute the expression for Θ_{xA}/Θ_{dA} (derived from (19)) in the expression for X_B to get

$$X_B = Q_A^{\zeta} \frac{\tau^{\frac{\beta k}{1-\beta}}\left(\frac{f_x}{f_d}\right)^{k-1}\left(\frac{Q_B}{Q_A}\right)^{\zeta + k\frac{\beta-\zeta}{1-\beta}} - 1}{\tau^{\frac{2\beta k}{1-\beta}}\left(\frac{f_x}{f_d}\right)^{2(k-1)} - 1}.$$

Now note that X_B decreases in τ since Q_A and Q_B/Q_A decrease in τ and $Q_B > Q_A$.

Proof that N_A/N_B decreases in τ when $b_A > b_B$. In the text we show that $N_A + N_B$ increases as τ falls. We show now that when $b_A > b_B$, N_A/N_B decreases as τ falls, which implies that N_B necessarily increases. Under the Pareto assumption, $\delta_{dj} + \delta_{xj} = k f_e$. Therefore, equations (23) and (24) imply

$$\frac{\omega_{0A} N_A}{\omega_{0B} N_B} = \frac{M_A}{M_B} = \frac{\delta_{dB} Q_A^{\zeta} - \delta_{xB} Q_B^{\zeta}}{\delta_{dA} Q_B^{\zeta} - \delta_{xA} Q_A^{\zeta}} = \frac{1 - \frac{\delta_{xB}}{k f_e}\left[1 + \left(\frac{Q_B}{Q_A}\right)^{\zeta}\right]}{\frac{\delta_{dA}}{k f_e}\left[1 + \left(\frac{Q_B}{Q_A}\right)^{\zeta}\right] - 1} < 1,$$

where the last inequality comes from Lemma 5 under the assumption that $b_A > b_B$. Recall that ω_{0A}/ω_{0B} depends only on a_{0A}/a_{0B} and does not depend on τ. From Proposition 1, Q_B/Q_A increases as τ falls. Taking this and the fact that $N_A < N_B$ into account, it is sufficient to show that $d\delta_{xB} - d\delta_{dA} = \delta_{xB}\hat{\delta}_{xB} - \delta_{dA}\hat{\delta}_{dA} > 0$ in response to a fall in τ, to establish that N_A/N_B declines in this case. Under Pareto-distributed productivity,

$$\frac{\delta_{xB}\hat{\delta}_{xB} - \delta_{dA}\hat{\delta}_{dA}}{-\hat{\tau}} = \frac{k\left(\delta_{dA}\hat{\Theta}_{dA} - \delta_{xB}\hat{\Theta}_{xB}\right)}{-\hat{\tau}} = k\frac{(\delta_{dB}\delta_{xB} - \delta_{dA}\delta_{xA})(\delta_{dA} - \delta_{xA})}{\Delta} > 0,$$

where the second equality comes from (22) and the inequality is obtained by Lemma 4 and the fact that under the Pareto assumption $\delta_{dA} + \delta_{xA} = \delta_{dB} + \delta_{xB} = k f_e$. This proves that N_B increases as τ falls when $b_A > b_B$. Since changes in τ do not affect labour market tightness, x_{0B} and x_B, the only effect on the unemployment rate u_B is through N_B, and hence the unemployment rate in the flexible country increases in response to trade liberalization.

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