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## FDI, skill-specific unemployment, and institutional spillover effects

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## **FDI, Skill-Specific Unemployment, and Institutional Spillover Effects**

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**Abstract** This paper proposes a multi-industry trade model with integrated capital markets and Mortensen and Pissarides search frictions in the labor market. Institutional changes in the model trigger adjustments at the intensive and extensive margin of labor demand. At the extensive margin a shift of the specialization pattern amongst the integrated countries magnifies the effects at the intensive industry margin via trade and FDI. Moreover, the distinction between high- and low-skill workers facilitates the analysis of skill-specific institutional changes. A government can influence wages and unemployment of the low-skilled by manipulating labor market institutions concerning high-skill workers only. One-sided interventions affect all workers at home and abroad irrespective of their level of skill.

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## 1. Introduction

An enormous reduction of transportation costs and barriers to trade and capital fueled a lively debate about potential risks of job losses triggered by a reallocation of home production to low-cost countries. At odds with many canonical trade studies, policy makers often emphasized those risks in order to defend protectionist tendencies within a country. Hence, the widespread belief that globalization is responsible for massive job destruction could in principal also explain the recent surge in protectionism as observed in countries like Brazil, China, or the U.S.. Instead of withdrawing from trade, governments could also decide to react to heightened pressure on the labor markets by improving institutional measures in order to compensate workers from potential job or income losses. To what extent changes in institutions feedback through the product market by reducing the respective country's competitiveness within certain industries is however not yet fully understood.

In his seminal paper, Davis (1998) stressed the importance of institutions, which are crucial for the explanation of different labor market patterns in countries that are internationally interdependent. In line with Davis (1998), Egger, Greenaway, and Seidel (2011) distinguish between the long- and short-run effects of capital mobility in their theoretical and empirical analysis of labor market rigidities and its effects on the share of intra-industry trade measured by a bilateral Grubel-Loyd index. Felbermayr, Larch, and Lechthaler (2009) show that bad institutions in one country negatively spillover to labor market outcomes in their trading partners. My contribution to the literature is to develop a model that allows to assess how unilateral changes in labor market institutions affect labor markets not only in the respective but also the integrated countries. The outcome of the model differs in that it can explain skill-specific institutional changes, as well as skill-specific effects due to the assumption of heterogeneous workers along the lines proposed by Feenstra and Hanson (1996, 1997) and Moore and Ranjan (2005). Moreover, the model employed in this paper is able to explain an observable reversing trend in Chinese foreign direct investment. The implications drawn from the comparative static exercise in this paper suggest a two-way relationship with wages being jointly determined by labor market institutions and international trade. It will be shown that trade and *FDI* affects labor demand at both the intensive and extensive margin. At the extensive industry margin countries imposing institutional changes by

improving unemployment benefits, the workers position during wage negotiations, or the recruitment process indirectly influence a country's comparative advantage within a certain range of industries, thereby affecting aggregate labor demand and unemployment. The impact of such an industry-reallocation at the extensive margin magnifies the effects at the intensive margin, where wages directly trigger responses of within-industry labor demand. The assumption that high- and low-skill workers are complements leads to inter-skill spillover effects within a country. Moreover, better labor market institutions protecting the workers render foreign direct investment more attractive. This magnification effect holds irrespective of the complementarity assumption, imposed to keep the model tractable. Applied to the model, recent improvements in the Chinese security system and workers' labor rights can explain the aforementioned reversing trend in capital flows into China, where the rapid opening up to global markets was accompanied by massive capital inflows and a strengthening of Chinese firms in the 80s and 90s. Increasing wages due to improving labor standards likely contributed to the massive capital outflows observed during the last decade.<sup>1</sup>

The model itself is based on Schmerer (2011), where search frictions were already introduced into a Feenstra and Hanson (1996, 1997) trade model but without distinguishing between skill-specific unemployment rates. The predictions about the foreign direct investment and unemployment nexus derived from the model were tested using OECD data on unemployment, labor market institutions, and foreign direct investment. The model proposed in this paper is tied closer to the original Feenstra and Hanson (1996, 1997) approach due to the distinction between low- and high-skill workers, which facilitates an analysis of skill-specific institutional spillover effects. A government can influence wages and unemployment of the low-skilled by manipulating labor market institutions concerning high-skill workers only. It will be shown that this reduces the position of high-skilled workers, while low-skilled benefit from rising wages and employment through the feedback effects at the intensive- and extensive-margin. The latter is due to international trade and foreign direct investment, which open a new channel through which the positive effects are magnified due to the expansion of the domestic economy. Concerning wage inequality such a high-skill specific change in labor market institutions reduces wage inequality by reducing the high-skilled and raising the wages of the less skilled workers through the magnification effect.

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<sup>1</sup>See Braunstein and Epstein (2002) for instance.

Closely related to this paper is for instance Beissinger (2001), who studies spillover effects of unilateral labor market reforms on capital flows between two countries. Boulhol (2009) focuses on the pressure of trade liberalization on labor market deregulations. Lin and Wang (2008) empirically investigate this relationship by studying how capital-outflows affect unemployment using panel data.

Also related to this paper are Mitra and Ranjan (2007) and Davidson and Matusz (2008). Both papers study the effects of outsourcing on labor market outcomes in trade models with search frictions. Mitra and Ranjan (2007) have a two sector model with labor being the only input factor. In their model, outsourcing decreases equilibrium unemployment. Conversely, Davidson and Matusz (2008) propose a model where outsourcing forces some of the high-skill workers in the North to search for jobs in the low-skill intermediate sector. This stirs up job competition in that sector and thus triggers a rise in unemployment.

Kohler and Wrona (2010) stress the non-monotonic relationship between offshoring and labor demand/unemployment within industries by showing that the sign of the effect in their model may depend on the level of offshoring.<sup>2</sup> Although the theoretical literature on global sourcing and unemployment is sparse and incomplete, the number of studies focusing on the effects of trade liberalization on unemployment is numerous. Brecher (1974) introduced minimum wages in the classical Heckscher Ohlin model and analyzed how equilibrium unemployment changes when moving from autarky to free trade. Davidson and Matusz (1988, 2004) or Davidson et al. (1999) were amongst the first to extend the canonical Heckscher Ohlin model by implementing search frictions. Building on their work, Moore and Ranjan (2005) came forward with a model that permits studying how globalization affects skill specific unemployment in such a Heckscher Ohlin framework.

More recently, researchers started to focus on the popular Melitz (2003) international trade model with heterogeneous firms. Egger and Kreickemeier (2009) incorporate fair wages into the Melitz (2003) model in order to explain the trade and inequality nexus. Helpman and Itshkoki (2007), Helpman, Itshkoki, and Redding (2010), Felbermayr and Prat (2011) and Felbermayr, Prat and Schmerer (2011 a) introduced search frictions in the Melitz model. In our approach exit of less productive firms boosts firms'

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<sup>2</sup>Non-monotonic means that outsourcing decreases labor demand when the level of outsourcing is low, but increases labor demand beyond a certain threshold level.

recruiting efforts and thus reduces unemployment in the long run. Helpman, Itshkoki and Redding (2008) extend their model and address worker heterogeneity. Larch and Lechthaler (2011) distinguish between high- and low-skill workers in line with Bernard, Redding and Schott (2007) and analyze the effects of trade liberalization on skill-specific unemployment in a model with heterogeneous firms and search frictions.

Two empirical papers that shed light on the interaction of globalization and labor market outcomes are Felbermayr, Prat and Schmerer (2011 b) and Dutt, Mitra, and Ranjan (2009). Using macroeconomic data, both papers successfully test some of the major predictions derived from theory. Felbermayr, Prat, and Schmerer (2011 b) show that trade openness is negatively associated with equilibrium unemployment using panel and cross-sectional data. Moreover, in line with theory they identify TFP as potential channel variable through which globalization affects unemployment. Dutt, Mitra, and Ranjan (2010) employ cross-sectional data and find the same negative relationship.

## 2. The benchmark model

The product market equilibrium is characterized by a two-stage production process: final goods are assembled by downstream producers using intermediate goods produced by high- and low-skill intermediates producers, and capital. Firms producing high-skill intermediates do this by solely using high-skill labor, whereas low-skill intermediate good producers employ low-skill labor only. Upstream producers and workers take expected prices charged by downstream producers into consideration and bargain about wages. Search frictions drive a wedge between labor costs and prices charged for intermediate goods. The production and consumption side is interacted over all stages since labor and capital costs together pin down national income, world income, and (international) goods' prices.

**Consumer demand.** Following Feenstra and Hanson (1996, 1997) aggregate demand for intermediate goods  $Y$  over all industries reads as

$$\ln Y = \int_0^1 \varphi(z) \ln x(z) dz , \quad (1)$$

where  $x(z)$  denotes the amount of intermediate goods demanded from industry  $z$  and  $\varphi(z)$  is industry  $z$ 's Cobb Douglas consumption share.<sup>3</sup> The aggregate consumption good is produced without costs and sold for an aggregate price level  $P$ . Prices and wages are jointly determined by upstream producers, workers, and downstream producers. Aggregate demand for the final output good equals total expenditure  $YP = E$ . The aggregate demand function (1) implies that a constant fraction  $\varphi(z)$  of world expenditure is spent on the consumption of good  $z$ . Thus, consumer demand for output generated in industry  $z$  reads as

$$x(z) = \frac{\varphi(z)E}{\kappa(z)}, \quad (2)$$

so that the share of expenditure spent for that particular industry  $z$  is equal to the revenue generated in the respective industry. Perfect competition implies that total revenue in industry  $z$  is equal to the quantity produced,  $x(z)$ , times unit costs,  $\kappa(z)$ . One can solve the standard utility maximization problem of the representative consumer who maximizes utility (1) subject to the budget constraint, which depends upon prices, consumption, and income available for consumption. The first order condition of the utility maximization problem yields equation (2).

**Final consumption goods producers.** We borrow the heterogeneous worker concept from Feenstra and Hanson (1996, 1997) by assuming that goods are produced in a continuum of industries using the input factors capital, high-, and low-skill workers. However, the model setup is different in that workers are not directly used by the final output good producers, instead those final goods are produced using intermediates obtained from small firms hiring either low- or high skill workers. The input coefficients that determine labor requirements for the production in  $z$  are given exogenously.<sup>4</sup> Goods in the continuum are ranked according to their skill intensities  $a_h(z)$  and  $a_l(z)$ , both described by linear functions increasing in  $z$ . The assumption that the input coefficient curves that pin down low- and high-skill labor requirement are both steeper in the foreign country than in the home country give rise to gains from trade and determine the free trade pattern that stems from cross-country differences in production costs. It

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<sup>3</sup>Summing up the shares over the whole continuum of industries must equal unity.

<sup>4</sup>Demand for intermediate goods produced maps into labor requirement due to the small firm assumption and perfect competition. Each upstream producer hires exactly one worker to produce one intermediate good.

is worth mentioning that technology plays a minor role in this setup since the results are not driven by differences in endowments or technology. Countries produce goods where they have a comparative advantage by means of lower unit costs compared to the unit costs in the competing country. However, it is sensible to link the input requirement curves to relative factor endowments so that, on average, low-skill abundant countries have a relatively higher low-skill labor demand in all industries. In the following all countries are assumed to be low-skill abundant and all industries therefore have higher low-skill requirement on average.<sup>5</sup> The functional form of both input coefficient curves is

$$a_{li}(z) = \alpha_{li} + \gamma_{li}(z) , \quad (3)$$

$$a_{hi}(z) = \alpha_{hi} + \gamma_{hi}(z) \quad (4)$$

where  $i$  is the country identifier,  $l$  denotes low-, and  $h$  denotes high-skill. For the input coefficients we assume that  $\alpha$  is a country-specific constant and  $\gamma$  denotes the industry specific component of labor requirement depending on  $z$ . Similar to Feenstra and Hanson (1996, 1997) the final intermediate good is assembled according to the nested Leontief production function

$$x_i(z) = \left[ \min \left\{ \frac{l_l(z)}{a_{li}(z)}, \frac{l_h(z)}{a_{hi}(z)} \right\} \right]^\zeta [k_i(z)]^{1-\zeta} . \quad (5)$$

Input over high- and low-skill intermediates is assumed to be Leontief, which implies that input-relation between high- and low-skill intermediates is fixed. The aggregated intermediate-good is nested into a Cobb Douglas production function that combines intermediates with capital to produce the final consumption good. Let  $p(z)$  denote the price of each final intermediate input good,  $l_l(z)$  is low-skill labor demand in industry  $z$ , and  $l_h(z)$  is high-skill labor demand in industry  $z$ . Under autarky the whole continuum of goods is produced domestically. Under free trade however, both countries specialize and the range of active industries within each country is determined by the cutoff condition

$$p_d(z^*) = p_f(z^*) . \quad (6)$$

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<sup>5</sup>Whether a country is high- or low-skill abundant highly depends on how both categories are classified. On average the world is medium skill abundant. Using WDI data in order to decompose the total labor force into low-, medium and high-skill components we find that on average 33 percent of the labor force has a low-skill education and only 16 percent of the work force hold a high-skill qualification.



Downstream producer prices equal production costs depending on the firm's input coefficients, wages earned by workers that produce the intermediates for the upstream producers, and search cost paid by upstream producers in order to recruit workers. Goods are ordered according to their relative skill intensity. We know that intermediate good prices are equalized over the whole continuum. This implies that the unit cost ranking of industries solely depends on the input coefficients, which are exogenously given and increasing in  $z$ . Wages in both countries are equalized across sectors  $z$  but not across skill groups. Each firm has to pay  $q_h$  for high-skill intermediate goods and  $q_L$  for low-skill intermediates. Intermediate goods' prices are taken as given in the final production stage and set in the stage below where firms use high- and low-skill labor to produce the intermediates. Downstream producers adjust their labor demand with respect to prices charged by upstream producers. Perfect competition implies that the industry price level equals the respective industry unit costs

$$p_i(z) = \kappa_i(z) = B(q_h a_{hi}(z) + q_L a_{Li}(z))^\zeta r_i^{1-\zeta}, \quad (7)$$

where  $B = \zeta^{-\zeta}(1 - \zeta)^{-(1-\zeta)}$  and  $\kappa(z)$  denotes minimum unit costs in sector  $z$  obtained by solving the standard cost minimization problem for firms producing according to the production function (5).

**Intermediate input producers.** Firms in this final stage use labor to produce intermediate input goods. There are two different type of firms, one producing high-skill intermediates by input of high-skill labor, and one producing low-skill intermediates by input of low-skill labor. This assumption is consistent with the notion of firms producing different parts with different skill requirements in separated plants. The number of potential firms is given by  $L_i$  and  $H_i$  since each intermediate goods producer employs one worker, and since demand for high- and low-skill intermediates is dictated by the Leontief production function (5) in the downstream production process. However, search frictions reduce the number of firms since some of the workers are unemployed.<sup>6</sup> Labor markets are not perfect. Employers and employees have to be matched to each other and firms have to post vacancies before hiring workers. Bargaining between firms and workers is separated according to the workers' skills without intra firm

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<sup>6</sup>See Ebell and Haefke (2004) on a further discussion why the small firm assumption is harmless under the assumption of perfect competition. Under monopolistic competition the number of firms is crucial for determining the equilibrium. Thus, the standard small firm assumption is not feasible anymore.

bargaining across skills. However, there is an interaction between high- and low-skill workers since upstream producers take downstream retail prices into consideration when negotiating wages. Equation (5) implies that there is no substitution between high- and low-skill workers since both inputs are used in a certain relation. Thus, firms' revenue is zero if bargaining with one or the other type of worker fails. Even if the relation in the production process is different, their importance for the revenue generated is equal since the real amount of both input factors is equal in production. Factors with higher input coefficients are more productive and therefore less units are used. Given that the price for the intermediate good depends on wages paid by upstream producers, labor market clearing hinges on a certain pair of equilibrium market tightness to secure that revenue generated by the downstream producers is exactly equal to  $\kappa_i(z)x_i(z)$ .

**Properties of the labor market equilibrium condition.** Since the latter product market equilibrium depends on the labor market equilibrium more clarification is needed to shed light on the implications from vacancy posting costs for intermediate input prices. Firms can pay vacancy posting costs in terms of income, in terms of the good produced by the respective firm, aggregate price or in terms of the wage rate. The Pissarides (2000) assumption that vacancy posting costs are paid in terms of goods' prices is used in the following sections in order to solve for a unique equilibrium.

**Proposition 1.** *a) The intermediate input prices are governed by*

$$q_{ld} = \frac{(1 - \beta)b_{ld}}{(1 - \beta) - c_{kd}(\beta\theta_{ld} + \frac{\eta_d + \lambda}{m(\theta_{ld})})} \quad (8)$$

$$q_{hd} = \frac{(1 - \beta)b_{hd}}{(1 - \beta) - c_{kd}(\beta\theta_{hd} + \frac{\eta_d + \lambda}{m(\theta_{hd})})} \quad (9)$$

*b) An increase in the equilibrium market tightness  $\theta_k$  leads to an increase in wages and thus intermediate input goods prices since  $\frac{\partial q_i}{\partial \theta_k} > 0$ . This proposition holds irrespective of whether vacancy posting costs are paid in terms of numeraire or in terms of intermediate input prices.*

*Proof.* Part a) follows from solving the standard Bellman equations as in Pissarides (2000) or Dutt et al. (2010). A detailed solution and proof can be found in the appendix. Part b) of proposition (1) is easily proved by deriving the first derivative of the labor

market equilibrium condition with respect to  $\theta_k$ , which is increasing since the vacancy filling rate is decreasing in the equilibrium market tightness  $\frac{\partial m(\theta_k)}{\partial \theta_k} < 0$ . Thus the first derivative of (8) and (9) with respect to  $\theta_k$  is positive.  $\square$

Solving the product and labor market equilibrium pins down the low- and high-skill equilibrium market tightness and unemployment in both countries via the skill-specific Beveridge curves

$$u(\theta_{ki}) = \frac{\delta}{\delta + \theta_k m(\theta_{ki})} . \quad (10)$$

The Beveridge curve relates the unemployment-to-vacancy ratio such that the flow into unemployment equals the flow out of unemployment and therefore pins down long-run equilibrium unemployment rates in the economy. The Beveridge curve is convex due to the concave matching technology. Thus, the magnitude of the relationship between  $\theta_k$  and  $u$  is stronger for relatively low values of unemployment.

## 2.1. Labor market clearing

The labor market clears when labor supply equals labor demand. However, due to search frictions labor supply is the fraction of matched workers outside the pool of unemployed workers. On the other hand, firms adjust their labor demand to the intermediate input prices that now do depend on wages and search cost. Thus, search costs drive a wedge between intermediate input prices and the wage earned by the firms' workers, but perfect competition still implies that prices are equal to production cost.

**Proposition 2.** *Final good producers are price takers and base their labor demand decision on the (already optimal) high- and low-skill intermediate goods' prices, given that wages are bargained between intermediate goods producers and workers, and given that those wages are optimal. Wages therefore map into intermediate goods' prices.*

Using Shephard's Lemma we know that demand for intermediates produced is equal to

$$l_k(z) = \frac{\partial \kappa_k(q_h, q_l, r; z)}{\partial q_k(z)} = B \zeta a_k(z) (q_l a_l(z) + q_h a_h(z))^{\zeta-1} r^{1-\zeta} . \quad (11)$$

Domestic labor market equilibrium requires that labor demand at the aggregate level is

equal to total labor supply which is satisfied if

$$L_d(1 - u_{ld}) = \int_{\underline{z}_d}^{\bar{z}_d} B\zeta \left[ \frac{r_d}{q_{ld}a_{ld}(z) + q_{ld}a_{ld}(z)} \right]^{1-\zeta} a_{ld}(z)x(z)dz , \quad (12)$$

and

$$H_d(1 - u_{hd}) = \int_{\underline{z}_d}^{\bar{z}_d} B\zeta \left[ \frac{r_d}{q_{hd}a_{hd}(z) + q_{hd}a_h(z)} \right]^{1-\zeta} a_{hd}(z)x(z)dz , \quad (13)$$

holds. The right hand side is aggregate labor demand obtained by aggregating industry level labor demand over all industries depending on input prices following (11). The specialization pattern under free trade is ex-ante unknown and depends on the unit cost schedule over all industries, where  $\bar{z}_i$  denotes the upper and  $\underline{z}_i$  the lower bound of the continuum of active industries in the respective country. Prices of high- and low-skill intermediates depend on the endogenous equilibrium market tightness, and some exogenous parameters only.  $q$  can be substituted in the labor market clearing condition so that this condition only depends on  $\theta_k$ . Following Feenstra and Hanson (1996, 1997) we exploit (2) and equation (7) in order to link the aggregate demand, labor-, and product-market equilibrium via

$$L_d(1 - u_{ld}(\theta_{ld})) = \int_{\underline{z}_d}^{\bar{z}_d} \zeta \left[ \frac{a_{ld}(z)\varphi(z)E}{q_{ld}(\theta_{ld})a_{ld}(z) + q_{hd}(\theta_{hd})a_{hd}(z)} \right] dz , \quad (14)$$

$$H_d(1 - u_{hd}(\theta_{hd})) = \int_{\underline{z}_d}^{\bar{z}_d} \zeta \left[ \frac{a_{hd}(z)\varphi(z)E}{q_{ld}(\theta_{ld})a_{ld}(z) + q_{hd}(\theta_{hd})a_{hd}(z)} \right] dz . \quad (15)$$

Thus, the number of matches equals the number of intermediate goods available. The consumption share for each industry  $z$  is constant and by assumption equalized over the whole continuum. In the continuous scenario the mass of one single industry is close to zero. It is thus necessary to compute the mass of a certain range of industries within the whole continuum. To understand the implications of the assumption made above we compare the continuous scenario with the discrete scenario. Suppose  $n$ , the number of goods produced, is large and each industry has the same constant Cobb Douglas expenditure share  $\varphi$ , which is assumed to be uniformly distributed over the whole continuum of industries. This would allow us to approximate  $\varphi(z) = 1/n$ .<sup>7</sup> The approximation in the continuous case is similar but here we need the notion of a mass of industries over the range  $\underline{z}$  and  $\bar{z}$ . A solution to the integral is determined by sub-

<sup>7</sup>As in the continuous case, the consumption share of one particular industry goes to zero if  $n$  is large.

stitution and integration by parts. We define  $f_k(z) = a_k(z)$  and  $g'(z) = (q_l(\theta_l)a_l(z) + q_h(\theta_h)a_h(z))^{-1}$  to obtain a solution for (14) and (15) as

$$\begin{aligned}
L_d(1 - u_{ld}(\theta_{ld})) &= (\bar{z}_d - \underline{z}_d)\zeta E \left( [a_{ld}(z)g(z)]_{\underline{z}_d}^{\bar{z}_d} - \int_{\underline{z}_d}^{\bar{z}_d} a'_{hd}(z)g(z)dz \right) \\
&= \frac{(\bar{z}_d - \underline{z}_d)\zeta E}{\varpi'_d} \left( [a_{ld}(z) \ln \varpi(z)]_{\underline{z}_d}^{\bar{z}_d} - \frac{\gamma_{ld}}{\varpi'_d} [(\varpi(\ln \varpi - 1))]_{\underline{z}_d}^{\bar{z}_d} \right) \\
H_d(1 - u_{hd}(\theta_{hd})) &= (\bar{z}_d - \underline{z}_d)\zeta E \left( [a_{hd}(z)g(z)]_{\underline{z}_d}^{\bar{z}_d} - \int_{\underline{z}_d}^{\bar{z}_d} a'_{hd}(z)g(z)dz \right) \\
&= \frac{(\bar{z}_d - \underline{z}_d)\zeta E}{\varpi'_d} \left( [a_{hd}(z) \ln \varpi(z)]_{\underline{z}_d}^{\bar{z}_d} - \frac{\gamma_{hd}}{\varpi'_d} [(\varpi(\ln \varpi - 1))]_{\underline{z}_d}^{\bar{z}_d} \right)
\end{aligned}$$

where we use  $\varpi = q_{ld}(\theta_l)a_{ld}(z) + q_{hd}(\theta_h)a_{hd}(z)$  and  $\varpi'(z) = q_l(\theta_l)\gamma_l + q_h(\theta_h)\gamma_h$ . For the foreign country we obtain

$$\begin{aligned}
L_f(1 - u_{lf}(\theta_{lf})) &= (\bar{z}_f - \underline{z}_f)E\zeta \left( [a_{lf}(z)g_f(z)]_{\underline{z}_f}^{\bar{z}_f} - \int_{\underline{z}_f}^{\bar{z}_f} a'_{hf}(z)g_f(z)dz \right) \\
&= \frac{(\bar{z}_f - \underline{z}_f)E\zeta}{\varpi'_f} \left( [a_{lf}(z) \ln \varpi_f(z)]_{\underline{z}_f}^{\bar{z}_f} - \frac{\gamma_{lf}}{\varpi'_f} [(\varpi_f(\ln \varpi_f - 1))]_{\underline{z}_f}^{\bar{z}_f} \right) \\
H_f(1 - u_{hf}(\theta_{hf})) &= (\bar{z}_f - \underline{z}_f)E\zeta \left( [a_{hf}(z)g_f(z)]_{\underline{z}_f}^{\bar{z}_f} - \int_{\underline{z}_f}^{\bar{z}_f} a'_{hf}(z)g_f(z)dz \right) \\
&= \frac{(\bar{z}_f - \underline{z}_f)E\zeta}{\varpi'_f} \left( [a_{hf}(z) \ln \varpi_f(z)]_{\underline{z}_f}^{\bar{z}_f} - \frac{\gamma_{hf}}{\varpi'_f} [(\varpi_f(\ln \varpi_f - 1))]_{\underline{z}_f}^{\bar{z}_f} \right)
\end{aligned}$$

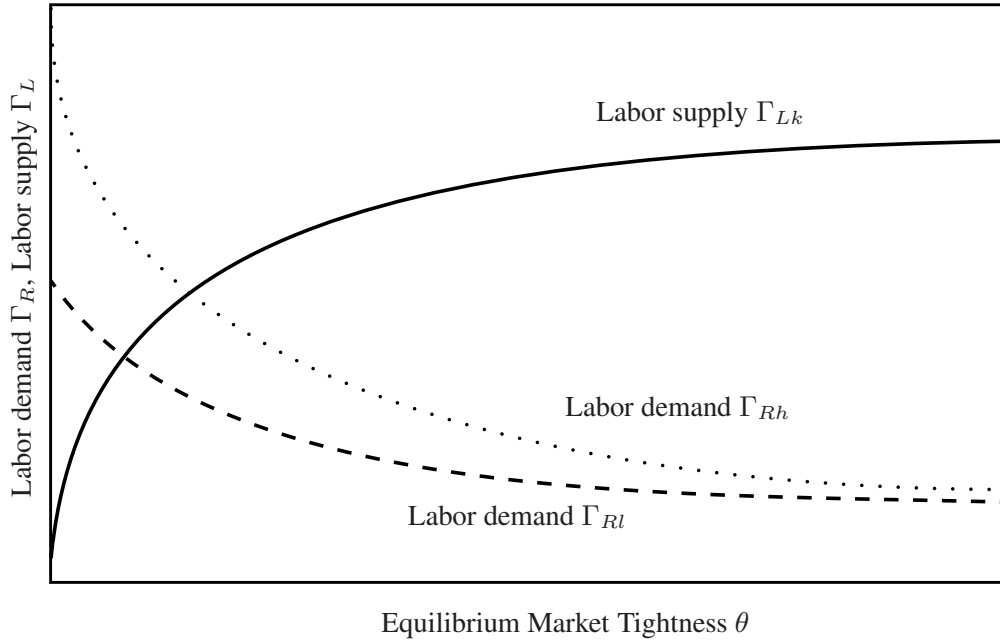
**Proposition 3.** *Labor market clearing requires that labor demand equals labor supply in each country and skill group. The labor market clearing conditions therefore pin down four  $\theta_k$ s, and each  $\theta_k$  in turn pins down the respective wage and skill-specific unemployment rate. The equilibrium is unique since there exists exactly one pair of equilibrium market tightness satisfying all  $2 \times 2$  labor market clearing conditions for a given cutoff  $z^*$ .*

*Proof.* Let  $\Gamma_L$  denote the left-, and  $\Gamma_R$  the right hand side of the labor market clearing condition. We further define  $f_k(z) = \frac{\varphi(z)Ea_k(z)}{q_l(\theta_l)a_l(z) + q_h(\theta_h)a_h(z)}$ . The left hand side of both labor market clearing conditions has its origin at zero and converges to an upper bound. The right hand side is also well behaved. Labor demand is decreasing in  $\theta_k$ . An increase in  $\theta_k$  triggers an increase in intermediate input good prices, which in turn reduces de-

mand for intermediates. Applying the Leibniz rule to the right hand side of the labor market clearing condition and assuming that the bounds of the integral being constant yields

$$\frac{\partial \Gamma_R}{\partial q_k} = \int_{\underline{z}}^{\bar{z}} \frac{\partial f(z, q_l, q_h)}{\partial q_k} dz < 0, \quad (16)$$

where world income is set as numeraire so that  $E = 1$ .<sup>8</sup> The first derivative approaches 0 when  $q_k$  goes to infinity and  $\frac{\partial^2 \Gamma_R}{\partial q_k^2} > 0$ . Therefore, firms' labor demand is decreasing in  $\theta_k$  and converges to zero. Figure 1 illustrates the equilibrium. Notice, that there is an interaction between the low- and high-skill labor market clearing condition. The high-skill labor market tightness shifts low-skill labor demand  $\Gamma_R$  through the increase in the wage rate that enters both group's labor market clearing condition.  $\square$



**Figure 1:** Labor market clearing condition

Figure 1 depicts the left and right hand side of the labor market clearing condition in

<sup>8</sup>Note that this normalization helps to solve some ambiguities. However, as shown later on world income does not change by much due to some countervailing effects of FDI on both countries' wages.

both skill sectors. The focus lies on the interaction between equilibrium market tightness  $\theta_k$  and labor demand / supply. For the sake of clarity we assume that the labor supply function  $\Gamma_L$  are equal in both sectors.<sup>9</sup> A change in one skill group's equilibrium market tightness also affects the respectively other skill-groups  $\Gamma_R$ . The equilibrium is unique since  $\Gamma_L$  has its origin at zero and converges to the upper bound whereas  $\Gamma_L$  converges to zero when  $\theta_k$  goes to infinity.

**Proposition 4.** *a) The right hand side of the labor market clearing condition is increasing in  $z^*$  in the country where  $z^*$  determines the lower bound of active industries. Conversely, countries where  $z^*$  pins down the lower bound of industries suffer from a decrease in labor demand if  $z^*$  increases.*

*Proof.* Part one of this proposition follows directly from the first derivative of the right hand side of the labor market clearing condition with respect of  $z^*$ , which is positive or negative depending on whether  $z^*$  is the upper or lower bound of the integral.  $\square$

**Proposition 5.** *If we allow for free trade both countries are better off by specializing on production in sectors where they have an comparative advantage. A free trade equilibrium requires one unique cutoff  $z^* \in (0, 1)$  for which each of the four labor markets is in equilibrium and for which the cutoff condition*

$$p_d(z^*) = p_f(z^*) \Leftrightarrow \kappa_d(\theta_{ld}, \theta_{hd}; z^*) = \kappa_f(\theta_{lf}, \theta_{hf}; z^*) \quad (17)$$

*is fulfilled.*

However, proposition 4 states that each cutoff  $z^* \in [0, \infty]$  is associated with one unique combination of  $\theta_l$  and  $\theta_h$ . Thus, a necessary requirement for the free trade equilibrium is a cutoff associated with a combination of equilibrium market tightness parameters for which all labor markets clear and for which domestic equals foreign unit costs. Obviously, there is no upper bound for  $z$  which means that - given the exogenous parameters - such a cutoff might be outside the feasible space of industries, which is restricted to lie within the continuum  $z \in [0, 1]$ . If the cutoff condition is fulfilled for  $z^* > 1$  only, we would obtain a corner solution where one country could produce all

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<sup>9</sup>That would be the case if matching functions and labor endowments are equal for both high- and low-skilled. Differences in endowments would shift  $\Gamma_L$  without affecting the shape of the curves. Our institutional variables as unemployment benefits, search costs, or the bargaining power of the workers do not affect the labor supply curves directly.

goods cheaper. In that case there are no incentives for one of the countries to participate in international trade so that both economies remain under autarky and produce the whole continuum domestically. Both cost schedules are increasing in  $z$ . Thus, an increase in the capital rental or the intermediate goods shift the unit cost schedules up. This shift in unit costs over the whole continuum will result in a loss of the comparative advantage in some industries located close to the former cutoff, resulting in a shift of  $z^*$ .

### 3. General Equilibrium

To close the model we still have to determine world income and capital returns. Income is not normalized to unity and equals world factor payments

$$E = L_d(1 - u_{ld})q_{ld} + H_d(1 - u_{hd})q_{hd} + r_d K_d + L_f(1 - u_{lf})q_{lf} + H_f(1 - u_{hf})q_{hf} + r_f K_f . \quad (18)$$

The capital rental is determined exploiting the Cobb Douglas shares and Shephards Lemma again

$$r_d K_d = (1 - \zeta)(\bar{z}_d - \underline{z}_d)E , \quad (19)$$

$$r_f K_f = (1 - \zeta)(\bar{z}_f - \underline{z}_f)E . \quad (20)$$

Thus, the fraction  $\zeta$  is spend for intermediates which gives us

$$L_d(1 - u_{ld})q_{ld} + H_d(1 - u_{hd})q_{hd} = \zeta(\bar{z}_d - \underline{z}_d)E , \quad (21)$$

$$L_f(1 - u_{lf})q_{lf} + H_f(1 - u_{hf})q_{hf} = \zeta(\bar{z}_f - \underline{z}_f)E . \quad (22)$$

Both equilibrium conditions can be solves for  $E$  in order to derive

$$r_d K_d = \frac{(1 - \zeta)}{\zeta} (L_d(1 - u_{ld})q_{ld} + H_d(1 - u_{hd})q_{hd}) , \quad (23)$$

$$r_f K_f = \frac{(1 - \zeta)}{\zeta} (L_f(1 - u_{lf})q_{lf} + H_f(1 - u_{hf})q_{hf}) . \quad (24)$$

The equilibrium thus depends on 8 endogenous variables: 4 equilibrium market tightness, capital return in the foreign and home country, one cutoff, as well as world in-



come. We follow Feenstra and Hanson (1996, 1997) setting world income as numeraire so that we can drop one equilibrium condition as suggested by Walras' law.

## **4. Comparative statics**

We now turn to the comparative statics of the model and analyze how labor market institutional changes trigger foreign direct investments. Second, the effects of a unilateral change in labor market institutions on unemployment in both countries are analyzed. Interest rates are treated as exogenous. An increase in unemployment benefits for instance shifts the unit cost schedule upwards, followed by adjustments at the extensive margin. Capital has to flow between the two economies in order to restore equilibrium since interest rates are fixed and equalized across countries.

The distinction between high- and low-skill labor allows us to disentangle the effects according to skill. Institutional reforms always affect skill-specific unemployment in both the low- and the high-skill group directly through the wage setting mechanism and/or indirectly through the adjustments at the extensive margin. Put differently, improvements in the bargaining power of the low-skilled workers at Home directly affect their wages and thus unemployment of the low-skilled only. Beyond that, wages and unemployment of all workers at home and abroad are affected through trade and FDI.

### **4.1. Changes in labor market institutions**

Extending the Feenstra and Hanson (1996) framework by implementing a micro based wage setting mechanism in combination with search frictions allows us to study the implications of labor market institutional variables. Without loss of generality, interest rates are set exogenously and remain fixed in the comparative static exercise conducted below. Policies that intend to improve the workers' rights have an increasing effect on wages. As shown in the appendix, increases in unemployment benefits or bargaining power boost equilibrium wages in all industries and thus shift the unit cost schedule for downstream producers upwards. Although such changes in labor market institutions are unilateral, spillover effects might influence domestic labor markets in countries integrated via trade and FDI. It shall be shown that such spillover effects occur in the model presented above. Adjustments with exogenous interest rates take place at

the extensive margin only. An increase in  $b$  or  $\beta$  will increase the respective country's wages in all industries, inducing an upwards shift of the unit cost schedule in country  $i$ . Adjustment at the extensive margin further reduces labor demand since all jobs connected to those industries get lost in the home country. The destruction of industries also lead to excess capital supply in country  $i$ , which will be shifted to countries suffering from excess capital demand due to the enhanced production. In country  $i \neq j$  adjustments take place at the extensive margin only since interest rates do not change. The receiving country's unit cost schedule therefore remains constant. However, since production expands in the receiving country, labor demand goes up, accompanied by an increased labor supply. A higher wage rate is needed to trigger an increase in labor supply. Therefore, the new equilibrium requires a higher market tightness in both skill sectors to satisfy the increase in labor demand.

**Proposition 6.** *a) An unilateral increase in unemployment benefits  $b_i$ , bargaining power  $\beta_i$ , or search costs  $c$  leads to an increase in country  $i$ 's unemployment and wages and triggers capital outflows. b) Country  $j \neq i$ 's capital inflows will reduce its equilibrium unemployment but increase its employees' wages.*

*Proof.* a) follows directly by  $\frac{\partial w_{ki}}{\partial b_i} > 0$  or  $\frac{\partial w_{ki}}{\partial \beta_i} > 0$  where we assume that the labor market institutions across high- and low-skill sectors are equal. Therefore, unit costs in all industries rise and labor is substituted with capital. Labor supply  $\Gamma_{li}$  must go down in both skill sectors, since labor demand  $\frac{\partial \Gamma_{ri}}{\partial q_{hi}} < 0$  and  $\frac{\partial \Gamma_{ri}}{\partial q_{li}} < 0$ . Again we first assume that the cutoff remains constant. At the extensive margin, we know that the unit cost schedule shifts upwards in country  $i$  followed by adjustments in the cutoff. The adjustments at the extensive margin are already derived for the prove of proposition (3). For country  $i \neq j$  the capital inflow and the expansion of its production to additional industries boosts labor demand and thus reduces unemployment, even if labor market institutions in that country remain unchanged. Again, a formal proof is already provided for proposition (3). To analyze how capital changes in the aftermath of institutional reforms we have to introduce capital market clearing conditions by aggregating individual industry demand for capital as

$$\frac{\partial \kappa_i(z)}{\partial r_i} = B(1 - \zeta)(q_{hi}a_{hi}(z) + q_{li}a_{li}(z))^\zeta r_i^{-\zeta} . \quad (25)$$

On the aggregate level capital demand is pinned down by

$$K_i = \int_{\underline{z}_d}^{\bar{z}_d} \frac{(1 - \zeta)\varphi(z)E}{r_i} dz, \quad (26)$$

which is found by aggregating individual industry capital demand (25) over the whole continuum of active industries. The cutoff is therefore directly linked to capital demand since interest rates and world capital stock is fixed per assumption and  $\frac{\partial K_i}{\partial Z} > 0$  and  $\frac{\partial K_i}{\partial \underline{z}} < 0$ . This follows from the two country scenario where  $z^*$  is always one country's upper and the other country's lower bound of active industries.  $\square$

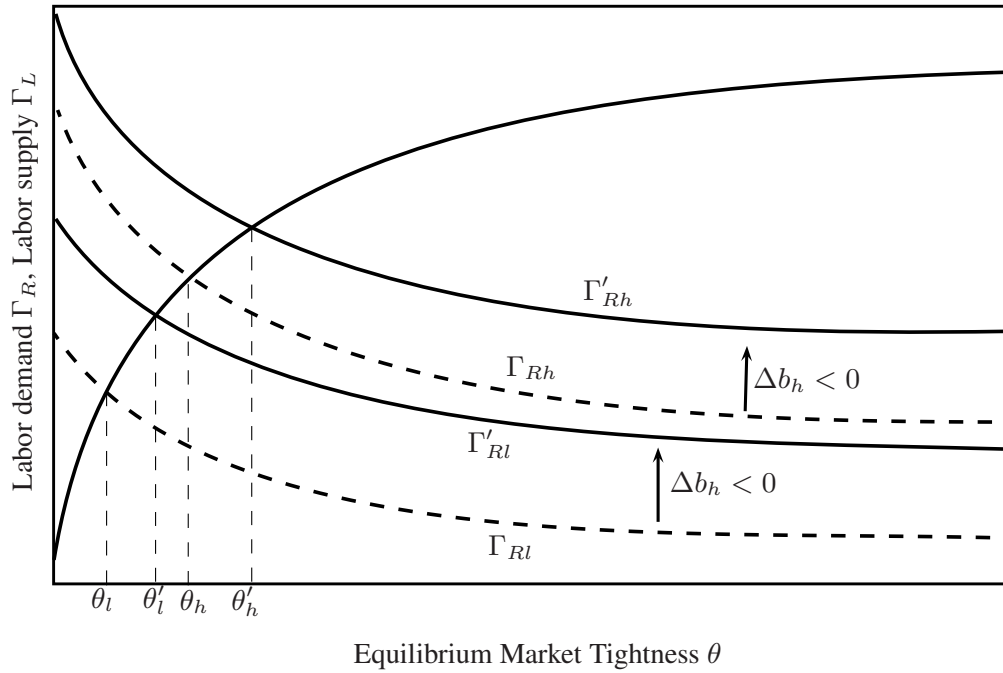
**Skill-specific institutional changes.** Suppose that the government decides to implement a partial labor market reform that affects the high-skilled workers only.

**Proposition 7.** *a) An unilateral decrease in high-skill specific unemployment benefits  $b_{hi}$ , bargaining power  $\beta_{hi}$ , or recruitment costs  $c_{hi}$  decreases unemployment and wages in both skill groups. b) Unemployment in country  $j \neq i$  is increasing in both skill groups through the adjustments at the extensive margin.*

*Proof.* Suppose that the domestic country has a comparative advantage in industries closer to the lower bound of the mass of industries so that  $z^*$  is the domestic upper variable bound of active industries. Without a change in the equilibrium market tightness  $\theta$ , the reduction in  $b_{hd}$ ,  $\beta_{hd}$ , or  $c_i$  boosts industry labor demand at the intensive margin due to  $\frac{\partial l_h}{\partial q_h} < 0$ . Moreover, high- and low-skill workers are compliments. Institutional changes that are intended to affect high-skill workers also affect demand for intermediates produced by low-skill workers due to  $\frac{\partial l_l}{\partial q_h} < 0$ . A second effect stems from the adjustments at the extensive margin, where the increase in  $z^*$  through the shift of the unit cost schedule increases aggregate labor demand, thereby magnifying the positive employment effects. The additional demand for capital can be satisfied through foreign direct investments from abroad. Capital owners abroad are willing to invest due to excess supply of capital as some industries are reallocated at the extensive margin. Unemployment in the foreign country must rise in both skill groups as the economy contracts.  $\square$

Figure (2) illustrates the comparative static exercise for the case of a reduction in domestic high-skill unemployment benefits. At the intensive margin, within-industry

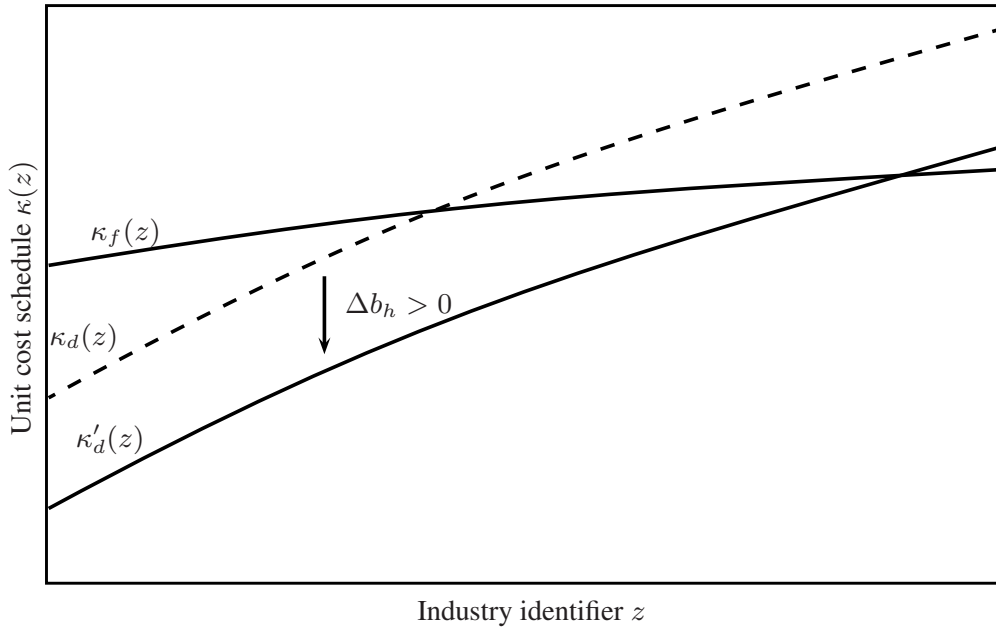
labor demand has increased for both skill groups, which shifts the aggregate labor demand curves  $\Gamma_{Rl}$  and  $\Gamma_{Rh}$  upwards. As already mentioned, institutions do not affect labor supply so that  $\Gamma_L$  remains unchanged. To satisfy the increased labor demand unemployment must decrease in both sectors as illustrated by the rise in both skill groups equilibrium market tightness from  $\theta$  to  $\theta'$ .



**Figure 2:** Labor demand for skill-specific institutional changes

Effects at the extensive margin are illustrated in Figure (3). A reduction in the skill-specific unemployment benefits reduces labor costs over the whole continuum of industries so that  $\kappa(z)$  is lower as well, illustrated by a downward shift of the domestic unit cost schedule. The initial specialization pattern is not optimal any more and must readjust. Domestic production expands and foreign production contracts so that the new intersection of the domestic and the foreign unit cost schedule is such that  $z^{*'} > z^*$ . It follows from Proposition 4 that the reallocation of industries from Foreign to Home rises aggregate labor demand at Home but reduces aggregate labor demand at Foreign so that skill-specific unemployment rates decrease further, whereas skill-specific un-

employment in Foreign is increasing for both types of skill.



**Figure 3:** Skill-specific institutional spillover effects

At the extensive margin this shift in the specialization pattern due to the increased cutoff  $z^*$  affects wages and unemployment according to Proposition 4. In the scenario sketched above the domestic economy benefits from the labor market reform, whereas the foreign economy loses due to contraction of the foreign economy. Again, to countervail the decreased labor demand at the extensive margin, unemployment must rise, accompanied by lower equilibrium market tightness and lower wages.

## 5. Conclusion

In a nutshell, this paper's main contribution is to extend the Feenstra and Hanson (1996, 1997) international trade model by Pissarides (2000) search frictions in a way that allows for a two-dimensional analysis where wages and the equilibrium market tightness link labor and product markets. This in turn implies that wages and capital flows are triggered by both, trade liberalization and changes in labor market institutions. Moreover, the notion of a continuum of industries not only permits the study of spillover

effects across countries, it also gives rise to a new channel through which FDI affects labor demand at the extensive margin where whole industries are shifted abroad. As a result, I can show that countries benefit from institutional changes in other countries through an expanding of their production to industries formerly associated with the reforming country. This widening of the production to initially inactive industries, combined with the adjustments at the intensive margin reduce unemployment and increase wages in the new equilibrium. However, the reforming country's workers suffer from the loss in competitiveness in some of its initially active industries located close to the former cutoff. Without the continuum of industries, adjustments would take place at the intensive margin only. The increased capital supply in the FDI-in countries would reduce capital cost and thus lead to a substitution of capital by labor, thereby unambiguously increasing unemployment. Wages in the original Feenstra and Hanson (1997,1998) model adjust independently from labor market institutions. The novel micro-founded wage setting mechanism in the Feenstra and Hanson model also facilitates the study of one-sided changes in labor market institutions and its effects on FDI and labor market outcomes. Moreover, it is possible to show that those institutional changes not only affect workers' wages and unemployment, it also indirectly affect FDI flows across countries. Surging labor costs render FDI more attractive and therefore lead to an increase in FDI outflows accompanied by higher wages and higher rates of unemployment.

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## 1. Solution to the intermediate input prices

Each high (low) skill intermediate producers employs exactly one high (low) skilled worker to produce one intermediate for the downstream producers. Firms have to post vacancies in order to recruit new workers, which incurs vacancy posting costs. In the following we assume that firms pay recruitment cost  $c$  in some common units  $p$ . This is a more general formulation as in Pissarides (2000) where vacancy costs are paid in terms of the individual price or Felbermayr, Prat, Schmerer (2011) where vacancy costs are paid in terms of the aggregate price level. The common vacancy price index  $p$  is measured either in units of numeraire, intermediate good prices, the aggregate price level, or the wage rate.<sup>10</sup> In line with Pissarides (2000), I assume that vacancy posting costs are paid in terms of intermediate goods prices when solving the general equilibrium of the model. The matching process itself is modeled according to a standard Cobb-Douglas matching function  $m(\theta_k)$ , which is concave and has constant returns to scale properties. We follow Pissarides (2000) in modeling the problem of the workers and the firms.

**Job Creation**  $J_k$  in (27) denotes the present discounted value of expected profits from an occupied job in skill group  $k$ ,  $V_k$  in (28) denotes the value of a vacant job in skill group  $k$ , and  $\eta$  denotes the exogenously given discount rate.<sup>11</sup> The value of a vacant job negatively depends on unit recruitment costs, but increases in the difference between the value of the filled job and the opportunity costs given by the value of the vacant job. The matching function itself pins down the probability of a successful match due to the assumption of constant returns to scale. The flow value of the filled job is revenue generated by the worker minus the wage rate paid to the worker.<sup>12</sup> Job separation due to an exogenous shock hits the firm with poisson arrival rate  $\lambda$  and destroys the value associated with that firm, which reads as

$$\eta V_k = -cp + m(\theta_k)(J_k - V_k) ; \quad (27)$$

$$\eta J_k = \varrho_k(z) - w_k - \lambda J_k . \quad (28)$$

<sup>10</sup>One important feature of  $p$  is that it is measured in the common unit. Income, wages, and prices have the same units and are therefore valid.

<sup>11</sup> $k$  is either  $l$  for low or  $h$  for high-skill.

<sup>12</sup>A firm's revenue  $\varrho(z)$  equals the price charged for each intermediate good due to the small firm assumption. Prices still depend on  $z$  but it is possible to proof that prices do not hinge on industry specific parameters.

In equilibrium the value of unoccupied jobs is zero since firms continue to post vacancies until all profits are exploited

$$J_k = \frac{cp}{m(\theta_k)} . \quad (29)$$

We can combine (28) and (29) in order to obtain the Job Creation condition under perfect competition with search frictions as

$$q_k(z) - w_k - \frac{cp}{m(\theta_k)}(\eta + \lambda) = 0 , \quad (30)$$

which states that the firm's revenue must equal variable production and recruitment costs. Wages are equalized across firms. This proposition is proved below and due to the definition of the equilibrium market tightness which is defined as the ratio of the number of vacancies posted and the number of unemployed workers. It is sufficient to compute the optimal wage/equilibrium market tightness for the cutoff firm. However, unit costs/prices differ across firms since per worker costs for the intermediate good are equal but the input requirement of workers in  $z$  is lower than in  $z'$  if  $z < z'$ .

**Wage Curve.** To the worker the value of a job is worth the wage minus the opportunity cost of being employed. The firm might be destroyed with a certain probability. In that particular case the value of the job becomes zero and the worker receives her outside option worth  $\eta U_k$ . Unemployed workers receive some unemployment benefits  $b$  and with a certain probability they successfully find a new job in another firm, which translates into

$$\eta W_k = w_k - \lambda(W_k - U_k) ; \quad (31)$$

$$\eta U_k = b_k + m(\theta_h)(W_k^e - U_k) . \quad (32)$$

We follow Dutt et al. (2009) and introduce  $W_k^e$  in order to take into account that workers are randomly matched to firms and therefore have to build expectations about  $W$ . This also implies that all firms pay the same wage rate and therefore only differ with respect to production. Wages itself are bargained and satisfy the bargaining condition

$$W_k - U_k = \beta(J_k + W_k - V_k - U_k) . \quad (33)$$

Thus the distribution of total gains depends on both actors' bargaining power, which implies

$$w_k = \eta U_k + \beta(\varrho_k(z) - \eta U_k) \quad (34)$$

and

$$\eta U_k = b_k + \frac{\beta}{1 - \beta} cp\theta_k . \quad (35)$$

We obtain a wage condition by combining the equilibrium conditions (35) and (34) as shown in the Appendix to solve for

$$w_k = (1 - \beta)b_k + \beta cp\theta_k + \beta\varrho_k(z) , \quad (36)$$

which is the pendant to the labor supply curve in the standard Feenstra and Hanson (1996, 1997) model.

**Equilibrium in the high-skill intermediate sector.** In equilibrium, the wage and the equilibrium market tightness  $\theta_k$  are determined by interacting the wage curve and the job creation curve such that

$$(1 - \beta)b_h + \beta cp\theta_h + \beta\varrho_h(z) = \varrho_h(z) - \frac{cp}{m(\theta_h)}(\eta + \lambda) . \quad (37)$$

Simplifying then yields

$$\varrho_h(z) = \left( b_h + \frac{cp}{1 - \beta} \left( \beta\theta_h + \frac{\eta + \lambda}{m(\theta_h)} \right) \right) . \quad (38)$$

Therefore, equation (38) implies that all downstream producers pay the same price for intermediate goods denoted  $q_h(z) = \varrho_h(z)$  so that  $q_h(z') = q_h(z'')$  for  $z' \neq z''$ . Intermediate good prices only depend on exogenous parameters and the equilibrium market tightness, which is common to all firms in all industries. Moreover, we assume that the discount rate  $\eta$  and the capital rental  $r$  are tied to the capital rental and we assume that the discount rate is predetermined by the capital rental.

**Equilibrium in the low-skill intermediate good sector.** Following the same line of reasoning we can derive the equilibrium condition for low-skill intermediate input prices

as

$$q_l(z) = \left( b_l + \frac{cp}{1-\beta} \left( \beta\theta_l + \frac{\eta + \lambda}{m(\theta_l)} \right) \right) . \quad (39)$$

We denote the price paid by downstream producers for the purchase of low-skill intermediate inputs  $q_l(z) = \varrho_l(z)$ , which is possible due to the small firm assumption. Each firm employs one worker and produced exactly one intermediate good. The firm's revenue is thus equal the intermediate good price paid by the final output good producers. Moreover, the assumption that search costs are paid in terms of intermediate goods prices gives rise to the solution presented in proposition 1

## A Proofs

**Derivation of equation (37).** To derive the ETC conditions for both high- and low-skill intermediate producers we need to derive and interact the wage and the job creation curves. To solve for the job creation curve equation (29) and (28) are combined so that

$$(\eta + \lambda) \frac{cp}{m(\theta_k)} = \varrho_k(z) - w_k \quad (40)$$

which can be rearranged to equation (30). To solve for the wage curve we start with rearranging equation (33) as

$$W_k - U_k = \frac{\beta}{1-\beta} J_k . \quad (41)$$

Equation (28) can be rewritten as

$$(\eta + \lambda) J_k = \varrho_k(z) - w_k . \quad (42)$$

Expanding equation (31) by subtracting  $(\eta + \lambda)U_k$  on both sides gives

$$(\eta + \lambda)(W_k - U_k) = w_k + \lambda U_k - (\eta + \lambda)(U_k) \quad (43)$$

$$(\eta + \lambda)(W_k - U_k) = w_k - \eta U_k \quad (44)$$

A solution for the outside option is obtained by combining equation (32), equation (41), and equation (29) as

$$\eta U_k = b_k + \theta_k m(\theta_k) \frac{\beta}{1-\beta} \frac{cp}{m(\theta_k)} \quad (45)$$

Combining equation (44), (41), (42), and (45) gives

$$(\eta + \lambda) \frac{\beta}{1 - \beta} J_k = w_k - \eta U_k \quad (46)$$

$$(\eta + \lambda) \frac{\beta}{1 - \beta} \frac{\varrho_k(z) - w_k}{\eta + \lambda} = w_k - \eta U_k \quad (47)$$

$$(\eta + \lambda) \frac{\beta}{1 - \beta} \frac{\varrho_k(z) - w_k}{\eta + \lambda} = w_k - b_k - \theta_k m(\theta_k) \frac{\beta}{1 - \beta} \frac{cp}{m(\theta_k)} \quad (48)$$

$$\beta \varrho_k(z) - \beta w_k = (1 - \beta) w_k - (1 - \beta) b_k - \theta_k \beta cp \quad (49)$$

$$w_k = (1 - \beta) b_k + \beta(\varrho_k(z) + \theta_k cp) \quad (50)$$

To solve for the equilibrium intermediate good price we can interact the wage curve (36) and the job creation curve (30) and solve for  $\varrho_k(z)$

$$(1 - \beta) b_k + \beta(\varrho_k(z) + \theta_k cp) = \varrho_k(z) - (\eta + \lambda) \frac{cp}{m(\theta_k)} \quad (51)$$

$$\varrho_k(z) = b_k + \frac{cp}{1 - \beta} \left( \beta \theta_k + \frac{\eta + \lambda}{m(\theta_k)} \right) \quad (52)$$

**Derivation of the LMC curve.** We know that firms' demand for intermediate goods is given by equation (11). Aggregating low-skill labor demand over all industries and equating aggregate labor demand and supply yields

$$L_i(1 - u_{li}) = \int_{\underline{Z}_d}^{\bar{Z}_d} l(z) x(z) dz \quad (53)$$

$$L_i(1 - u_{li}) = \int_{\underline{Z}_d}^{\bar{Z}_d} B \zeta a_l(z) (q_l a_l(z) + q_h a_h(z))^{\zeta - 1} r^{1 - \zeta} x(z) dz \quad (54)$$

where we can use (2) to substitute out  $x(z)$  and (7) to solve for (12) or (14) in order to derive a simpler version of the LMC and in order to calibrate the whole model. The assumption that all industries have equal share in the consumers' expenditure is made to solve the integral. See Feenstra (2010) for an equal treatment. This assumption allows us to introduce a constant instead of  $\varphi(z)$  which is thus independent of  $z$  and instead depends on the bounds of the integral. To solve the integral by integration by parts we define  $f_k(z) = a_k(z)$  and  $g'_k(z) = (q_l a_l(z) + q_h a_h(z))^{-1}$ , which gives us  $\int f(z) g'(z) =$

$[f(z)g(z)] - \int f'(z)g(z)$  and solves as

$$\begin{aligned} L_d(1 - u_{ld}(\theta_{ld})) &= (\bar{z}_d - z_d)\zeta E \left( [a_{ld}(z)g(z)]_{z_d}^{\bar{z}_d} - \int_{z_d}^{\bar{z}_d} a'_{hd}(z)g(z)dz \right) \\ &= \frac{(\bar{z}_d - z_d)\zeta E}{\varpi'_d} \left( [a_{ld}(z) \ln \varpi(z)]_{z_d}^{\bar{z}_d} - \gamma_{ld} \int_{z_d}^{\bar{z}_d} \ln \varpi(z)dz \right) \end{aligned}$$

where we use  $\varpi = q_{ld}(\theta_l)a_{ld}(z) + q_{hd}(\theta_h)a_{hd}(z)$  and  $\varpi'(z) = q_l(\theta_l)\Gamma_l + q_h(\theta_h)\gamma_h$ . The second integral is solved by substitution so that we obtain equation (16) as a final solution.

**Proof of Proposition (3).** First, notice that the left hand of the LMC curve  $\Gamma_L$  is well behaved due to the convexity of the Beveridge curve. For  $\lim_{\theta \rightarrow \infty} \Gamma_L = L$  since  $\lim_{\theta \rightarrow \infty} u(\theta) = 0$ . Let the equilibrium market tightness go to zero and we find that  $\lim_{\theta \rightarrow 0} \Gamma_L = 0$  since  $\lim_{\theta \rightarrow 0} u(\theta) = 1$ . Thus, for  $\theta = 0$  we have full unemployment and no worker is willing to search for a job. The right hand side of the LMC curve is also well behaved. Demand for intermediates hinges on the intermediate goods prices  $q_k$  and  $q_k$  depends on exogenous parameters and the equilibrium market tightness. However, equation (37) is asymptotic in  $\theta$  so that the necessary restriction for  $\theta_k$  is

$$\beta\theta_k + \frac{\eta + \lambda}{m(\theta_k)} < \frac{(1 - \beta)}{c}$$

to secure that  $q_k(\theta) > 0$ . However, this is not a strong assumption for reasonable values of the exogenous parameters. The first derivative of equation (37) is positive since

$$\frac{\partial q(\theta_k)}{\partial \theta_k} = - \frac{-c [\beta + \alpha(r + \lambda)m\theta_k^{\alpha-1}] (1 - \beta)b_k}{\left[ (1 - \beta) - c\left(\beta\theta_k + \frac{\eta + \lambda}{m(\theta_k)}\right) \right]^2} > 0$$

which is needed to derive  $\frac{\partial \Gamma_R}{\partial \theta_k} < 0$ . It is enough to apply the Leibniz rule on  $\Gamma_R$  in order to derive

$$\frac{\partial \Gamma_R}{\partial q_k} = \int_{z_d}^{\bar{z}_d} - \frac{\zeta \varphi(z) E(a_k(z))^2}{[q_l a_l(z) + q_h a_h(z)]^2} dz < 0 \quad (55)$$

which implies that  $\frac{\partial \Gamma_R}{\partial \theta_k} < 0$ . To derive this proof the assumption that the upper and the lower bound remain constant was made. The intermediate good price for the other skill group is also implicitly assumed constant and optimal. However, there is an interaction between both skill groups. A change in the price of the other intermediate good shifts

the regarded labor demand curve  $\Gamma_R$ . Therefore, given the upper and lower bounds of  $z$  there exists exactly one combination for both market tightness for which both skill group's LMC curves are jointly satisfied.

**Proof of Proposition (4).** Part a) follows immediately by deriving the first derivative of  $\Gamma_R$  with respect to  $z^*$ . Notice, that for each country we ex-ante know whether  $z^*$  is the upper or lower bound. In the two country scenario both countries have one constant bound (either 0 or 1) and one variable bound  $z^*$ . So it is important to determine whether  $z^*$  is the upper or lower bound for each country, which depends on the regarded country's comparative advantage. For the moment we assume that home has a comparative advantage in the production of goods closer to 1 and foreign has a comparative advantage in the production of goods closer to 0. For the home country  $z^*$  is therefore the lower bound of active industries. Changing the bounds and deriving the first derivative with respect to  $z^*$  therefore yields

$$\frac{\partial \Gamma_R}{\partial z^*} = -\frac{a_{kd}(z^*)\varphi(z^*)E}{q_{ld}a_{ld}(z^*) + q_{hd}a_{hd}(z^*)} < 0 \quad (56)$$

for Home and respectively

$$\frac{\partial \Gamma_R}{\partial z^*} = \frac{a_{kf}(z^*)\varphi(z^*)E}{q_{lf}a_{lf}(z^*) + q_{hf}a_{hf}(z^*)} > 0 \quad (57)$$

for Foreign. An increase in the cutoff industry thus reduces labor demand at the extensive margin due to a reduction in active industries. Part b) follows from the assumption made about relative skill endowments and technology that  $a_h > a_l$  and c) is also straightforward.

**Proof of Proposition (6) and (7).** The first derivative of the ETC curve with respect to  $b$  is

$$\frac{\partial q_k}{\partial b_k} = \frac{(1 - \beta)}{(1 - \beta) - c(\beta\theta_k + \frac{\eta+\lambda}{m(\theta_k)})} > 0 \quad (58)$$

Thus, the intermediate good's price  $q_k$  increases for each  $\theta_k$  which shifts the respective unit cost curve upwards. Again the former equilibrium  $z^*$  is not optimal anymore and has to adjust. Take for instance an increase in the bargaining power. Again, the first



derivative reads

$$\frac{\partial q_k}{\partial \beta} = \frac{-b_k \left[ (1 - \beta) - c(\beta\theta_k + \frac{\eta+\lambda}{m(\theta_k)}) \right] + (1 - \beta)b_k c\theta_k + (1 - \beta)b_k}{\left[ (1 - \beta) - c(\beta\theta_k + \frac{\eta+\lambda}{m(\theta_k)}) \right]^2} \quad (59)$$

$$= \frac{-b_k(1 - \beta) + b_k c\beta\theta_k + b_k c\beta \frac{\eta+\lambda}{m(\theta_k)} + (1 - \beta)b_k c\theta_k + (1 - \beta)b_k}{\left[ (1 - \beta) - c(\beta\theta_k + \frac{\eta+\lambda}{m(\theta_k)}) \right]^2} \quad (60)$$

$$= \frac{+b_k c\beta \frac{\eta+\lambda}{m(\theta_k)} + b_k c\theta_k}{\left[ (1 - \beta) - c(\beta\theta_k + \frac{\eta+\lambda}{m(\theta_k)}) \right]^2} > 0 \quad (61)$$

$$(62)$$

Institutions that reduce search frictions due to lower search costs have the same effects as

$$\frac{\partial q_k}{\partial c_k} = \frac{(1 - \beta)b_k c\beta\theta_k + \frac{\eta+\lambda}{m(\theta_k)}}{\left( (1 - \beta) - c_k \left( \beta\theta_k + \frac{\eta+\lambda}{m(\theta_k)} \right) \right)^2} > 0 \quad (63)$$

The shift of the unit cost schedule and the change in the cutoff industry also affects the other countries through spillover effects according to Proposition 4. Firstly, the unit cost schedule in the country where labor market institutions change in favor of the workers shift up. The unit cost schedule in the other country remains unchanged. The cutoff changes exactly as already described for the increase in the capital rental, so that  $\Gamma_R$  and  $\Gamma_L$  have to adjust accordingly. See the proof for Proposition 4 for more details.

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