Benedikt Heid, Mario Larch

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Gravity with Unemployment

Benedikt Heid and Mario Larch*

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Abstract

Quantifying the welfare effects of trade liberalization is a core issue in international trade. Existing frameworks assume perfect labor markets and therefore ignore the effects of aggregate employment changes for welfare. We develop a quantitative trade framework which explicitly models labor market frictions. To illustrate, we assess the effects of trade and labor market reforms for 28 OECD countries. Welfare effects of trade agreements are typically magnified when accounting for employment changes. While employment and welfare increase in most countries, some experience higher unemployment and lower welfare. Labor market reforms in one country have small positive spillover effects on trading partners.

Keywords: welfare effects of trade; quantitative trade theory; unemployment; trade costs; structural estimation; gravity equation
JEL-Codes: F14; F16; F13; F17

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*Heid: University of Bayreuth, CESifo, Universitätsstraße 30, 95447 Bayreuth, Germany, `benedikt.heid@uni-bayreuth.de`. Larch: University of Bayreuth, CESifo, ifo Institute, and GEP at University of Nottingham, Universitätsstraße 30, 95447 Bayreuth, Germany, `mario.larch@uni-bayreuth.de`. A previous version of this paper has been circulated under the title "International Trade and Unemployment: A Quantitative Framework". Funding from the DFG under project 592405 is gratefully acknowledged. We thank Daniel Bernhofen, Hartmut Egger, Christian Holzner, Kala Krishna, John McLaren, Marc-Andreas Muendler, Emanuel Ornelas, Yoto Yotov, participants at the GEP Postgraduate Conference 2012, the CESifo Area Conference on Global Economy 2012, the European Trade Study Group 2012, the Annual Meeting of the European Society of Population Economics 2012, the Annual Meeting of the Verein für Socialpolitik 2013, the Annual Congress of the European Economic Association 2013, the CAGE International Trade Research Day 2013, research seminars at the Universities of Trier and Innsbruck, and the 7th FIW-Research Conference on International Economics 2014, for helpful comments. As always, we have a property right on any remaining errors.

1 Introduction

The quantification of the welfare effects of trade liberalization is one of the core issues in empirical international trade. The workhorse model for evaluating welfare effects of trade policies is the structural gravity model. All variants of this workhorse model so far assume perfect labor markets with full employment. For example, Arkolakis et al. (2012) have shown that an ex post analysis of the welfare effects (measured in terms of real income) of a move from autarky to the observed level of trade liberalization is possible by using only data on the observed import share in a country and an estimate of the trade elasticity. If we relax the assumption of full employment, then real income is given by the real wage bill in terms of the price level P_j of all employed workers, i.e., $e_j L_j w_j / P_j$, where e_j is the share of the labor force L_j which is employed times the wage w_j which is paid to a worker. Hence assuming a constant labor force, any change in welfare W_j can be decomposed into a change in net employment and the real wage, i.e.,

$$\hat{W}_j \equiv \frac{W_j'}{W_j} = \hat{e}_j \widehat{\left(\frac{w_j}{P_j}\right)}, \tag{1}$$

where the hat denotes the ratio of welfare levels W_j' and W_j in two situations. In Arkolakis et al. (2012), $\hat{e}_j = 1$ by assumption, and the ratio in real wages is given by $\hat{\lambda}_{jj}^{1/\varepsilon}$, the change in the share of domestic expenditure, $\hat{\lambda}_{jj}$, raised to some power of ε, the elasticity of imports with respect to variable trade costs (the trade elasticity, for short). Assuming full employment allows Arkolakis et al. (2012) to conduct a very simple ex post analysis of the welfare effects of moving from autarky to the observed level of trade integration. As $\lambda_{jj} = 1$ under autarky, one can calculate the welfare gains from trade from the observed domestic expenditure share when an estimate of the trade elasticity is available. When we allow for unemployment, however, this is not feasible any longer as we do not observe the counterfactual employment level under autarky. When we are interested in an ex ante evaluation of any counterfactual trade policy besides autarky, we additionally need estimates of trade cost parameters to get an estimate of the counterfactual domestic consumption share, which typically are obtained from estimating gravity models, regardless of whether we assume perfect or imperfect labor markets.

In the following, we present a simple quantitative framework for bilateral trade flows based on Armington (1969) preferences and recently developed models of international trade with search and matching labor market frictions, specifically Felbermayr et al. (2013).[1] This framework allows us to derive sufficient statistics for the welfare effects of trade liberalization similar to those of Arkolakis et al. (2012) but augmented by the aggregate employment change. The additional insights of incorporating labor market frictions into a quantitative trade model come at minimal cost: we only require knowledge of the elasticity of the matching function. Hence, this framework is easily applied to all topics where trade flow effects are inferred, such as trade agreements, currency unions, borders, or ethnic networks.

We apply the framework to a sample of 28 OECD countries from 1988 to 2006 in order to evaluate three scenarios. First, we calculate the effects of introducing regional trade agreements (RTAs) starting from a counterfactual world without any RTAs. Second, we evaluate the effects of the U.S.-Australia Free Trade Agreement. Third, we evaluate the effects of a hypothetical labor market reform in the United States. We find that the introduction of RTAs as observed in 2006 leads to seven percent larger welfare effects on average when allowing for imperfect labor markets. When we use commonly assumed values for the elasticities in our model instead of our estimates, we find that accounting for labor market frictions increases the welfare gains by more than 50 percent. Similar additional welfare gains arise for Australia and the United States when evaluating the U.S.-Australia Free Trade Agreement. In our framework, changes in trade costs or labor market policies affect labor market outcomes through changes in relative prices and income effects. When trade costs fall, imports of foreign varieties become cheaper, leading to a lower consumer price

[1] In order to check the sensitivity of our framework to different wage determination processes, we employ several approaches to divide the rent between workers and firms. In addition to wage bargaining considered by Felbermayr et al. (2013), we also consider minimum wages and efficiency wages.

index in the corresponding country. When labor markets are characterized by search frictions, firms have to incur costs to post vacancies in order to find workers. The lower price level translates one-to-one into lower recruiting costs for domestic firms.[2] Firms *ceteris paribus* create more vacancies so that more workers find a job and unemployment is reduced. Hence, standard methods neglecting labor market effects typically underestimate the welfare gains from trade liberalization.

Our third counterfactual experiment analyzes a hypothetical improvement of labor market institutions in the United States. As expected, welfare increases in the United States but also improves for its trading partners due to positive spillover effects of the labor market reform. A unilateral labor market reform which for example increases the matching efficiency will increase the number of successful matches between workers and firms and thus rise employment, total sales, and welfare in the corresponding country. As workers spend part of their income on foreign varieties, the increase in income leads to higher import demand for all trading partners. This translates into lower unemployment in the trading partners, leading to a positive correlation between changes in unemployment rates across countries.

The paper is structured as follows: in Section 2 we present our quantitative framework and derive expressions for the counterfactual trade and employment levels for welfare evaluations of trade and labor market policy changes. Section 3 shows how to estimate trade cost parameters and elasticities. We then illustrate the application of our estimated model by evaluating the effects of regional trade agreements and labor market reforms for a sample of 28 OECD countries. Section 4 concludes.

Our paper is related to several literatures, notably the gravity literature which models bilateral trade flows. Within our framework, changes in employment and expenditure directly affect bilateral trade flows which can be described by a gravity equation. It captures the key stylized facts that trade

[2]Felbermayr et al. (2011a) and Felbermayr et al. (2013) on the one hand and Helpman and Itskhoki (2010) on the other use a similar mechanism in a one- and two-sector model, respectively.

increases with market size and decreases with distance. The empirical success of the gravity equation spurred a great deal of interest in its theoretical underpinnings. Anderson (1979) and Bergstrand (1985) address the role of multilateral price effects for trade flows. A more recent contribution by Eaton and Kortum (2002) develops a quantifiable Ricardian model of international trade to investigate the role of comparative advantage and geography for bilateral trade flows. Anderson and van Wincoop (2003) refine the gravity equation's theoretical foundations by highlighting the importance of controlling for multilateral resistance terms and proper empirical comparative static analysis. Fieler (2011) introduces non-homothetic preferences into the Ricardian framework of Eaton and Kortum (2002) to rationalize the fact that bilateral trade is large between rich countries and small between poor countries. Waugh (2010) provides a complementary framework with asymmetric trade costs to explain the cross-country-pair differences in bilateral trade volumes and income levels. Caliendo and Parro (2015) extend the Eaton and Kortum (2002) framework to allow for sectoral linkages and intermediate goods to evaluate NAFTA. Anderson and Yotov (2010) elaborate on the incidence of bilateral trade costs in the Anderson and van Wincoop (2003) framework. These theoretical developments allow one to employ the gravity equation to infer the welfare effects of counterfactual trade liberalization scenarios accounting for general equilibrium effects, which is a core issue in empirical work on international trade.

Despite this multitude of theoretical foundations for the gravity equation, to date all of them assume perfect labor markets. Crucially, this implies that changes in real welfare ignore changes in the total number of employed workers due to trade liberalization or labor market reforms. A different strand of the theoretical trade literature stresses various channels through which trade liberalization affects (un)employment. Brecher (1974), Davis (1998), and Egger et al. (2012) focus on minimum wages to analyze the interactions between trade and labor market policies. A binding minimum wage prevents downward wage adjustments when a country opens up to trade. Instead, firms adjust the number of employed workers. Others have stressed labor market frictions arising due to fair wages or efficiency wages (Amiti and Davis 2012; Davis and

Harrigan 2011; Egger and Kreickemeier 2009). Fair wages or efficiency wages lead firms to pay wages above the market clearing level in order to ensure compliance of workers. When trade is liberalized, average productivity of firms increases, which leads to an increase of the fair or efficiency wage due to rent-sharing as well as an increase in unemployment. Finally, search-theoretic foundations of labor market frictions are introduced into trade models (Davidson et al. 1988, 1999; Dutt et al. 2009; Felbermayr et al. 2011a; Helpman et al. 2010; Helpman and Itskhoki 2010; Hasan et al. 2012; Felbermayr et al. 2013). In these models, workers search for jobs and firms for workers. Once a firm-worker match is established, they bargain over the match-specific surplus. Trade and labor markets interact via relative prices of hiring workers and goods prices which affect search and recruitment efforts. In multiple sector models, trade liberalization leads to higher prices and employment in the export-oriented sector. The opposite occurs in the import-competing sector. Due to the one-sector nature of our framework, we abstract from the employment effects resulting from reallocating employment across sectors, possibly biasing upwards our estimates of the effects of trade liberalization.[3]

Relatedly, the static one sector nature of our framework precludes us from analyzing the transition dynamics and costs which potentially arise in a multiple sector model. When trade liberalization induces the economy to specialize in the export-oriented sector, the employment reallocation across sectors may imply that former import-competing sector workers have to undergo some training to be employable in the export sector. This entails both monetary training costs as well as the opportunity cost of the foregone production during training. As Davidson and Matusz (2009) show in a small open economy model, these dynamic adjustment costs may eat up a substantial amount of the gains from trade. Still, as in our model, higher labor market frictions lead to higher gains from trade. Davidson and Matusz (2006) show that comparing steady states, as we do, may also underestimate the potential gains from a

[3] Cuñat and Melitz (2010) and Cuñat and Melitz (2012) study the effect of differences in labor market frictions on patterns of comparative advantage. However, their model neither considers trade costs, the center piece of gravity analysis, nor does it feature unemployment.

trade liberalization episode derived from a dynamic net present value comparison. Obviously, adjustment dynamics are important for welfare evaluations of trade liberalization. Therefore, our framework should be seen as a first step to take into account labor market frictions in structural gravity models.

Taking into account sectoral reallocation and adjustment dynamics leads to theoretically ambiguous effects of trade liberalization on aggregate employment. Empirically, Dutt et al. (2009) as well as Felbermayr et al. (2011b) provide reduced-form evidence that more open economies have lower unemployment rates on average in cross-country (panel) regressions.[4] In contrast to these reduced-form approaches, our structural quantitative framework accounts for country-specific general equilibrium effects and allows one to quantify employment and welfare effects of policies.[5]

2 A quantitative framework for trade and unemployment

2.1 Goods market

The representative consumer in country j is characterized by the utility function U_j. We assume that goods are differentiated by country of origin, i.e., we use the simplest possible way to provide a rationale for bilateral trade between similar countries based on preferences à la Armington (1969).[6] In an Online

[4] Also, Hasan et al. (2012) find at least no increase in unemployment after trade liberalization in India; Heid and Larch (2012b) find no increase of unemployment in a sample of OECD countries.

[5] A recent literature studies the labor market effects of trade liberalization using structural dynamic models (Kambourov, 2009; Artuç et al., 2010; Coşar et al., 2015; Menezes-Filho and Muendler, 2011; Coşar, 2013; Dix-Carneiro, 2014; Helpman et al., 2015). However, all these studies focus on single countries and hence abstract from the interdependencies of trade flows between countries, a decisive feature of our model. Also, with the exception of Artuç et al. (2010) who study the United States, this literature focuses on the effects of trade liberalization in Latin American emerging economies, not developed countries.

[6] Consequently, we deliberately abstract from distinguishing between the intensive and extensive margin of international trade as for example in Chaney (2008) or Helpman et al. (2008).

Appendix, we demonstrate that our framework and counterfactual analysis are isomorphic to a Ricardian model of international trade along the lines of Eaton and Kortum (2002). Country j purchases quantity q_{ij} of goods from country i, leading to the utility function

$$U_j = \left[\sum_{i=1}^{n} \beta_i^{\frac{1-\sigma}{\sigma}} q_{ij}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where n is the number of countries, σ is the elasticity of substitution in consumption, and β_i is a positive preference parameter measuring the product appeal for goods from country i.

Trade of goods from i to j imposes iceberg trade costs $t_{ij} \geq 1$. Assuming factory-gate pricing for all firms implies that $p_{ij} = p_i t_{ij}$, where p_i denotes the factory-gate price in country i.

The representative consumer maximizes Equation (2) subject to the budget constraint $Y_j = \sum_{i=1}^{n} p_i t_{ij} q_{ij}$, with Y_j denoting nominal expenditure in country j.[7] The value of sales of goods from country i to country j can then be expressed as

$$X_{ij} \;=\; p_i t_{ij} q_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j} \right)^{1-\sigma} Y_j, \tag{3}$$

and P_j is the standard CES price index given by $P_j = [\sum_{i=1}^{n} (\beta_i p_i t_{ij})^{1-\sigma}]^{1/(1-\sigma)}$. In general equilibrium, total sales of country i correspond to expenditure of country i, i.e.,

$$Y_i \;=\; \sum_{j=1}^{n} X_{ij} = \sum_{j=1}^{n} \left(\frac{\beta_i p_i t_{ij}}{P_j} \right)^{1-\sigma} Y_j = (\beta_i p_i)^{1-\sigma} \sum_{j=1}^{n} \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} Y_j. \tag{4}$$

[7] In the Online Appendix, we generalize our model by allowing for trade imbalances following Dekle et al. (2007) and revenue-generating tariffs as in Anderson and van Wincoop (2001). All our counterfactual simulations in the main text use this generalized version of the model. We stick to the assumptions of balanced trade and no tariff revenue for ease of exposition in the main text. We also conducted counterfactual scenarios assuming balanced trade or zero tariffs, but our results changed very little, see the results in the Online Appendix.

Solving for scaled prices $\beta_i p_i$ and defining $Y^W \equiv \sum_j Y_j$, we can write bilateral trade flows as given in Equation (3) as

$$X_{ij} = \frac{Y_i Y_j}{Y^W} \left(\frac{t_{ij}}{\Pi_i P_j} \right)^{1-\sigma}, \quad \text{where} \tag{5}$$

$$\Pi_i = \left(\sum_{j=1}^{n} \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \frac{Y_j}{Y^W} \right)^{1/(1-\sigma)}, \quad P_j = \left(\sum_{i=1}^{n} \left(\frac{t_{ij}}{\Pi_i} \right)^{1-\sigma} \frac{Y_i}{Y^W} \right)^{1/(1-\sigma)}, \tag{6}$$

and where Π_i and P_j are the multilateral resistance terms and where we substituted equilibrium scaled prices into the definition of the price index to obtain P_j.

Note that this system of equations exactly corresponds to the gravity system given in Equations (9)-(11) in Anderson and van Wincoop (2003) or Equations (5.32) and (5.35) in Feenstra (2004), even when labor markets are imperfect. The intuition for this result is that total sales appear in Equation (5) and consumer preferences are homothetic. Assuming labor to be the only factor of production which produces one unit of output per worker, total sales in a world with imperfect labor markets are given by total production of the final output good multiplied with its price, i.e., $Y_i = p_i(1 - u_i)L_i$, where u_i denotes the unemployment rate in country i. The only difference is that now total sales are produced by *employed workers*, not all workers, as is assumed with perfect labor markets.

By adding a stochastic error term, Equation (5) can be written as

$$Z_{ij} \equiv \frac{X_{ij}}{Y_i Y_j} = \exp\left[k + (1-\sigma)\ln t_{ij} - \ln \Pi_i^{1-\sigma} - \ln P_j^{1-\sigma} + \varepsilon_{ij}\right], \tag{7}$$

where ε_{ij} is a random disturbance term or measurement error, assumed to be identically distributed and mean-independent of the remaining terms on the right-hand side of Equation (7), and k is a constant capturing the logarithm of world sales. Importer and exporter fixed effects can be used to control for the outward and inward multilateral resistance terms Π_i and P_j, respectively, as suggested by Anderson and van Wincoop (2003) and Feenstra (2004). Hence, even with labor market frictions, we can use established methods to estimate trade costs using the gravity equation, independently of the underlying labor market model. We summarize this result in Implication 1:

Implication 1 *The estimation of trade costs is unchanged when allowing for imperfect labor markets.*

To evaluate ex ante welfare effects of changes in trade policies, we need the counterfactual changes in employment and total sales in addition to trade cost parameter estimates. To derive these, we have to take a stance on how to model the labor market, to which we turn in the next section.

2.2 Labor market

We model the labor market using a one-shot version of the search and matching framework (SMF, see Mortensen and Pissarides, 1994 and Pissarides, 2000) which is closely related to Felbermayr et al. (2013).[8] Search-theoretic frameworks fit stylized facts of labor markets in developed economies as they explain why some workers are unemployed even if firms cannot fill all their vacancies.[9]

The labor market is characterized by frictions. All potential workers in country j, L_j, have to search for a job, and firms post vacancies V_j in order to find workers. The number of successful matches between an employer and a worker, M_j, is given by $M_j = m_j L_j^{\mu} V_j^{1-\mu}$, where $\mu \in (0, 1)$ is the elasticity of the matching function with respect to the unemployed and m_j measures the

[8] See Rogerson et al. (2005) for a survey of search and matching models, including an exposition of a simplified one-shot (directed) search model. For other recent trade models using a similar static framework without directed search, see for example Keuschnigg and Ribi (2009), Helpman and Itskhoki (2010), and Heid et al. (2013). We use the labor market setup from Felbermayr et al. (2013). However, they do not investigate its implications for the estimation of gravity equations nor do they structurally estimate it or use it for a counterfactual quantitative analysis. They also do not present labor market setups with minimum and efficiency wages nor do they consider alternative trade models such as the Eaton and Kortum (2002) framework as we do in our Online Appendix.

[9] They are less successful in explaining the cyclical behavior of unemployment and vacancies, see Shimer (2005). This deficiency is not crucial in our case as we purposely focus on the steady state.

overall efficiency of the labor market.[10] Only a fraction of open vacancies will be filled, $M_j/V_j = m_j\left(V_j/L_j\right)^{-\mu} = m_j\vartheta_j^{-\mu}$, and only a fraction of all workers will find a job, $M_j/L_j = m_j\left(V_j/L_j\right)^{1-\mu} = m_j\vartheta_j^{1-\mu}$, where $\vartheta_j \equiv V_j/L_j$ denotes the degree of labor market tightness in country j.[11] This implies that the unemployment rate is given by

$$u_j = 1 - m_j\vartheta_j^{1-\mu}. \tag{8}$$

As is standard in search models, we assume that every firm employs one worker. Similar to Helpman and Itskhoki (2010), this assumption does not lead to any loss of generality as long as the firm operates under perfect competition and constant returns to scale. In addition, we assume that all firms have the same productivity and produce a homogeneous good. In order to employ a worker (i.e., to enter the market), the firm has to post a vacancy at a cost of c_jP_j, i.e., in units of the final output good.[12] Vacancy posting costs can be direct costs of searching for workers but also training costs. In our setup, they can also be interpreted as firm setup costs or as a reduced form capital good (machines etc.) which cannot be produced by labor internal to firm but have to be bought on the market before workers can actually start producing.

After paying these costs, a firm finds a worker with probability $m_j\vartheta_j^{-\mu}$. When a match between a worker and a firm has been established, we assume that they bargain over the total match surplus. Alternatively, we consider

[10] Note that we assume a constant returns to scale matching function in line with empirical studies, see Petrongolo and Pissarides (2001).

[11] We assume that the matching efficiency is sufficiently low to ensure that M_j/V_j and M_j/L_j lie between 0 and 1.

[12] This implies that not all of produced output is available for final consumption (and hence welfare) of workers. Another option would be to denote the vacancy posting costs in terms of the domestic good, which in equilibrium is proportional to the domestic wage. This would imply that vacancy posting costs consist only of domestic labor costs. More realistically, vacancy posting costs may consist of both expenditures for labor as well as final goods expenditures (which include intermediates). In Appendix A we investigate the implications of this more general framework. In the case that vacancy posting costs are paid in domestic labor only, trade liberalization does not have any effect on the unemployment rate. In this sense, our model can be seen as an upper bound analysis of the effects of trade on unemployment.

minimum and efficiency wages in the Online Appendix as mechanisms for wage determination. All three approaches are observationally equivalent in our setting.

In the bargaining case, the match gain of the firm is given by its revenue from sales of one unit of the homogeneous product minus wage costs, $p_j - w_j$, as the firm's outside option is zero. The match surplus of a worker is given by $w_j - b_j$, where b_j is the outside option of the worker, i.e., the unemployment benefits (b_j) she receives when she is unemployed.[13]

As is standard in the literature, we use a generalized Nash bargaining solution to determine the surplus splitting rule. Hence, wages w_j are chosen to maximize $(w_j - b_j)^{\xi_j}(p_j - w_j)^{1-\xi_j}$, where the bargaining power of the worker is given by $\xi_j \in (0,1)$. The unemployment benefits are expressed as a fraction γ_j of the market wage rate. Note that both the worker and the firm neglect the fact that in general equilibrium, higher wages lead to higher unemployment benefits, i.e., they both treat the level of unemployment benefits as exogenous (see Pissarides, 2000). The first order conditions of the bargaining problem yield $w_j - \gamma_j w_j = (p_j - w_j)\,\xi_j/(1-\xi_j)$. Solving for w_j results in the **wage curve** $w_j = p_j\xi_j/(1+\gamma_j\xi_j - \gamma_j)$. Due to the one-shot matching, the wage curve does not depend on ϑ_j.

Given wages w_j, profits of a firm π_j are given by $\pi_j = p_j - w_j$. As we assume one worker firms and the probability of filling an open vacancy is $m_j\vartheta_j^{-\mu}$, expected profits are equal to $(p_j - w_j)m_j\vartheta_j^{-\mu}$. Firms enter the market until these expected profits cover the entry costs c_jP_j. This condition can be used to yield the **job creation curve** $w_j = p_j - P_jc_j/(m_j\vartheta_j^{-\mu})$.

As pointed out by Felbermayr et al. (2013), combining the job creation and

[13] Unemployment benefits are financed via lump-sum transfers from employed workers to the unemployed. As we assume homothetic preferences, which are identical across employed and unemployed workers, this does not show up in the economy-wide budget constraint Y_j, see Equation (4). Hence, demand can be fully described by aggregate expenditure. We also assume costless redistribution of the lump-sum transfer to the unemployed. These assumptions allow us to abstract from modeling the government more explicitly.

wage curves determines the equilibrium labor market tightness as

$$\vartheta_j = \left(\frac{p_j}{P_j}\right)^{1/\mu} \left(\frac{c_j}{m_j}\Omega_j\right)^{-1/\mu}. \tag{9}$$

$\Omega_j \equiv \frac{1-\gamma_j+\gamma_j\xi_j}{1-\gamma_j+\gamma_j\xi_j-\xi_j} \geq 1$ is a summary measure for the impact of the worker's bargaining power ξ_j and the replacement rate γ_j on labor market tightness.[14] The relative price p_j/P_j is determined by the demand and the supply of goods. It therefore provides the link between the labor and goods market. In case vacancy posting costs are denoted in terms of domestic labor only, labor market tightness is independent of the general price level P_j and therefore independent of the level of international trade. More generally, to get a model where trade liberalization has an impact on unemployment, trade liberalization has to influence the costs of creating a vacancy and the revenues of filling a vacancy differently. We achieve this in the simplest possible way by denoting vacancy posting costs in terms of c_jP_j, while revenues are a function of p_j. As we show in Appendix A, barring the extreme case where vacancy posting costs only consist of domestic labor, the qualitative mechanism linking trade and unemployment remains the same.

2.3 Counterfactual analysis

Most researchers estimate gravity equations in order to evaluate counterfactual policy changes. Often researchers estimate reduced-form gravity equations and interpret the estimated trade cost parameters as marginal effects on trade flows. This neglects the general equilibrium effects of trade cost changes due to relative changes of trade costs and the income effects induced by the policy change. For large-scale policy changes like regional trade agreements or economy-wide labor market reforms these general equilibrium effects are crucial. While we can recover the trade cost parameters without assumptions concerning the labor market according to Implication 1, to calculate the coun-

[14] The replacement rate is the percentage of the equilibrium wage a worker receives as unemployment benefits when she is unemployed.

terfactual trade, welfare, and employment effects, we have to take into account the full structure of our general equilibrium framework. Hence, accounting for labor market frictions matters for the quantification of policy changes.

To use our framework for counterfactual analyses, we use the following steps: 1.) We estimate the trade cost parameters. 2.) Given these estimates, we solve the system of equations given by Equation (6) for the multilateral resistance terms (MRTs) P_j and Π_i, using observed GDPs to calculate world expenditure shares, Y_j/Y^W. This yields the solutions for the baseline scenario. 3.) Using these baseline MRTs, we can estimate μ (and σ, if it has not been estimated alongside the trade cost parameters using tariff data). 4.) After defining counterfactual trade costs, e.g. setting the RTA dummy variable to 0, we again solve the system of equations given by Equation (6) to receive MRTs in the counterfactual scenario, P_j^c and Π_i^c, but now taking into account that counterfactual sales, Y_j^c, change endogenously due to the model structure and are given by $\hat{Y}_j Y_j$, where $\hat{Y}_j$ is given by Implication 4, as explained in detail below.[15]

When calculating counterfactual total sales, all approaches to date neglect changes in the total number of employed workers. For example, in the framework of Anderson and van Wincoop (2003) with perfect (or non-existent) labor markets, calculating total sales and corresponding shares in world expenditure is easy as "*quantities produced are assumed fixed*" (p. 190). However, this assumption is also very restrictive, as it implies that welfare changes are solely due to changes in (real) prices. Similarly, in Eaton and Kortum (2002) the number of employed workers remains constant.

In contrast, our model also leads to *employment* adjustments. When total sales fall, unemployment will rise, which in turn will impact wages. In essence, our model allows labor market variables to affect income. Hence, assuming perfect or imperfect labor markets matters for the proper counterfactual analysis.

In the following, we derive and discuss in turn counterfactual welfare along

[15]See Appendix B for a description of the solution of the system of multilateral resistance terms with asymmetric trade costs and trade deficits.

the lines of Arkolakis et al. (2012), (un)employment, total sales, and trade flows as functions of the multilateral resistance terms in the baseline and counterfactual scenario.

2.3.1 Counterfactual welfare

We can now consider the welfare consequences of a counterfactual change in trade costs that leaves the ability to serve the own market, t_{jj}, unchanged as in Arkolakis et al. (2012). Additionally, we follow their normalization and take labor in the considered country j as our numéraire, leading to $w_j = 1$. In our economy, total sales are given by total production of the final output good multiplied with its price, i.e., $Y_i = p_i(1 - u_i)L_i$, whereas wage income is given by $(1 - u_j)w_j L_j$.[16] We then come up with the following sufficient statistics (see Appendix C for the derivation):

Implication 2 *Welfare effects of trade liberalization in our model with imperfect labor markets can be expressed as*

$$\hat{W}_j = \hat{e}_j \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}.$$

Hence, welfare depends on the employment change, $\hat{e}_j$, the change in the share of domestic expenditures, $\hat{\lambda}_{jj}$, and the partial elasticity of imports with respect to variable trade costs, given in our case by $(1 - \sigma)$. Note that in the case of perfect labor markets $\hat{e}_j = 1$ and $\hat{W}_j = \hat{\lambda}_{jj}^{1/(1-\sigma)}$, which is exactly Equation (6) in Arkolakis et al. (2012).

When $\hat{\lambda}_{jj}$ is observed, assuming imperfect or perfect labor markets leads to different welfare predictions. The difference in the welfare change is given by $\hat{e}_j$. If employment increases, welfare goes up as well. If trade liberalization improves the relative price p_j/P_j of country j, labor market tightness goes up (see Equation (9)), and hence employment goes up. Assuming perfect labor

[16] Total wage income consists of the income of employed workers $(1 - u_j)w_j L_j - B_j$, and the income of unemployed workers B_j where $B_j = u_j L_j b_j$. The total sum of unemployment benefits is financed by a lump-sum transfer from employed workers to the unemployed. As we assume homothetic preferences, demand can be fully described by aggregate income.

markets neglects the effects on employment and the corresponding welfare effects. Further, note that $\hat{\lambda}_{jj}^{1/(1-\sigma)} = \widehat{(p_j/P_j)}$ (see Appendix C), and hence, the improvement of the relative price leads to a higher openness increasing welfare. Whether welfare increases or decreases in a particular country depends on the magnitude of the relative price change p_j/P_j.

While Implication 2 already describes how to calculate welfare within our framework, we can equivalently express the change in welfare as a function of the multilateral resistance terms by using the equivalent variation, i.e., the amount of income the representative consumer would need to make her as well off under current prices P_j as in the counterfactual situation with price level P_j^c. Using the definitions for total sales $Y_j = p_j(1-u_j)L_j$ and wage income $(1-u_j)w_jL_j$, and noting that from the wage curve it follows that $w_j = \xi_j p_j/(1+\gamma_j\xi_j - \gamma_j)$, we can express wage income as $\xi_j Y_j/(1+\gamma_j\xi_j-\gamma_j)$. Defining $v_j = \xi_j/(1+\gamma_j\xi_j-\gamma_j)$ and $\hat{v}_j \equiv v_j^c/v_j$, respectively, we can express the change in wage income as a function of the change in total sales and $\hat{v}_j$, $\hat{v}_j\hat{Y}_j$. We can then express the equivalent variation in percent as follows:

$$EV_j = \frac{v_j^c Y_j^c \frac{P_j}{P_j^c} - v_j Y_j}{v_j Y_j} = \frac{v_j^c Y_j^c}{v_j Y_j}\frac{P_j}{P_j^c} - 1 = \hat{v}_j\hat{Y}_j\frac{P_j}{P_j^c} - 1. \qquad (10)$$

Hence welfare can be calculated by using the expressions for the price indices (which can be derived from the multilateral resistance terms) and the counterfactual change in total sales. To derive the counterfactual change in total sales, it turns out to be useful to first derive an expression for the counterfactual change in (un)employment.

2.3.2 Counterfactual (un)employment

We follow Anderson and van Wincoop (2003) and use Equation (4) to solve for scaled prices as follows:

$$(\beta_j p_j)^{1-\sigma} = \frac{Y_j}{\sum_{i=1}^{n}\left(\frac{t_{ji}}{P_i}\right)^{1-\sigma} Y_i} = \frac{Y_j}{Y^W}\Pi_j^{\sigma-1}. \qquad (11)$$

We then use the definition of u_j given in Equation (8), replacing ϑ_j by the expression given in Equation (9) and defining $\Xi_j \equiv m_j \left(\frac{c_j}{m_j}\Omega_j\right)^{\frac{\mu-1}{\mu}}$ and $\hat{\kappa}_j \equiv \Xi_j^c/\Xi_j$, where superscript c denotes counterfactual values:

$$\frac{e_j^c}{e_j} \equiv \frac{1-u_j^c}{1-u_j} = \hat{\kappa}_j \left(\frac{p_j^c}{p_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{P_j}{P_j^c}\right)^{\frac{1-\mu}{\mu}}, \tag{12}$$

where e_j denotes the employment rate. Noting the derivation of Equation (11) and remembering that $P_j^{1-\sigma} = \sum_i t_{ij}^{1-\sigma}(Y_i/Y^W)\Pi_i^{\sigma-1}$ (see the definition of the price index), we can express the ratios of the prices and price indices as functions of $(Y_j/Y^W)\Pi_j^{\sigma-1}$ and $t_{ij}^{1-\sigma}$ to end up with counterfactual (un)employment levels summarized in the following implication:

Implication 3 *Whereas in the setting with perfect labor markets (un)employment effects are zero by assumption, the (un)employment effects in our gravity system with imperfections on the labor market are given by:*

$$\begin{aligned}
\hat{e}_j &\equiv \frac{e_j^c}{e_j} = \hat{\kappa}_j \widehat{\left(\frac{p_j}{P_j}\right)}^{\frac{1-\mu}{\mu}} = \hat{\kappa}_j \left(\frac{p_j^c/P_j^c}{p_j/P_j}\right)^{\frac{1-\mu}{\mu}} \\
&= \hat{\kappa}_j \left(\frac{\frac{Y_j^c}{Y^{W,c}}\left(\Pi_j^c\right)^{\sigma-1}}{\frac{Y_j}{Y^W}\Pi_j^{\sigma-1}}\right)^{\frac{1-\mu}{\mu(1-\sigma)}} \left(\frac{\sum_i t_{ij}^{1-\sigma}\frac{Y_i}{Y^W}\Pi_i^{\sigma-1}}{\sum_i \left(t_{ij}^c\right)^{1-\sigma}\frac{Y_i^c}{Y^{W,c}}\left(\Pi_i^c\right)^{\sigma-1}}\right)^{\frac{1-\mu}{\mu(1-\sigma)}}, \\
\Delta u_j &\equiv u_j^c - u_j = (1-u_j)(1-\hat{e}_j).
\end{aligned}$$

Implication 3 reveals that a country can directly affect its (un)employment level by changes in its labor market institutions, as reflected by changes in $\hat{\kappa}_j$.[17] In addition, all trading partners are affected by such a labor market reform due to changes in prices as reflected by $(Y_j/Y^W)\Pi_j^{\sigma-1}$. Direct effects are scaled by changes in relative prices p_j/P_j which are proportional to $\left\{(Y_j/Y^W)\Pi_j^{\sigma-1}/[\sum_i t_{ij}^{1-\sigma}(Y_i/Y^W)\Pi_i^{\sigma-1}]\right\}^{1/(1-\sigma)}$, reflecting the spillovers of labor market reforms to other countries. Changes of relative prices due to trade liberalization therefore provide the link to the labor market.

[17] Note that employment changes are homogeneous of degree zero in prices, implying that a normalization does not matter for the employment effects.

Even with imperfect labor markets we just need one additional parameter alongside σ, namely μ, the elasticity of the matching function, in order to calculate counterfactual values once we have solved for the multilateral resistance terms. Note that μ plays a crucial role for the importance of the labor market frictions. To illustrate, assume that all labor market institutions remain the same (i.e., $\hat{\kappa}_j = 1$) and μ approaches one. Then, the (un)employment effects vanish.[18] A lower μ, i.e., higher labor market frictions, leads to larger changes in (un)employment for given relative price changes. Additionally, all (potential) changes in labor market policies are succinctly summarized in a reduced-form fashion in $\hat{\kappa}_j$. This ultimately also translates into the importance of the extent of labor market frictions for the magnitude of welfare. Using $\hat{e}_j = \hat{\kappa}_j \widehat{(p_j/P_j)}^{\frac{1-\mu}{\mu}}$ and $\hat{\lambda}_{jj}^{1/(1-\sigma)} = \widehat{(p_j/P_j)}$ for the welfare formula given in Implication 2, we can express welfare as: $\hat{W}_j = \hat{\kappa}_j \widehat{(p_j/P_j)}^{1/\mu}$. Trade liberalization changes the relative price. $1/\mu$ is the elasticity of the welfare change with respect to the relative price change p_j/P_j $\left(1/\mu \equiv \partial \ln \hat{W}_j / \partial \ln \widehat{(p_j/P_j)}\right)$. When μ goes to zero this elasticity tends to infinity, rendering the welfare change from trade liberalization arbitrarily large. This observation may help to resolve the typical finding of modest welfare gains from trade in trade gravity models (see Costinot and Rodríguez-Clare, 2014, and Melitz and Redding, 2014). Without labor market frictions, the welfare formula simplifies to $\hat{W}_j = \widehat{(p_j/P_j)}$. Hence, for given relative price changes, $\widehat{(p_j/P_j)}$, welfare is magnified when accounting for labor market imperfections. Note, however, that price changes for any counterfactual analysis will be different when assuming perfect or imperfect labor markets. Specifically, for small welfare changes, welfare effects with imperfect labor markets may be smaller in absolute values, as the additional employment changes may lead to smaller relative price changes.

2.3.3 Counterfactual total sales

We next derive counterfactual total sales. Using the definition of total sales, $Y_j = p_j(1-u_j)L_j = p_j e_j L_j$, and taking the ratio of counterfactual total sales,

[18] In this case the level of unemployment is given by $u_j = 1 - m_j$.

Y_j^c, and total sales in the baseline scenario, Y_j, we can use Implication 3 and Equation (11) to come up with the following implication:

Implication 4 *Counterfactual total sales are given by:*

$$\begin{array}{ll} \textit{imperfect labor markets:} & \hat{Y}_j = \hat{\kappa}_j \left(\frac{\frac{Y_j^c}{Y^{W,c}} \left(\Pi_j^c\right)^{\sigma-1}}{\frac{Y_j}{Y^W} \Pi_j^{\sigma-1}} \right)^{\frac{1}{\mu(1-\sigma)}} \left(\frac{\sum_i t_{ij}^{1-\sigma} \frac{Y_i}{Y^W} \Pi_i^{\sigma-1}}{\sum_i \left(t_{ij}^c\right)^{1-\sigma} \frac{Y_i^c}{Y^{W,c}} \left(\Pi_i^c\right)^{\sigma-1}} \right)^{\frac{1-\mu}{\mu(1-\sigma)}}, \\ \textit{perfect labor markets:} & \hat{Y}_j = \left(\frac{\frac{Y_j^c}{Y^{W,c}} \left(\Pi_j^c\right)^{\sigma-1}}{\frac{Y_j}{Y^W} \Pi_j^{\sigma-1}} \right)^{\frac{1}{1-\sigma}}. \end{array}$$

If we assume $\mu = 1$, we end up with the case of perfect labor markets which is identical to the model employed by Anderson and van Wincoop (2003).

It is illuminating to decompose the change in total sales as follows:

$$\begin{aligned} \hat{Y}_j &= \underbrace{\left(\frac{\frac{Y_j^c}{Y^{W,c}} \left(\Pi_j^c\right)^{\sigma-1}}{\frac{Y_j}{Y^W} \Pi_j^{\sigma-1}} \right)^{\frac{1}{1-\sigma}}}_{\text{price change}} \\ & \quad \underbrace{\times \hat{\kappa}_j \left(\frac{\frac{Y_j^c}{Y^{W,c}} \left(\Pi_j^c\right)^{\sigma-1}}{\frac{Y_j}{Y^W} \Pi_j^{\sigma-1}} \right)^{\frac{1-\mu}{\mu(1-\sigma)}} \left(\frac{\sum_i t_{ij}^{1-\sigma} \frac{Y_i}{Y^W} \Pi_i^{\sigma-1}}{\sum_i \left(t_{ij}^c\right)^{1-\sigma} \frac{Y_i^c}{Y^{W,c}} \left(\Pi_i^c\right)^{\sigma-1}} \right)^{\frac{1-\mu}{\mu(1-\sigma)}}}_{\text{employment change}}, \end{aligned} \quad (13)$$

with the price change defined as implied by Equation (11) and the employment change as defined in Implication 3.

To gain intuition, remember that $Y_j = p_j e_j L_j$, and hence $\hat{Y}_j = \hat{p}_j \hat{e}_j$ if the labor force remains constant. We can use Equation (11) to express $\hat{Y}_j$ in terms of price changes. Let us now use $P_j = P_j^c = 1$ as a numéraire for a moment. We then realize that $\hat{Y}_j = (p_j^c/p_j)(p_j^c/p_j)^{(1-\mu)/\mu}$ if labor market institutions remain constant, i.e., $\hat{\kappa}_j = 1$. Then, the two terms are equal except for their exponents: the price change term rises to the power of 1 and the employment change term to the power of $(1-\mu)/\mu$. Hence, the relative importance of price and employment changes only depends on μ. If μ approaches one, the labor market rigidities vanish, and the total change in total sales is due to the price change, as in models assuming perfect labor markets. With any value of μ between zero and one, the share of the change in total sales attributable to the price change is μ and the share due to the employment change $1-\mu$. To illustrate, let $\mu = 0.75$, then three-quarters of the change in total sales are due to the price change and one-quarter is due to the employment change. In all other countries, the additional changes in price indices lead to a more complex relationship.[19] A lower price index lowers recruiting costs and thus spurs employment. This effect is captured by the last parenthesis in Equation (13). On the other hand, lower variety prices render recruiting less attractive, which is reflected by the first term of the employment change. Hence, the overall effect is ambiguous.

Taking logs, we can attribute the share of log change in total sales due to changes in prices and employment as follows:

$$1 = \frac{\ln \hat{p}_j}{\ln \hat{Y}_j} + \frac{\ln \hat{e}_j}{\ln \hat{Y}_j}. \tag{14}$$

Alongside changes in total sales, we will report this decomposition in all our counterfactual exercises.

2.3.4 Counterfactual trade flows

Finally, given estimates of $t_{ij}^{1-\sigma}$, data on Y_i, and a value for σ, we can calculate (scaled) baseline trade flows as $X_{ij}Y^W/(Y_iY_j) = (t_{ij}/(\Pi_i P_j))^{1-\sigma}$, where Π_i and P_j are given by Equation (6). With counterfactual total sales given by Implication 4, we can calculate counterfactual trade flows as $X_{ij}^c Y^{W,c}/(Y_i^c Y_j^c) = (t_{ij}^c/(\Pi_i^c P_j^c))^{1-\sigma}$, where Π_i^c and P_j^c are defined analogously to their counterparts in the baseline scenario given in Equation (6).[20] Due to direct effects of changes in trade costs via t_{ij} and non-trivial changes in Π_i and P_j, trade may change more or less when assuming imperfect labor markets in comparison

[19] Note that the change in total sales can only be solved up to scale, see also Costinot and Rodríguez-Clare (2014), pages 201 and 204. We choose the price index of one country as the numéraire. This choice leads to a simpler interpretation of total sales changes for the numéraire country.

[20] Note that P_j and P_j^c are homogeneous of degree one in prices while Π_i and Π_i^c are homogeneous of degree minus one. Hence, scaled trade flows $X_{ij}Y^W/(Y_iY_j)$ and $X_{ij}^c Y^{W,c}/(Y_i^c Y_j^c)$ are homogeneous of degree zero in prices. In other words, they do not depend on the normalization chosen.

with the baseline case of perfect labor markets.

3 Regional trade agreements and labor market frictions

We now apply our framework to evaluate the trade effects of regional trade agreements and labor market reforms in a sample of 28 OECD countries for the years 1988 to 2006.[21] Trade data and GDP data, our measure for total sales, are from Head et al. (2010). We use internationally comparable harmonized unemployment rates as well as employment and civil labor force data from OECD (2012). Internationally comparable gross average replacement rates are from OECD (2007).[22] For the estimation of the elasticity of the matching function, we use data from 2006.[23]

3.1 Estimation of trade cost parameters

To obtain an estimable gravity equation as given in Equation (7), we need to parameterize trade costs. Trade is hampered by two types of trade barriers: resource-consuming non-revenue generating trade costs, t_{ijs}, for imports from country i to j in year s, as well as non-resource-consuming and revenue-generating import tariffs, τ_{ijs}, for imports from i to j in year s.[24] We follow the literature and proxy trade costs by a vector of trade barrier variables as

[21] See Heid and Larch (2012a), the working paper version of this paper, for a longer panel starting in 1950 but without considering tariff rates.

[22] This OECD summary measure is defined as the average of the gross unemployment benefit replacement rates for two earnings levels, three family situations and three durations of unemployment (for details of its calculation see Martin, 1996). As Mexico does not have any unemployment insurance scheme but is characterized by a large informal employment share, its labor market institutions are markedly different to the other OECD countries in our sample. Consequently, no replacement rate data are available for Mexico. We therefore exclude it from our analysis. For all other countries, we use the simple average of replacement rates between 2005 and 2007 as data for 2006 are not available.

[23] In the Online Appendix in Section J, we show results using panel data.

[24] In Appendix A of the Online Appendix, we derive our model also including tariffs.

follows:

$$\tau_{ijs}^{-\sigma} t_{ijs}^{1-\sigma} = \exp[\delta_1 \ln(1 + TARIFFRATE_{ijs}) + \delta_2 RTA_{ijs} + \delta_3 \ln DIST_{ij} + \delta_4 CONTIG_{ij} + \delta_5 COMLANG_{ij}]. \quad (15)$$

$TARIFFRATE_{ijs}$ data are from the World Integrated Trade Solution (WITS) available from 1988 to 2006, which also defines our sample period. We use three average tariff rates: the simple average at the HS 6 digit level of the effectively applied tariff rate, the simple average of the effectively applied tariff rate at the tariff line level, as well as the weighted average of the effectively applied tariff rate with the weights given by the corresponding trade value.[25] RTA_{ijs} is an indicator variable of regional trade agreement membership between country pair ij in year s from Mario Larch's RTA database.[26] It is constructed from the notifications to the World Trade Organization (WTO) and augmented and corrected by using information from RTA secretariat webpages. $DIST_{ij}$ is bilateral distance, $CONTIG_{ij}$ is a dummy variable indicating whether countries i and j are contiguous, and $COMLANG_{ij}$ indicates whether the two countries share a common official language.[27] $DIST_{ij}$, $CONTIG_{ij}$, and $COMLANG_{ij}$ are from Head et al. (2010). Table 1 contains summary statistics of the data.

[Table 1 about here.]

Obviously, countries do not randomly sign RTAs nor set tariff levels at random. This has long been recognized in the international trade literature, see for example Trefler (1993), Magee (2003), Baier and Bergstrand (2007), and references therein. Empirical evidence shows that the exogeneity assumption of RTAs is inappropriate when attempting to quantify the effects of regional trade agreements. To avoid potential endogeneity, we follow Baier and

[25] For a detailed description and discussion of the tariff data, see Section H of the Online Appendix.

[26] It can be accessed at `http://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html`. A list of the included agreements can be found in Appendix D.

[27] We do not use common colonizer indicators or similar variables regularly used in the literature as these have very little variation in our OECD sample.

Bergstrand (2007) and Anderson and Yotov (2015) and use a two-step estimation approach to obtain consistent estimates of trade cost coefficients. In a first step, we estimate Equation (7) including directional bilateral fixed effects, i.e., we estimate

$$\begin{aligned} Z_{ijs} &= \exp[k + \delta_1 \ln(1 + TARIFFRATE_{ijs}) + \delta_2 RTA_{ijs} \\ &\quad + \varphi_{is} + \phi_{js} + \nu_{ij} + \varepsilon_{ijs}], \end{aligned} \tag{16}$$

where φ_{is} and ϕ_{js} are exporter and importer time-varying fixed effects and ν_{ij} is a time-constant directional bilateral fixed effect. Note that φ_{is} and ϕ_{js} control for the time-varying multilateral resistance terms Π_{is} and P_{js}, and the bilateral fixed effect also captures the time-invariant geography variables. In a second step, we re-estimate Equation (7) with trade costs proxied as in Equation (15) to obtain estimates for the coefficients of the time-invariant geography variables, δ_3 to δ_5. We therefore use only exporter and importer time-varying fixed effects and constrain the coefficients of $\ln(1 + TARIFFRATE_{ijs})$ and RTA_{ijs}, δ_1 and δ_2, to their estimates of the first step, $\tilde{\delta}_1$ and $\tilde{\delta}_2$.[28]

3.2 Estimation of elasticities

We have now set the stage for our counterfactual welfare analysis—if we follow most of the gravity literature and merely assume plausible values for the elasticity of substitution, σ, and, in our case, the matching elasticity, μ. In the following, we demonstrate that under additional parameter restrictions, both elasticities can, in principle, be estimated within our quantitative framework.

The additional assumptions we have to introduce are due to the fact that measures of recruiting costs, bargaining power, and matching efficiencies which are comparable across countries are hard to come by. Specifically, we assume identical recruiting costs, c_j, across countries and that the bargaining power of workers, ξ_j, is 0.5 in all countries. Finally, we assume identical matching efficiencies, m_j, across countries. We relax the latter assumption in Section

[28] We use tildes to refer to estimated parameters to prevent confusion with ratios of variables which we indicate by hats.

J of the Online Appendix using panel data on both trade and labor market data.

Impatient (or unconvinced) readers may as well simply assume values for σ and μ and continue with Section 3.3. In addition, we present results of our counterfactual analysis for different assumed values of the elasticities in Table 4.

3.2.1 Estimating the elasticity of substitution

The elasticity of substitution σ (which relates to the elasticity of imports with respect to variable trade costs, in short the trade elasticity, by $1-\sigma$) is one of the most important elasticities for the evaluation of trade policies. This importance has even increased since the influential paper by Arkolakis et al. (2012) which shows that welfare gains from trade policy changes can be calculated by using changes in the share of domestic expenditure alongside the elasticity of imports with respect to variable trade costs. There are many different ways to obtain estimates for the trade elasticity.[29]

Head and Mayer (2014) nicely summarize in their Section 4.2 what they call "gravity-based estimates", which regress bilateral trade flows on measures of bilateral trade costs (such as tariffs) or on wages or productivity (recent examples are de Sousa et al., 2012 and Fitzgerald and Haller, 2014). As is visible in their Table 3.5, results vary widely, which is partly due to different methods, and partly due to different levels of aggregation of the trade data. Head and Mayer (2014) conclude that their "...preferred estimate for [the trade elasticity] is -5.03 [implying $\sigma = 6.03$], the median coefficient obtained using tariff variation, while controlling for multilateral resistance terms" (p. 165). Our first approach is therefore to use our tariff data and recover the elasticity of substitution directly from the coefficient on the tariff rates in our structural gravity estimates, i.e., $\tilde{\delta}_1 = -\sigma$.[30] This approach for estimating σ controls for the potential endogeneity of RTAs and tariffs, multilateral resis-

[29]See Feenstra (2010) for a detailed discussion of estimates of the elasticity of substitution in international trade.

[30]See Section A of the Online Appendix for a detailed derivation.

tance terms and takes into account the heteroskedasticity of trade flows. Also note that the time-varying importer and exporter fixed effects also control for most favored nation (MFN) tariffs which, by definition, are identical for all import source countries.

Obviously, using tariff rates is not without problems. Firstly, as we use aggregate trade flows, tariff rates also have to be aggregated up in some way. It is well known that using trade volumes to create a weighted average creates a downward bias in the effective tariff rate; the opposite argument can be applied to simple averages. In addition, tariff evasion, as documented by Fisman and Wei (2004) and Javorcik and Narciso (2008), may distort the measure of σ, as explained by Egger and Larch (2012). We therefore also use a second approach following Bergstrand et al. (2013) who show how to obtain estimates for σ within their proposed framework without relying on tariff data besides trade flow data.[31] We show that a variant of their approach is also applicable when assuming imperfect labor markets. A major advantage of using tariff data is its parsimony in terms of data requirements and assumptions. To estimate σ using a variant of Bergstrand et al. (2013), apart from trade data we need data on unemployment rates and civil labor force data. In addition, we have to assume that β_js are identical across countries.

First, note that we can rewrite trade flows as given in Equation (3) by observing that the variety price can be substituted by $p_i = Y_i/[(1-u_i)L_i]$. This yields $X_{ij} = ((\beta_i Y_i t_{ij})/((1-u_i)L_i P_j))^{1-\sigma} Y_j$. Estimation of Equation (7) using observable determinants of bilateral trade costs generates estimates $\widetilde{t_{ij}^{1-\sigma}}$. We next substitute $\widetilde{t_{ij}^{1-\sigma}}$ in Equation (5) to generate $\tilde{X}_{ij}$ and $\widetilde{t_{mj}^{1-\sigma}}$ in its analogue

[31] Besides these two approaches, there are at least two additional ones. Feenstra (1994) and Broda and Weinstein (2006) estimate the trade elasticity using variations in the variances of the demand and supply curves across countries to infer the trade elasticity. Eaton and Kortum (2002) and Simonovska and Waugh (2014) use the relation of trade and price gaps to infer the elasticity of substitution. As these two approaches use additional data not used in our applied framework, we stick with the two other, less data-demanding ones to obtain values for the trade elasticity.

to generate $\tilde{X}_{mj}$. Using observed unemployment rates we end up with:

$$\frac{\tilde{X}_{ij}}{\tilde{X}_{mj}} = \frac{\widetilde{t_{ij}^{1-\sigma}}}{\widetilde{t_{mj}^{1-\sigma}}} \left(\frac{Y_i(1-u_m)L_m}{Y_m(1-u_i)L_i}\right)^{1-\sigma}, \tag{17}$$

where we have assumed that $\beta_j = \beta \; \forall \; j$. We can solve Equation (17) for σ, where Y_i, Y_m, L_i, L_m, u_i, and u_m are observables. Then, we can calculate $n^2(n-1)$ values of σ by using all combinations i, j, and m ($m \neq i$). As a measure of central tendency, we follow Bergstrand et al. (2013) and use the median of all values as our estimate. In Section I in the Online Appendix, we show the full distribution of the σ values. We use a parametric bootstrap to obtain a standard error for σ.

3.2.2 Estimating the elasticity of the matching function

The other crucial parameter for our counterfactual analysis is the elasticity of the matching function, μ. As with the elasticity of substitution, there are a great many of plausible estimates of the matching elasticity available in the literature. We demonstrate that it is also possible to obtain an estimate of μ within our structural gravity framework relying on the cross-country-pair variation in bilateral trade flows.

Using Equations (8) and (9) and defining $\Xi_j \equiv m_j \left(\frac{c_j}{m_j}\Omega_j\right)^{\frac{\mu-1}{\mu}}$, we can write $1-u_j = \Xi_j \left(p_j/P_j\right)^{(1-\mu)/\mu}$. As we observe u_j in the baseline, we may take ratios for two countries and the log of this ratio to obtain:

$$\ln\left(\frac{1-u_j}{1-u_m}\right) = \frac{1-\mu}{\mu}\left[\ln\left(\frac{p_j}{p_m}\frac{P_m}{P_j}\right) - \ln\left(\frac{c_j\Omega_j}{c_m\Omega_m}\right)\right] + \frac{1}{\mu}\ln\left(\frac{m_j}{m_m}\right). \tag{18}$$

Assuming $m_j = m_m$, we can solve Equation (18) for μ, where u_j, c_j and Ω_j are in principle observable. The unobservable variety prices p_j can be replaced again by $p_i = Y_i/[(1-u_i)L_i]$ and the price indices P_j by $P_j^{1-\sigma} = \sum_{i=1}^{n} t_{ij}^{1-\sigma} \frac{Y_i}{Y^W} \Pi_i^{\sigma-1}$, respectively. $\frac{Y_i}{Y^W}\Pi_i^{\sigma-1}$s can be recovered from solving the system of equations given in Equation (6) for observed trade flows using the estimated $\widetilde{t_{ij}^{1-\sigma}}$. In our application, we assume identical recruiting costs, c_j, across countries as comparable data across countries of these costs are hard to come by. We also assume that the bargaining power of workers, ξ_j, is 0.5 in all countries. However, we use observed unemployment benefits across countries from OECD (2007).[32] Hence γ_j and thus Ω_j vary across countries and reflect the heterogeneity in the replacement rate across countries.

We can then calculate $n(n-1)/2$ such values of μ by using all combinations of j and m ($m \neq j$). As a summary estimate, we average over all estimated values within the unit interval, the admissable range for μ. We use a parametric bootstrap for the standard errors of μ.[33]

We show the full distribution of μ values in Section I in the Online Appendix. In addition, in Section J of the Online Appendix, we investigate a regression-based estimate of μ which allows for country-specific and time-varying m_j when panel data on both the trade and labor market data are available. The results remain similar when using this approach.

3.3 Estimation results

We present results estimating log-linearized scaled trade flows by OLS as well as the Poisson pseudo-maximum-likelihood (PPML) estimator for the scaled trade flows in levels following the recommendation by Santos Silva and Tenreyro (2006) in Table 2. For every specification, we present results for these two estimators. Columns (1) and (2) present estimates excluding tariff rates as regressors. Columns (3) to (8) all include tariffs. Specifically, columns (3) and (4) use the simple average of effectively applied tariff rates to construct $\ln(1 + TARIFFRATE_{ijs})$; columns (5) and (6) use the simple average but calculated at the tariff line level, and columns (7) and (8) use the weighted average of the effectively applied tariff. All columns include directional bilateral fixed effects as well as time-varying inward and outward multilateral resistance terms by including time-varying importer and exporter fixed effects.

[Table 2 about here.]

[32] For further details on the data, see Section 3.

[33] We use analytical standard errors for the trade cost parameters.

RTAs increase trade by 17.23 percent (column (6)) to 24.86 percent (column (1)) when neglecting general equilibrium effects.[34] Controlling for tariffs, our RTA coefficients remain highly significant but decrease slightly in magnitude. Judging by the standard errors, we cannot reject the hypothesis that the RTA coefficients in the tariff regressions are different from the values in columns (1) and (2). The second stage regressors are also hardly affected by the inclusion of tariff rates. The general equilibrium effects are accounted for in the counterfactual analysis, to which we turn in Section 3.4. When comparing the RTA coefficient across OLS and Poisson estimates, we see that Poisson estimates are a bit lower.

Our estimates are by and large in accordance with well-known results from the empirical trade literature. Distance is a large obstacle to trade, whereas contiguity and RTAs enhance trade. Comparing OLS with PPML estimates shows a clear pattern: distance coefficients are basically identical, contiguity coefficients are larger and common language coefficients are smaller. Interestingly, we find a negative impact of common language on bilateral trade flows using PPML. While surprising, this is consistent with the meta study by Head and Mayer (2014), which reports a standard deviation of common language coefficients which also encloses our negative value within two standard deviations. Note also that in the working paper version of this paper, Heid and Larch (2012a), where we use a panel from 1950 to 2006 without including tariffs as an additional regressor, common language has the expected positive and significant coefficient.

Instead of the regression coefficients of $\ln(1 + TARIFFRATE_{ijs})$, we directly report the implied σ estimates (i.e., $\tilde{\sigma} = -\tilde{\delta}_1$) for columns (3) to (8). σs are highly significant, have the correct sign and are all larger than 1 with exception of column (5), where we at least cannot reject the null hypothesis that it is larger than 1. They are similar to our σ estimates from columns (1) and (2) which use the alternative estimation method for σ without including tariff rates as regressors.

[34] Effects are calculated as $(\exp(\tilde{\delta}_{RTA}) - 1) \times 100$ [percent].

Our significant estimates lie between 0.954 in column (5) and 1.765 in column (4). These results are in line with recent evidence from Feenstra et al. (2014) who report estimates for the Armington elasticity between domestic and foreign goods in a similar range.

Finally, our estimates of the matching elasticity vary between 0.930 and 0.992 and are significant at standard levels of significance. With our method, we find that the elasticity of labor markets in OECD countries indicates a very low level of labor market frictions and a very high matching elasticity compared to previous estimates. For example, Yashiv (2000) estimates μ between 0.2 and 0.6 for Israel for the years between 1975 and 1989. A literature review by Petrongolo and Pissarides (2001) reports estimates between 0.12 and 0.81 across studies focusing on several countries and time periods. Hall (2005) finds $\mu = 0.24$ for the United States for the years 2000 to 2002. Rogerson and Shimer (2011) estimate $\mu = 0.58$ for the same data for the years 2000 to 2009.[35] Even though our estimates are on the high side, note that our method infers the matching elasticity from (ratios) of bilateral trade flows using their cross-country-pair variation at one point in time. All other estimates of the matching elasticity in the literature use time series data on the number of matches, vacancies, and the unemployed from a single labor market. Hence, it is not too surprising that our estimates are somewhat different from the literature. Also note that we show in Appendix A that our μ is an upper bound estimate when allowing for a more general vacancy posting cost function. In the counterfactual analysis, to which we turn next, we therefore provide results for alternative values of the matching elasticity.

3.4 Counterfactual analysis

We conduct three counterfactual experiments in our OECD sample. First, we evaluate the effects of all RTAs between the 28 OECD countries. To this end, we compare a situation with RTAs as observed in 2006 with a counter-

[35]Note that the literature reports both estimates of the matching elasticity with respect to the unemployed, as we do, or with respect to vacancies. In our discussion, we transformed the estimates when necessary assuming constant returns to scale in the matching process.

factual situation without any RTAs, i.e., we counterfactually set RTA_{ij2006} to 0. Second, we evaluate the U.S.-Australia Free Trade Agreement. Finally, we evaluate a hypothetical improvement of labor market institutions in the United States.

3.4.1 Evaluating the effects of RTAs

Our first counterfactual experiment evaluates the effects of introducing RTAs as observed in 2006 compared to a counterfactual situation in which there are no RTAs.[36] While this is an ex-post evaluation, our framework can also be applied to ex-ante evaluate the potential trade, welfare, and employment effects of any currently negotiated free trade agreement. Note that even for the ex-post evaluation of abandoning all RTAs as observed in 2006 as studied in the following, using a reduced form approach would neglect the general equilibrium effects of this large scale policy change. We base our counterfactual analysis on parameter estimates from column (4) of Table 2 as they control for the heteroscedasticity of trade flows using PPML and include simple tariff averages which do not suffer from the downward aggregation bias as the weighted tariff average using trade values. PPML estimates for the tariff line average (column (6)) are quite similar to column (4).

For our counterfactual simulations, we use a generalized version of our model which also allows for trade imbalances as well as takes into account the tariff revenue generated by the effectively applied average tariff rate, i.e., we use the model described in detail in Section A of the Online Appendix. In Sections F and G of the Online Appendix, we present results of our counterfactual simulations imposing zero tariff rates for all country pairs and balanced trade, respectively. Results remain similar.

The results are shown in Table 3.[37] It is organized as follows. Column (1),

[36] This scenario assumes the same partial effect for all regional trade agreements in place in 2006, irrespective of their depth or when they were concluded. This is obviously a very strong assumption, but helps to focus on the mechanics of the model. Additionally, it allows a direct comparison with the results of Egger et al. (2011), who make the same assumption and also investigate the effects of switching on all RTAs while controlling for endogeneity as we do.

[37] In the Online Appendix, we additionally provide results concerning the changes in trade

"PLM %Y", gives the percentage change in nominal total sales for the case of perfect labor markets. Column (2), "SMF %Y", gives the same change within our search and matching framework. Columns (3) and (4) use Equation (14) and decompose the log change in total sales of Column (2) into log price and log employment changes. Column (5) reports the percentage change in the employment share for the case of imperfect labor markets, whereas Column (6) reports unemployment changes in percentage points. Finally, Columns (7) and (8) report the equivalent variation (EV) for the case of perfect and imperfect labor markets, respectively. Note that all changes are expressed as changes from the counterfactual scenario without any RTA to the observed scenario with RTAs as observed in 2006. For the baseline, we use observed GDPs from 2006 as our measure for total sales, while the changes in total sales are endogenously determined in the counterfactual.

Table 3 reveals that introducing RTAs as observed in 2006 has quite heterogeneous effects on total sales. Some countries gain substantially more than the average, for example Canada with a gain of 10.95 percent, whereas other countries such as Japan experience a smaller increase of 2.38 percent. Please note, however, that these changes can only be interpreted relative to each other, as their absolute level depends on the numéraire chosen.[38] The decomposition of the change in (log) sales into (log) price and (log) employment changes highlights that for many of our sample countries, roughly 15 percent of the increase in sales is driven by the increase in employment. Countries with only slight increases in sales may even see negative employment effects, as can be seen in Column (5) of Table 3. As explained in Section 2.3.1, welfare effects are typically magnified when taking into account employment effects as

flows across countries.

[38]Note that levels and changes of nominal variables like total sales can only be solved up to scale, see Costinot and Rodríguez-Clare (2014), pages 201 and 204, respectively. As mentioned in footnote 12 in Anderson and van Wincoop (2003), the solution of the multilateral resistance terms (MRTs) adopts a particular normalization. In general, this applied normalization may vary between the baseline MRTs and the counterfactual MRTs. In order to ensure a common numéraire, we normalize $\Pi_{United\,States} = \Pi^c_{United\,States} = 1$, i.e., changes in total sales are in terms of the outward multilateral resistance term of the United States.

both trade openness and employment effects depend positively on the relative price p_j/P_j. For example, the standard welfare estimate for Canada is about 3 percent larger when taking into account labor markets imperfections.

To assess the fit of our model, we first compare the implied changes in both openness (measured as imports plus exports over GDP) and in unemployment rates predicted by our model with actually observed data for our sample. While it is straightforward to calculate these changes for our model, we cannot, of course, observe "real-world" counterfactual openness and unemployment rates. Thus, to compare model predictions with observed data, we take a simple and admittedly very crude approach: we calculate the observed change in openness and the unemployment rate as the change between the first year for which unemployment rate data are available and 2006.[39] Note that we standardize changes for comparison reasons. As can be seen from Figure 1, our model replicates the average negative correlation between openness and unemployment.

[Figure 1 about here.]

[Figure 2 about here.]

As an additional validation of our results, we conducted another counterfactual exercise, where we shut down all RTAs which were signed between 1988, the first year of our data set, and 2006. We then compute the predicted counterfactual unemployment rates and compare them to the observed unemployment rates in 1988 for those countries where unemployment rates are available. Figure 2 shows the scatterplot of the counterfactual versus observed unemployment rates. The correlation between the observed and predicted

[39] The first year is 1955 for the United States and Japan, 1956 for New Zealand, Ireland, France, and Canada, 1958 for Finland, 1959 for Italy, 1960 for Denmark and Turkey, 1961 for Greece, 1962 for Germany, 1964 for Australia and Austria, 1970 for Sweden, 1972 for Norway, Spain, and the United Kingdom, 1975 for Switzerland, 1983 for Belgium and the Netherlands, 1984 for Portugal, 1989 for Korea, 1990 for Poland, 1991 for Iceland, 1992 for Hungary, 1993 for the Czech Republic, and 1994 for the Slovak Republic. Note that all countries either had no or only a few RTAs in place for the first year in which we observe the unemployment rate, but all of them had experienced a tremendous increase in RTAs by 2006.

counterfactual unemployment rate is 0.34 which is tantamount to explaining 12 percent of the variation in the observed unemployment rate. Thus, although there is room for improving the model fit, we are the first to explain any of the observed variation in unemployment rates by changes in international trade policy changes using a structural gravity model.

As in every quantitative trade model, the resulting magnitudes of policy changes crucially depend on the exact values of the elasticities. We therefore test the sensitivity of our results to different values of the elasticity of substitution σ and the elasticity of the matching function μ. In the interest of brevity, we present only average effects in Table 4. The total sales, employment, and EV effects crucially depend on the values of σ and μ. When the elasticity of substitution increases, total sales, employment, and EV changes become smaller. This is because varieties are better substitutes, making trade less important. Hence, switching on the RTA dummy leads to smaller predicted gains in terms of total sales, employment, and welfare. Changes in the elasticity of the matching function μ also show a clear pattern. Lower values of μ indicate higher total sales, employment, and welfare changes. A lower μ corresponds to larger labor market imperfections. When μ approaches 1 we end up in the case of perfect labor markets. The reason for this is that larger frictions on the labor market imply that firms have to post more vacancies in order to find a worker, effectively increasing recruiting costs. As trade liberalization decreases the overall price level, it also lessens a firm's recruiting costs. This reduction of recruiting costs is more important in labor markets with higher frictions, making trade liberalization more attractive. Overall, Table 4 highlights that the extent of labor market frictions plays a crucial role in assessing the quantitative impact of regional trade agreements.

[Table 3 about here.]

[Table 4 about here.]

3.4.2 Evaluating the effects of the U.S.-Australia Free Trade Agreement

Our first counterfactual exercise has evaluated the combined effect of abolishing all RTAs signed between the 28 OECD countries in our data set simultaneously. Hence positive welfare effects for member countries of one RTA are partly offset by negative welfare effects of other RTAs if a country is a non-signatory party.

To illustrate how allowing for imperfect labor markets affects the evaluation of a specific RTA, we analyze the U.S.-Australia Free Trade Agreement (FTA). It entered into force on January 1, 2005.[40] It is the second RTA between the United States and a developed country after the U.S.-Canada FTA in 1988. The RTA between the U.S. and Australia is far reaching, as it not only liberalizes 99 percent of U.S. manufactured goods exports, but also leads to harmonization in the areas of intellectual property rights, services trade, government procurement, e-commerce and investment.[41] This agreement is therefore interesting to investigate in the context of our framework, which is very suitable to study trade liberalization between developed countries.[42]

Additionally, the welfare effects of this agreement have not yet been in-

[40] `https://ustr.gov/trade-agreements/free-trade-agreements/australian-fta`, accessed May 15, 2015.

[41] `https://ustr.gov/archive/Document_Library/Press_Releases/2004/February/US_Australia_Complete_Free_Trade_Agreement.html`, accessed May 15, 2015.

[42] Alternatively, we could have investigated the U.S.-Canada Free Trade Agreement. However, this agreement was superseded by the North American Free Trade Agreement (NAFTA) in 1994, which included Mexico. As this is a developing country and we do not have (un)employment data for Mexico, we did not analyze NAFTA. Concerning the U.S.-Australia FTA, note that recently the Transpacific Partnership (TPP) has been negotiated. TPP is an expansion of the Trans-Pacific Strategic Economic Partnership Agreement, which is an RTA between Brunei, Chile, Singapore, and New Zealand concluded in 2006. In September 2008, the United States announced its intention to join the TPP negotiations. Since 2008, additional countries joined and by now TPP has twelve participating countries: Australia, Brunei, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, the United States, and Vietnam (see `https://ustr.gov/tpp/`, accessed January 13, 2016). On October 5th, 2015, TPP was successfully concluded (see `http://www.state.gov/secretary/remarks/2015/10/247870.htm`, accessed January 13, 2016) and therefore the U.S.-Australia FTA overlaps with TPP. As we have only parts of the involved countries in our data set, we focus on the U.S.-Australia FTA to highlight the working of our framework for a single agreement.

tensively analyzed. Quiggin (2004) provides a qualitative assessment of the agreement to the Parliament of Australia, while Dee (2005) comments the results of a study commissioned by the Australian Department of Foreign Affairs and Trade. Armstrong (2015) uses the point estimates from a gravity model to assess the trade effects of the agreement. Krever (2006) and Ranald (2006) provide a historical and political view on the U.S.-Australia FTA. Closest to our welfare analysis, Siriwardana (2007) uses the Global Trade Analysis Project (GTAP) multi-sector, multi-country general equilibrium model to evaluate the welfare effects of the U.S.-Australia FTA.

To implement the counterfactual scenario, i.e., a world without the U.S.-Australia FTA, we 1.) set the RTA dummy between Australia and the U.S. to 0 and 2.) set bilateral tariffs between Australia and the U.S. to their level in 2004, i.e., before the FTA entered into force.

We report results from this exercise in Table 5. We find that the U.S.-Australia FTA increases Australia's welfare substantially by 5.95 percent, whereas U.S. welfare increases only slightly by 0.28 percent if assuming perfect labor markets. Accounting for imperfect labor markets increases welfare effects by 6 and 7 percent to 6.30 and 0.30 percent, respectively. Most non-member countries are hardly affected except the direct neighboring countries like New Zealand and, to a lesser extent, Canada. Interestingly, the negative change in total sales in New Zealand is driven by negative employment effects which overcompensate the price increase (indicated by the -19.71 percent in column (3)), as can be inferred from comparing columns (3) and (4) in combination with columns (2) and (5). Concerning unemployment, our model predicts that Australia's unemployment rate is 0.39 percentage points lower due to the U.S.-Australia FTA.

Our results are comparatively larger than those from Siriwardana (2007). He finds that the U.S.-Australia FTA increases real GDP by only 0.13 percent in Australia and 0.02 percent in the U.S. While these differences are substantial, note that the difference between the GTAP approach by Siriwardana (2007) and ours does not stem from our modeling of the labor market, as becomes clear from comparing columns (7) and (8), but rather from the fact that Siriwardana (2007) models the U.S.-Australia FTA as tariff reductions only. Thereby he abstracts from modeling the reduction of non-tariff barriers by RTAs as we do by changing the RTA dummy.[43]

[Table 5 about here.]

3.4.3 Evaluating the effects of a hypothetical labor market reform

In our third counterfactual experiment, we evaluate the effects of a hypothetical labor market reform which improves U.S. labor market institutions. We implement this by a 5.4 percent increase in $\hat{\kappa}_j$ for the United States, i.e., we set $\hat{\kappa}_{U.S.}$ to 1.054. Given our estimate of the matching elasticity of $\mu = 0.933$, this change in $\hat{\kappa}_{U.S.}$ corresponds to either an increase of exactly 5 percent in the overall matching efficiency m_j or a 51 percent reduction of recruiting costs in the United States. Note that within our framework we do not necessarily have to specify the explicit source of changes in labor market institutions. The results of this experiment are set out in Table 6.[44]

[Table 6 about here.]

In all countries, unemployment falls when U.S. labor market institutions improve. This highlights the positive spillover effects, recently theorized by Egger et al. (2012) and Felbermayr et al. (2013), and documented empirically in a reduced-form setting in Felbermayr et al. (2013). Of course, when perfect labor markets are assumed, it is not possible to evaluate any change in them. Therefore, Columns (1) and (7) are uninformative. The decomposition of (log) total sales into (log) price and (log) employment changes highlights that in the United States prices fall and all increases in expenditure are due to increases in employment. This result can be understood when looking at the changes in the relative price p_j/P_j. When the U.S. labor market becomes more efficient, U.S. output will increase leading to a fall in prices of U.S.

[43] Welfare effects of RTAs are sensitive to these modeling choices. For a more detailed discussion, see Felbermayr et al. (2015b).

[44] Again, detailed results on the heterogeneous trade effects can be found in the Online Appendix.

goods relative to its imports. This deterioration of the relative price in the U.S. mitigates the increases in total sales due to the improvement in their labor-market institutions. For the trading partners of the United States, the effects on total sales are quite heterogeneous but, compared to the effect in the U.S., rather small, with the exception of Canada.

Concerning welfare, obviously the United States profit the most from the improvement in its labor market institutions, with an increase in welfare of 4.68 percent. However and importantly, all other countries also gain, with the highest gains for Canada at 2.72 percent.

4 Conclusion

State of the art frameworks for quantitative analyses of international trade policies to evaluate the trade and welfare implications of trade liberalization all assume perfect labor markets. However, net employment effects are at the heart of the political debate on trade integration. Accordingly, recent developments in international trade theory have highlighted the link between trade liberalization and labor market outcomes.

We build on these theoretical contributions to develop a quantitative framework of bilateral trade flows which takes into account labor market frictions within a search and matching framework. Our model allows counterfactual analyses of changes in trade costs and labor market reforms on total sales, trade flows, employment, and welfare.

We apply our structural model to a sample of 28 OECD countries from 1988 to 2006 to evaluate the effects of regional trade agreements (RTAs) and a hypothetical labor market reform in the United States. We find that introducing RTAs as observed in 2006 leads to greater welfare increases when accounting for aggregate employment effects for most countries. Countries with only slight increases in total sales see negative employment effects. As our second counterfactual, we analyze the U.S.-Australian Free Trade Agreement and find that it increases welfare in the United States by 0.30 percent and by 6.30 percent in Australia, while all other countries see slight negative welfare effects. Our third counterfactual analysis assumes a hypothetical improvement of labor market institutions in the United States. Typically, average welfare effects are substantially magnified when taking into account employment effects. While the United States profits the most from improvements of its labor market institutions with an equivalent variation of 4.68 percent, all of its trading partners also experience an increase in welfare due to positive spillover effects.

As our approach does not require any information about the labor market except for the elasticity of the matching function, it can be easily applied to any other field in which the gravity equation is employed.

The single sector nature of our homogeneous firm framework abstracts from short-run reallocation frictions across firms and sectors. Even though these effects might well be important, see Davidson and Matusz (2006), we leave these for future research.

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Appendix

Introduction to the Appendix

In this Appendix, we present further results and derivations.

In Section A we discuss the implications of a more general vacancy posting cost function for our quantitative framework.

In Section B, we derive the solution of the system of asymmetric multilateral resistance equations.

In Section C, we derive sufficient statistics for welfare with imperfect labor markets and show that in the case of imperfect labor markets, the welfare statistics presented in Arkolakis et al. (2012) are augmented by the net employment change.

A A more general vacancy posting cost function

In the main text, we assume that vacancy posting costs are denoted in terms of the final good, $c_j P_j$. This implies that the firm has to buy all the goods and services needed to open a vacancy on the market for a price of P_j. For example, the firm has to pay for advertisements or worker screenings like assessment centers etc. In reality, a firm may be able to produce at least some of these services within the firm. As the firm has to devote workers to do so who could otherwise produce a good which can be sold at price p_j, using in-house labor to produce the vacancy posting costs implies an opportunity cost for the firm of p_j. Hence, we can generalize our vacancy posting cost function by assuming that vacancy posting costs are a weighted average of the following Cobb-Douglas form:

$$c_j p_j^{\eta} P_j^{1-\eta}, \tag{19}$$

where η is the cost share of internally produced vacancy posting services in terms of firm output.[45]

Equalizing expected profits of a firm from employing an additional worker, $(p_j - w_j)m_j\vartheta_j^{-\mu}$, with the new vacancy posting cost function leads to the job creation curve:

$$w_j = p_j \left(1 - \frac{c_j \left(\frac{p_j}{P_j}\right)^{\eta-1}}{m_j\vartheta_j^{-\mu}}\right). \tag{20}$$

Combining the job creation curve with the wage curve, which is still given by $w_j = p_j\xi_j/(1 + \gamma_j\xi_j - \gamma_j)$, we can solve for the labor market tightness ϑ_j:

$$\vartheta_j = \left(\frac{p_j}{P_j}\right)^{\frac{1-\eta}{\mu}} \left(\frac{c_j}{m_j}\Omega_j\right)^{-\frac{1}{\mu}}. \tag{21}$$

Counterfactual employment effects for constant labor market institutions are given by $\hat{e}_j = [(p_j^c/P_j^c)/(p_j/P_j)]^{[(1-\eta)(1-\mu)/\mu]}$. The total differential of the exponent of the expression for the employment effect implies $d\mu/d\eta = -(1-\mu)\mu/(1-\eta) < 0$, i.e., for a given counterfactual change in the relative price p_j/P_j, μ and η act as substitutes: given the multiplicative form of the exponent, μ and η are not separately identified. In other words, for a given change in the relative price, our framework allows for different combinations of μ and η for a given μ estimated under the assumption $\eta = 0$ as we do in the main text and will still imply the same employment effects: one may choose a combination of μ and η according to whether one believes that labor market frictions are severe (implying low values of μ) and vacancy posting costs are predominantly payed in domestic goods (implying high values of η), or vice versa. Both a lower μ or a lower η will imply a larger impact of trade liberalization on the labor market. In this sense, μ and η are interchangeable.

We can redo the steps described in Section 3.2.2 to come up with an alternative estimator for μ: using Equation (8), i.e., $u_j = 1 - m_j\vartheta_j^{1-\mu}$, and Equation

[45] We thank one of the referees for this suggestion.

(21) and defining $\Xi_j \equiv m_j \left(\frac{c_j}{m_j}\Omega_j\right)^{\frac{\mu-1}{\mu}}$, we can write

$$1 - u_j = m_j \vartheta_j^{1-\mu} = m_j \left(\frac{p_j}{P_j}\right)^{\frac{(1-\eta)(1-\mu)}{\mu}} \left(\frac{c_j}{m_j}\Omega_j\right)^{-\frac{1-\mu}{\mu}} = \Xi_j \left(\frac{p_j}{P_j}\right)^{\frac{(1-\eta)(1-\mu)}{\mu}}.$$

As we observe u_j in the baseline, we may take ratios for two countries and the log of this ratio to obtain:

$$\ln\left(\frac{1-u_j}{1-u_m}\right) = \frac{(1-\eta)(1-\mu)}{\mu}\left[\ln\left(\frac{p_j}{P_j}\frac{P_m}{p_m}\right)\right] + \frac{\mu-1}{\mu}\left[\ln\left(\frac{c_j\Omega_j}{c_m\Omega_m}\right)\right] + \frac{1}{\mu}\ln\left(\frac{m_j}{m_m}\right).$$

Assuming $m_j = m_m$ and defining $\mu' = (1-\mu)/\mu$, we end up with

$$\ln\left(\frac{1-u_j}{1-u_m}\right) = \mu'(1-\eta)\left[\ln\left(\frac{p_j}{P_j}\frac{P_m}{p_m}\right)\right] + \mu'\left[-\ln\left(\frac{c_j\Omega_j}{c_m\Omega_m}\right)\right].$$

This expression can be solved for μ':

$$\mu' = \frac{\ln\left(\frac{1-u_j}{1-u_m}\right)}{(1-\eta)\ln\left(\frac{p_j}{P_j}\frac{P_m}{p_m}\right) - \ln\left(\frac{c_j\Omega_j}{c_m\Omega_m}\right)}. \tag{22}$$

As one can see from this expression, the value of μ' (and therefore μ) cannot be uniquely determined without knowing the value of η. With $\eta = 0$, we are back in our simplified model where vacancy posting costs are entirely paid in terms of the final good. With $\eta = 1$ we are in the other extreme case where vacancy posting costs are entirely paid in terms of firm's own goods. In this case, prices do no longer affect the estimate of μ'. Plausibly, η is somewhere between zero and one, so that prices will affect μ' , but less so than in the case where vacancy posting costs are fully paid in terms of the final good.

Deriving μ' from Equation (22) with respect to η and plugging in $u_j = 1 - m_j\vartheta_j^{1-\mu}$ while replacing ϑ_j by Equation (21), one can show that $\partial\mu/\partial\eta = (\partial\mu/\partial\mu')(\partial\mu'/\partial\eta) = -(1-\mu)\mu/(1-\eta) < 0$ if labor market institutions are identical across countries, i.e., $m_j = m_m$, $c_j = c_m$ and $\Omega_j = \Omega_m$. Note that this does not imply that unemployment rates are identical across countries, as labor market tightness depends on prices which differ across countries. This implies that our estimates under the assumption of $\eta = 0$ may well be an upper bound on the actual value of μ. This may explain why we find very high values of μ in our estimation in the main text if one considers labor market institutions across OECD countries to be relatively similar. Therefore, allowing for $\eta > 0$ if the researcher has data about the value of η implies a lower value of μ and hence implies higher labor market frictions as long as labor market institutons are sufficiently similar.

B Solution of asymmetric multilateral resistance equations

Using Equation (6), we can write $\Pi_i^{1-\sigma} = \sum_{j=1}^{n} t_{ij}^{1-\sigma} P_j^{\sigma-1} \frac{Y_j}{Y^W}$. Defining $\mathbb{P}_j \equiv \frac{Y_j}{Y^W} P_j^{\sigma-1}$ leads to $\Pi_i^{1-\sigma} = \sum_{j=1}^{n} t_{ij}^{1-\sigma} \mathbb{P}_j$. Similarly, P_j can be written as $P_j^{1-\sigma} = \sum_{i=1}^{n} t_{ij}^{1-\sigma} \Pi_i^{\sigma-1} \frac{Y_i}{Y^W}$. Defining $\mathbb{\Pi}_i \equiv \frac{Y_i}{Y^W} \Pi_i^{\sigma-1}$ leads to $P_j^{1-\sigma} = \sum_{i=1}^{n} t_{ij}^{1-\sigma} \mathbb{\Pi}_i$. Now dividing $\Pi_i^{1-\sigma} = \sum_{j=1}^{n} t_{ij}^{1-\sigma} \mathbb{P}_j$ by $\Pi_i^{1-\sigma}$ and using again $\mathbb{\Pi}_i = \frac{Y_i}{Y^W} \Pi_i^{\sigma-1}$ leads to $\frac{Y_i}{Y^W} = \mathbb{\Pi}_i \sum_{j=1}^{n} t_{ij}^{1-\sigma} \mathbb{P}_j$. Similarly, dividing $P_j^{1-\sigma} = \sum_{i=1}^{n} t_{ij}^{1-\sigma} \mathbb{\Pi}_i$ by $P_j^{1-\sigma}$ and using again $\mathbb{P}_j = \frac{Y_j}{Y^W} P_j^{\sigma-1}$ leads to $\frac{Y_j}{Y^W} = \mathbb{P}_j \sum_{i=1}^{n} t_{ij}^{1-\sigma} \mathbb{\Pi}_i$. $\frac{Y_i}{Y^W} = \mathbb{\Pi}_i \sum_{j=1}^{n} t_{ij}^{1-\sigma} \mathbb{P}_j$ and $\frac{Y_j}{Y^W} = \mathbb{P}_j \sum_{i=1}^{n} t_{ij}^{1-\sigma} \mathbb{\Pi}_i$ define a system of $2n$ equations that can be solved for the $2n$ unknowns $\mathbb{\Pi}_i$ and $\mathbb{P}_j$ in the observed baseline scenario.

To solve for the counterfactual $\mathbb{\Pi}_i^c$s and $\mathbb{P}_j^c$s, we take into account the changes in Y_j^c according to Implication 4 when solving for the $2n$ $\mathbb{\Pi}_i^c$s and $\mathbb{P}_j^c$s. Finally, we can compute P_j, Π_i, P_j^c, and Π_i^c from the solutions $\mathbb{P}_j$, $\mathbb{\Pi}_i$, $\mathbb{P}_j^c$, and $\mathbb{\Pi}_i^c$ using their definitions above.

C Sufficient statistics for welfare with imperfect labor markets

We follow Arkolakis et al. (2012) in the following derivations. Using $Y_j = p_j(1-u_j)L_j$, we can write $d\ln Y_j = d\ln p_j - u_j/(1-u_j)d\ln u_j = -u_j/(1-u_j)d\ln u_j$ assuming that the labor force remains constant. The second expression on the right-hand side uses the wage curve $w_j = p_j\xi_j/(1+\gamma_j\xi_j-\gamma_j)$, implying $d\ln w_j = d\ln p_j$ as we hold constant all labor market parameters and choose the wage of the particular country j under study as our numéraire (in this section). Defining real wages as $W_j \equiv w_j(1-u_j)L_j/P_j$ and taking logs, the total differential is given by $d\ln W_j = -u_j/(1-u_j)d\ln u_j - d\ln P_j$.

The total differential of $\ln P_j = \ln\left\{\left[\sum_{i=1}^{n}\left(\beta_i p_i t_{ij}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}\right\}$ is given by

$$d\ln P_j \;=\; \sum_{i=1}^{n}\left(\left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{1-\sigma} d\ln p_i + \left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{1-\sigma} d\ln t_{ij}\right).$$

Using $X_{ij} = \left((\beta_i p_i t_{ij})/P_j\right)^{1-\sigma} Y_j$ and defining $\lambda_{ij} = X_{ij}/Y_j = \left((\beta_i p_i t_{ij})/P_j\right)^{1-\sigma}$, yields

$$d\ln P_j = \sum_{i=1}^{n}\lambda_{ij}\left(d\ln p_i + d\ln t_{ij}\right). \tag{23}$$

Noting again that $d\ln p_i = d\ln w_i$ holds, we can also write: $d\ln P_j = \sum_{i=1}^{n}\lambda_{ij}\left(d\ln w_i + d\ln t_{ij}\right)$. Combining terms leads to $d\ln W_j = d\ln Y_j - d\ln P_j = -\frac{u_j}{1-u_j}d\ln u_j - \sum_{i=1}^{n}\lambda_{ij}\left(d\ln w_i + d\ln t_{ij}\right)$. Taking the ratio of λ_{ij} and λ_{jj} we can write $\lambda_{ij}/\lambda_{jj} = \left[(\beta_i p_i t_{ij})/(\beta_j p_j t_{jj})\right]^{1-\sigma}$. Assuming that $dt_{jj} = 0$, i.e., internal trade costs of country j do not change, and that w_j is the numéraire, so that $dw_j = dp_j = 0$, the log-change of this ratio is given by $d\ln\lambda_{ij} - d\ln\lambda_{jj} = (1-\sigma)\left(d\ln p_i + d\ln t_{ij}\right)$. Combining this with Equation (23) leads to:

$$d\ln P_j \;=\; \frac{1}{1-\sigma}\left(\sum_{i=1}^{n}\lambda_{ij} d\ln\lambda_{ij} - d\ln\lambda_{jj}\sum_{i=1}^{n}\lambda_{ij}\right).$$

Noting that $Y_j = \sum_{i=1}^{n} X_{ij}$, it follows that $\sum_{i=1}^{n} \lambda_{ij} = 1$ and $d\sum_{i=1}^{n} \lambda_{ij} = \sum_{i=1}^{n} d\lambda_{ij} = 0$. Hence, $\sum_{i=1}^{n} \lambda_{ij} d\ln\lambda_{ij} = \sum_{i=1}^{n} d\lambda_{ij} = 0$. Using these facts, the above expression simplifies to $d\ln P_j = -\frac{1}{1-\sigma} d\ln\lambda_{jj}$. The welfare change can then be expressed as $d\ln W_j = -\frac{u_j}{1-u_j} d\ln u_j + \frac{1}{1-\sigma} d\ln\lambda_{jj}$. Integrating between the initial and the counterfactual situation we get $\ln\hat{W}_j = \ln\hat{e}_j + \frac{1}{1-\sigma}\ln\hat{\lambda}_{jj}$, where $e_j = 1 - u_j$ is the share of employed workers. Taking exponents leads to $\hat{W}_j = \hat{e}_j \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}$. Note that $\hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}$ can be expressed as $\hat{\lambda}_{jj}^{\frac{1}{1-\sigma}} = \widehat{\left(\frac{p_j}{P_j}\right)}$ using $\lambda_{jj} = ((\beta_j p_j t_{jj})/P_j)^{1-\sigma}$ and recalling that β_j and t_{jj} are constant. Moving from any observed level of trade to autarky, i.e., $\lambda_{jj}^{c} = 1$, yields $\hat{W}_j = \hat{e}_j (\lambda_{jj})^{-\frac{1}{1-\sigma}}$. Note, however, that in contrast to the case with perfect labor markets considered in Arkolakis et al. (2012), even this expression needs information about employment changes.

D List of included RTAs

For our *RTA* dummy, we use Mario Larch's RTA database which can be accessed at `http://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html`. It includes the following RTAs: Australia New Zealand Closer Economic Agreement (CER), European Free Trade Association (EFTA), Protocol on Trade Negotiations (PTN), European Community/Union and Turkey, European Community/Union and Slovak Republic, European Community/Union and Austria, European Community/Union and Poland, EFTA and Hungary, Finland and Hungary, Turkey and Poland, European Community/Union and Switzerland, EFTA and Turkey, South Pacific Regional Trade and Economic Cooperation Agreement (SPARTECA), EFTA and Korea, European Community/Union and Czechoslovakia, Canada United States Free Trade Agreement, European Community/Union and Czech Republic and Slovak Republic, European Community/Union and Sweden, EFTA and Poland, Finland and Poland, European Community/Union, European Community/Union and Iceland, EFTA and Iceland, North American Free Trade Agreement (NAFTA), European Community/Union and Hungary, Czech Republic and Slovak Republic, European Community/Union and Finland, EFTA and Slovak Republic, Hungary and Turkey, Central European Free Trade Agreement (CEFTA), European Community/Union and Norway, European Economic Area (EEA), U.S.-Australia Free Trade Agreement, Czech Republic and Turkey, EFTA and Switzerland, Finland and Germany, Slovak Republic and Turkey.

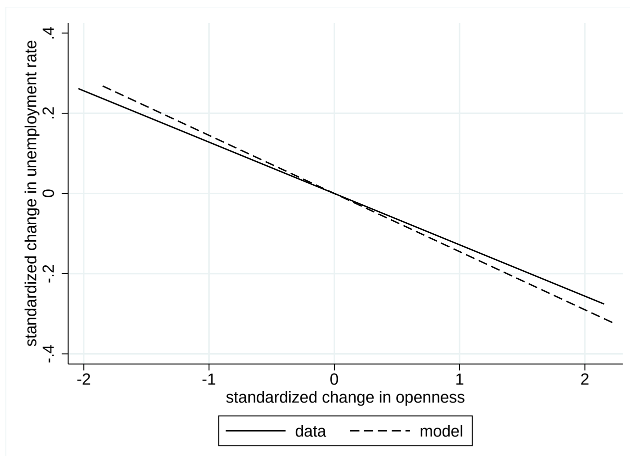

Figure 1: Implied regression lines of changes in openness and unemployment rates for both model and data.

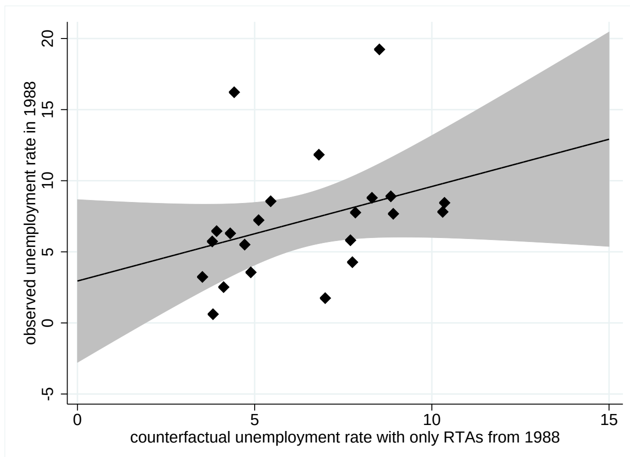

Figure 2: Graph depicts the implied regression line and the according 95% confidence interval of the regression of observed unemployment rates in 1988 on the counterfactual unemployment rates implied by the model with RTAs signed until 1988 only as well as the according scatterplot.

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.
X_{ijs} (current million US$)	5367.178	15340.135	0.061	348420.6
GDP_{is} (current million US$)	933259.51	1888767.495	5588.502	13201819
GDP_{js} (current million US$)	1018788.019	1940871.763	6127.601	13201819
RTA_{ijs}	0.586	0.493	0	1
$\ln(1 + simpleaveragetariffAPPLIED)_{ijs}$	0.032	0.034	0	0.341
$\ln(1 + simpletarifflineaveragetariffAPPLIED)_{ijs}$	0.037	0.038	0	0.77
$\ln(1 + weightedaveragetariffAPPLIED)_{ijs}$	0.027	0.036	0	0.452
$\ln DIST_{ij}$	7.987	1.127	5.081	9.880
$CONTIG_{ij}$	0.079	0.27	0	1
$COMLANG_{ij}$	0.084	0.277	0	1
N		10956		

Notes: Summary statistics for the OECD regression sample from 1988 to 2006. The 28 countries included are Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. Data are taken from Head et al. (2010), Mario Larch's RTA data base, and WITS. As bilateral tariff rates are not available as a balanced panel, the summary statistics for GDP_{is} and GDP_{js} are different.

Table 2: Estimation results for OECD sample, 1988-2006

	(1) OLS $\ln Z_{ijs}$	(2) PPML Z_{ijs}	(3) OLS $\ln Z_{ijs}$	(4) PPML Z_{ijs}	(5) OLS $\ln Z_{ijs}$	(6) PPML Z_{ijs}	(7) OLS $\ln Z_{ijs}$	(8) PPML Z_{ijs}
First stage								
RTA_{ijs}	0.222***	0.182**	0.188***	0.160**	0.199***	0.159**	0.203***	0.161**
	(0.036)	(0.073)	(0.036)	(0.071)	(0.036)	(0.071)	(0.036)	(0.071)
Second stage								
$\ln DIST_{ij}$	-1.080***	-1.077***	-1.071***	-1.065***	-1.075***	-1.066***	-1.075***	-1.072***
	(0.016)	(0.015)	(0.016)	(0.015)	(0.016)	(0.015)	(0.016)	(0.015)
$CONTIG_{ij}$	0.297***	0.512***	0.301***	0.519***	0.300***	0.519***	0.296***	0.513***
	(0.031)	(0.034)	(0.031)	(0.035)	(0.031)	(0.035)	(0.031)	(0.035)
$COMLANG_{ij}$	0.145***	-0.113***	0.147***	-0.112***	0.146***	-0.114***	0.151***	-0.111***
	(0.027)	(0.037)	(0.027)	(0.037)	(0.027)	(0.037)	(0.027)	(0.037)
Estimated elasticities								
σ using method from Section 3.2.1	1.089***	1.064***						
	(0.014)	(0.005)						
σ using $\ln(1 + simpleaverageAPPLIED_{ijs})$			1.673***	1.765***				
			(0.254)	(0.356)				
σ using $\ln(1 + simpletarifflineaverageAPPLIED_{ijs})$					0.954***	1.515***		
					(0.192)	(0.320)		
σ using $\ln(1 + weightedaverageAPPLIED_{ijs})$							1.351***	1.276***
							(0.171)	(0.289)
μ using method from Section 3.2.2	0.981***	0.989***	0.930***	0.933***	0.992***	0.946***	0.946***	0.964***
	(0.004)	(0.003)	(0.011)	(0.015)	(0.019)	(0.017)	(0.017)	(0.022)
N	10956	10956	10956	10956	10956	10956	10956	10956

Notes: Results for trade flows between 28 OECD countries between 1988 and 2006 (unbalanced panel) estimated by ordinary least squares (OLS) and Poisson pseudo-maximum-likelihood (PPML). Z_{ijs} are trade flows standardized by importer and exporter GDPs. RTA_{ijs} is an indicator variable equal to 1 if there exists a regional trade agreement between exporting country i and importing country j in year s, $\ln DIST_{ij}$ is the logarithm of the distance between exporting and importing country, $CONTIG_{ij}$ is an indicator variable equal to 1 if the exporting and importing countries share a common border, and $COMLANG_{ij}$ is an indicator variable equal to 1 if the exporting and importing country share a common official language. $\ln(1 + simpleaverageAPPLIED_{ijs})$ is the logarithm of 1 plus the simple average of the effectively applied tariff rate for imports from i in j calculated at the HS 6-digit level, $\ln(1 + simpletarifflineaverageAPPLIED_{ijs})$ is the logarithm of 1 plus the simple average of the effectively applied tariff rate for imports from i in j calculated at the tariff line level, and $\ln(1 + weightedaverageAPPLIED_{ijs})$ is 1 plus the logarithm of the weighted average of the effectively applied tariff rate with weights given by the corresponding trade value. All regressions control for multilateral resistance terms (MRTs) via time-varying exporter and importer fixed effects. To control for the potential endogeneity of RTA_{ijs} and the tariff variables, all first stage regressions additionally include directional bilateral time-invariant fixed effects. Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors for μ in all columns as well as σ in columns (1) and (2) are bootstrapped. Remaining standard errors are analytic heteroscedasticity-robust standard errors.

Table 3: Comparative static effects of RTA inception controlling for trade imbalances and tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share %Y SMF		SMF	SMF	PLM	SMF
	%Y	%Y	$\% \ln(\hat{p})$	$\% \ln(\hat{e})$	%$\hat{e}$	Δu	%EV	%EV
Australia	4.04	4.57	92.09	7.91	0.35	-0.34	4.91	5.23
Austria	7.89	9.03	84.50	15.50	1.35	-1.27	20.43	21.68
Belgium	7.87	9.00	84.71	15.29	1.33	-1.20	20.03	21.29
Canada	9.80	10.95	84.43	15.57	1.63	-1.50	25.86	26.65
Czech Republic	8.29	9.47	84.29	15.71	1.43	-1.31	21.85	23.07
Denmark	7.56	8.65	84.80	15.20	1.27	-1.20	19.09	20.24
Finland	6.42	7.37	85.58	14.42	1.03	-0.94	15.16	16.03
France	6.98	8.01	85.08	14.92	1.16	-1.04	17.20	18.31
Germany	6.26	7.20	86.18	13.82	0.97	-0.86	14.06	15.06
Greece	6.02	6.94	85.59	14.41	0.97	-0.88	14.23	15.15
Hungary	7.67	8.78	84.67	15.33	1.30	-1.19	19.56	20.66
Iceland	5.95	6.82	85.99	14.01	0.93	-0.89	13.61	14.32
Ireland	7.68	8.74	84.95	15.05	1.27	-1.20	19.14	20.09
Italy	6.13	7.06	86.00	14.00	0.96	-0.89	13.99	14.95
Japan	2.07	2.38	101.06	-1.06	-0.02	0.02	-0.47	-0.49
Korea	2.13	2.45	100.50	-0.50	-0.01	0.01	-0.30	-0.30
Netherlands	7.60	8.67	85.27	14.73	1.23	-1.16	18.45	19.58
New Zealand	3.68	4.20	92.12	7.88	0.33	-0.31	4.43	4.61
Norway	7.24	8.27	85.26	14.74	1.18	-1.12	17.65	18.79
Poland	7.53	8.62	84.69	15.31	1.27	-1.08	19.18	20.29
Portugal	6.99	8.00	85.07	14.93	1.16	-1.06	17.25	18.25
Slovak Republic	8.10	9.26	84.38	15.62	1.39	-1.19	21.16	22.33
Spain	6.07	6.99	85.74	14.26	0.97	-0.88	14.14	15.07
Sweden	6.97	7.98	85.17	14.83	1.15	-1.05	17.02	18.00
Switzerland	7.97	9.12	84.47	15.53	1.36	-1.30	20.75	22.15
Turkey	6.09	7.00	85.88	14.12	0.96	-0.85	14.08	14.97
United Kingdom	4.94	5.73	87.03	12.97	0.73	-0.68	10.32	11.11
United States	2.44	2.82	97.49	2.51	0.07	-0.07	0.76	0.91
Average	4.39	5.04	92.41	7.59	0.53	-0.48	7.71	8.23

Notes: Counterfactual analysis is based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table 4: Average comparative static effects of RTA inception for various parameter values

μ	σ	PLM $\%Y$	SMF $\%Y$	SMF $\%\hat{e}$	SMF Δu	PLM $\%EV$	SMF $\%EV$
	5	0.75	6.83	5.77	-4.85	1.40	7.30
0.2	10	0.33	2.91	2.51	-2.21	0.62	3.16
	15	0.21	1.84	1.60	-1.44	0.40	2.01
	5	0.75	2.24	1.40	-1.26	1.40	2.84
0.5	10	0.33	0.96	0.62	-0.56	0.62	1.24
	15	0.21	0.61	0.40	-0.36	0.40	0.80
	5	0.75	1.25	0.46	-0.42	1.40	1.88
0.75	10	0.33	0.54	0.21	-0.19	0.62	0.83
	15	0.21	0.34	0.13	-0.12	0.40	0.53
	5	0.75	0.92	0.15	-0.14	1.40	1.56
0.9	10	0.33	0.40	0.07	-0.06	0.62	0.69
	15	0.21	0.25	0.04	-0.04	0.40	0.44
	5	0.75	0.77	0.01	-0.01	1.40	1.42
0.99	10	0.33	0.33	0.01	-0.01	0.62	0.62
	15	0.21	0.21	0.00	-0.00	0.40	0.40

Notes: Table reports average changes in total sales, employment, unemployment, and the equivalent variation in percent assuming either a perfect labor market (PLM) or using a search and matching framework (SMF) for the labor market assuming balanced trade and setting tariffs to 0 with varying elasticity of substitution σ and elasticity of the matching function μ. The remaining parameters are set to values from column (4) of Table 2.

Table 5: Comparative static effects of the U.S.-Australia Free Trade Agreement controlling for trade imbalances and tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share %Y SMF		SMF	SMF	PLM	SMF
	%Y	%Y	$\%\ln(\hat{p})$	$\%\ln(\hat{e})$	$\%\hat{e}$	Δu	$\%EV$	$\%EV$
Australia	2.28	2.51	83.43	16.57	0.41	-0.39	5.95	6.30
Austria	-0.04	-0.04	97.07	2.93	-0.00	0.00	-0.01	-0.01
Belgium	-0.04	-0.04	97.95	2.05	-0.00	0.00	-0.01	-0.01
Canada	-0.09	-0.09	91.75	8.25	-0.01	0.01	-0.11	-0.10
Czech Republic	-0.04	-0.04	97.04	2.96	-0.00	0.00	-0.01	-0.01
Denmark	-0.04	-0.04	96.68	3.32	-0.00	0.00	-0.02	-0.02
Finland	-0.05	-0.04	94.09	5.91	-0.00	0.00	-0.04	-0.04
France	-0.04	-0.04	97.12	2.88	-0.00	0.00	-0.01	-0.01
Germany	-0.04	-0.04	97.25	2.75	-0.00	0.00	-0.01	-0.01
Greece	-0.04	-0.04	94.53	5.47	-0.00	0.00	-0.03	-0.03
Hungary	-0.04	-0.04	95.75	4.25	-0.00	0.00	-0.02	-0.02
Iceland	-0.06	-0.05	92.42	7.58	-0.00	0.00	-0.06	-0.06
Ireland	-0.04	-0.04	96.70	3.30	-0.00	0.00	-0.02	-0.02
Italy	-0.04	-0.04	96.12	3.88	-0.00	0.00	-0.02	-0.02
Japan	-0.02	-0.02	83.82	16.18	-0.00	0.00	-0.04	-0.04
Korea	-0.02	-0.02	83.70	16.30	-0.00	0.00	-0.04	-0.04
Netherlands	-0.04	-0.04	97.87	2.13	-0.00	0.00	-0.01	-0.01
New Zealand	-0.03	-0.03	-19.71	119.71	-0.03	0.03	-0.54	-0.50
Norway	-0.04	-0.04	94.95	5.05	-0.00	0.00	-0.03	-0.03
Poland	-0.04	-0.04	95.99	4.01	-0.00	0.00	-0.02	-0.02
Portugal	-0.04	-0.04	95.05	4.95	-0.00	0.00	-0.03	-0.03
Slovak Republic	-0.04	-0.04	96.15	3.85	-0.00	0.00	-0.02	-0.02
Spain	-0.04	-0.04	95.45	4.55	-0.00	0.00	-0.03	-0.03
Sweden	-0.04	-0.04	95.24	4.76	-0.00	0.00	-0.03	-0.03
Switzerland	-0.04	-0.04	97.58	2.42	-0.00	0.00	-0.01	-0.01
Turkey	-0.04	-0.04	92.56	7.44	-0.00	0.00	-0.04	-0.04
United Kingdom	-0.04	-0.04	97.16	2.84	-0.00	0.00	-0.01	-0.01
United States	0.02	0.03	40.61	59.39	0.02	-0.02	0.28	0.30
Average	0.03	0.05	73.26	26.74	0.01	-0.01	0.21	0.23

Notes: Counterfactual analysis is based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table 6: Comparative static effects of $\hat{\kappa}_{U.S.} = 1.054$ controlling for trade imbalances and tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share %Y SMF		SMF	SMF	PLM	SMF
	%Y	%Y	$\% \ln(\hat{p})$	$\% \ln(\hat{e})$	$\%\hat{e}$	Δu	$\%EV$	$\%EV$
Australia	0.00	0.14	73.01	26.99	0.04	-0.04	-0.00	0.60
Austria	0.00	-0.01	267.65	-167.65	0.01	-0.01	0.00	0.21
Belgium	0.00	-0.02	139.88	-39.88	0.01	-0.01	-0.00	0.16
Canada	0.00	0.81	77.53	22.47	0.18	-0.17	-0.00	2.72
Czech Republic	0.00	-0.00	615.17	-515.17	0.01	-0.01	0.00	0.22
Denmark	0.00	0.01	-11.89	111.89	0.01	-0.01	0.00	0.26
Finland	0.00	0.08	66.90	33.10	0.03	-0.02	0.00	0.46
France	-0.00	-0.00	993.89	-893.89	0.01	-0.01	-0.00	0.22
Germany	-0.00	-0.01	302.57	-202.57	0.01	-0.01	-0.00	0.21
Greece	0.00	0.03	37.06	62.94	0.02	-0.02	0.00	0.33
Hungary	0.00	0.02	31.43	68.57	0.02	-0.01	0.00	0.30
Iceland	-0.00	0.23	75.04	24.96	0.06	-0.06	-0.00	0.92
Ireland	0.00	0.02	26.63	73.37	0.02	-0.02	0.00	0.31
Italy	-0.00	0.01	-7.07	107.07	0.01	-0.01	-0.00	0.27
Japan	0.00	0.03	57.94	42.06	0.01	-0.01	-0.00	0.25
Korea	0.00	0.03	54.60	45.40	0.01	-0.01	0.00	0.27
Netherlands	-0.00	-0.02	149.87	-49.87	0.01	-0.01	-0.00	0.18
New Zealand	0.00	0.16	73.52	26.48	0.04	-0.04	0.00	0.70
Norway	0.00	0.07	64.47	35.53	0.02	-0.02	0.00	0.41
Poland	0.00	0.02	31.04	68.96	0.02	-0.01	0.00	0.29
Portugal	0.00	0.06	59.63	40.37	0.03	-0.02	0.00	0.44
Slovak Republic	0.00	0.01	1.50	98.50	0.01	-0.01	0.00	0.27
Spain	-0.00	0.05	52.67	47.33	0.02	-0.02	-0.00	0.38
Sweden	0.00	0.05	59.78	40.22	0.02	-0.02	0.00	0.38
Switzerland	0.00	-0.02	152.95	-52.95	0.01	-0.01	0.00	0.17
Turkey	0.00	0.07	63.23	36.77	0.03	-0.02	-0.00	0.45
United Kingdom	-0.00	0.00	-338.74	438.74	0.01	-0.01	-0.00	0.24
United States	0.00	2.92	-80.16	180.16	5.32	-5.08	0.00	4.68
Average	0.00	1.12	63.25	36.75	1.98	-1.89	0.00	1.99

Notes: Counterfactual analysis is based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Gravity with Unemployment
Online Appendix

Benedikt Heid and Mario Larch*

*Heid: University of Bayreuth, CESifo, Universitätsstraße 30, 95447 Bayreuth, Germany, benedikt.heid@uni-bayreuth.de. Larch: University of Bayreuth, CESifo, ifo Institute, and GEP at University of Nottingham, Universitätsstraße 30, 95447 Bayreuth, Germany, mario.larch@uni-bayreuth.de. A previous version of this paper has been circulated under the title "International Trade and Unemployment: A Quantitative Framework". Funding from the DFG under project 592405 is gratefully acknowledged. We thank Daniel Bernhofen, Hartmut Egger, Christian Holzner, Kala Krishna, John McLaren, Marc-Andreas Muendler, Emanuel Ornelas, Yoto Yotov, participants at the GEP Postgraduate Conference 2012, the CESifo Area Conference on Global Economy 2012, the European Trade Study Group 2012, the Annual Meeting of the European Society of Population Economics 2012, the Annual Meeting of the Verein für Socialpolitik 2013, the Annual Congress of the European Economic Association 2013, the CAGE International Trade Research Day 2013, research seminars at the Universities of Trier and Innsbruck, and the 7th FIW-Research Conference on International Economics 2014, for helpful comments. As always, we have a property right on any remaining errors.

Introduction to the Online Appendix

In this Online Appendix, we present further results and robustness checks for the paper "Gravity with Unemployment".

In Section A, we extend our basic model to allow for tariff revenues and trade imbalances.

In Section B, we present a variant of our model where wages are determined by a binding minimum wage instead of bargaining once the match between a worker and firm is established. We derive counterfactual changes in employment and show that for constant labor market institutions, calculated employment changes are identical to the ones assuming wage bargaining as in the main text.

In Section C, we assume that the wage setting process is determined within an efficiency wage framework. Again, when labor market institutions remain unchanged, calculated changes in employment and total sales are identical to the model presented in the main text.

In Section D, we present an alternative model setup in the vein of the Ricardian model of international trade by Eaton and Kortum (2002) and show that our results from the main text hold when reinterpreting the elasticity of substitution as the technology dispersion parameter used in Eaton and Kortum (2002).

Section E presents further results on trade flow and employment changes for the evaluation of RTAs and the hypothetical labor market reform in the United States.

Section F presents results from the evaluation of RTAs with tariff rates set to 0, i.e., without tariff income.

Section G presents results for the counterfactual analyses in Section 3.4 from the main text under the assumption of balanced trade.

Section H provides additional details concerning the tariff data.

Section I presents the full distributions of the estimated elasticities when using the estimation methods described in Section 3.2 from the main text.

Finally, Section J derives an alternative, more robust estimation method for the elasticity of the matching function, μ, if a panel of both trade flows and labor market data is available.

A A quantitative framework for trade and unemployment with trade imbalances and tariffs

A.1 Goods market

The representative consumer in country j is characterized by the utility function U_j. We assume that goods are differentiated by country of origin, i.e., we use the simplest possible way to provide a rationale for bilateral trade between similar countries based on preferences à la Armington (1969).[1] In Section D of this Online Appendix, we demonstrate that our framework and counterfactual analysis are isomorphic to a Ricardian model of international trade along the lines of Eaton and Kortum (2002). Country j purchases quantity q_{ij} of goods from country i, leading to the utility function

$$U_j = \left[\sum_{i=1}^{n} \beta_i^{\frac{1-\sigma}{\sigma}} q_{ij}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{24}$$

where n is the number of countries, σ is the elasticity of substitution in consumption, and β_i is a positive preference parameter measuring the product appeal for goods from country i.

Trade of goods from i to j imposes iceberg trade costs $t_{ij} \geq 1$ and ad-valorem tariffs τ_{ij}, defined as 1 plus the tariff rate. Assuming factory-gate pricing implies that $p_{ij} = p_i t_{ij} \tau_{ij}$, where p_i denotes the factory gate price of the good in country i.

The representative consumer maximizes Equation (24) subject to the bud-

[1] Consequently, we deliberately abstract from distinguishing between the intensive and extensive margin of international trade as for example in Chaney (2008) or Helpman et al. (2008).

get constraint $E_j = \sum_{i=1}^{n} p_i t_{ij} \tau_{ij} q_{ij}$, where her expenditure E_j is given by $E_j = Y_j(1 + d_j) + T_j$, with Y_j denoting total sales in country j, d_j the share of the exogenously given trade deficit (if $d_j > 0$) or surplus (if $d_j < 0$) of country j in terms of total sales, following Dekle et al. (2007) and Costinot and Rodríguez-Clare (2014), and T_j are tariff revenues of country j. Trade deficits are calculated as the difference between a country's imports and exports from the trade flow matrix between all countries in our data set. This ensures that trade deficits are lump-sum transfers across countries, i.e., $\sum_{i=1}^{n} d_i Y_i = 0$. It also implies that trade is balanced at the world level. The value of aggregate sales of goods from country i to country j before tariffs are levied can then be expressed as

$$X_{ij} \;\; = \;\; p_i t_{ij} q_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j} \right)^{1-\sigma} \tau_{ij}^{-\sigma} E_j, \tag{25}$$

and P_j is the standard CES price index given by $P_j = [\sum_{i=1}^{n} (\beta_i p_i t_{ij} \tau_{ij})^{1-\sigma}]^{1/(1-\sigma)}$. Tariff revenues are given by the sum of all tariffs levied on all imports, i.e., $T_i = \sum_{j=1}^{n} (\tau_{ji} - 1) X_{ji}$.

In general equilibrium, total sales correspond to the sum of all exports, i.e., $Y_i = \sum_{j=1}^{n} X_{ij}$. Assuming labor to be the only factor of production which produces one unit of output per worker, total sales in a world with imperfect labor markets is given by total production of the final output good multiplied with its price, i.e., $Y_i = p_i(1 - u_i)L_i$.

This setup implies a gravity equation for bilateral trade flows. Using

$$\begin{aligned} Y_i &= \sum_{j=1}^{n} X_{ij} = \sum_{j=1}^{n} \left(\frac{\beta_i t_{ij} p_i}{P_j} \right)^{1-\sigma} \tau_{ij}^{-\sigma} E_j \\ &= (\beta_i p_i)^{1-\sigma} \sum_{j=1}^{n} \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \tau_{ij}^{-\sigma} E_j, \end{aligned} \tag{26}$$

and solving for scaled prices $\beta_i p_i$ and defining $Y^W \equiv \sum_j Y_j$, we can write bilateral trade flows as given in Equation (25) as

$$X_{ij} = \frac{Y_i E_j}{Y^W} \left(\frac{t_{ij}}{\Pi_i P_j} \right)^{1-\sigma} \tau_{ij}^{-\sigma}, \quad \text{where} \tag{27}$$

$$\Pi_i = \left(\sum_{j=1}^{n} \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \tau_{ij}^{-\sigma} \frac{E_j}{Y^W} \right)^{1/(1-\sigma)}, \quad P_j = \left(\sum_{i=1}^{n} \left(\frac{t_{ij}\tau_{ij}}{\Pi_i} \right)^{1-\sigma} \frac{Y_i}{Y^W} \right)^{1/(1-\sigma)}, \tag{28}$$

while we substituted equilibrium scaled prices into the definition of the price index to obtain the multilateral resistance terms P_j.

Note that this system of equations exactly corresponds to the system given in Equations (9)-(11) in Anderson and van Wincoop (2003) or Equations (5.32) and (5.35) in Feenstra (2004) assuming balanced trade, $d_i = 0$ for all i, and no tariffs, i.e., $\tau_{ij} = 1$ between all i and j (i.e., $Y_i{=}E_i$), even when labor markets are imperfect.

By adding a stochastic error term, Equation (27) can be written as

$$Z_{ij} \equiv \frac{X_{ij}}{Y_i E_j} = \exp\left[k - (1-\sigma)\ln t_{ij} - \sigma \ln \tau_{ij} - \ln \Pi_i^{1-\sigma} - \ln P_j^{1-\sigma} + \varepsilon_{ij}\right], \tag{29}$$

where ε_{ij} is a random disturbance term or measurement error, assumed to be identically distributed and mean-independent of the remaining terms on the right-hand side of Equation (29), and k is a constant capturing the logarithm of world sales. Importer and exporter fixed effects can be used to control for the outward and inward multilateral resistance terms Π_i and P_j, respectively, as suggested by Anderson and van Wincoop (2003) and Feenstra (2004). Hence, even with labor market frictions, we can use established methods to estimate trade costs using the gravity equation, independently of the underlying labor market model. We summarize this result in Implication 5:

Implication 5 *The estimation of trade costs is unchanged when allowing for imperfect labor markets, even when allowing for trade imbalances and tariffs.*

To evaluate ex ante welfare effects of changes in trade policies, we need the counterfactual changes in employment and total sales in addition to trade cost parameter estimates. To derive these, we have to take a stance on how to model the labor market, to which we turn in the next section.

A.2 Labor market

We model the labor market using a one-shot version of the search and matching framework (SMF, see Mortensen and Pissarides, 1994 and Pissarides, 2000) which is closely related to Felbermayr et al. (2013).[2] Search-theoretic frameworks fit stylized facts of labor markets in developed economies as they explain why some workers are unemployed even if firms cannot fill all their vacancies.[3]

The labor market is characterized by frictions. All potential workers in country j, L_j, have to search for a job, and firms post vacancies V_j in order to find workers. The number of successful matches between an employer and a worker, M_j, is given by $M_j = m_j L_j^{\mu} V_j^{1-\mu}$, where $\mu \in (0,1)$ is the elasticity of the matching function with respect to the unemployed and m_j measures the overall efficiency of the labor market.[4] Only a fraction of open vacancies will be filled, $M_j/V_j = m_j \left(V_j/L_j\right)^{-\mu} = m_j \vartheta_j^{-\mu}$, and only a fraction of all workers will find a job, $M_j/L_j = m_j \left(V_j/L_j\right)^{1-\mu} = m_j \vartheta_j^{1-\mu}$, where $\vartheta_j \equiv V_j/L_j$ denotes the degree of labor market tightness in country j.[5] This implies that

[2] See Rogerson et al. (2005) for a survey of search and matching models, including an exposition of a simplified one-shot (directed) search model. For other recent trade models using a similar static framework without directed search, see for example Keuschnigg and Ribi (2009), Helpman and Itskhoki (2010), and Heid et al. (2013). We use the labor market setup from Felbermayr et al. (2013). However, they do not investigate its implications for the estimation of gravity equations nor do they structurally estimate it or use it for a counterfactual quantitative analysis. They also do not present labor market setups with minimum and efficiency wages nor do they consider alternative trade models such as the Eaton and Kortum (2002) framework as we do in our Online Appendix.

[3] They are less successful in explaining the cyclical behavior of unemployment and vacancies, see Shimer (2005). This deficiency is not crucial in our case as we purposely focus on the steady state.

[4] Note that we assume a constant returns to scale matching function in line with empirical studies, see Petrongolo and Pissarides (2001).

[5] We assume that the matching efficiency is sufficiently low to ensure that M_j/V_j and M_j/L_j lie between 0 and 1.

the unemployment rate is given by

$$u_j = 1 - m_j \vartheta_j^{1-\mu}. \tag{30}$$

As is standard in search models, we assume that every firm employs one worker. Similar to Helpman and Itskhoki (2010), this assumption does not lead to any loss of generality as long as the firm operates under perfect competition and constant returns to scale. In addition, we assume that all firms have the same productivity and produce a homogeneous good. In order to employ a worker (i.e., to enter the market), the firm has to post a vacancy at a cost of $c_j P_j$, i.e., in units of the final output good.[6] After paying these costs, a firm finds a worker with probability $m_j \vartheta_j^{-\mu}$. When a match between a worker and a firm has been established, we assume that they bargain over the total match surplus. Alternatively, we consider minimum and efficiency wages in Sections B and C of this Online Appendix as mechanisms for wage determination. All three approaches are observationally equivalent in our setting.

In the bargaining case, the match gain of the firm is given by its revenue from sales of one unit of the homogeneous product minus wage costs, $p_j - w_j$, as the firm's outside option is zero. The match surplus of a worker is given by $w_j - b_j$, where b_j is the outside option of the worker, i.e., the unemployment benefits (b_j) she receives when she is unemployed.[7]

As is standard in the literature, we use a generalized Nash bargaining solution to determine the surplus splitting rule. Hence, wages w_j are chosen to maximize $(w_j - b_j)^{\xi_j}(p_j - w_j)^{1-\xi_j}$, where the bargaining power of the worker is given by $\xi_j \in (0, 1)$. The unemployment benefits are expressed as a fraction γ_j of the market wage rate. Note that both the worker and the firm neglect the

[6] This implies that not all of total sales are available for final consumption (and hence welfare) of workers.

[7] Unemployment benefits are financed via lump-sum transfers from employed workers to the unemployed. As we assume homothetic preferences, which are identical across employed and unemployed workers, this does not show up in the economy-wide budget constraint Y_j, see Equation (26). Hence, demand can be fully described by aggregate expenditure. We also assume costless redistribution of the lump-sum transfer to the unemployed. These assumptions allow us to abstract from modeling the government more explicitly.

fact that in general equilibrium, higher wages lead to higher unemployment benefits, i.e., they both treat the level of unemployment benefits as exogenous (see Pissarides 2000). The first order conditions of the bargaining problem yield $w_j - \gamma_j w_j = (p_j - w_j)\,\xi_j/(1-\xi_j)$. Solving for w_j results in the **wage curve** $w_j = p_j\xi_j/(1+\gamma_j\xi_j - \gamma_j)$. Due to the one-shot matching, the wage curve does not depend on ϑ_j.

Given wages w_j, profits of a firm π_j are given by $\pi_j = p_j - w_j$. As we assume one worker firms and the probability of filling an open vacancy is $m_j\vartheta_j^{-\mu}$, expected profits are equal to $(p_j - w_j)m_j\vartheta_j^{-\mu}$. Firms enter the market until these expected profits cover the entry costs $c_j P_j$. This condition can be used to yield the **job creation curve** $w_j = p_j - P_j c_j/(m_j\vartheta_j^{-\mu})$.

As pointed out by Felbermayr et al. (2013), combining the job creation and wage curves determines the equilibrium labor market tightness as

$$\vartheta_j = \left(\frac{p_j}{P_j}\right)^{1/\mu}\left(\frac{c_j}{m_j}\Omega_j\right)^{-1/\mu}. \tag{31}$$

$\Omega_j \equiv \frac{1-\gamma_j+\gamma_j\xi_j}{1-\gamma_j+\gamma_j\xi_j-\xi_j} \geq 1$ is a summary measure for the impact of the worker's bargaining power ξ_j and the replacement rate γ_j on labor market tightness.[8]

A.3 Counterfactual analysis

In the following, we derive and discuss in turn counterfactual welfare along the lines of Arkolakis et al. (2012), (un)employment, total sales, and trade flows as functions of the multilateral resistance terms in the baseline and counterfactual scenario.

A.3.1 Counterfactual welfare

We can now consider the welfare consequences of a counterfactual change in trade costs that leaves the ability to serve the own market, t_{jj}, unchanged as in Arkolakis et al. (2012). Additionally, we follow their normalization and take

[8] The replacement rate is the percentage of the equilibrium wage a worker receives as unemployment benefits when she is unemployed.

labor in the considered country j as our numéraire, leading to $w_j = 1$. In our economy, total sales are given by total production of the final output good multiplied with its price, i.e., $Y_i = p_i(1-u_i)L_i$, whereas consumer expenditure is given by $(1-u_j)w_jL_j + d_jY_j + T_j$.[9] We then come up with the following sufficient statistics:

Implication 6 *Welfare effects of trade liberalization in our model with imperfect labor markets, tariffs, and trade imbalances can be expressed as*

$$\hat{W}_j = \hat{\psi}_j \hat{e}_j \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}},$$

where ψ_j is a tariff multiplier defined below.

To prove this implication, we follow Arkolakis et al. (2012). We use total consumer expenditure of country j as our starting point, given by $CE_j = (1-u_j)w_jL_j + d_jY_j + T_j$. In order to be able to derive sufficient statistics with tariffs and trade imbalances, we follow Felbermayr et al. (2015a) and write

$$\begin{aligned} CE_j &= (1-u_j)w_jL_j + d_jY_j + T_j \\ &= \frac{\xi_j}{(1+\gamma_j\xi_j-\gamma_j)}(1-u_j)p_jL_j + d_jY_j + T_j \\ &= \frac{\xi_j}{1+\gamma_j\xi_j-\gamma_j}Y_j + d_jY_j + T_j \\ &= \psi_j\left(\frac{\xi_j}{1+\gamma_j\xi_j-\gamma_j} + d_j\right)Y_j, \end{aligned} \tag{32}$$

where ψ_j is a tariff multiplier defined as

$$\psi_j \equiv \left(1 + \frac{T_j}{\left(\frac{\xi_j}{1+\gamma_j\xi_j-\gamma_j} + d_j\right)Y_j}\right) = \left(1 - \frac{T_j}{CE_j}\right)^{-1} \geq 1,$$

[9] Total consumer expenditure consists of the income of employed workers $(1-u_j)w_jL_j + d_jY_j + T_j - B_j$, and the income of unemployed workers B_j where $B_j = u_jL_jb_j$. The total sum of unemployment benefits is financed by a lump-sum transfer from employed workers to the unemployed.

and where we used $Y_j = p_j(1-u_j)L_j$ and $w_j = p_j\xi_j/(1+\gamma_j\xi_j-\gamma_j)$. Using again $Y_j = p_j(1-u_j)L_j$, we can write $d\ln CE_j = d\ln\psi_j + d\ln p_j - u_j/(1-u_j)d\ln u_j = d\ln\psi_j - u_j/(1-u_j)d\ln u_j$ assuming that the labor force L_j and trade imbalances d_j remain constant. The second expression on the right-hand side uses the wage curve $w_j = p_j\xi_j/(1+\gamma_j\xi_j-\gamma_j)$, implying $d\ln w_j = d\ln p_j$ holding all labor market parameters constant and the choice of numéraire w_j. Defining real consumer expenditure as $W_j \equiv CE_j/P_j = \left[\psi_j\left(\frac{\xi_j}{1+\gamma_j\xi_j-\gamma_j}+d_j\right)Y_j\right]/P_j$ and taking logs, the total differential is given by $d\ln W_j = d\ln\psi_j + d\ln Y_j - d\ln P_j$, where we again assume d_j and labor market parameters to be constant.

The total differential of $\ln P_j = \ln\left\{\left[\sum_{i=1}^n(\beta_i p_i t_{ij}\tau_{ij})^{1-\sigma}\right]^{\frac{1}{1-\sigma}}\right\}$ is given by

$$\begin{aligned} d\ln P_j &= \sum_{i=1}^n\left(\left(\frac{\beta_i p_i t_{ij}\tau_{ij}}{P_j}\right)^{1-\sigma} d\ln p_i + \left(\frac{\beta_i p_i t_{ij}\tau_{ij}}{P_j}\right)^{1-\sigma} d\ln t_{ij}\right. \\ &\quad \left. + \left(\frac{\beta_i p_i t_{ij}\tau_{ij}}{P_j}\right)^{1-\sigma} d\ln\tau_{ij}\right). \end{aligned}$$

Using $\tau_{ij}X_{ij} = \left((\beta_i p_i t_{ij}\tau_{ij})/P_j\right)^{1-\sigma}E_j$ and defining $\lambda_{ij} \equiv \tau_{ij}X_{ij}/E_j = \left((\beta_i p_i t_{ij}\tau_{ij})/P_j\right)^{1-\sigma}$, yields

$$d\ln P_j = \sum_{i=1}^n \lambda_{ij}\left(d\ln p_i + d\ln t_{ij} + d\ln\tau_{ij}\right). \tag{33}$$

Noting again that $d\ln p_i = d\ln w_i$ holds, we can also write $d\ln P_j = \sum_{i=1}^n \lambda_{ij}(d\ln w_i + d\ln t_{ij} + d\ln\tau_{ij})$. Combining terms leads to $d\ln W_j = d\ln\psi_j + d\ln Y_j - d\ln P_j = d\ln\psi_j - \frac{u_j}{1-u_j}d\ln u_j - \sum_{i=1}^n\lambda_{ij}(d\ln w_i + d\ln t_{ij} + d\ln\tau_{ij})$. Taking the ratio of λ_{ij} and λ_{jj} we can write $\lambda_{ij}/\lambda_{jj} = [(\beta_i p_i t_{ij}\tau_{ij})/(\beta_j p_j t_{jj}\tau_{jj})]^{1-\sigma}$. Noting that $dt_{jj} = d\tau_{jj} = 0$ by assumption and that w_j is the numéraire, so that $dw_j = dp_j = 0$, the log-change of this ratio is given by $d\ln\lambda_{ij} - d\ln\lambda_{jj} = (1-\sigma)\left(d\ln p_i + d\ln t_{ij} + d\ln\tau_{ij}\right)$. Combining this with Equation (33) leads to:

$$d\ln P_j = \frac{1}{1-\sigma}\left(\sum_{i=1}^n \lambda_{ij} d\ln\lambda_{ij} - d\ln\lambda_{jj}\sum_{i=1}^n\lambda_{ij}\right).$$

Noting that $E_j = \sum_{i=1}^{n} \tau_{ij} X_{ij}$, it follows that $\sum_{i=1}^{n} \lambda_{ij} = 1$ and $d \sum_{i=1}^{n} \lambda_{ij} = \sum_{i=1}^{n} d\lambda_{ij} = 0$. Hence, $\sum_{i=1}^{n} \lambda_{ij} d \ln \lambda_{ij} = \sum_{i=1}^{n} d\lambda_{ij} = 0$. Using these facts, the above expression simplifies to $d \ln P_j = -\frac{1}{1-\sigma} d \ln \lambda_{jj}$. The welfare change can then be expressed as $d \ln W_j = d \ln \psi_j - \frac{u_j}{1-u_j} d \ln u_j + \frac{1}{1-\sigma} d \ln \lambda_{jj}$. Integrating between the initial and the counterfactual situation we get $\ln \hat{W}_j = \ln \hat{\psi}_j + \ln \hat{e}_j + \frac{1}{1-\sigma} \ln \hat{\lambda}_{jj}$, where $e_j = 1 - u_j$ is the share of employed workers. Taking exponents leads to $\hat{W}_j = \hat{\psi}_j \hat{e}_j \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}$. Note that $\hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}$ can be expressed as $\hat{\lambda}_{jj}^{\frac{1}{1-\sigma}} = \widehat{\left(\frac{p_j}{P_j}\right)}$ using $\lambda_{jj} = ((\beta_j p_j t_{jj} \tau_{jj})/P_j)^{1-\sigma}$ and recalling that β_j, t_{jj} and τ_{jj} are constant. Moving from any observed level of trade to autarky, i.e., $\lambda_{jj}^c = 1$ and $\psi_j^c = 1$, yields $\hat{W}_j = \psi_j \hat{e}_j \left(\lambda_{jj}\right)^{-\frac{1}{1-\sigma}}$. Note, however, that in contrast to the case with perfect labor markets considered in Arkolakis et al. (2012), even this expression needs information about employment changes.

Hence, welfare depends on the change in the tariff multiplier, $\hat{\psi}_j$, the employment change, $\hat{e}_j$, the change in the share of domestic expenditures, $\hat{\lambda}_{jj}$, and the partial elasticity of imports with respect to variable trade costs, given in our case by $(1-\sigma)$. Note that in the case of perfect labor markets $\hat{e}_j = 1$ and $\hat{W}_j = \hat{\psi}_j \hat{\lambda}_{jj}^{1/(1-\sigma)}$, which extends Equation (6) in Arkolakis et al. (2012) to account for tariff revenues.

When $\hat{\lambda}_{jj}$ and $\hat{\psi}_j$ are observed, assuming imperfect or perfect labor markets leads to different welfare predictions. The difference in the welfare change is given by $\hat{e}_j$. Hence, assuming perfect labor markets neglects the effects on employment and the corresponding welfare effects. Whether welfare increases or decreases in a particular country depends on the magnitude of relative price change p_j/P_j.

While Implication 6 already describes how to calculate welfare within our framework with tariff revenues and allowing for trade imbalances, we can equivalently express the change in welfare as a function of the multilateral resistance terms by using the equivalent variation, i.e., the amount of income the representative consumer would need to make her as well off under current prices P_j as in the counterfactual situation with price level P_j^c. Using the definition for consumer expenditure CE_j as given in Equation (32), and defining $v_j = \psi_j \left(\frac{\xi_j}{1+\gamma_j \xi_j - \gamma_j} + d_j \right)$ and $\hat{v}_j \equiv v_j^c / v_j$, we can express the change in consumer expenditure as a function of the change in total sales and $\hat{v}_j$, $\hat{v}_j \hat{Y}_j$. We can then express the equivalent variation in percent as follows:

$$EV_j = \frac{v_j^c Y_j^c \frac{P_j}{P_j^c} - v_j Y_j}{v_j Y_j} = \frac{v_j^c Y_j^c}{v_j Y_j} \frac{P_j}{P_j^c} - 1 = \hat{v}_j \hat{Y}_j \frac{P_j}{P_j^c} - 1. \tag{34}$$

Hence welfare can be calculated by using the expressions for the price indices (which can be derived from the multilateral resistance terms) and the counterfactual change in total sales. To derive the counterfactual change in total sales, it turns out to be useful to first derive an expression for the counterfactual change in (un)employment.

A.3.2 Counterfactual (un)employment

We follow Anderson and van Wincoop (2003) and use Equation (26) to solve for scaled prices as follows:

$$(\beta_j p_j)^{1-\sigma} = \frac{Y_j}{\sum_{i=1}^{n} \left(\frac{t_{ji}}{P_i} \right)^{1-\sigma} \tau_{ij}^{-\sigma} E_i} = \frac{Y_j}{Y^W} \Pi_j^{\sigma-1} = \sqcap_j, \tag{35}$$

where $\sqcap_j \equiv \frac{Y_j}{Y^W} \Pi_j^{\sigma-1}$. We then use the definition of u_j given in Equation (30), replacing ϑ_j by the expression given in Equation (31) and defining $\Xi_j \equiv m_j \left(\frac{c_j}{m_j} \Omega_j \right)^{\frac{\mu-1}{\mu}}$ and $\hat{\kappa}_j \equiv \Xi_j^c / \Xi_j$, where superscript c denotes counterfactual values:

$$\frac{e_j^c}{e_j} \equiv \frac{1-u_j^c}{1-u_j} = \hat{\kappa}_j \left(\frac{p_j^c}{p_j} \right)^{\frac{1-\mu}{\mu}} \left(\frac{P_j}{P_j^c} \right)^{\frac{1-\mu}{\mu}}, \tag{36}$$

where e_j denotes the employment rate. Noting the derivation of Equation (26) and remembering that $P_j^{1-\sigma} = \sum_i (t_{ij} \tau_{ij})^{1-\sigma} \sqcap_i$ (see the definition of the price index and (35)), we can express the ratios of the prices and price indices as functions of $\sqcap_i$ and $(t_{ij} \tau_{ij})^{1-\sigma}$ to end up with counterfactual (un)employment levels summarized in the following implication:

Implication 7 *Whereas in the setting with perfect labor markets (un)employment effects are zero by assumption, the (un)employment effects in our gravity system with imperfections on the labor market, taking into account tariff revenues and allowing for trade imbalances, are given by:*

$$\begin{aligned}\hat{e}_j &\equiv \frac{e_j^c}{e_j} = \hat{\kappa}_j \left(\frac{\Pi_j^c}{\Pi_j}\right)^{\frac{1-\mu}{\mu(1-\sigma)}} \left(\frac{\sum_i \left(t_{ij}\tau_{ij}\right)^{1-\sigma} \Pi_i}{\sum_i \left(t_{ij}^c\tau_{ij}^c\right)^{1-\sigma} \Pi_i^c}\right)^{\frac{1-\mu}{\mu(1-\sigma)}}, \\ \Delta u_j &\equiv u_j^c - u_j = (1-u_j)(1-\hat{e}_j).\end{aligned}$$

Implication 7 reveals that a country can directly affect its (un)employment level by changes in its labor market institutions, as reflected by changes in $\hat{\kappa}_j$.[10] In addition, all trading partners are affected by such a labor market reform due to changes in prices as reflected by Π_i. Direct effects are scaled by changes in relative prices p_j/P_j which are proportional to $\left(\Pi_j/\sum_i \left(t_{ij}\tau_{ij}\right)^{1-\sigma} \Pi_i\right)^{1/(1-\sigma)}$, reflecting the spillovers of labor market reforms to other countries. Changes of relative prices due to trade liberalization therefore provide the link to the labor market.

A.3.3 Counterfactual total sales

We next derive counterfactual total sales. Using the definition of total sales, $Y_j = p_j(1-u_j)L_j = p_j e_j L_j$, and taking the ratio of counterfactual total sales, Y_j^c, and observed sales, Y_j, we can use Implication 7 and Equation (26) to come up with the following implication:

Implication 8 *Counterfactual total sales allowing for tariff revenues and trade imbalances are given by:*

$$\begin{aligned}&\textit{imperfect labor markets:} \quad \hat{Y}_j = \hat{\kappa}_j \left(\frac{\Pi_j^c}{\Pi_j}\right)^{\frac{1}{\mu(1-\sigma)}} \left(\frac{\sum_i (t_{ij}\tau_{ij})^{1-\sigma}\Pi_i}{\sum_i \left(t_{ij}^c\tau_{ij}^c\right)^{1-\sigma}\Pi_i^c}\right)^{\frac{1-\mu}{\mu(1-\sigma)}}, \\ &\textit{perfect labor markets:} \quad \hat{Y}_j = \left(\frac{\Pi_j^c}{\Pi_j}\right)^{\frac{1}{1-\sigma}}.\end{aligned}$$

[10] Note that employment changes are homogeneous of degree zero in prices, implying that a normalization does not matter for the employment effects.

If we assume $\mu = 1$, balanced trade, and zero tariffs, we end up with the case of perfect labor markets which is identical to the model employed by Anderson and van Wincoop (2003).

It is illuminating to decompose the change in total sales as follows:

$$\hat{Y}_j = \underbrace{\left(\frac{\Pi_j^c}{\Pi_j}\right)^{\frac{1}{1-\sigma}}}_{\text{price change}} \underbrace{\hat{\kappa}_j \left(\frac{\Pi_j^c}{\Pi_j}\right)^{\frac{1-\mu}{\mu(1-\sigma)}} \left(\frac{\sum_i \left(t_{ij}\tau_{ij}\right)^{1-\sigma} \Pi_i}{\sum_i \left(t_{ij}^c \tau_{ij}^c\right)^{1-\sigma} \Pi_i^c}\right)^{\frac{1-\mu}{\mu(1-\sigma)}}}_{\text{employment change}}, \tag{37}$$

with the price change defined as implied by Equation (35) and the employment change as defined in Implication 7.

Taking logs, we can attribute the share of log change in total sales due to changes in prices and employment as follows:

$$1 = \frac{\ln \hat{p}_j}{\ln \hat{Y}_j} + \frac{\ln \hat{e}_j}{\ln \hat{Y}_j}. \tag{38}$$

Alongside changes in total sales, we will report this decomposition in all our counterfactual exercises.

A.3.4 Counterfactual trade flows

Finally, given estimates of $t_{ij}^{1-\sigma}$, data on Y_i, and a value for σ, we can calculate (scaled) baseline trade flows as $X_{ij}Y^W/(Y_i E_j) = (t_{ij}/(\Pi_i P_j))^{1-\sigma}\tau_{ij}^{-\sigma}$, where Π_i and P_j are given by Equation (28). With counterfactual total sales given by Implication 8, we can calculate counterfactual trade flows as $X_{ij}^c Y^{W,c}/(Y_i^c E_j^c) = (t_{ij}^c/(\Pi_i^c P_j^c))^{1-\sigma}\left(\tau_{ij}^c\right)^{-\sigma}$, where Π_i^c and P_j^c are defined analogously to their counterparts in the baseline scenario given in Equation (28).[11] Due to direct effects of changes in trade costs via t_{ij}, tariffs via τ_{ij}, and non-trivial changes in Π_i and P_j, trade may change more or less when assuming

[11] Note that P_j and P_j^c are homogeneous of degree one in prices while Π_i and Π_i^c are homogeneous of degree minus one. Hence, scaled trade flows $X_{ij}Y^W/(Y_i E_j)$ and $X_{ij}^c Y^{W,c}/(Y_i^c E_j^c)$ are homogeneous of degree zero in prices. In other words, they do not depend on the normalization chosen.

imperfect labor markets in comparison with the baseline case of perfect labor markets.

A.3.5 Tariff revenues

The last missing part to determine changes in consumable income and welfare are the tariff revenues. Tariff revenues are given by $T_i = \sum_{j=1}^{n}(\tau_{ji} - 1)X_{ji}$. In the baseline we take observed GDP as our measure of total sales. When solving for the baseline MRTs, we simultaneously solve for implied tariff revenues using predicted trade flows and observed tariff rates. In the counterfactual, we simultaneously solve for counterfactual MRTs and counterfactual $T_i^c = \sum_{j=1}^{n}(\tau_{ji}^c - 1)X_{ji}^c$.

B Minimum wages within the search and matching framework

In this section, we introduce minimum wages in our search and matching framework. The binding minimum wage replaces the bargaining of workers and firms that are matched. We then show that this leads to expressions for counterfactual changes in total sales, employment, trade flows, and welfare which are isomorphic to those in the main text.

We assume balanced trade and do not consider revenue-generating tariffs for the following derivations. Let us first consider the bounds for a binding minimum wage. If the minimum wage is below the wage that a firm and a worker agree upon, it is not binding and hence not relevant. The lower bound for a binding minimum wage, denoted by $\underline{w}_j$, is therefore given by the **wage curve** from the main text

$$\underline{w}_j = w_j = \frac{\xi_j}{1 + \gamma_j \xi_j - \gamma_j} p_j. \tag{39}$$

The upper bound for a minimum wage, denoted by $\overline{w}_j$, is given by the job's output, as firms would not be able to recover recruiting costs. Hence, $\overline{w}_j = p_j$.

A well defined equilibrium with a binding minimum wage $\breve{w}_j$ exists if $\underline{w}_j < \breve{w}_j < \overline{w}_j$. With a given binding minimum wage, the wage curve is no longer relevant. ϑ_j can be solved by using the **job creation curve** given in the main text

$$\begin{aligned}\breve{w}_j = p_j - \frac{P_j c_j}{m_j \vartheta_j^{-\mu}} \Rightarrow \\ \vartheta_j = \left(\frac{p_j - \breve{w}_j}{P_j}\right)^{1/\mu} \left(\frac{c_j}{m_j}\right)^{-1/\mu},\end{aligned} \tag{40}$$

which corresponds to Equation (9) in the main text. By replacing u_j by Equation (8) from the main text and using Equation (40), total sales in country j can be written as:

$$Y_j = p_j(1-u_j)L_j = p_j m_j \left(\frac{p_j - \breve{w}_j}{P_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{c_j}{m_j}\right)^{\frac{\mu-1}{\mu}} L_j. \tag{41}$$

Assuming that the nominal minimum wage is indexed to prices, we can express it as a share of prices, i.e., $\breve{w}_j = \xi_j p_j$. This allows us to express total sales solely as a function of prices and parameters. Similarly, (counterfactual) employment can be rewritten using Equation (8) in the main text and Equation (40). Then, defining $\breve{\Xi}_j = m_j \left(\frac{c_j}{m_j}\right)^{\frac{\mu-1}{\mu}}$ and $\hat{\breve{\kappa}}_j = \breve{\Xi}_j^c / \breve{\Xi}_j$, we get

$$\frac{1-u_j^c}{1-u_j} = \hat{\breve{\kappa}}_j \left(\frac{p_j^c - \breve{w}_j}{p_j - \breve{w}_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{P_j}{P_j^c}\right)^{\frac{1-\mu}{\mu}}. \tag{42}$$

Using again that $\breve{w}_j = \xi_j p_j$, the last expression simplifies to

$$\frac{1-u_j^c}{1-u_j} = \hat{\breve{\kappa}}_j^* \left(\frac{p_j^c}{p_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{P_j}{P_j^c}\right)^{\frac{1-\mu}{\mu}}, \tag{43}$$

where $\hat{\breve{\kappa}}_j^* = \hat{\breve{\kappa}}_j((1-\xi_j^c)/(1-\xi_j))^{(1-\mu)/\mu}$. Equation (43) exactly corresponds to Equation (12) in the main text except for the replacement of $\hat{\kappa}_j$ by $\hat{\breve{\kappa}}_j^*$. Hence, when assuming that labor market institutions (here: minimum wage levels) do not change, we can proceed as with bargained wages to calculate employment effects.

Note that in the case of binding minimum wages, all changes in total sales are due to employment changes. Hence, counterfactual sales changes correspond to employment changes.

Counterfactual trade flows and welfare can be calculated as in the case of bargained wages.

C Efficiency wages within the search and matching framework

In this section, we show how efficiency wages in the spirit of Stiglitz and Shapiro (1984) can be introduced into our search and matching framework by replacing the bargaining of workers and firms with the no-shirking condition. Note that we assume balanced trade, do not consider revenue-generating tariffs and assume risk neutral workers in the following.

We first derive the utility for a shirker, s, and a non-shirker, ns. The non-shirker ns earns wage w_j while exerting effort e_j. Hence, her utility in our one-shot framework is given by

$$E_j^{ns} = w_j - e_j. \tag{44}$$

A shirker s also earns wage w_j but does not exert any effort e_j. However, a share α_j of shirkers is detected by firms and gets fired, which leads to unemployment. When the worker is unemployed she earns $\gamma_j w_j$, and hence the expected utility for a shirker can be written as

$$E_j^s = (1 - \alpha_j)w_j + \alpha_j \gamma_j w_j. \tag{45}$$

The no-shirking condition $E^{ns} \geq E^s$ leads to $E^{ns} = E^s$ in equilibrium. Hence, using Equations (44) and (45), the wage can be written as:

$$w_j = \frac{1}{\alpha_j(1-\gamma_j)} e_j. \tag{46}$$

As in the case of bargaining, wages can be solved without knowledge of ϑ_j. ϑ_j can be solved by using the **job creation curve** given in the main text:

$$\begin{aligned} \frac{1}{\alpha_j(1-\gamma_j)} e_j &= p_j - \frac{P_j c_j}{m_j \vartheta_j^{-\mu}} \Rightarrow \\ \vartheta_j^{\mu} &= \left(\frac{m_j}{P_j c_j}\right)\left(p_j - \frac{1}{\alpha_j(1-\gamma_j)} e_j\right). \end{aligned} \tag{47}$$

Now assume that effort e_j can be expressed in terms of prices p_j as $e_j = \xi_j p_j$. Then we can simplify Equation (47) to:

$$\vartheta_j = \left(\frac{p_j}{P_j}\right)^{1/\mu} \left(\frac{c_j}{m_j} \check{\Omega}_j\right)^{-1/\mu}, \tag{48}$$

with $\check{\Omega}_j = \frac{\alpha_j(1-\gamma_j)}{\alpha_j(1-\gamma_j)-\xi_j}$, which corresponds to Equation (9).

Counterfactual employment can be calculated using the definition of u_j given in Equation (8) in the main text, replacing ϑ_j by the expression given in Equation (48) and defining $\check{\Xi}_j = m_j \left(\frac{c_j}{m_j}\check{\Omega}_j\right)^{\frac{\mu-1}{\mu}}$ and $\hat{\check{\kappa}}_j = \check{\Xi}_j^c / \check{\Xi}_j$:

$$\frac{1-u_j^c}{1-u_j} = \hat{\check{\kappa}}_j \left(\frac{p_j^c}{p_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{P_j}{P_j^c}\right)^{\frac{1-\mu}{\mu}}, \tag{49}$$

which exactly corresponds to Equation (12) in the main text except for the replacement of $\hat{\kappa}_j$ by $\hat{\check{\kappa}}_j$. Hence, when assuming that labor market institutions do not change, we can proceed as with bargained wages to calculate employment effects.

Using the definition of $\check{\Xi}_j$, total sales can be expressed as:

$$Y_j = p_j e_j L_j = p_j m_j \left(\frac{p_j}{P_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{c_j}{m_j}\check{\Omega}_j\right)^{\frac{\mu-1}{\mu}} L_j = p_j \left(\frac{p_j}{P_j}\right)^{\frac{1-\mu}{\mu}} \check{\Xi}_j L_j. \tag{50}$$

Now take the ratio of counterfactual total sales, Y_j^c, and observed total sales, Y_j, and note that the labor force, L_j, stays constant:

$$Y_j^c = \hat{\check{\kappa}}_j \frac{p_j^c \left(\frac{p_j^c}{P_j^c}\right)^{\frac{1-\mu}{\mu}}}{p_j \left(\frac{p_j}{P_j}\right)^{\frac{1-\mu}{\mu}}} = \hat{\check{\kappa}}_j \left(\frac{p_j^c}{p_j}\right)^{\frac{1}{\mu}} \left(\frac{P_j}{P_j^c}\right)^{\frac{1-\mu}{\mu}} Y_j, \tag{51}$$

where $\hat{\check{\kappa}}_j = \check{\Xi}_j^c / \check{\Xi}_j$. Then, using Equation (11) from the main text and the fact that $P_j^{1-\sigma} = \sum_i t_{ij}^{1-\sigma} \frac{Y_i}{Y^W} \Pi_i^{\sigma-1}$, we end up with exactly the same expression as given in the result in Implication 4 in the main text except for the replacement of $\hat{\kappa}_j$ by $\hat{\check{\kappa}}_j$. Hence, we can calculate counterfactual total sales as in the case of bargained wages. Similarly, counterfactual trade flows and welfare can be calculated as in the case with bargained wages.

D A Ricardian trade model with imperfect labor markets following Eaton and Kortum (2002)

In the following, we introduce search and matching frictions in the Ricardian model of international trade by Eaton and Kortum (2002) and show that this leads to expressions for counterfactual changes in total sales, employment, trade flows, and welfare which are isomorphic to those in the main text. Note that in the following we assume balanced trade and abstract from revenue-generating tariffs.

The representative consumer in country j is again characterized by the utility function U_j. As in Eaton and Kortum (2002), we assume a continuum of goods $k \in [0,1]$. Consumption of individual goods is denoted by $q(k)$, leading to the following utility function

$$U_j = \left[\int_0^1 q(k)^{\frac{\sigma-1}{\sigma}} dk\right]^{\frac{\sigma}{\sigma-1}}, \tag{52}$$

where σ is the elasticity of substitution in consumption. Again, trade of goods from i to j imposes iceberg trade costs $t_{ij} > 1$.

Countries differ in the efficiency with which they can produce goods. We denote country i's efficiency in producing good $k \in [0, 1]$ as $\mathfrak{z}_i(k)$. Denoting input costs in country i as $\mathfrak{c}_i$, the cost of producing a unit of good k in country i is then $\mathfrak{c}_i/\mathfrak{z}_i(k)$.

Taking trade barriers into account, delivering a unit of good k produced in country i to country j costs

$$p_{ij}(k) = \left(\frac{\mathfrak{c}_i}{\mathfrak{z}_i(k)}\right) t_{ij}. \tag{53}$$

Assuming perfect competition, $p_{ij}(k)$ is the price which consumers in country j would pay if they bought good k from country i. With international trade, consumers can choose from which country to buy a good. Hence, the price they actually pay for good k is $\underline{p}_j(k)$, the lowest price across all sources i:

$$\underline{p}_j(k) = \min\left\{p_{ij}(k); i = 1, \cdots, n\right\}, \tag{54}$$

where n denotes the number of countries.

Let country i's efficiency in producing good k be the realization of an independently drawn Fréchet random variable with distribution $F_i(\mathfrak{z}) = e^{-T_i\mathfrak{z}^{-\theta}}$, where T_i is the location parameter (also called "state of technology" by Eaton and Kortum, 2002) and θ governs the variance of the distribution and thereby also the comparative advantage within the continuum of goods.

Plugging Equation (53) in $F_i(\mathfrak{z})$ leads to $G_{ij}(p) = Pr[P_{ij} \leq p] = 1 - e^{-[T_i(\mathfrak{c}_i t_{ij})^{-\theta}]p^{\theta}}$. Noting that the distribution of prices for which a country j buys is given by $G_j(p) = Pr[P_j \leq p] = 1 - \prod_{i=1}^{n}[1 - G_{ij}(p)]$ leads to:

$$G_j(p) = 1 - e^{-\Phi_j p^{\theta}}, \tag{55}$$

where $\Phi_j = \sum_{i=1}^{n} T_i \left(\mathfrak{c}_i t_{ij}\right)^{-\theta}$.

The probability that country i provides good k at the lowest price to country j is given by (see Eaton and Kortum 2002, page 1748):

$$\pi_{ij} = \frac{T_i \left(\mathfrak{c}_i t_{ij}\right)^{-\theta}}{\Phi_j}. \tag{56}$$

With a continuum of goods between zero and one this is also the fraction of goods that country j buys from country i. Eaton and Kortum (2002) show that the price of a good that country j actually buys from any country i is also distributed $G_j(p)$, and that the exact price index is given by $P_j = \breve{\Gamma}\Phi_j^{-1/\theta}$ with $\breve{\Gamma} = \left[\Gamma\left(\frac{\theta+1-\sigma}{\theta}\right)\right]^{\frac{1}{1-\sigma}}$ where Γ is the Gamma function.

The fraction of goods that country j buys from country i, π_{ij}, is also the fraction of its expenditures on goods from country i, X_{ij}, due to the fact that the average expenditures per good do not vary by source. Hence,

$$X_{ij} = \frac{T_i(\mathfrak{c}_i t_{ij})^{-\theta}}{\Phi_j} Y_j = \frac{T_i(\mathfrak{c}_i t_{ij})^{-\theta}}{\sum_{k=1}^{n} T_k(\mathfrak{c}_k t_{kj})^{-\theta}} Y_j, \tag{57}$$

where Y_j is country j's total spending.

Assuming balanced trade, exporters' total sales (including home sales) are equal to total expenditure and are given by:

$$Y_i = \sum_{j=1}^{n} X_{ij} = T_i \mathfrak{c}_i^{-\theta} \sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\Phi_j} Y_j. \tag{58}$$

Solving for $T_i \mathfrak{c}_i^{-\theta}$ leads to:

$$T_i \mathfrak{c}_i^{-\theta} = \frac{Y_i}{\sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\Phi_j} Y_j}. \tag{59}$$

Replacing $T_i \mathfrak{c}_i^{-\theta}$ in Equation (57) with this expression leads to:

$$X_{ij} \quad = \quad \frac{t_{ij}^{-\theta}}{\Phi_j \left(\sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\Phi_j} Y_j\right)} Y_i Y_j.$$

Using $P_j = \breve{\Gamma}\Phi_j^{-\frac{1}{\theta}}$ to replace Φ_j in both terms of the denominator leads to:

$$X_{ij} = \frac{t_{ij}^{-\theta}}{\breve{\Gamma}^{\theta} P_j^{-\theta} \left(\sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\breve{\Gamma}^{\theta} P_j^{-\theta}} Y_j \right)} Y_i Y_j.$$

Define

$$\Pi_i = \left(\sum_{j=1}^{n} \left(\frac{t_{ij}}{P_j} \right)^{-\theta} \frac{Y_j}{Y^W} \right)^{-\frac{1}{\theta}},$$

and note that we can express P_j also as follows:

$$\begin{aligned} P_j &= \left(\breve{\Gamma}^{-\theta} \Phi_j \right)^{-\frac{1}{\theta}} = \left(\breve{\Gamma}^{-\theta} \sum_{i=1}^{n} T_i (\mathfrak{c}_i t_{ij})^{-\theta} \right)^{-\frac{1}{\theta}} = \left(\breve{\Gamma}^{-\theta} \sum_{i=1}^{n} \frac{t_{ij}^{-\theta} Y_i}{\sum_{l=1}^{n} \frac{t_{il}^{-\theta}}{\Phi_l} Y_l} \right)^{-\frac{1}{\theta}}, \\ &= \left(\sum_{i=1}^{n} \left(\frac{t_{ij}}{\Pi_i} \right)^{-\theta} \frac{Y_i}{Y^W} \right)^{-\frac{1}{\theta}}, \end{aligned}$$

where $Y^W = \sum_j Y_j$. Then we can write:

$$X_{ij} = \frac{Y_i Y_j}{Y^W} \left(\frac{t_{ij}}{\Pi_i P_j} \right)^{-\theta}.$$

Replacing $-\theta$ by $1-\sigma$ we end up with exactly the same system as in the model by Anderson and van Wincoop (2003).

Hence, our approach can be applied to both worlds with the only difference that the interpretation differs and the roles of θ and σ have to be exchanged.

D.1 Counterfactual expenditure in the Eaton and Kortum (2002) framework with perfect labor markets

We assume that there are no intermediates and $\mathfrak{z}_i$ units of the final good are produced with one unit of labor, hence $\mathfrak{c}_i = w_i$. Equation (59) can be written as

$$T_i w_i^{-\theta} = \frac{Y_i}{\sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\Phi_j} Y_j} = \frac{\frac{Y_i}{Y^W}}{\sum_{j=1}^{n} \breve{\Gamma}^{-\theta} \left(\frac{t_{ij}}{P_j}\right)^{-\theta} \frac{Y_j}{Y^W}} = \breve{\Gamma}^{\theta} \frac{Y_i}{Y^W} \Pi_i^{\theta}.$$

Solving for w_i leads to:

$$w_i = \breve{\Gamma}^{-1} T_i^{\frac{1}{\theta}} \left(\frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}} \Pi_i^{-1}.$$

As $Y_i = w_i L_i$, the change in expenditure is given by $Y_i^c / Y_i = w_i^c / w_i$. Hence,

$$\frac{Y_i^c}{Y_i} = \frac{\breve{\Gamma} T_i^{\frac{1}{\theta}} \left(\frac{Y_i^c}{Y^{W,c}}\right)^{-\frac{1}{\theta}} (\Pi_i^c)^{-1}}{\breve{\Gamma} T_i^{\frac{1}{\theta}} \left(\frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}} \Pi_i^{-1}} = \frac{\left(\frac{Y_i^c}{Y^{W,c}}\right)^{-\frac{1}{\theta}} (\Pi_i^c)^{-1}}{\left(\frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}} \Pi_i^{-1}} = \left(\frac{\mathbb{\Pi}_i^c}{\mathbb{\Pi}_i}\right)^{-\frac{1}{\theta}},$$

where $\mathbb{\Pi}_i = \frac{Y_i}{Y^W} \Pi_i^{\theta}$.

D.2 Counterfactuals in the Eaton and Kortum (2002) framework with imperfect labor markets

We assume that there are no intermediates and $\mathfrak{z}_i$ units of the final good k are produced using one unit of labor. For simplicity, we omit the product index k in the following. Denoting the net price earned by the producer by $p_i = p_{ij}/t_{ij}$, the total surplus of a successful match is given by $\mathfrak{z}_i p_i - b_i$, while the firm's rent is given by $\mathfrak{z}_i p_i - w_i$ and the worker's by $w_i - b_i$. Nash bargaining leads to $w_i - b_i = (\mathfrak{z}_i p_i - w_i)\xi_i/(1 - \xi_i)$. Using $b_i = \gamma_i w_i$ and combining leads to

$$w_i = \frac{\xi_i}{1 - \gamma_i + \xi_i \gamma_i} \mathfrak{z}_i p_i = \frac{\xi_i}{1 - \gamma_i + \xi_i \gamma_i} \mathfrak{c}_i, \tag{60}$$

as firms create vacancies until all rents are dissipated. The free entry (zero profit) condition is given by $(\mathfrak{z}_i p_i - w_i) M_i / V_i = P_i c_i$. Rewriting leads to the job creation curve

$$w_i = \mathfrak{z}_i p_i - \frac{P_i c_i}{m_i \vartheta_i^{-\mu}} = \mathfrak{c}_i - \frac{P_i c_i}{m_i \vartheta_i^{-\mu}}. \tag{61}$$

We can combine Equations (60) and (61) to write the wage paid by a firm as

$$w_i = \frac{\xi_i}{1 - \gamma_i + \gamma_i \xi_i - \xi_i} \frac{P_i c_i}{m_i \vartheta^{-\mu}}. \tag{62}$$

The wage paid by a firm producing variety k is solely determined by parameters and aggregate variables and does neither depend on its variety-specific price nor on productivity. Hence, as wages are equalized across firms, Equation (61) then implies that also $\mathfrak{c}_i$ is the same across firms, irrespective of the variety they produce. Hence the job creation and wage curve are the same for all firms and we can thus determine aggregate labor market tightness ϑ_i as the locus of intersection of both curves:

$$\vartheta_i = \left(\frac{\mathfrak{c}_i}{P_i}\right)^{1/\mu} \left(\frac{c_i}{m_i}\Omega_i\right)^{-1/\mu}. \tag{63}$$

Equation (59) can be written as

$$T_i \mathfrak{c}_i^{-\theta} \quad = \quad \frac{Y_i}{\sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\Phi_j} Y_j} = \frac{\frac{Y_i}{Y^W}}{\sum_{j=1}^{n} \breve{\Gamma}^{-\theta} \left(\frac{t_{ij}}{P_j}\right)^{-\theta} \frac{Y_j}{Y^W}} = \breve{\Gamma}^{\theta} \frac{Y_i}{Y^W} \Pi_i^{\theta}.$$

Solving for $\mathfrak{c}_i$ leads to:

$$\mathfrak{c}_i = \breve{\Gamma}^{-1} T_i^{\frac{1}{\theta}} {\frac{Y_i}{Y^W}}^{-\frac{1}{\theta}} \Pi_i^{-1}. \tag{64}$$

As $Y_i = \mathfrak{c}_i(1-u_i)L_i$, assuming a constant labor force the change in expenditure is given by $Y_i^c/Y_i = (1-u_i^c)\mathfrak{c}_i^c/[(1-u_i)\mathfrak{c}_i]$ leading to

$$\begin{aligned}
\frac{Y_i^c}{Y_i} &= \frac{(1-u_i^c)\breve{\Gamma}T_i^{\frac{1}{\theta}}\left(\frac{Y_i^c}{Y^{W,c}}\right)^{-\frac{1}{\theta}}(\Pi_i^c)^{-1}}{(1-u_i)\breve{\Gamma}T_i^{\frac{1}{\theta}}\left(\frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}}\Pi_i^{-1}} \\
&= \frac{(1-u_i^c)\left(\frac{Y_i^c}{Y^{W,c}}\right)^{-\frac{1}{\theta}}(\Pi_i^c)^{-1}}{(1-u_i)\left(\frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}}\Pi_i^{-1}} \\
&= \frac{(1-u_i^c)}{(1-u_i)}\left(\frac{\mathbb{\Pi}_i^c}{\mathbb{\Pi}_i}\right)^{-\frac{1}{\theta}}, \qquad (65)
\end{aligned}$$

where $\mathbb{\Pi}_i = \frac{Y_i}{Y^W}\Pi_i^{\theta}$.

For the change in employment (the first fraction on the right-hand side of Equation (65)) the same relationship holds as is given in the main text in Equation (12) when we remember once more that $-\theta = 1-\sigma$. Hence, we end up with

$$\frac{Y_i^c}{Y_i} = \hat{\kappa}_i\left(\frac{\mathbb{\Pi}_i^c}{\mathbb{\Pi}_i}\right)^{-\frac{1}{\mu\theta}}\left(\frac{\sum_i t_{ij}^{-\theta}\mathbb{\Pi}_i}{\sum_i \left(t_{ij}^c\right)^{-\theta}\mathbb{\Pi}_i^c}\right)^{-\frac{1-\mu}{\mu\theta}}, \qquad (66)$$

which is the same relationship as given in Implication 4 in the main text when we again replace $1-\sigma$ by $-\theta$.

Besides counterfactual employment, also counterfactual trade flows and welfare can be calculated as in the main text.

E Further results for counterfactual analyses

E.1 Further results for introducing RTAs as observed in 2006

This section reports additional results for the counterfactual analysis presented in Section 3.4.1 in the main text.

Tables A.1 and A.2 report goods trade changes for perfect and imperfect labor markets, respectively. Trade changes are heterogeneous across importers and exporters. To summarize this heterogeneity, we present quantiles of calculated trade flow changes across all destination countries for all exporters. Both tables report the minimum and maximum changes, along with the 0.025, 0.25, 0.5, 0.75, and 0.975 quantiles. Comparing numbers across columns for each row reveals the heterogeneity across importers, while comparing numbers across rows for each column highlights the heterogeneity across exporters.

Table A.1 reveals that every country experiences both positive and negative bilateral trade flow changes. For example, the introduction of RTAs as observed in 2006 implies that the change in trade flows for the United Kingdom is larger than 5.54% for 25% of all countries importing goods from the United Kingdom. Turning to the trade flow results of our model with imperfect labor markets (Table A.2), we find a similar pattern for trade flow changes. Again, changes are heterogeneous across importers and exporters and, again, small and remote countries experience larger changes. The implied trade flow changes differ from the case with perfect labor markets but are of similar magnitude.

[Table A.1 about here.]

[Table A.2 about here.]

[Table A.3 about here.]

The employment effects of incepting RTAs from column (5) of Table 3 in the main text are illustrated graphically in Figure A.1.

[Figure A.1 about here.]

E.2 Further results for the labor market reform in the U.S.

Table A.3 summarizes the trade effects of the hypothetical labor market reform in the U.S. presented in Section 3.4.3 in the main text. A labor market reform in the United States spurs trade changes across the whole sample. The effects of exports by the United States range between -1.46% and -0.14%. Effects across other exporters range from -1.45% for Canada to 1.05% for Belgium, the Netherlands, and Switzerland. On average, 50% of trade flow changes are larger than 0.81%. The size pattern of the spillover effects of labor market reforms in the United States clearly depends on the bilateral distance and the trade volume of the corresponding country with the United States.

The employment effects of the counterfactual U.S. labor market reform from column (5) of Table 6 are graphically illustrated in Figure A.2.

[Figure A.2 about here.]

F Results without tariff income

Table A.4 presents results for introducing all RTAs observed in 2006 taking into account trade imbalances but without taking into account tariff income, i.e., with tariff rates equal to zero for all country pairs in both the baseline and the counterfactual scenario.

[Table A.4 about here.]

G Results with balanced trade

The following tables present the results for the same counterfactual experiments as presented in Section 3.4 in the main text but we assume balanced trade throughout, i.e., $E_j = Y_j$. Results basically remain the same, both qualitatively and quantitatively. For comparison reasons, we keep the trade cost parameter estimates as well as the elasticities from column (4) of Table 2 in the main text.

G.1 Introducing RTAs as observed in 2006

Table A.5 presents the results from switching on RTAs as observed in 2006 starting from a counterfactual situation without any RTAs assuming balanced trade. Tables A.6 and A.7 present the changes in trade flows for both perfect and imperfect labor markets, similar to Tables A.1 and A.2.

[Table A.5 about here.]

[Table A.6 about here.]

[Table A.7 about here.]

G.2 Evaluating the effects of the U.S.-Australia Free Trade Agreement

Table A.8 presents the results for the evaluation of the U.S.-Australia Free Trade Agreement assuming balanced trade but controlling for tariff revenues.

[Table A.8 about here.]

G.3 Evaluating the effects of a labor market reform in the U.S.

Tables A.9 and A.10 present the results from the counterfactual labor market reform in the U.S. assuming balanced trade but controlling for tariff revenues.

[Table A.9 about here.]

[Table A.10 about here.]

H Additional details concerning tariff data

In this section, we present additional details concerning the tariff measures we use in the main text.

We use data from the World Integrated Trade Solution (WITS), the most comprehensive database on bilateral tariff data compiled by the World Bank in collaboration with the United Nations Conference on Trade and Development (UNCTAD) and the World Trade Organization (WTO).[12] Specifically, we use data from the UNCTAD Trade Analysis Information System (TRAINS), which is part of WITS. TRAINS contains tariff data beginning only in 1988. This implies that including tariff rates as an additional regressor substantially reduces the time dimension of our data set. In addition, data even for the countries in our sample are not available for all years beginning in 1988. In the end, our sample for which tariff information is available consists of 10,916 observations, down from around 37,000 observations when compared to the working paper version of this paper, Heid and Larch (2012a), where we use the years 1950 to 2006 but do not consider tariff rates.[13]

Specifically, we have used three average tariff rates: the simple average at the HS 6 digit level of the effectively applied tariff rate, the simple average of the effectively applied tariff rate at the tariff line level, as well as the weighted average of the effectively applied tariff rate with the weights given by the corresponding trade value.

Whereas trade-weighted tariff rates underestimate the actual level of protection, simple averages may overestimate the actual level of protection. We therefore included several tariff rates in our regressions.[14] Figure A.3 shows a histogram of the prevailing tariff rates for the simple average of effectively applied tariffs in our sample. We also calculated the according yearly tar-

[12]The data as well as a detailed user guide can be downloaded at `http://wits.worldbank.org/default.aspx`, accessed 2015/03/13.

[13]We set effectively applied tariffs within the EU equal to zero. We also excluded nine observations for which the availability of tariff data does not allow us to identify the according exporter-year effect as we only observe the tariff rate for the exporter in one year.

[14]Technically, we include the log of one plus the tariff rate, as implied by the model structure.

iff revenue as a share of GDP using the simple average for our data set. A histogram of these tariff revenue shares can be seen in Figure A.4.

[Figure A.3 about here.]

[Figure A.4 about here.]

All averages are calculated from the effectively applied tariff rate. It equals either the most favored nation (MFN) rate or, if there is a preferential trade agreement between the two countries, the according preferential tariff rate. In principle, all firms have access to the lower preferential tariff rate. However, preferential tariff rates may be tied to strict rules of origin for which some firms do not qualify. Also, documenting that intermediates used for production are in line with those rules of origin in itself implies a cost which may be higher than the gain from using the lower preferential tariff rate, see Demidova and Krishna (2008). In addition, given that we use aggregate trade data, we abstract from product lines which may have preferential access and those which do only get MFN tariff rates. As Carpenter and Lendle (2010) document, about 27 percent of North-North trade consists of non-preferential imports, and hence it is not clear whether one should use effectively applied or MFN tariff rates for aggregate trade flows. As by definition the MFN tariff rate is the same for all import source countries, and our analysis includes importer-year effects, our regression results can be interpreted as being conditional on the MFN tariff rate of a country.

I Distribution of elasticity estimates

In this section, we present the full distribution of the estimates of σ and μ when using the estimation methods described in Section 3.2 in the main text.

I.1 Distribution of μ

In the main text, we calculate all $n(n-1)/2$ possible values for μ and then take the mean of those values which lie in the admissible range, i.e., between zero and one. Figure A.5 shows the unrestricted distribution of the calculated values using the trade cost parameter and σ estimates from column (4) of Table 2 in the main text to calculate the price indices necessary to calculate μ. The vertical bars indicate the admissible range. Note that we have dropped one outlier value of $\mu = 67.891$ to ensure the readability of the histogram. In total, 58 percent of the calculated values for μ lie within the admissible range.

[Figure A.5 about here.]

I.2 Distribution of σ

If tariff data are not available to estimate σ, we propose an alternative estimator of σ in Section 3.2. We use this estimator for the estimates of σ in columns (1) and (2) of Table 2. Specifically, we calculate all $n^2(n-1)$ possible values for σ and then take the median of those values, following Bergstrand et al. (2013). Figure A.6 shows the unrestricted distribution of the calculated values using the trade cost parameter estimates from column (2) of Table 2 in the main text to calculate the price indices necessary to calculate σ. The vertical bar indicates the limit of the admissible range, i.e., $\sigma > 1$. Note that we have dropped about 2 percent of outliers of the calculated values ($|\sigma| > 100$) to ensure the readability of the histogram. In total, 51 percent of the calculated values for σ lie within the admissible range.

[Figure A.6 about here.]

J A more robust estimation method for the matching elasticity

When panel data on the trade cost variables like RTAs etc. as well as for the unemployment and replacement rates are available, we can relax the assumption of time-invariant and equal matching efficiencies, m_j, across countries when using a different estimation method for μ. To illustrate our approach, we add time indices s to Equation (18) from the main text to receive the following Equation:

$$\ln\left(\frac{1-u_{js}}{1-u_{ms}}\right)=\frac{1-\mu}{\mu}\left[\ln\left(\frac{p_{js}}{p_{ms}}\frac{P_{ms}}{P_{js}}\right)-\ln\left(\frac{c_{js}\Omega_{js}}{c_{ms}\Omega_{ms}}\right)\right]+\frac{1}{\mu}\ln\left(\frac{m_{js}}{m_{ms}}\right), \quad (67)$$

where we have assumed that the matching elasticity, μ, is time-invariant. Assuming that the vacancy posting cost may vary over time but is the same across countries, and adding a well behaved stochastic error term, ε_{jms}, we can rewrite this expression as

$$\ln\left(\frac{1-u_{js}}{1-u_{ms}}\right)=\frac{1-\mu}{\mu}\left[\ln\left(\frac{p_{js}}{p_{ms}}\frac{P_{ms}}{P_{js}}\right)-\ln\left(\frac{\Omega_{js}}{\Omega_{ms}}\right)\right]+\tilde{\nu}_{js}+\tilde{\upsilon}_{ms}+\varepsilon_{jms}, \quad (68)$$

where $\tilde{\nu}_{js}$ and $\tilde{\upsilon}_{ms}$ are time-varying country fixed effects to capture the variation in the term $1/\mu\ln(m_{js}/m_{ms})=1/\mu\ln(m_{js})-1/\mu\ln(m_{ms})$.

As in the main text, p_{js} can be replaced again by $p_{js}=Y_{js}/[(1-u_{js})L_{js}]$ and the price indices P_{js} by $P_{js}^{1-\sigma}=\sum_{i=1}^{n}t_{ijs}^{1-\sigma}\frac{Y_{is}}{Y_s^W}\Pi_{is}^{\sigma-1}$ from the solution of the multilateral resistance terms system of Equation (6) from the main text. Ω_{js} is in principle observable, as the dependent variable, the log employment ratio. Then, Equation (68) can be estimated via OLS to get an estimate of $(1-\mu)/\mu$. Importantly, the time-varying country fixed effects control for other time-varying determinants of the unemployment rate such as business cycles which may be correlated with both the measure of labor market institutions, Ω_{js}, and the real price ratio.

We present results from this regression in Table A.11. For these estimations, we only use data from 1994 to 2006 due to patchy labor market data before 1994. We also neglect tariffs and tariff income as the tariff data are not balanced for all years between 1994 and 2006. We use parameter estimates from the corresponding column of Table 2 in the main text to solve for the baseline price levels. We calculate the standard error of μ by the delta method.

[Table A.11 about here.]

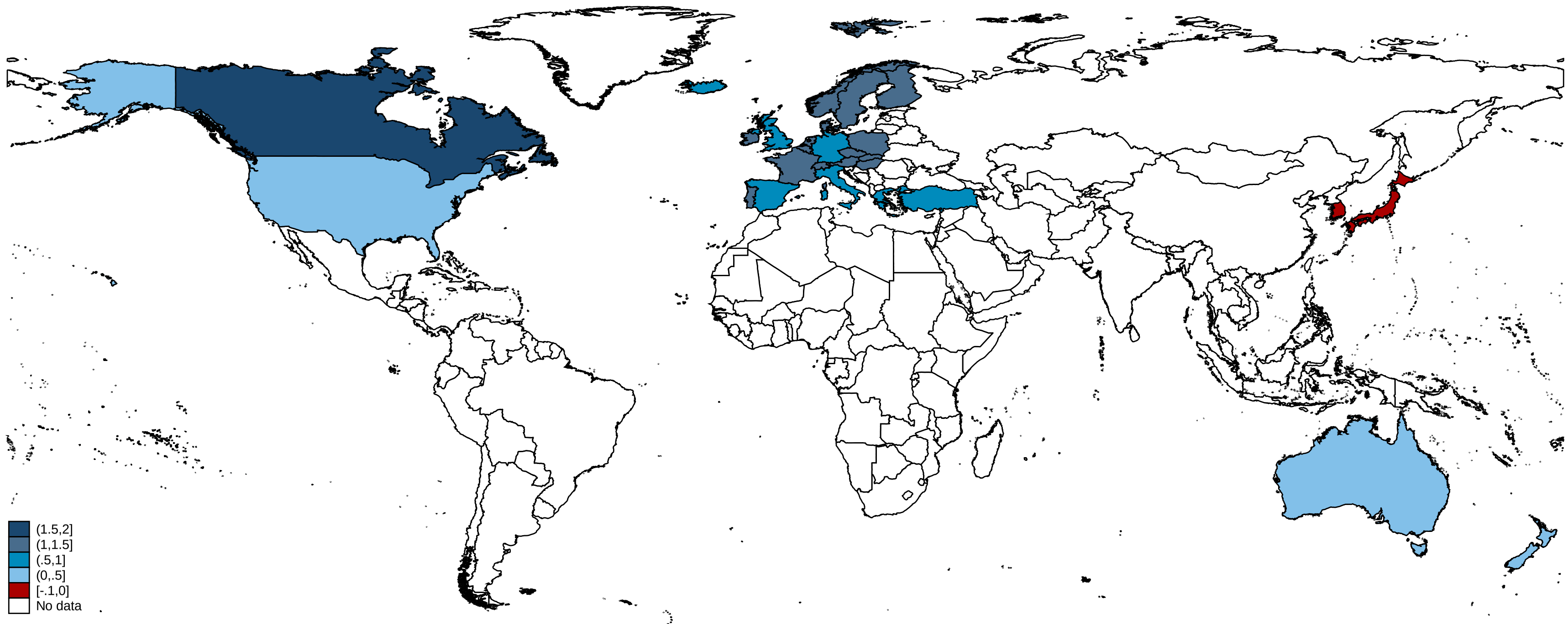

Figure A.1: Employment effects of incepting RTAs as observed in 2006.

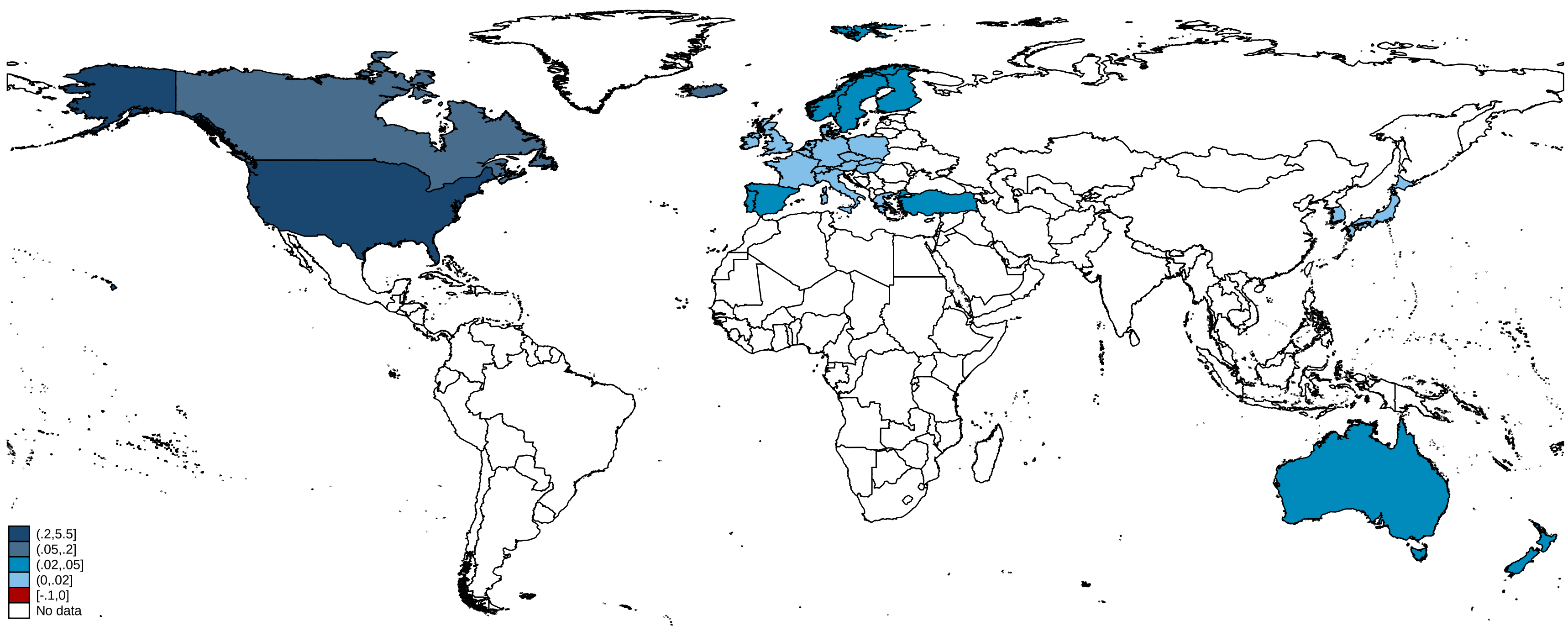

Figure A.2: Employment effects of a hypothetical labor market reform in the United States ($\hat{\kappa}_{US} = 1.054$).

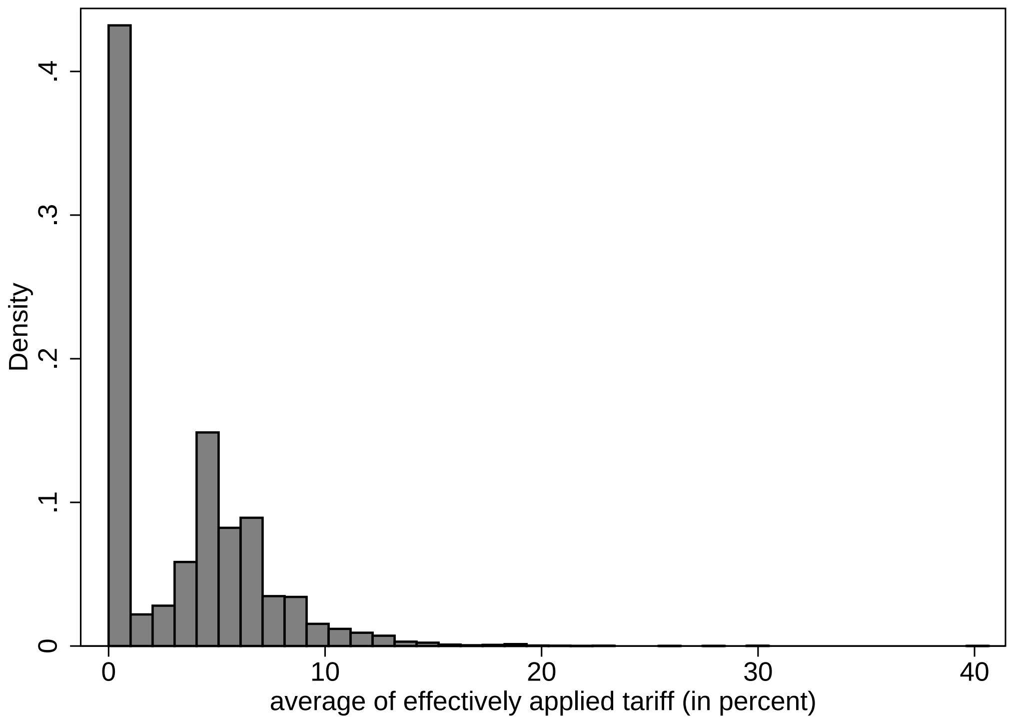

Figure A.3: Histogram of the bilateral simple average of effectively applied tariff rates for the tariff sample

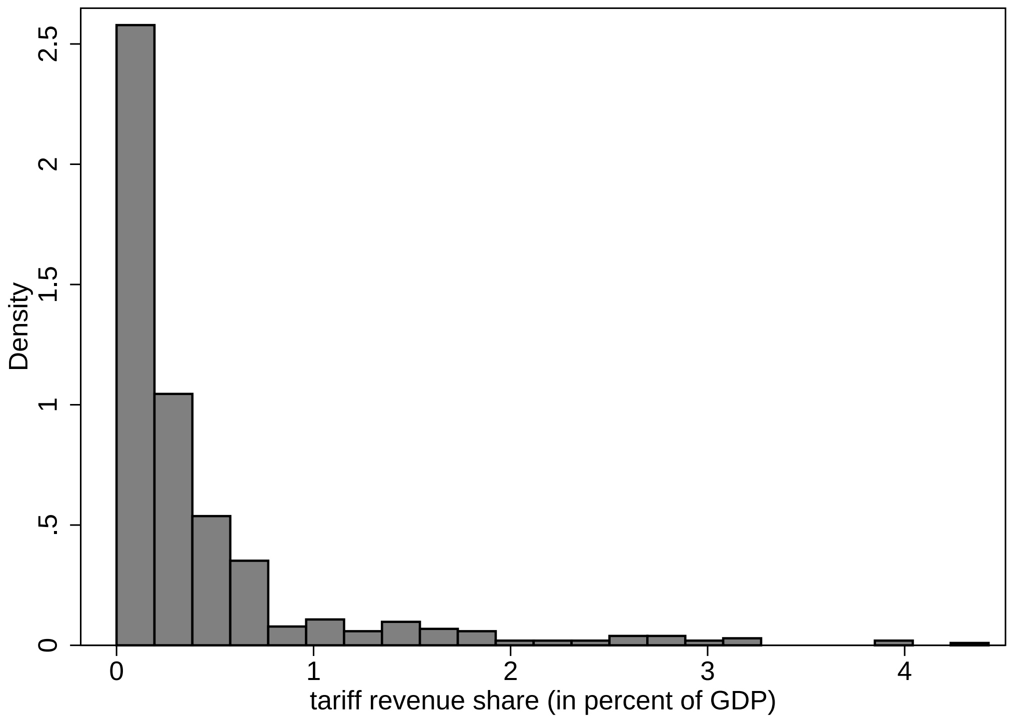

Figure A.4: Histogram of the calculated tariff revenue as a share of GDP using the bilateral simple average of effectively applied tariff rates for the tariff sample

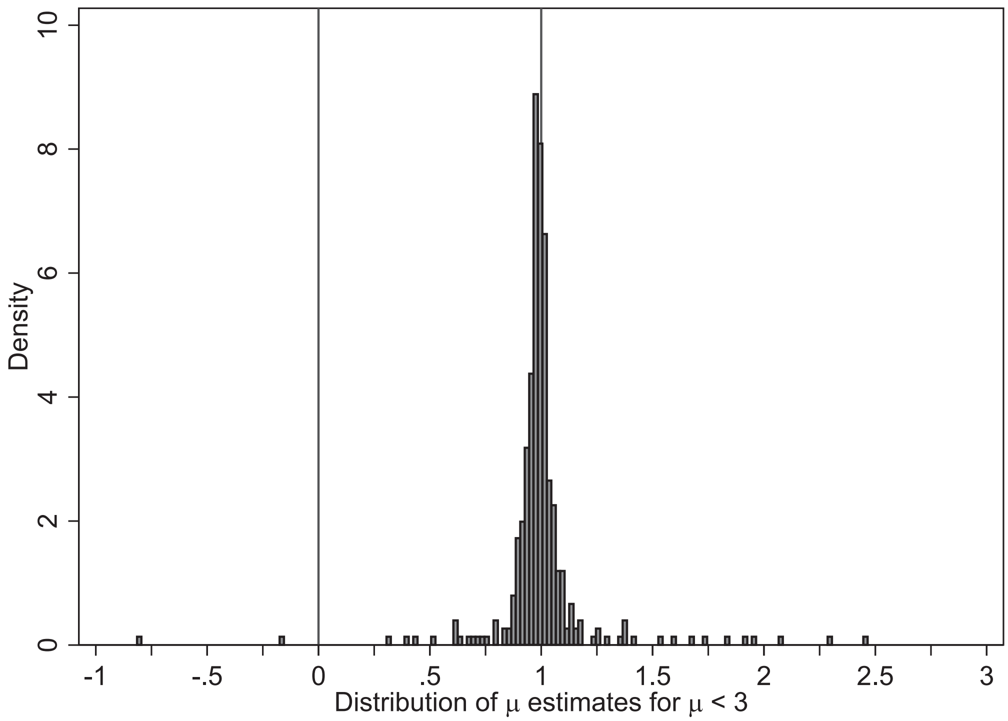

Figure A.5: Histogram of the different values of μ

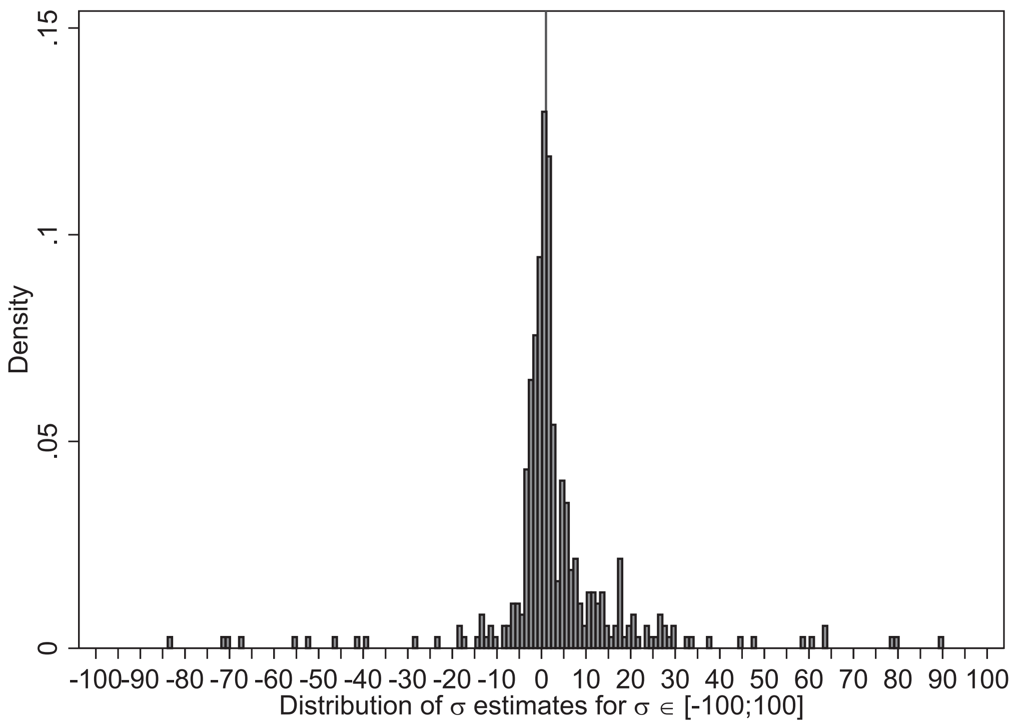

Figure A.6: Histogram of the different values of σ

Table A.1: Heterogeneity of comparative static trade effects of RTA inception with perfect labor markets and controlling for trade imbalances and tariff revenues in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-12.45	-12.23	-10.26	-9.35	-7.93	15.20	15.57
Austria	-17.89	-16.41	-2.17	-0.99	0.98	2.72	3.00
Belgium	-17.87	-16.38	-2.14	-0.96	1.01	2.76	3.04
Canada	-19.25	-19.21	-18.30	-17.51	-16.25	2.46	5.08
Czech Republic	-18.43	-16.95	-2.54	-1.64	0.32	2.05	2.33
Denmark	-17.45	-15.96	-1.64	-0.46	1.52	3.27	3.55
Finland	-15.88	-14.36	0.23	1.40	3.24	5.24	5.52
France	-16.65	-15.14	-0.69	0.47	2.50	4.28	4.56
Germany	-15.66	-14.13	0.50	1.67	3.24	5.52	5.81
Greece	-15.32	-13.79	0.90	2.08	3.65	5.94	6.23
Hungary	-17.60	-16.11	-1.82	-0.63	1.34	3.09	3.37
Iceland	-15.23	-13.69	1.29	2.23	4.26	11.48	12.56
Ireland	-17.60	-16.11	-1.83	-0.68	1.33	3.08	3.36
Italy	-15.48	-13.95	0.71	1.88	3.46	5.75	6.03
Japan	-9.45	-9.22	-7.18	-6.24	-4.77	2.33	2.44
Korea	-9.55	-9.32	-7.16	-5.48	-0.15	11.69	11.72
Netherlands	-17.49	-16.00	-1.69	-0.55	1.47	3.22	3.50
New Zealand	-11.92	-11.70	-9.72	-8.80	-7.37	11.56	14.07
Norway	-17.01	-15.51	-0.85	0.07	2.22	9.13	10.19
Poland	-17.41	-15.92	-1.60	-0.41	1.57	3.33	3.60
Portugal	-16.67	-15.16	-0.71	0.45	2.48	4.25	4.54
Slovak Republic	-18.18	-16.70	-2.45	-1.33	0.63	2.37	2.65
Spain	-15.38	-13.85	0.82	2.00	3.57	5.87	6.15
Sweden	-16.64	-15.13	-0.68	0.48	2.52	4.29	4.58
Switzerland	-18.00	-16.52	-2.01	-0.72	1.00	7.82	8.87
Turkey	-15.42	-13.89	1.05	1.99	4.02	11.22	12.30
United Kingdom	-13.77	-12.21	2.74	3.94	5.54	6.49	6.50
United States	-8.76	-8.71	-7.68	-6.78	-5.36	14.59	16.50
Average	-15.66	-14.44	-2.67	-1.57	0.36	6.11	6.70

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2 in the main text. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.2: Heterogeneity of comparative static trade effects of RTA inception with imperfect labor markets and controlling for trade imbalances and tariff revenues in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-12.33	-12.15	-10.35	-9.43	-8.02	15.33	15.71
Austria	-17.94	-16.46	-2.46	-1.24	0.72	2.48	2.75
Belgium	-17.91	-16.43	-2.43	-1.21	0.75	2.51	2.78
Canada	-19.30	-19.26	-18.34	-17.54	-16.23	2.64	5.25
Czech Republic	-18.47	-17.00	-2.83	-1.88	0.07	1.81	2.08
Denmark	-17.48	-16.00	-1.92	-0.69	1.28	3.05	3.32
Finland	-15.89	-14.38	-0.02	1.16	3.02	5.04	5.31
France	-16.68	-15.18	-0.97	0.20	2.26	4.05	4.32
Germany	-15.70	-14.18	0.20	1.39	2.98	5.28	5.55
Greece	-15.34	-13.81	0.64	1.83	3.42	5.73	6.01
Hungary	-17.64	-16.15	-2.10	-0.88	1.09	2.86	3.13
Iceland	-15.19	-13.66	1.09	2.07	4.10	11.54	12.68
Ireland	-17.61	-16.12	-2.07	-0.91	1.13	2.89	3.16
Italy	-15.51	-13.99	0.43	1.62	3.21	5.51	5.79
Japan	-9.26	-9.07	-7.21	-6.26	-4.80	2.59	2.71
Korea	-9.36	-9.17	-7.18	-5.47	0.02	11.75	11.80
Netherlands	-17.53	-16.05	-1.98	-0.82	1.22	2.98	3.25
New Zealand	-11.80	-11.61	-9.80	-8.88	-7.46	11.69	14.19
Norway	-17.03	-15.53	-1.10	-0.14	1.99	9.12	10.23
Poland	-17.44	-15.96	-1.87	-0.65	1.33	3.10	3.37
Portugal	-16.68	-15.18	-0.96	0.21	2.26	4.05	4.32
Slovak Republic	-18.22	-16.75	-2.74	-1.58	0.37	2.12	2.39
Spain	-15.40	-13.88	0.56	1.75	3.34	5.65	5.92
Sweden	-16.66	-15.16	-0.94	0.23	2.29	4.08	4.35
Switzerland	-18.05	-16.57	-2.30	-1.02	0.73	7.77	8.87
Turkey	-15.42	-13.90	0.81	1.79	3.81	11.23	12.36
United Kingdom	-13.78	-12.22	2.49	3.70	5.32	6.32	6.35
United States	-8.82	-8.78	-7.73	-6.83	-5.36	14.74	16.65
Average	-15.66	-14.45	-2.90	-1.77	0.17	6.00	6.59

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2 in the main text. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.3: Heterogeneity of comparative static trade effects of $\hat{\kappa}_{U.S.} = 1.054$ controlling for trade imbalances and tariff revenues with imperfect labor markets in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-0.54	-0.51	0.66	0.74	0.77	0.79	0.79
Austria	-0.30	-0.27	0.89	0.97	1.00	1.03	1.03
Belgium	-0.28	-0.25	0.92	0.99	1.03	1.05	1.05
Canada	-1.45	-1.30	-0.40	-0.33	-0.30	-0.27	-0.27
Czech Republic	-0.31	-0.28	0.89	0.96	1.00	1.03	1.03
Denmark	-0.33	-0.31	0.86	0.94	0.98	1.00	1.00
Finland	-0.44	-0.41	0.76	0.83	0.87	0.89	0.89
France	-0.31	-0.28	0.89	0.96	1.00	1.02	1.02
Germany	-0.30	-0.28	0.89	0.97	1.00	1.03	1.03
Greece	-0.36	-0.33	0.84	0.92	0.95	0.97	0.98
Hungary	-0.35	-0.32	0.85	0.93	0.96	0.98	0.98
Iceland	-0.68	-0.66	0.51	0.59	0.62	0.65	0.65
Ireland	-0.35	-0.32	0.85	0.93	0.96	0.99	0.99
Italy	-0.33	-0.31	0.86	0.94	0.98	1.00	1.00
Japan	-0.37	-0.34	0.83	0.91	0.94	0.97	0.97
Korea	-0.36	-0.34	0.83	0.91	0.94	0.97	0.97
Netherlands	-0.28	-0.26	0.91	0.99	1.02	1.05	1.05
New Zealand	-0.57	-0.55	0.62	0.70	0.73	0.76	0.76
Norway	-0.42	-0.40	0.77	0.85	0.88	0.91	0.91
Poland	-0.35	-0.32	0.85	0.92	0.96	0.98	0.98
Portugal	-0.41	-0.39	0.79	0.86	0.89	0.92	0.92
Slovak Republic	-0.33	-0.31	0.86	0.94	0.97	1.00	1.00
Spain	-0.38	-0.36	0.81	0.89	0.92	0.95	0.95
Sweden	-0.40	-0.37	0.80	0.88	0.91	0.94	0.94
Switzerland	-0.28	-0.26	0.91	0.99	1.02	1.05	1.05
Turkey	-0.42	-0.40	0.77	0.85	0.88	0.91	0.91
United Kingdom	-0.31	-0.29	0.88	0.96	0.99	1.02	1.02
United States	-1.46	-1.29	-0.27	-0.20	-0.17	-0.14	-0.14
Average	-0.45	-0.42	0.74	0.81	0.85	0.87	0.87

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2 in the main text. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.4: Comparative static effects of RTA inception controlling for trade imbalances but with zero tariff rates for all country pairs in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share $\%Y$ SMF		SMF	SMF	PLM	SMF
	$\%Y$	$\%Y$	$\%\ln(\hat{p})$	$\%\ln(\hat{e})$	$\%\hat{e}$	Δu	$\%EV$	$\%EV$
Australia	3.93	4.47	91.82	8.18	0.36	-0.34	5.03	5.40
Austria	7.95	9.09	84.67	15.33	1.34	-1.26	20.43	21.80
Belgium	7.93	9.06	84.87	15.13	1.32	-1.20	20.05	21.42
Canada	9.72	10.86	84.34	15.66	1.63	-1.50	25.96	26.99
Czech Republic	8.37	9.55	84.47	15.53	1.43	-1.31	21.87	23.30
Denmark	7.61	8.70	84.97	15.03	1.26	-1.20	19.09	20.37
Finland	6.47	7.42	85.80	14.20	1.02	-0.93	15.13	16.20
France	7.03	8.06	85.26	14.74	1.15	-1.04	17.20	18.41
Germany	6.32	7.27	86.35	13.65	0.96	-0.86	14.08	15.20
Greece	6.06	6.99	85.78	14.22	0.96	-0.87	14.21	15.24
Hungary	7.73	8.84	84.86	15.14	1.29	-1.18	19.55	20.88
Iceland	5.97	6.85	86.26	13.74	0.91	-0.88	13.46	14.40
Ireland	7.72	8.79	85.13	14.87	1.26	-1.19	19.14	20.36
Italy	6.19	7.12	86.18	13.82	0.95	-0.88	14.00	15.07
Japan	2.04	2.36	101.12	-1.12	-0.03	0.03	-0.45	-0.44
Korea	2.10	2.43	100.55	-0.55	-0.01	0.01	-0.27	-0.24
Netherlands	7.66	8.74	85.43	14.57	1.23	-1.16	18.48	19.77
New Zealand	3.59	4.11	92.16	7.84	0.32	-0.30	4.40	4.73
Norway	7.30	8.33	85.42	14.58	1.17	-1.12	17.65	18.84
Poland	7.59	8.69	84.88	15.12	1.27	-1.08	19.17	20.47
Portugal	7.00	8.01	85.24	14.76	1.14	-1.04	17.16	18.30
Slovak Republic	8.16	9.32	84.56	15.44	1.39	-1.18	21.15	22.56
Spain	6.11	7.04	85.95	14.05	0.96	-0.87	14.12	15.17
Sweden	7.01	8.03	85.37	14.63	1.14	-1.05	17.00	18.17
Switzerland	8.04	9.19	84.60	15.40	1.36	-1.29	20.77	22.17
Turkey	6.15	7.06	86.07	13.93	0.95	-0.85	14.06	15.06
United Kingdom	5.00	5.80	87.23	12.77	0.72	-0.68	10.33	11.20
United States	2.44	2.83	97.53	2.47	0.07	-0.07	0.80	0.98
Average	4.41	5.06	92.50	7.50	0.52	-0.48	7.74	8.32

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table A.5: Comparative static effects of RTA inception assuming balanced trade but controlling for tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share %Y SMF		SMF	SMF	PLM	SMF
	%Y	%Y	$\%\ln(\hat{p})$	$\%\ln(\hat{e})$	$\%\hat{e}$	Δu	%EV	%EV
Australia	3.89	4.42	91.80	8.20	0.36	-0.34	4.98	5.31
Austria	8.12	9.25	84.84	15.16	1.35	-1.27	20.50	21.74
Belgium	8.00	9.12	84.93	15.07	1.32	-1.20	20.07	21.35
Canada	9.73	10.87	84.33	15.67	1.63	-1.50	25.91	26.74
Czech Republic	8.48	9.65	84.59	15.41	1.43	-1.31	21.87	23.12
Denmark	7.75	8.84	85.11	14.89	1.27	-1.20	19.15	20.31
Finland	6.66	7.61	86.01	13.99	1.03	-0.94	15.21	16.08
France	7.23	8.26	85.51	14.49	1.16	-1.04	17.27	18.37
Germany	6.33	7.27	86.35	13.65	0.96	-0.86	14.05	15.07
Greece	6.42	7.34	86.31	13.69	0.97	-0.88	14.31	15.18
Hungary	7.86	8.96	85.00	15.00	1.30	-1.18	19.56	20.68
Iceland	6.20	7.06	86.51	13.49	0.92	-0.89	13.59	14.25
Ireland	7.70	8.76	85.16	14.84	1.25	-1.18	18.95	20.01
Italy	6.31	7.23	86.40	13.60	0.95	-0.88	13.95	14.91
Japan	2.14	2.44	101.09	-1.09	-0.03	0.03	-0.45	-0.45
Korea	2.20	2.51	100.53	-0.53	-0.01	0.01	-0.27	-0.26
Netherlands	7.54	8.60	85.26	14.74	1.22	-1.16	18.38	19.57
New Zealand	3.69	4.19	92.12	7.88	0.32	-0.31	4.47	4.65
Norway	7.29	8.31	85.48	14.52	1.17	-1.11	17.51	18.67
Poland	7.78	8.86	85.07	14.93	1.28	-1.09	19.26	20.35
Portugal	7.26	8.27	85.56	14.44	1.15	-1.05	17.25	18.20
Slovak Republic	8.30	9.45	84.72	15.28	1.39	-1.19	21.16	22.36
Spain	6.37	7.29	86.34	13.66	0.97	-0.87	14.15	15.05
Sweden	7.18	8.20	85.54	14.46	1.15	-1.05	17.08	18.08
Switzerland	8.20	9.34	84.83	15.17	1.36	-1.29	20.79	22.20
Turkey	6.35	7.25	86.38	13.62	0.96	-0.85	14.08	14.94
United Kingdom	5.31	6.10	87.71	12.29	0.73	-0.69	10.44	11.23
United States	2.50	2.88	97.49	2.51	0.07	-0.07	0.83	0.98
Average	4.51	5.15	92.57	7.43	0.53	-0.48	7.75	8.27

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table A.6: Heterogeneity of comparative static trade effects of RTA inception with perfect labor markets assuming balanced trade but controlling for tariff revenues in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-12.18	-11.93	-9.80	-8.87	-7.47	15.64	16.01
Austria	-18.15	-16.68	-2.27	-1.07	0.95	2.67	2.95
Belgium	-17.99	-16.52	-2.09	-0.88	1.15	2.87	3.15
Canada	-18.95	-18.90	-17.99	-17.19	-15.89	2.73	5.35
Czech Republic	-18.63	-17.16	-2.56	-1.65	0.36	2.07	2.35
Denmark	-17.66	-16.18	-1.69	-0.48	1.56	3.29	3.57
Finland	-16.16	-14.66	0.10	1.24	3.18	5.16	5.45
France	-16.95	-15.46	-0.85	0.29	2.43	4.17	4.45
Germany	-15.71	-14.19	0.64	1.79	3.40	5.73	6.02
Greece	-15.83	-14.32	0.49	1.64	3.24	5.57	5.86
Hungary	-17.80	-16.32	-1.86	-0.65	1.38	3.11	3.39
Iceland	-15.52	-14.01	1.15	2.10	4.19	11.23	12.29
Ireland	-17.59	-16.10	-1.60	-0.48	1.65	3.38	3.66
Italy	-15.67	-14.16	0.68	1.83	3.44	5.78	6.06
Japan	-9.51	-9.25	-7.05	-6.09	-4.66	2.37	2.48
Korea	-9.60	-9.34	-7.03	-5.32	-0.18	11.92	11.96
Netherlands	-17.36	-15.88	-1.34	-0.21	1.92	3.66	3.93
New Zealand	-11.87	-11.62	-9.48	-8.54	-7.15	11.58	14.06
Norway	-17.03	-15.54	-0.65	0.28	2.50	9.25	10.29
Poland	-17.69	-16.21	-1.72	-0.51	1.52	3.25	3.53
Portugal	-16.99	-15.50	-0.89	0.24	2.38	4.13	4.41
Slovak Republic	-18.39	-16.92	-2.51	-1.36	0.66	2.37	2.65
Spain	-15.76	-14.24	0.58	1.73	3.34	5.67	5.96
Sweden	-16.88	-15.39	-0.76	0.37	2.51	4.26	4.54
Switzerland	-18.25	-16.79	-2.10	-0.93	0.99	7.64	8.66
Turkey	-15.72	-14.21	0.91	1.86	3.94	10.97	12.03
United Kingdom	-14.25	-12.71	2.38	3.55	5.18	6.17	6.20
United States	-8.62	-8.57	-7.54	-6.64	-5.17	14.47	16.36
Average	-15.81	-14.60	-2.67	-1.57	0.41	6.11	6.70

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.7: Heterogeneity of comparative static effects of RTA inception with imperfect labor markets and assuming balanced trade but controlling for tariff revenues in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-12.06	-11.85	-9.88	-8.92	-7.54	15.77	16.16
Austria	-18.19	-16.73	-2.56	-1.32	0.70	2.43	2.70
Belgium	-18.04	-16.57	-2.38	-1.13	0.89	2.62	2.89
Canada	-19.00	-18.95	-18.03	-17.22	-15.87	2.91	5.52
Czech Republic	-18.67	-17.21	-2.85	-1.89	0.11	1.83	2.10
Denmark	-17.69	-16.22	-1.96	-0.71	1.32	3.06	3.33
Finland	-16.17	-14.67	-0.16	1.00	2.96	4.96	5.23
France	-16.99	-15.50	-1.12	0.02	2.18	3.94	4.21
Germany	-15.75	-14.24	0.35	1.51	3.13	5.49	5.76
Greece	-15.85	-14.34	0.23	1.39	3.01	5.36	5.64
Hungary	-17.84	-16.37	-2.14	-0.89	1.13	2.87	3.14
Iceland	-15.49	-13.98	0.95	1.95	4.03	11.29	12.39
Ireland	-17.60	-16.12	-1.85	-0.71	1.43	3.18	3.45
Italy	-15.71	-14.20	0.40	1.57	3.19	5.54	5.82
Japan	-9.30	-9.08	-7.05	-6.06	-4.64	2.64	2.76
Korea	-9.39	-9.17	-7.03	-5.30	0.01	12.01	12.06
Netherlands	-17.41	-15.93	-1.62	-0.48	1.66	3.41	3.68
New Zealand	-11.74	-11.53	-9.55	-8.59	-7.21	11.72	14.18
Norway	-17.05	-15.56	-0.92	0.06	2.27	9.23	10.32
Poland	-17.72	-16.25	-2.00	-0.75	1.28	3.02	3.29
Portugal	-17.00	-15.52	-1.14	0.01	2.17	3.92	4.19
Slovak Republic	-18.43	-16.97	-2.80	-1.61	0.40	2.13	2.39
Spain	-15.78	-14.27	0.32	1.48	3.10	5.46	5.73
Sweden	-16.91	-15.42	-1.03	0.12	2.28	4.04	4.31
Switzerland	-18.30	-16.84	-2.39	-1.22	0.72	7.59	8.65
Turkey	-15.72	-14.22	0.67	1.66	3.74	10.98	12.08
United Kingdom	-14.25	-12.72	2.13	3.31	4.97	6.00	6.04
United States	-8.69	-8.64	-7.60	-6.69	-5.17	14.61	16.50
Average	-15.81	-14.61	-2.89	-1.76	0.22	6.00	6.59

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.8: Comparative static effects of the U.S.-Australia Free Trade Agreement assuming balanced trade but controlling for tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share $\%Y$ SMF		SMF	SMF	PLM	SMF
	$\%Y$	$\%Y$	$\%\ln(\hat{p})$	$\%\ln(\hat{e})$	$\%\hat{e}$	Δu	$\%EV$	$\%EV$
Australia	2.03	2.27	81.54	18.46	0.41	-0.39	5.99	6.34
Austria	-0.06	-0.06	98.28	1.72	-0.00	0.00	-0.01	-0.02
Belgium	-0.06	-0.06	98.81	1.19	-0.00	0.00	-0.01	-0.01
Canada	-0.11	-0.10	93.16	6.84	-0.01	0.01	-0.11	-0.10
Czech Republic	-0.06	-0.06	98.25	1.75	-0.00	0.00	-0.02	-0.02
Denmark	-0.06	-0.06	98.01	1.99	-0.00	0.00	-0.02	-0.02
Finland	-0.07	-0.06	96.32	3.68	-0.00	0.00	-0.04	-0.04
France	-0.06	-0.06	98.30	1.70	-0.00	0.00	-0.01	-0.02
Germany	-0.06	-0.06	98.38	1.62	-0.00	0.00	-0.01	-0.01
Greece	-0.07	-0.06	96.80	3.20	-0.00	0.00	-0.03	-0.03
Hungary	-0.07	-0.06	97.45	2.55	-0.00	0.00	-0.02	-0.02
Iceland	-0.08	-0.07	94.83	5.17	-0.00	0.00	-0.06	-0.06
Ireland	-0.06	-0.06	98.00	2.00	-0.00	0.00	-0.02	-0.02
Italy	-0.06	-0.06	97.69	2.31	-0.00	0.00	-0.02	-0.02
Japan	-0.05	-0.05	94.57	5.43	-0.00	0.00	-0.04	-0.04
Korea	-0.05	-0.05	94.51	5.49	-0.00	0.00	-0.04	-0.04
Netherlands	-0.06	-0.06	98.76	1.24	-0.00	0.00	-0.01	-0.01
New Zealand	-0.13	-0.12	72.28	27.72	-0.03	0.03	-0.54	-0.50
Norway	-0.07	-0.06	96.86	3.14	-0.00	0.00	-0.03	-0.03
Poland	-0.07	-0.06	97.59	2.41	-0.00	0.00	-0.02	-0.02
Portugal	-0.07	-0.06	96.93	3.07	-0.00	0.00	-0.03	-0.03
Slovak Republic	-0.06	-0.06	97.71	2.29	-0.00	0.00	-0.02	-0.02
Spain	-0.07	-0.06	97.20	2.80	-0.00	0.00	-0.03	-0.03
Sweden	-0.07	-0.06	97.07	2.93	-0.00	0.00	-0.03	-0.03
Switzerland	-0.06	-0.06	98.59	1.41	-0.00	0.00	-0.01	-0.01
Turkey	-0.07	-0.07	95.52	4.48	-0.00	0.00	-0.05	-0.05
United Kingdom	-0.06	-0.06	98.31	1.69	-0.00	0.00	-0.01	-0.02
United States	0.00	0.02	-6.34	106.34	0.02	-0.02	0.28	0.30
Average	0.01	0.02	58.36	41.64	0.01	-0.01	0.21	0.23

Notes: Counterfactual analysis is based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table A.9: Comparative static effects of $\hat{\kappa}_{U.S.} = 1.054$ assuming balanced trade but controlling for tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share %Y SMF		SMF	SMF	PLM	SMF
	$\%Y$	$\%Y$	$\%\ln(\hat{p})$	$\%\ln(\hat{e})$	$\%\hat{e}$	Δu	$\%EV$	$\%EV$
Australia	0.00	0.17	76.76	23.24	0.04	-0.04	-0.00	0.58
Austria	0.00	0.04	73.08	26.92	0.01	-0.01	0.00	0.18
Belgium	0.00	0.03	70.80	29.20	0.01	-0.01	-0.00	0.14
Canada	0.00	0.83	78.00	22.00	0.18	-0.17	0.00	2.70
Czech Republic	0.00	0.05	74.17	25.83	0.01	-0.01	0.00	0.19
Denmark	0.00	0.06	74.36	25.64	0.01	-0.01	0.00	0.23
Finland	0.00	0.12	76.54	23.46	0.03	-0.03	0.00	0.43
France	-0.00	0.05	73.59	26.41	0.01	-0.01	-0.00	0.20
Germany	-0.00	0.04	73.07	26.93	0.01	-0.01	-0.00	0.18
Greece	0.00	0.08	75.27	24.73	0.02	-0.02	0.00	0.31
Hungary	0.00	0.07	75.57	24.43	0.02	-0.02	0.00	0.27
Iceland	-0.00	0.26	77.61	22.39	0.06	-0.06	-0.00	0.90
Ireland	0.00	0.07	75.03	24.97	0.02	-0.02	0.00	0.27
Italy	0.00	0.06	74.66	25.34	0.02	-0.01	-0.00	0.25
Japan	0.00	0.06	74.35	25.65	0.01	-0.01	-0.00	0.22
Korea	0.00	0.06	74.13	25.87	0.01	-0.01	0.00	0.25
Netherlands	0.00	0.03	71.35	28.65	0.01	-0.01	-0.00	0.14
New Zealand	0.00	0.19	76.73	23.27	0.04	-0.04	0.00	0.68
Norway	0.00	0.11	76.17	23.83	0.03	-0.02	0.00	0.38
Poland	0.00	0.07	75.60	24.40	0.02	-0.01	0.00	0.27
Portugal	0.00	0.11	75.86	24.14	0.03	-0.03	0.00	0.43
Slovak Republic	0.00	0.06	75.10	24.90	0.02	-0.01	0.00	0.25
Spain	0.00	0.09	75.79	24.21	0.02	-0.02	-0.00	0.36
Sweden	0.00	0.09	75.87	24.13	0.02	-0.02	0.00	0.35
Switzerland	0.00	0.03	70.87	29.13	0.01	-0.01	0.00	0.14
Turkey	0.00	0.12	76.49	23.51	0.03	-0.02	-0.00	0.44
United Kingdom	-0.00	0.05	73.97	26.03	0.01	-0.01	-0.00	0.22
United States	0.00	2.94	-79.04	179.04	5.32	-5.08	-0.00	4.65
Average	0.00	1.15	17.76	82.24	1.98	-1.89	0.00	1.96

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table A.10: Heterogeneity of comparative static trade effects of $\hat{\kappa}_{U.S.} = 1.054$ with imperfect labor markets and assuming balanced trade but controlling for tariff revenues in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-0.55	-0.52	0.67	0.75	0.77	0.81	0.81
Austria	-0.35	-0.32	0.86	0.94	0.97	1.01	1.01
Belgium	-0.33	-0.30	0.88	0.96	0.99	1.02	1.03
Canada	-1.44	-1.30	-0.39	-0.31	-0.28	-0.25	-0.25
Czech Republic	-0.35	-0.33	0.86	0.94	0.96	1.00	1.00
Denmark	-0.37	-0.35	0.84	0.92	0.95	0.98	0.99
Finland	-0.47	-0.44	0.74	0.83	0.85	0.89	0.89
France	-0.36	-0.33	0.85	0.93	0.96	1.00	1.00
Germany	-0.35	-0.32	0.86	0.94	0.97	1.01	1.01
Greece	-0.41	-0.38	0.80	0.89	0.92	0.95	0.95
Hungary	-0.39	-0.37	0.82	0.90	0.93	0.96	0.96
Iceland	-0.70	-0.67	0.51	0.59	0.62	0.65	0.65
Ireland	-0.39	-0.36	0.82	0.91	0.93	0.97	0.97
Italy	-0.38	-0.35	0.83	0.91	0.94	0.98	0.98
Japan	-0.37	-0.34	0.84	0.92	0.95	0.99	0.99
Korea	-0.37	-0.35	0.84	0.92	0.95	0.98	0.98
Netherlands	-0.33	-0.30	0.88	0.96	0.99	1.02	1.03
New Zealand	-0.58	-0.56	0.63	0.71	0.74	0.77	0.77
Norway	-0.45	-0.42	0.76	0.84	0.87	0.90	0.90
Poland	-0.39	-0.36	0.82	0.90	0.93	0.97	0.97
Portugal	-0.46	-0.43	0.75	0.83	0.86	0.89	0.90
Slovak Republic	-0.38	-0.35	0.83	0.91	0.94	0.98	0.98
Spain	-0.43	-0.40	0.78	0.86	0.89	0.92	0.93
Sweden	-0.43	-0.40	0.78	0.87	0.90	0.93	0.93
Switzerland	-0.33	-0.31	0.88	0.96	0.98	1.02	1.02
Turkey	-0.46	-0.44	0.75	0.83	0.86	0.89	0.89
United Kingdom	-0.36	-0.34	0.85	0.93	0.96	0.99	0.99
United States	-1.45	-1.29	-0.25	-0.17	-0.15	-0.11	-0.11
Average	-0.49	-0.45	0.72	0.80	0.83	0.86	0.86

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.11: Estimates of the matching elasticity using panel data regressions, 1994-2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
time-varying country fixed effects								
μ	.966	.966	.986	.985	1.000	.991	.994	.996
	(.001)	(.001)	(.001)	(.001)	(.000)	(.001)	(.000)	(.000)
country fixed effects								
μ	.971	.971	.99	.99	1.000	.994	.997	.999
	(.001)	(.001)	(.001)	(.001)	(.000)	(.001)	(.000)	(.000)
N	4675							

Notes: Estimates of μ based on Equation (68) and the trade cost parameter estimates and corresponding σ estimates from columns (1) to (8) of Table 2. Unbalanced panel from 1994 to 2006. Standard errors calculated by the delta method.

Gravity with Unemployment

Benedikt Heid and Mario Larch*

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Abstract

Quantifying the welfare effects of trade liberalization is a core issue in international trade. Existing frameworks assume perfect labor markets and therefore ignore the effects of aggregate employment changes for welfare. We develop a quantitative trade framework which explicitly models labor market frictions. To illustrate, we assess the effects of trade and labor market reforms for 28 OECD countries. Welfare effects of trade agreements are typically magnified when accounting for employment changes. While employment and welfare increase in most countries, some experience higher unemployment and lower welfare. Labor market reforms in one country have small positive spillover effects on trading partners.

Keywords: welfare effects of trade; quantitative trade theory; unemployment; trade costs; structural estimation; gravity equation
JEL-Codes: F14; F16; F13; F17

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*Heid: University of Bayreuth, CESifo, Universitätsstraße 30, 95447 Bayreuth, Germany, `benedikt.heid@uni-bayreuth.de`. Larch: University of Bayreuth, CESifo, ifo Institute, and GEP at University of Nottingham, Universitätsstraße 30, 95447 Bayreuth, Germany, `mario.larch@uni-bayreuth.de`. A previous version of this paper has been circulated under the title "International Trade and Unemployment: A Quantitative Framework". Funding from the DFG under project 592405 is gratefully acknowledged. We thank Daniel Bernhofen, Hartmut Egger, Christian Holzner, Kala Krishna, John McLaren, Marc-Andreas Muendler, Emanuel Ornelas, Yoto Yotov, participants at the GEP Postgraduate Conference 2012, the CESifo Area Conference on Global Economy 2012, the European Trade Study Group 2012, the Annual Meeting of the European Society of Population Economics 2012, the Annual Meeting of the Verein für Socialpolitik 2013, the Annual Congress of the European Economic Association 2013, the CAGE International Trade Research Day 2013, research seminars at the Universities of Trier and Innsbruck, and the 7th FIW-Research Conference on International Economics 2014, for helpful comments. As always, we have a property right on any remaining errors.

1 Introduction

The quantification of the welfare effects of trade liberalization is one of the core issues in empirical international trade. The workhorse model for evaluating welfare effects of trade policies is the structural gravity model. All variants of this workhorse model so far assume perfect labor markets with full employment. For example, Arkolakis et al. (2012) have shown that an ex post analysis of the welfare effects (measured in terms of real income) of a move from autarky to the observed level of trade liberalization is possible by using only data on the observed import share in a country and an estimate of the trade elasticity. If we relax the assumption of full employment, then real income is given by the real wage bill in terms of the price level P_j of all employed workers, i.e., $e_j L_j w_j / P_j$, where e_j is the share of the labor force L_j which is employed times the wage w_j which is paid to a worker. Hence assuming a constant labor force, any change in welfare W_j can be decomposed into a change in net employment and the real wage, i.e.,

$$\hat{W}_j \equiv \frac{W_j'}{W_j} = \hat{e}_j \widehat{\left(\frac{w_j}{P_j}\right)}, \tag{1}$$

where the hat denotes the ratio of welfare levels W_j' and W_j in two situations. In Arkolakis et al. (2012), $\hat{e}_j = 1$ by assumption, and the ratio in real wages is given by $\hat{\lambda}_{jj}^{1/\varepsilon}$, the change in the share of domestic expenditure, $\hat{\lambda}_{jj}$, raised to some power of ε, the elasticity of imports with respect to variable trade costs (the trade elasticity, for short). Assuming full employment allows Arkolakis et al. (2012) to conduct a very simple ex post analysis of the welfare effects of moving from autarky to the observed level of trade integration. As $\lambda_{jj} = 1$ under autarky, one can calculate the welfare gains from trade from the observed domestic expenditure share when an estimate of the trade elasticity is available. When we allow for unemployment, however, this is not feasible any longer as we do not observe the counterfactual employment level under autarky. When we are interested in an ex ante evaluation of any counterfactual trade policy besides autarky, we additionally need estimates of trade cost parameters to get an estimate of the counterfactual domestic consumption share, which typically are obtained from estimating gravity models, regardless of whether we assume perfect or imperfect labor markets.

In the following, we present a simple quantitative framework for bilateral trade flows based on Armington (1969) preferences and recently developed models of international trade with search and matching labor market frictions, specifically Felbermayr et al. (2013).[1] This framework allows us to derive sufficient statistics for the welfare effects of trade liberalization similar to those of Arkolakis et al. (2012) but augmented by the aggregate employment change. The additional insights of incorporating labor market frictions into a quantitative trade model come at minimal cost: we only require knowledge of the elasticity of the matching function. Hence, this framework is easily applied to all topics where trade flow effects are inferred, such as trade agreements, currency unions, borders, or ethnic networks.

We apply the framework to a sample of 28 OECD countries from 1988 to 2006 in order to evaluate three scenarios. First, we calculate the effects of introducing regional trade agreements (RTAs) starting from a counterfactual world without any RTAs. Second, we evaluate the effects of the U.S.-Australia Free Trade Agreement. Third, we evaluate the effects of a hypothetical labor market reform in the United States. We find that the introduction of RTAs as observed in 2006 leads to seven percent larger welfare effects on average when allowing for imperfect labor markets. When we use commonly assumed values for the elasticities in our model instead of our estimates, we find that accounting for labor market frictions increases the welfare gains by more than 50 percent. Similar additional welfare gains arise for Australia and the United States when evaluating the U.S.-Australia Free Trade Agreement. In our framework, changes in trade costs or labor market policies affect labor market outcomes through changes in relative prices and income effects. When trade costs fall, imports of foreign varieties become cheaper, leading to a lower consumer price

[1] In order to check the sensitivity of our framework to different wage determination processes, we employ several approaches to divide the rent between workers and firms. In addition to wage bargaining considered by Felbermayr et al. (2013), we also consider minimum wages and efficiency wages.

index in the corresponding country. When labor markets are characterized by search frictions, firms have to incur costs to post vacancies in order to find workers. The lower price level translates one-to-one into lower recruiting costs for domestic firms.[2] Firms *ceteris paribus* create more vacancies so that more workers find a job and unemployment is reduced. Hence, standard methods neglecting labor market effects typically underestimate the welfare gains from trade liberalization.

Our third counterfactual experiment analyzes a hypothetical improvement of labor market institutions in the United States. As expected, welfare increases in the United States but also improves for its trading partners due to positive spillover effects of the labor market reform. A unilateral labor market reform which for example increases the matching efficiency will increase the number of successful matches between workers and firms and thus rise employment, total sales, and welfare in the corresponding country. As workers spend part of their income on foreign varieties, the increase in income leads to higher import demand for all trading partners. This translates into lower unemployment in the trading partners, leading to a positive correlation between changes in unemployment rates across countries.

The paper is structured as follows: in Section 2 we present our quantitative framework and derive expressions for the counterfactual trade and employment levels for welfare evaluations of trade and labor market policy changes. Section 3 shows how to estimate trade cost parameters and elasticities. We then illustrate the application of our estimated model by evaluating the effects of regional trade agreements and labor market reforms for a sample of 28 OECD countries. Section 4 concludes.

Our paper is related to several literatures, notably the gravity literature which models bilateral trade flows. Within our framework, changes in employment and expenditure directly affect bilateral trade flows which can be described by a gravity equation. It captures the key stylized facts that trade increases with market size and decreases with distance. The empirical success

[2] **?** and Felbermayr et al. (2013) on the one hand and Helpman and Itskhoki (2010) on the other use a similar mechanism in a one- and two-sector model, respectively.

of the gravity equation spurred a great deal of interest in its theoretical underpinnings. **?** and **?** address the role of multilateral price effects for trade flows. A more recent contribution by Eaton and Kortum (2002) develops a quantifiable Ricardian model of international trade to investigate the role of comparative advantage and geography for bilateral trade flows. Anderson and van Wincoop (2003) refine the gravity equation's theoretical foundations by highlighting the importance of controlling for multilateral resistance terms and proper empirical comparative static analysis. **?** introduces non-homothetic preferences into the Ricardian framework of Eaton and Kortum (2002) to rationalize the fact that bilateral trade is large between rich countries and small between poor countries. **?** provides a complementary framework with asymmetric trade costs to explain the cross-country-pair differences in bilateral trade volumes and income levels. **?** extend the Eaton and Kortum (2002) framework to allow for sectoral linkages and intermediate goods to evaluate NAFTA. **?** elaborate on the incidence of bilateral trade costs in the Anderson and van Wincoop (2003) framework. These theoretical developments allow one to employ the gravity equation to infer the welfare effects of counterfactual trade liberalization scenarios accounting for general equilibrium effects, which is a core issue in empirical work on international trade.

Despite this multitude of theoretical foundations for the gravity equation, to date all of them assume perfect labor markets. Crucially, this implies that changes in real welfare ignore changes in the total number of employed workers due to trade liberalization or labor market reforms. A different strand of the theoretical trade literature stresses various channels through which trade liberalization affects (un)employment. **?**, **?**, and **?** focus on minimum wages to analyze the interactions between trade and labor market policies. A binding minimum wage prevents downward wage adjustments when a country opens up to trade. Instead, firms adjust the number of employed workers. Others have stressed labor market frictions arising due to fair wages or efficiency wages (**???**). Fair wages or efficiency wages lead firms to pay wages above the market clearing level in order to ensure compliance of workers. When trade is liberalized, average productivity of firms increases, which leads to an increase of the fair or efficiency wage due to rent-sharing as well as an increase in unemployment. Finally, search-theoretic foundations of labor market frictions are introduced into trade models (?????Helpman and Itskhoki 2010; ?; Felbermayr et al. 2013). In these models, workers search for jobs and firms for workers. Once a firm-worker match is established, they bargain over the match-specific surplus. Trade and labor markets interact via relative prices of hiring workers and goods prices which affect search and recruitment efforts. In multiple sector models, trade liberalization leads to higher prices and employment in the export-oriented sector. The opposite occurs in the import-competing sector. Due to the one-sector nature of our framework, we abstract from the employment effects resulting from reallocating employment across sectors, possibly biasing upwards our estimates of the effects of trade liberalization.[3]

Relatedly, the static one sector nature of our framework precludes us from analyzing the transition dynamics and costs which potentially arise in a multiple sector model. When trade liberalization induces the economy to specialize in the export-oriented sector, the employment reallocation across sectors may imply that former import-competing sector workers have to undergo some training to be employable in the export sector. This entails both monetary training costs as well as the opportunity cost of the foregone production during training. As ? show in a small open economy model, these dynamic adjustment costs may eat up a substantial amount of the gains from trade. Still, as in our model, higher labor market frictions lead to higher gains from trade. ? show that comparing steady states, as we do, may also underestimate the potential gains from a trade liberalization episode derived from a dynamic net present value comparison. Obviously, adjustment dynamics are important for welfare evaluations of trade liberalization. Therefore, our framework should be seen as a first step to take into account labor market frictions in structural gravity models.

[3]? and ? study the effect of differences in labor market frictions on patterns of comparative advantage. However, their model neither considers trade costs, the center piece of gravity analysis, nor does it feature unemployment.

Taking into account sectoral reallocation and adjustment dynamics leads to theoretically ambiguous effects of trade liberalization on aggregate employment. Empirically, **?** as well as **?** provide reduced-form evidence that more open economies have lower unemployment rates on average in cross-country (panel) regressions.[4] In contrast to these reduced-form approaches, our structural quantitative framework accounts for country-specific general equilibrium effects and allows one to quantify employment and welfare effects of policies.[5]

2 A quantitative framework for trade and unemployment

2.1 Goods market

The representative consumer in country j is characterized by the utility function U_j. We assume that goods are differentiated by country of origin, i.e., we use the simplest possible way to provide a rationale for bilateral trade between similar countries based on preferences à la Armington (1969).[6] In an Online Appendix, we demonstrate that our framework and counterfactual analysis are isomorphic to a Ricardian model of international trade along the lines of Eaton and Kortum (2002). Country j purchases quantity q_{ij} of goods from country i, leading to the utility function

$$U_j = \left[\sum_{i=1}^{n} \beta_i^{\frac{1-\sigma}{\sigma}} q_{ij}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

[4] Also, **?** find at least no increase in unemployment after trade liberalization in India; **?** find no increase of unemployment in a sample of OECD countries.

[5] A recent literature studies the labor market effects of trade liberalization using structural dynamic models (**?**, **?**; **?**, **?**; **?**, **?**; **?**, **?**; **?**, **?**; **?**, **?**; **?**, **?**). However, all these studies focus on single countries and hence abstract from the interdependencies of trade flows between countries, a decisive feature of our model. Also, with the exception of **?** who study the United States, this literature focuses on the effects of trade liberalization in Latin American emerging economies, not developed countries.

[6] Consequently, we deliberately abstract from distinguishing between the intensive and extensive margin of international trade as for example in Chaney (2008) or Helpman et al. (2008).

where n is the number of countries, σ is the elasticity of substitution in consumption, and β_i is a positive preference parameter measuring the product appeal for goods from country i.

Trade of goods from i to j imposes iceberg trade costs $t_{ij} \geq 1$. Assuming factory-gate pricing for all firms implies that $p_{ij} = p_i t_{ij}$, where p_i denotes the factory-gate price in country i.

The representative consumer maximizes Equation (2) subject to the budget constraint $Y_j = \sum_{i=1}^{n} p_i t_{ij} q_{ij}$, with Y_j denoting nominal expenditure in country j.[7] The value of sales of goods from country i to country j can then be expressed as

$$X_{ij} \quad = \quad p_i t_{ij} q_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{1-\sigma} Y_j, \tag{3}$$

and P_j is the standard CES price index given by $P_j = [\sum_{i=1}^{n} (\beta_i p_i t_{ij})^{1-\sigma}]^{1/(1-\sigma)}$. In general equilibrium, total sales of country i correspond to expenditure of country i, i.e.,

$$Y_i \quad = \quad \sum_{j=1}^{n} X_{ij} = \sum_{j=1}^{n} \left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{1-\sigma} Y_j = (\beta_i p_i)^{1-\sigma} \sum_{j=1}^{n} \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} Y_j. \tag{4}$$

Solving for scaled prices $\beta_i p_i$ and defining $Y^W \equiv \sum_j Y_j$, we can write bilateral trade flows as given in Equation (3) as

$$X_{ij} = \frac{Y_i Y_j}{Y^W} \left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma}, \quad \text{where} \tag{5}$$

[7] In the Online Appendix, we generalize our model by allowing for trade imbalances following Dekle et al. (2007) and revenue-generating tariffs as in **?**. All our counterfactual simulations in the main text use this generalized version of the model. We stick to the assumptions of balanced trade and no tariff revenue for ease of exposition in the main text. We also conducted counterfactual scenarios assuming balanced trade or zero tariffs, but our results changed very little, see the results in the Online Appendix.

$$\Pi_i = \left(\sum_{j=1}^{n} \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \frac{Y_j}{Y^W} \right)^{1/(1-\sigma)}, \quad P_j = \left(\sum_{i=1}^{n} \left(\frac{t_{ij}}{\Pi_i} \right)^{1-\sigma} \frac{Y_i}{Y^W} \right)^{1/(1-\sigma)}, \quad (6)$$

and where Π_i and P_j are the multilateral resistance terms and where we substituted equilibrium scaled prices into the definition of the price index to obtain P_j.

Note that this system of equations exactly corresponds to the gravity system given in Equations (9)-(11) in Anderson and van Wincoop (2003) or Equations (5.32) and (5.35) in Feenstra (2004), even when labor markets are imperfect. The intuition for this result is that total sales appear in Equation (5) and consumer preferences are homothetic. Assuming labor to be the only factor of production which produces one unit of output per worker, total sales in a world with imperfect labor markets are given by total production of the final output good multiplied with its price, i.e., $Y_i = p_i(1 - u_i)L_i$, where u_i denotes the unemployment rate in country i. The only difference is that now total sales are produced by *employed workers*, not all workers, as is assumed with perfect labor markets.

By adding a stochastic error term, Equation (5) can be written as

$$Z_{ij} \equiv \frac{X_{ij}}{Y_i Y_j} = \exp\left[k + (1-\sigma)\ln t_{ij} - \ln \Pi_i^{1-\sigma} - \ln P_j^{1-\sigma} + \varepsilon_{ij}\right], \quad (7)$$

where ε_{ij} is a random disturbance term or measurement error, assumed to be identically distributed and mean-independent of the remaining terms on the right-hand side of Equation (7), and k is a constant capturing the logarithm of world sales. Importer and exporter fixed effects can be used to control for the outward and inward multilateral resistance terms Π_i and P_j, respectively, as suggested by Anderson and van Wincoop (2003) and Feenstra (2004). Hence, even with labor market frictions, we can use established methods to estimate trade costs using the gravity equation, independently of the underlying labor market model. We summarize this result in Implication 1:

Implication 1 *The estimation of trade costs is unchanged when allowing for imperfect labor markets.*

To evaluate ex ante welfare effects of changes in trade policies, we need the counterfactual changes in employment and total sales in addition to trade cost parameter estimates. To derive these, we have to take a stance on how to model the labor market, to which we turn in the next section.

2.2 Labor market

We model the labor market using a one-shot version of the search and matching framework (SMF, see Mortensen and Pissarides, 1994 and Pissarides, 2000) which is closely related to Felbermayr et al. (2013).[8] Search-theoretic frameworks fit stylized facts of labor markets in developed economies as they explain why some workers are unemployed even if firms cannot fill all their vacancies.[9]

The labor market is characterized by frictions. All potential workers in country j, L_j, have to search for a job, and firms post vacancies V_j in order to find workers. The number of successful matches between an employer and a worker, M_j, is given by $M_j = m_j L_j^{\mu} V_j^{1-\mu}$, where $\mu \in (0,1)$ is the elasticity of the matching function with respect to the unemployed and m_j measures the overall efficiency of the labor market.[10] Only a fraction of open vacancies will be filled, $M_j/V_j = m_j \left(V_j/L_j\right)^{-\mu} = m_j \vartheta_j^{-\mu}$, and only a fraction of all workers will find a job, $M_j/L_j = m_j \left(V_j/L_j\right)^{1-\mu} = m_j \vartheta_j^{1-\mu}$, where $\vartheta_j \equiv V_j/L_j$ denotes

[8] See Rogerson et al. (2005) for a survey of search and matching models, including an exposition of a simplified one-shot (directed) search model. For other recent trade models using a similar static framework without directed search, see for example Keuschnigg and Ribi (2009), Helpman and Itskhoki (2010), and Heid et al. (2013). We use the labor market setup from Felbermayr et al. (2013). However, they do not investigate its implications for the estimation of gravity equations nor do they structurally estimate it or use it for a counterfactual quantitative analysis. They also do not present labor market setups with minimum and efficiency wages nor do they consider alternative trade models such as the Eaton and Kortum (2002) framework as we do in our Online Appendix.

[9] They are less successful in explaining the cyclical behavior of unemployment and vacancies, see Shimer (2005). This deficiency is not crucial in our case as we purposely focus on the steady state.

[10] Note that we assume a constant returns to scale matching function in line with empirical studies, see Petrongolo and Pissarides (2001).

the degree of labor market tightness in country j.[11] This implies that the unemployment rate is given by

$$u_j = 1 - m_j \vartheta_j^{1-\mu}. \tag{8}$$

As is standard in search models, we assume that every firm employs one worker. Similar to Helpman and Itskhoki (2010), this assumption does not lead to any loss of generality as long as the firm operates under perfect competition and constant returns to scale. In addition, we assume that all firms have the same productivity and produce a homogeneous good. In order to employ a worker (i.e., to enter the market), the firm has to post a vacancy at a cost of $c_j P_j$, i.e., in units of the final output good.[12] Vacancy posting costs can be direct costs of searching for workers but also training costs. In our setup, they can also be interpreted as firm setup costs or as a reduced form capital good (machines etc.) which cannot be produced by labor internal to firm but have to be bought on the market before workers can actually start producing.

After paying these costs, a firm finds a worker with probability $m_j \vartheta_j^{-\mu}$. When a match between a worker and a firm has been established, we assume that they bargain over the total match surplus. Alternatively, we consider minimum and efficiency wages in the Online Appendix as mechanisms for wage determination. All three approaches are observationally equivalent in our setting.

In the bargaining case, the match gain of the firm is given by its revenue from sales of one unit of the homogeneous product minus wage costs, $p_j - w_j$,

[11] We assume that the matching efficiency is sufficiently low to ensure that M_j/V_j and M_j/L_j lie between 0 and 1.

[12] This implies that not all of produced output is available for final consumption (and hence welfare) of workers. Another option would be to denote the vacancy posting costs in terms of the domestic good, which in equilibrium is proportional to the domestic wage. This would imply that vacancy posting costs consist only of domestic labor costs. More realistically, vacancy posting costs may consist of both expenditures for labor as well as final goods expenditures (which include intermediates). In Appendix A we investigate the implications of this more general framework. In the case that vacancy posting costs are paid in domestic labor only, trade liberalization does not have any effect on the unemployment rate. In this sense, our model can be seen as an upper bound analysis of the effects of trade on unemployment.

as the firm's outside option is zero. The match surplus of a worker is given by $w_j - b_j$, where b_j is the outside option of the worker, i.e., the unemployment benefits (b_j) she receives when she is unemployed.[13]

As is standard in the literature, we use a generalized Nash bargaining solution to determine the surplus splitting rule. Hence, wages w_j are chosen to maximize $(w_j - b_j)^{\xi_j}(p_j - w_j)^{1-\xi_j}$, where the bargaining power of the worker is given by $\xi_j \in (0, 1)$. The unemployment benefits are expressed as a fraction γ_j of the market wage rate. Note that both the worker and the firm neglect the fact that in general equilibrium, higher wages lead to higher unemployment benefits, i.e., they both treat the level of unemployment benefits as exogenous (see Pissarides, 2000). The first order conditions of the bargaining problem yield $w_j - \gamma_j w_j = (p_j - w_j)\,\xi_j/(1 - \xi_j)$. Solving for w_j results in the **wage curve** $w_j = p_j\xi_j/(1 + \gamma_j\xi_j - \gamma_j)$. Due to the one-shot matching, the wage curve does not depend on ϑ_j.

Given wages w_j, profits of a firm π_j are given by $\pi_j = p_j - w_j$. As we assume one worker firms and the probability of filling an open vacancy is $m_j\vartheta_j^{-\mu}$, expected profits are equal to $(p_j - w_j)m_j\vartheta_j^{-\mu}$. Firms enter the market until these expected profits cover the entry costs c_jP_j. This condition can be used to yield the **job creation curve** $w_j = p_j - P_jc_j/(m_j\vartheta_j^{-\mu})$.

As pointed out by Felbermayr et al. (2013), combining the job creation and wage curves determines the equilibrium labor market tightness as

$$\vartheta_j = \left(\frac{p_j}{P_j}\right)^{1/\mu}\left(\frac{c_j}{m_j}\Omega_j\right)^{-1/\mu}. \tag{9}$$

$\Omega_j \equiv \frac{1-\gamma_j+\gamma_j\xi_j}{1-\gamma_j+\gamma_j\xi_j-\xi_j} \geq 1$ is a summary measure for the impact of the worker's bargaining power ξ_j and the replacement rate γ_j on labor market tightness.[14]

[13] Unemployment benefits are financed via lump-sum transfers from employed workers to the unemployed. As we assume homothetic preferences, which are identical across employed and unemployed workers, this does not show up in the economy-wide budget constraint Y_j, see Equation (4). Hence, demand can be fully described by aggregate expenditure. We also assume costless redistribution of the lump-sum transfer to the unemployed. These assumptions allow us to abstract from modeling the government more explicitly.

[14] The replacement rate is the percentage of the equilibrium wage a worker receives as unemployment benefits when she is unemployed.

The relative price p_j/P_j is determined by the demand and the supply of goods. It therefore provides the link between the labor and goods market. In case vacancy posting costs are denoted in terms of domestic labor only, labor market tightness is independent of the general price level P_j and therefore independent of the level of international trade. More generally, to get a model where trade liberalization has an impact on unemployment, trade liberalization has to influence the costs of creating a vacancy and the revenues of filling a vacancy differently. We achieve this in the simplest possible way by denoting vacancy posting costs in terms of $c_j P_j$, while revenues are a function of p_j. As we show in Appendix A, barring the extreme case where vacancy posting costs only consist of domestic labor, the qualitative mechanism linking trade and unemployment remains the same.

2.3 Counterfactual analysis

Most researchers estimate gravity equations in order to evaluate counterfactual policy changes. Often researchers estimate reduced-form gravity equations and interpret the estimated trade cost parameters as marginal effects on trade flows. This neglects the general equilibrium effects of trade cost changes due to relative changes of trade costs and the income effects induced by the policy change. For large-scale policy changes like regional trade agreements or economy-wide labor market reforms these general equilibrium effects are crucial. While we can recover the trade cost parameters without assumptions concerning the labor market according to Implication 1, to calculate the counterfactual trade, welfare, and employment effects, we have to take into account the full structure of our general equilibrium framework. Hence, accounting for labor market frictions matters for the quantification of policy changes.

To use our framework for counterfactual analyses, we use the following steps: 1.) We estimate the trade cost parameters. 2.) Given these estimates, we solve the system of equations given by Equation (6) for the multilateral resistance terms (MRTs) P_j and Π_i, using observed GDPs to calculate world expenditure shares, Y_j/Y^W. This yields the solutions for the baseline scenario.

3.) Using these baseline MRTs, we can estimate μ (and σ, if it has not been estimated alongside the trade cost parameters using tariff data). 4.) After defining counterfactual trade costs, e.g. setting the RTA dummy variable to 0, we again solve the system of equations given by Equation (6) to receive MRTs in the counterfactual scenario, P_j^c and Π_i^c, but now taking into account that counterfactual sales, Y_j^c, change endogenously due to the model structure and are given by $\hat{Y}_j Y_j$, where $\hat{Y}_j$ is given by Implication 4, as explained in detail below.[15]

When calculating counterfactual total sales, all approaches to date neglect changes in the total number of employed workers. For example, in the framework of Anderson and van Wincoop (2003) with perfect (or non-existent) labor markets, calculating total sales and corresponding shares in world expenditure is easy as "*quantities produced are assumed fixed*" (p. 190). However, this assumption is also very restrictive, as it implies that welfare changes are solely due to changes in (real) prices. Similarly, in Eaton and Kortum (2002) the number of employed workers remains constant.

In contrast, our model also leads to *employment* adjustments. When total sales fall, unemployment will rise, which in turn will impact wages. In essence, our model allows labor market variables to affect income. Hence, assuming perfect or imperfect labor markets matters for the proper counterfactual analysis.

In the following, we derive and discuss in turn counterfactual welfare along the lines of Arkolakis et al. (2012), (un)employment, total sales, and trade flows as functions of the multilateral resistance terms in the baseline and counterfactual scenario.

2.3.1 Counterfactual welfare

We can now consider the welfare consequences of a counterfactual change in trade costs that leaves the ability to serve the own market, t_{jj}, unchanged as in Arkolakis et al. (2012). Additionally, we follow their normalization and take

[15] See Appendix B for a description of the solution of the system of multilateral resistance terms with asymmetric trade costs and trade deficits.

labor in the considered country j as our numéraire, leading to $w_j = 1$. In our economy, total sales are given by total production of the final output good multiplied with its price, i.e., $Y_i = p_i(1 - u_i)L_i$, whereas wage income is given by $(1 - u_j)w_j L_j$.[16] We then come up with the following sufficient statistics (see Appendix C for the derivation):

Implication 2 *Welfare effects of trade liberalization in our model with imperfect labor markets can be expressed as*

$$\hat{W}_j = \hat{e}_j \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}.$$

Hence, welfare depends on the employment change, $\hat{e}_j$, the change in the share of domestic expenditures, $\hat{\lambda}_{jj}$, and the partial elasticity of imports with respect to variable trade costs, given in our case by $(1 - \sigma)$. Note that in the case of perfect labor markets $\hat{e}_j = 1$ and $\hat{W}_j = \hat{\lambda}_{jj}^{1/(1-\sigma)}$, which is exactly Equation (6) in Arkolakis et al. (2012).

When $\hat{\lambda}_{jj}$ is observed, assuming imperfect or perfect labor markets leads to different welfare predictions. The difference in the welfare change is given by $\hat{e}_j$. If employment increases, welfare goes up as well. If trade liberalization improves the relative price p_j/P_j of country j, labor market tightness goes up (see Equation (9)), and hence employment goes up. Assuming perfect labor markets neglects the effects on employment and the corresponding welfare effects. Further, note that $\hat{\lambda}_{jj}^{1/(1-\sigma)} = \widehat{(p_j/P_j)}$ (see Appendix C), and hence, the improvement of the relative price leads to a higher openness increasing welfare. Whether welfare increases or decreases in a particular country depends on the magnitude of the relative price change p_j/P_j.

While Implication 2 already describes how to calculate welfare within our framework, we can equivalently express the change in welfare as a function of the multilateral resistance terms by using the equivalent variation, i.e., the amount of income the representative consumer would need to make her as

[16] Total wage income consists of the income of employed workers $(1 - u_j)w_j L_j - B_j$, and the income of unemployed workers B_j where $B_j = u_j L_j b_j$. The total sum of unemployment benefits is financed by a lump-sum transfer from employed workers to the unemployed. As we assume homothetic preferences, demand can be fully described by aggregate income.

well off under current prices P_j as in the counterfactual situation with price level P_j^c. Using the definitions for total sales $Y_j = p_j(1-u_j)L_j$ and wage income $(1-u_j)w_jL_j$, and noting that from the wage curve it follows that $w_j = \xi_j p_j/(1+\gamma_j\xi_j-\gamma_j)$, we can express wage income as $\xi_j Y_j/(1+\gamma_j\xi_j-\gamma_j)$. Defining $v_j = \xi_j/(1+\gamma_j\xi_j-\gamma_j)$ and $\hat{v}_j \equiv v_j^c/v_j$, respectively, we can express the change in wage income as a function of the change in total sales and $\hat{v}_j$, $\hat{v}_j\hat{Y}_j$. We can then express the equivalent variation in percent as follows:

$$EV_j = \frac{v_j^c Y_j^c \frac{P_j}{P_j^c} - v_j Y_j}{v_j Y_j} = \frac{v_j^c Y_j^c}{v_j Y_j}\frac{P_j}{P_j^c} - 1 = \hat{v}_j \hat{Y}_j \frac{P_j}{P_j^c} - 1. \tag{10}$$

Hence welfare can be calculated by using the expressions for the price indices (which can be derived from the multilateral resistance terms) and the counterfactual change in total sales. To derive the counterfactual change in total sales, it turns out to be useful to first derive an expression for the counterfactual change in (un)employment.

2.3.2 Counterfactual (un)employment

We follow Anderson and van Wincoop (2003) and use Equation (4) to solve for scaled prices as follows:

$$(\beta_j p_j)^{1-\sigma} = \frac{Y_j}{\sum_{i=1}^{n}\left(\frac{t_{ji}}{P_i}\right)^{1-\sigma} Y_i} = \frac{Y_j}{Y^W}\Pi_j^{\sigma-1}. \tag{11}$$

We then use the definition of u_j given in Equation (8), replacing ϑ_j by the expression given in Equation (9) and defining $\Xi_j \equiv m_j\left(\frac{c_j}{m_j}\Omega_j\right)^{\frac{\mu-1}{\mu}}$ and $\hat{\kappa}_j \equiv \Xi_j^c/\Xi_j$, where superscript c denotes counterfactual values:

$$\frac{e_j^c}{e_j} \equiv \frac{1-u_j^c}{1-u_j} = \hat{\kappa}_j \left(\frac{p_j^c}{p_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{P_j}{P_j^c}\right)^{\frac{1-\mu}{\mu}}, \tag{12}$$

where e_j denotes the employment rate. Noting the derivation of Equation (11) and remembering that $P_j^{1-\sigma} = \sum_i t_{ij}^{1-\sigma}(Y_i/Y^W)\Pi_i^{\sigma-1}$ (see the definition of the price index), we can express the ratios of the prices and price indices as functions of $(Y_j/Y^W)\Pi_j^{\sigma-1}$ and $t_{ij}^{1-\sigma}$ to end up with counterfactual (un)employment levels summarized in the following implication:

Implication 3 *Whereas in the setting with perfect labor markets (un)employment effects are zero by assumption, the (un)employment effects in our gravity system with imperfections on the labor market are given by:*

$$\begin{aligned}
\hat{e}_j &\equiv \frac{e_j^c}{e_j} = \hat{\kappa}_j \widehat{\left(\frac{p_j}{P_j}\right)}^{\frac{1-\mu}{\mu}} = \hat{\kappa}_j \left(\frac{p_j^c/P_j^c}{p_j/P_j}\right)^{\frac{1-\mu}{\mu}} \\
&= \hat{\kappa}_j \left(\frac{\frac{Y_j^c}{Y^{W,c}}\left(\Pi_j^c\right)^{\sigma-1}}{\frac{Y_j}{Y^W}\Pi_j^{\sigma-1}}\right)^{\frac{1-\mu}{\mu(1-\sigma)}} \left(\frac{\sum_i t_{ij}^{1-\sigma}\frac{Y_i}{Y^W}\Pi_i^{\sigma-1}}{\sum_i \left(t_{ij}^c\right)^{1-\sigma}\frac{Y_i^c}{Y^{W,c}}\left(\Pi_i^c\right)^{\sigma-1}}\right)^{\frac{1-\mu}{\mu(1-\sigma)}}, \\
\Delta u_j &\equiv u_j^c - u_j = (1-u_j)(1-\hat{e}_j).
\end{aligned}$$

Implication 3 reveals that a country can directly affect its (un)employment level by changes in its labor market institutions, as reflected by changes in $\hat{\kappa}_j$.[17] In addition, all trading partners are affected by such a labor market reform due to changes in prices as reflected by $(Y_j/Y^W)\Pi_j^{\sigma-1}$. Direct effects are scaled by changes in relative prices p_j/P_j which are proportional to $\left\{(Y_j/Y^W)\Pi_j^{\sigma-1}/[\sum_i t_{ij}^{1-\sigma}(Y_i/Y^W)\Pi_i^{\sigma-1}]\right\}^{1/(1-\sigma)}$, reflecting the spillovers of labor market reforms to other countries. Changes of relative prices due to trade liberalization therefore provide the link to the labor market.

Even with imperfect labor markets we just need one additional parameter alongside σ, namely μ, the elasticity of the matching function, in order to calculate counterfactual values once we have solved for the multilateral resistance terms. Note that μ plays a crucial role for the importance of the labor market frictions. To illustrate, assume that all labor market institutions remain the same (i.e., $\hat{\kappa}_j = 1$) and μ approaches one. Then, the (un)employment effects vanish.[18] A lower μ, i.e., higher labor market frictions, leads to larger changes in (un)employment for given relative price changes. Additionally, all

[17] Note that employment changes are homogeneous of degree zero in prices, implying that a normalization does not matter for the employment effects.

[18] In this case the level of unemployment is given by $u_j = 1 - m_j$.

(potential) changes in labor market policies are succinctly summarized in a reduced-form fashion in $\hat{\kappa}_j$. This ultimately also translates into the importance of the extent of labor market frictions for the magnitude of welfare. Using $\hat{e}_j = \hat{\kappa}_j \widehat{(p_j/P_j)}^{\frac{1-\mu}{\mu}}$ and $\hat{\lambda}_{jj}^{1/(1-\sigma)} = \widehat{(p_j/P_j)}$ for the welfare formula given in Implication 2, we can express welfare as: $\hat{W}_j = \hat{\kappa}_j \widehat{(p_j/P_j)}^{1/\mu}$. Trade liberalization changes the relative price. $1/\mu$ is the elasticity of the welfare change with respect to the relative price change p_j/P_j $\left(1/\mu \equiv \partial \ln \hat{W}_j / \partial \ln \widehat{(p_j/P_j)}\right)$. When μ goes to zero this elasticity tends to infinity, rendering the welfare change from trade liberalization arbitrarily large. This observation may help to resolve the typical finding of modest welfare gains from trade in trade gravity models (see Costinot and Rodríguez-Clare, 2014, and **?**, **?**). Without labor market frictions, the welfare formula simplifies to $\hat{W}_j = \widehat{(p_j/P_j)}$. Hence, for given relative price changes, $\widehat{(p_j/P_j)}$, welfare is magnified when accounting for labor market imperfections. Note, however, that price changes for any counterfactual analysis will be different when assuming perfect or imperfect labor markets. Specifically, for small welfare changes, welfare effects with imperfect labor markets may be smaller in absolute values, as the additional employment changes may lead to smaller relative price changes.

2.3.3 Counterfactual total sales

We next derive counterfactual total sales. Using the definition of total sales, $Y_j = p_j(1-u_j)L_j = p_j e_j L_j$, and taking the ratio of counterfactual total sales, Y_j^c, and total sales in the baseline scenario, Y_j, we can use Implication 3 and Equation (11) to come up with the following implication:

Implication 4 *Counterfactual total sales are given by:*

$$\textit{imperfect labor markets:} \quad \hat{Y}_j = \hat{\kappa}_j \left(\frac{\frac{Y_j^c}{Y^{W,c}} \left(\Pi_j^c\right)^{\sigma-1}}{\frac{Y_j}{Y^W} \Pi_j^{\sigma-1}} \right)^{\frac{1}{\mu(1-\sigma)}} \left(\frac{\sum_i t_{ij}^{1-\sigma} \frac{Y_i}{Y^W} \Pi_i^{\sigma-1}}{\sum_i \left(t_{ij}^c\right)^{1-\sigma} \frac{Y_i^c}{Y^{W,c}} \left(\Pi_i^c\right)^{\sigma-1}} \right)^{\frac{1-\mu}{\mu(1-\sigma)}},$$

$$\textit{perfect labor markets:} \quad \hat{Y}_j = \left(\frac{\frac{Y_j^c}{Y^{W,c}} \left(\Pi_j^c\right)^{\sigma-1}}{\frac{Y_j}{Y^W} \Pi_j^{\sigma-1}} \right)^{\frac{1}{1-\sigma}}.$$

If we assume $\mu = 1$, we end up with the case of perfect labor markets which is identical to the model employed by Anderson and van Wincoop (2003).

It is illuminating to decompose the change in total sales as follows:

$$\hat{Y}_j = \underbrace{\left(\frac{\frac{Y_j^c}{Y^{W,c}}\left(\Pi_j^c\right)^{\sigma-1}}{\frac{Y_j}{Y^W}\Pi_j^{\sigma-1}}\right)^{\frac{1}{1-\sigma}}}_{\text{price change}}$$

$$\times \underbrace{\hat{\kappa}_j \left(\frac{\frac{Y_j^c}{Y^{W,c}}\left(\Pi_j^c\right)^{\sigma-1}}{\frac{Y_j}{Y^W}\Pi_j^{\sigma-1}}\right)^{\frac{1-\mu}{\mu(1-\sigma)}} \left(\frac{\sum_i t_{ij}^{1-\sigma}\frac{Y_i}{Y^W}\Pi_i^{\sigma-1}}{\sum_i \left(t_{ij}^c\right)^{1-\sigma}\frac{Y_i^c}{Y^{W,c}}\left(\Pi_i^c\right)^{\sigma-1}}\right)^{\frac{1-\mu}{\mu(1-\sigma)}}}_{\text{employment change}}, \quad (13)$$

with the price change defined as implied by Equation (11) and the employment change as defined in Implication 3.

To gain intuition, remember that $Y_j = p_j e_j L_j$, and hence $\hat{Y}_j = \hat{p}_j \hat{e}_j$ if the labor force remains constant. We can use Equation (11) to express $\hat{Y}_j$ in terms of price changes. Let us now use $P_j = P_j^c = 1$ as a numéraire for a moment. We then realize that $\hat{Y}_j = (p_j^c/p_j)(p_j^c/p_j)^{(1-\mu)/\mu}$ if labor market institutions remain constant, i.e., $\hat{\kappa}_j = 1$. Then, the two terms are equal except for their exponents: the price change term rises to the power of 1 and the employment change term to the power of $(1-\mu)/\mu$. Hence, the relative importance of price and employment changes only depends on μ. If μ approaches one, the labor market rigidities vanish, and the total change in total sales is due to the price change, as in models assuming perfect labor markets. With any value of μ between zero and one, the share of the change in total sales attributable to the price change is μ and the share due to the employment change $1-\mu$. To illustrate, let $\mu = 0.75$, then three-quarters of the change in total sales are due to the price change and one-quarter is due to the employment change. In all other countries, the additional changes in price indices lead to a more complex relationship.[19] A lower price index lowers recruiting costs and thus spurs employment. This effect is captured by the last parenthesis in Equation

[19]Note that the change in total sales can only be solved up to scale, see also Costinot and Rodríguez-Clare (2014), pages 201 and 204. We choose the price index of one country as the numéraire. This choice leads to a simpler interpretation of total sales changes for the numéraire country.

(13). On the other hand, lower variety prices render recruiting less attractive, which is reflected by the first term of the employment change. Hence, the overall effect is ambiguous.

Taking logs, we can attribute the share of log change in total sales due to changes in prices and employment as follows:

$$1 = \frac{\ln \hat{p}_j}{\ln \hat{Y}_j} + \frac{\ln \hat{e}_j}{\ln \hat{Y}_j}. \tag{14}$$

Alongside changes in total sales, we will report this decomposition in all our counterfactual exercises.

2.3.4 Counterfactual trade flows

Finally, given estimates of $t_{ij}^{1-\sigma}$, data on Y_i, and a value for σ, we can calculate (scaled) baseline trade flows as $X_{ij}Y^W/(Y_iY_j) = (t_{ij}/(\Pi_i P_j))^{1-\sigma}$, where Π_i and P_j are given by Equation (6). With counterfactual total sales given by Implication 4, we can calculate counterfactual trade flows as $X_{ij}^c Y^{W,c}/(Y_i^c Y_j^c) = (t_{ij}^c/(\Pi_i^c P_j^c))^{1-\sigma}$, where Π_i^c and P_j^c are defined analogously to their counterparts in the baseline scenario given in Equation (6).[20] Due to direct effects of changes in trade costs via t_{ij} and non-trivial changes in Π_i and P_j, trade may change more or less when assuming imperfect labor markets in comparison with the baseline case of perfect labor markets.

3 Regional trade agreements and labor market frictions

We now apply our framework to evaluate the trade effects of regional trade agreements and labor market reforms in a sample of 28 OECD countries for the

[20]Note that P_j and P_j^c are homogeneous of degree one in prices while Π_i and Π_i^c are homogeneous of degree minus one. Hence, scaled trade flows $X_{ij}Y^W/(Y_iY_j)$ and $X_{ij}^c Y^{W,c}/(Y_i^c Y_j^c)$ are homogeneous of degree zero in prices. In other words, they do not depend on the normalization chosen.

years 1988 to 2006.[21] Trade data and GDP data, our measure for total sales, are from **?**. We use internationally comparable harmonized unemployment rates as well as employment and civil labor force data from **?**. Internationally comparable gross average replacement rates are from **?**.[22] For the estimation of the elasticity of the matching function, we use data from 2006.[23]

3.1 Estimation of trade cost parameters

To obtain an estimable gravity equation as given in Equation (7), we need to parameterize trade costs. Trade is hampered by two types of trade barriers: resource-consuming non-revenue generating trade costs, t_{ijs}, for imports from country i to j in year s, as well as non-resource-consuming and revenue-generating import tariffs, τ_{ijs}, for imports from i to j in year s.[24] We follow the literature and proxy trade costs by a vector of trade barrier variables as follows:

$$\begin{aligned} \tau_{ijs}^{-\sigma} t_{ijs}^{1-\sigma} &= \exp[\delta_1 \ln(1 + TARIFFRATE_{ijs}) + \delta_2 RTA_{ijs} + \delta_3 \ln DIST_{ij} \\ &\quad + \delta_4 CONTIG_{ij} + \delta_5 COMLANG_{ij}]. \end{aligned} \tag{15}$$

$TARIFFRATE_{ijs}$ data are from the World Integrated Trade Solution (WITS) available from 1988 to 2006, which also defines our sample period. We use three average tariff rates: the simple average at the HS 6 digit level of the effectively applied tariff rate, the simple average of the effectively applied tariff rate at the tariff line level, as well as the weighted average of the effectively applied tariff

[21] See Heid and Larch (2012), the working paper version of this paper, for a longer panel starting in 1950 but without considering tariff rates.

[22] This OECD summary measure is defined as the average of the gross unemployment benefit replacement rates for two earnings levels, three family situations and three durations of unemployment (for details of its calculation see **?**, **?**). As Mexico does not have any unemployment insurance scheme but is characterized by a large informal employment share, its labor market institutions are markedly different to the other OECD countries in our sample. Consequently, no replacement rate data are available for Mexico. We therefore exclude it from our analysis. For all other countries, we use the simple average of replacement rates between 2005 and 2007 as data for 2006 are not available.

[23] In the Online Appendix in Section J, we show results using panel data.

[24] In Appendix A of the Online Appendix, we derive our model also including tariffs.

rate with the weights given by the corresponding trade value.[25] RTA_{ijs} is an indicator variable of regional trade agreement membership between country pair ij in year s from Mario Larch's RTA database.[26] It is constructed from the notifications to the World Trade Organization (WTO) and augmented and corrected by using information from RTA secretariat webpages. $DIST_{ij}$ is bilateral distance, $CONTIG_{ij}$ is a dummy variable indicating whether countries i and j are contiguous, and $COMLANG_{ij}$ indicates whether the two countries share a common official language.[27] $DIST_{ij}$, $CONTIG_{ij}$, and $COMLANG_{ij}$ are from **?**. Table 1 contains summary statistics of the data.

[Table 1 about here.]

Obviously, countries do not randomly sign RTAs nor set tariff levels at random. This has long been recognized in the international trade literature, see for example **?**, **?**, **?**, and references therein. Empirical evidence shows that the exogeneity assumption of RTAs is inappropriate when attempting to quantify the effects of regional trade agreements. To avoid potential endogeneity, we follow **?** and **?** and use a two-step estimation approach to obtain consistent estimates of trade cost coefficients. In a first step, we estimate Equation (7) including directional bilateral fixed effects, i.e., we estimate

$$\begin{aligned} Z_{ijs} &= \exp[k + \delta_1 \ln(1 + TARIFFRATE_{ijs}) + \delta_2 RTA_{ijs} \\ &\quad + \varphi_{is} + \phi_{js} + \nu_{ij} + \varepsilon_{ijs}], \end{aligned} \tag{16}$$

where φ_{is} and ϕ_{js} are exporter and importer time-varying fixed effects and ν_{ij} is a time-constant directional bilateral fixed effect. Note that φ_{is} and ϕ_{js} control for the time-varying multilateral resistance terms Π_{is} and P_{js}, and the bilateral fixed effect also captures the time-invariant geography variables. In a second step, we re-estimate Equation (7) with trade costs proxied as in Equation

[25]For a detailed description and discussion of the tariff data, see Section H of the Online Appendix.

[26]It can be accessed at `http://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html`. A list of the included agreements can be found in Appendix D.

[27]We do not use common colonizer indicators or similar variables regularly used in the literature as these have very little variation in our OECD sample.

(15) to obtain estimates for the coefficients of the time-invariant geography variables, δ_3 to δ_5. We therefore use only exporter and importer time-varying fixed effects and constrain the coefficients of $\ln(1 + TARIFFRATE_{ijs})$ and RTA_{ijs}, δ_1 and δ_2, to their estimates of the first step, $\tilde{\delta}_1$ and $\tilde{\delta}_2$.[28]

3.2 Estimation of elasticities

We have now set the stage for our counterfactual welfare analysis—if we follow most of the gravity literature and merely assume plausible values for the elasticity of substitution, σ, and, in our case, the matching elasticity, μ. In the following, we demonstrate that under additional parameter restrictions, both elasticities can, in principle, be estimated within our quantitative framework.

The additional assumptions we have to introduce are due to the fact that measures of recruiting costs, bargaining power, and matching efficiencies which are comparable across countries are hard to come by. Specifically, we assume identical recruiting costs, c_j, across countries and that the bargaining power of workers, ξ_j, is 0.5 in all countries. Finally, we assume identical matching efficiencies, m_j, across countries. We relax the latter assumption in Section J of the Online Appendix using panel data on both trade and labor market data.

Impatient (or unconvinced) readers may as well simply assume values for σ and μ and continue with Section 3.3. In addition, we present results of our counterfactual analysis for different assumed values of the elasticities in Table 4.

3.2.1 Estimating the elasticity of substitution

The elasticity of substitution σ (which relates to the elasticity of imports with respect to variable trade costs, in short the trade elasticity, by $1 - \sigma$) is one of the most important elasticities for the evaluation of trade policies. This importance has even increased since the influential paper by Arkolakis

[28] We use tildes to refer to estimated parameters to prevent confusion with ratios of variables which we indicate by hats.

et al. (2012) which shows that welfare gains from trade policy changes can be calculated by using changes in the share of domestic expenditure alongside the elasticity of imports with respect to variable trade costs. There are many different ways to obtain estimates for the trade elasticity.[29]

? nicely summarize in their Section 4.2 what they call "gravity-based estimates", which regress bilateral trade flows on measures of bilateral trade costs (such as tariffs) or on wages or productivity (recent examples are **?** and **?**). As is visible in their Table 3.5, results vary widely, which is partly due to different methods, and partly due to different levels of aggregation of the trade data. **?** conclude that their "...preferred estimate for [the trade elasticity] is -5.03 [implying $\sigma = 6.03$], the median coefficient obtained using tariff variation, while controlling for multilateral resistance terms" (p. 165). Our first approach is therefore to use our tariff data and recover the elasticity of substitution directly from the coefficient on the tariff rates in our structural gravity estimates, i.e., $\tilde{\delta}_1 = -\sigma$.[30] This approach for estimating σ controls for the potential endogeneity of RTAs and tariffs, multilateral resistance terms and takes into account the heteroskedasticity of trade flows. Also note that the time-varying importer and exporter fixed effects also control for most favored nation (MFN) tariffs which, by definition, are identical for all import source countries.

Obviously, using tariff rates is not without problems. Firstly, as we use aggregate trade flows, tariff rates also have to be aggregated up in some way. It is well known that using trade volumes to create a weighted average creates a downward bias in the effective tariff rate; the opposite argument can be applied to simple averages. In addition, tariff evasion, as documented by **?** and **?**, may distort the measure of σ, as explained by **?**. We therefore also use a second approach following Bergstrand et al. (2013) who show how to obtain estimates for σ within their proposed framework without relying on tariff data besides trade flow data.[31] We show that a variant of their approach is also applicable

[29]See **?** for a detailed discussion of estimates of the elasticity of substitution in international trade.

[30]See Section A of the Online Appendix for a detailed derivation.

[31]Besides these two approaches, there are at least two additional ones. **?** and **?** estimate

when assuming imperfect labor markets. A major advantage of using tariff data is its parsimony in terms of data requirements and assumptions. To estimate σ using a variant of Bergstrand et al. (2013), apart from trade data we need data on unemployment rates and civil labor force data. In addition, we have to assume that β_js are identical across countries.

First, note that we can rewrite trade flows as given in Equation (3) by observing that the variety price can be substituted by $p_i = Y_i/[(1-u_i)L_i]$. This yields $X_{ij} = ((\beta_i Y_i t_{ij})/((1-u_i)L_i P_j))^{1-\sigma} Y_j$. Estimation of Equation (7) using observable determinants of bilateral trade costs generates estimates $\widetilde{t_{ij}^{1-\sigma}}$. We next substitute $\widetilde{t_{ij}^{1-\sigma}}$ in Equation (5) to generate $\tilde{X}_{ij}$ and $\widetilde{t_{mj}^{1-\sigma}}$ in its analogue to generate $\tilde{X}_{mj}$. Using observed unemployment rates we end up with:

$$\frac{\tilde{X}_{ij}}{\tilde{X}_{mj}} = \frac{\widetilde{t_{ij}^{1-\sigma}}}{\widetilde{t_{mj}^{1-\sigma}}} \left(\frac{Y_i(1-u_m)L_m}{Y_m(1-u_i)L_i} \right)^{1-\sigma}, \tag{17}$$

where we have assumed that $\beta_j = \beta \; \forall \; j$. We can solve Equation (17) for σ, where Y_i, Y_m, L_i, L_m, u_i, and u_m are observables. Then, we can calculate $n^2(n-1)$ values of σ by using all combinations i, j, and m ($m \neq i$). As a measure of central tendency, we follow Bergstrand et al. (2013) and use the median of all values as our estimate. In Section I in the Online Appendix, we show the full distribution of the σ values. We use a parametric bootstrap to obtain a standard error for σ.

3.2.2 Estimating the elasticity of the matching function

The other crucial parameter for our counterfactual analysis is the elasticity of the matching function, μ. As with the elasticity of substitution, there are a great many of plausible estimates of the matching elasticity available in the literature. We demonstrate that it is also possible to obtain an estimate of

the trade elasticity using variations in the variances of the demand and supply curves across countries to infer the trade elasticity. Eaton and Kortum (2002) and **?** use the relation of trade and price gaps to infer the elasticity of substitution. As these two approaches use additional data not used in our applied framework, we stick with the two other, less data-demanding ones to obtain values for the trade elasticity.

μ within our structural gravity framework relying on the cross-country-pair variation in bilateral trade flows.

Using Equations (8) and (9) and defining $\Xi_j \equiv m_j \left(\frac{c_j}{m_j}\Omega_j\right)^{\frac{\mu-1}{\mu}}$, we can write $1 - u_j = \Xi_j \left(p_j/P_j\right)^{(1-\mu)/\mu}$. As we observe u_j in the baseline, we may take ratios for two countries and the log of this ratio to obtain:

$$\ln\left(\frac{1-u_j}{1-u_m}\right) = \frac{1-\mu}{\mu}\left[\ln\left(\frac{p_j}{p_m}\frac{P_m}{P_j}\right) - \ln\left(\frac{c_j\Omega_j}{c_m\Omega_m}\right)\right] + \frac{1}{\mu}\ln\left(\frac{m_j}{m_m}\right). \quad (18)$$

Assuming $m_j = m_m$, we can solve Equation (18) for μ, where u_j, c_j and Ω_j are in principle observable. The unobservable variety prices p_j can be replaced again by $p_i = Y_i/[(1-u_i)L_i]$ and the price indices P_j by $P_j^{1-\sigma} = \sum_{i=1}^{n} t_{ij}^{1-\sigma}\frac{Y_i}{Y^W}\Pi_i^{\sigma-1}$, respectively. $\frac{Y_i}{Y^W}\Pi_i^{\sigma-1}$s can be recovered from solving the system of equations given in Equation (6) for observed trade flows using the estimated $\widetilde{t_{ij}^{1-\sigma}}$. In our application, we assume identical recruiting costs, c_j, across countries as comparable data across countries of these costs are hard to come by. We also assume that the bargaining power of workers, ξ_j, is 0.5 in all countries. However, we use observed unemployment benefits across countries from ?.[32] Hence γ_j and thus Ω_j vary across countries and reflect the heterogeneity in the replacement rate across countries.

We can then calculate $n(n-1)/2$ such values of μ by using all combinations of j and m ($m \neq j$). As a summary estimate, we average over all estimated values within the unit interval, the admissable range for μ. We use a parametric bootstrap for the standard errors of μ.[33]

We show the full distribution of μ values in Section I in the Online Appendix. In addition, in Section J of the Online Appendix, we investigate a regression-based estimate of μ which allows for country-specific and time-varying m_j when panel data on both the trade and labor market data are available. The results remain similar when using this approach.

[32] For further details on the data, see Section 3.

[33] We use analytical standard errors for the trade cost parameters.

3.3 Estimation results

We present results estimating log-linearized scaled trade flows by OLS as well as the Poisson pseudo-maximum-likelihood (PPML) estimator for the scaled trade flows in levels following the recommendation by **?** in Table 2. For every specification, we present results for these two estimators. Columns (1) and (2) present estimates excluding tariff rates as regressors. Columns (3) to (8) all include tariffs. Specifically, columns (3) and (4) use the simple average of effectively applied tariff rates to construct $\ln(1+TARIFFRATE_{ijs})$; columns (5) and (6) use the simple average but calculated at the tariff line level, and columns (7) and (8) use the weighted average of the effectively applied tariff. All columns include directional bilateral fixed effects as well as time-varying inward and outward multilateral resistance terms by including time-varying importer and exporter fixed effects.

[Table 2 about here.]

RTAs increase trade by 17.23 percent (column (6)) to 24.86 percent (column (1)) when neglecting general equilibrium effects.[34] Controlling for tariffs, our RTA coefficients remain highly significant but decrease slightly in magnitude. Judging by the standard errors, we cannot reject the hypothesis that the RTA coefficients in the tariff regressions are different from the values in columns (1) and (2). The second stage regressors are also hardly affected by the inclusion of tariff rates. The general equilibrium effects are accounted for in the counterfactual analysis, to which we turn in Section 3.4. When comparing the RTA coefficient across OLS and Poisson estimates, we see that Poisson estimates are a bit lower.

Our estimates are by and large in accordance with well-known results from the empirical trade literature. Distance is a large obstacle to trade, whereas contiguity and RTAs enhance trade. Comparing OLS with PPML estimates shows a clear pattern: distance coefficients are basically identical, contiguity coefficients are larger and common language coefficients are smaller. Interestingly, we find a negative impact of common language on bilateral trade flows

[34] Effects are calculated as $(\exp(\tilde{\delta}_{RTA}) - 1) \times 100$ [percent].

using PPML. While surprising, this is consistent with the meta study by **?**, which reports a standard deviation of common language coefficients which also encloses our negative value within two standard deviations. Note also that in the working paper version of this paper, Heid and Larch (2012), where we use a panel from 1950 to 2006 without including tariffs as an additional regressor, common language has the expected positive and significant coefficient.

Instead of the regression coefficients of $\ln(1 + TARIFFRATE_{ijs})$, we directly report the implied σ estimates (i.e., $\tilde{\sigma} = -\tilde{\delta}_1$) for columns (3) to (8). σs are highly significant, have the correct sign and are all larger than 1 with exception of column (5), where we at least cannot reject the null hypothesis that it is larger than 1. They are similar to our σ estimates from columns (1) and (2) which use the alternative estimation method for σ without including tariff rates as regressors.

Our significant estimates lie between 0.954 in column (5) and 1.765 in column (4). These results are in line with recent evidence from **?** who report estimates for the Armington elasticity between domestic and foreign goods in a similar range.

Finally, our estimates of the matching elasticity vary between 0.930 and 0.992 and are significant at standard levels of significance. With our method, we find that the elasticity of labor markets in OECD countries indicates a very low level of labor market frictions and a very high matching elasticity compared to previous estimates. For example, **?** estimates μ between 0.2 and 0.6 for Israel for the years between 1975 and 1989. A literature review by Petrongolo and Pissarides (2001) reports estimates between 0.12 and 0.81 across studies focusing on several countries and time periods. **?** finds $\mu = 0.24$ for the United States for the years 2000 to 2002. Rogerson and Shimer (2011) estimate $\mu = 0.58$ for the same data for the years 2000 to 2009.[35] Even though our estimates are on the high side, note that our method infers the matching elasticity from (ratios) of bilateral trade flows using their cross-country-pair

[35]Note that the literature reports both estimates of the matching elasticity with respect to the unemployed, as we do, or with respect to vacancies. In our discussion, we transformed the estimates when necessary assuming constant returns to scale in the matching process.

variation at one point in time. All other estimates of the matching elasticity in the literature use time series data on the number of matches, vacancies, and the unemployed from a single labor market. Hence, it is not too surprising that our estimates are somewhat different from the literature. Also note that we show in Appendix A that our μ is an upper bound estimate when allowing for a more general vacancy posting cost function. In the counterfactual analysis, to which we turn next, we therefore provide results for alternative values of the matching elasticity.

3.4 Counterfactual analysis

We conduct three counterfactual experiments in our OECD sample. First, we evaluate the effects of all RTAs between the 28 OECD countries. To this end, we compare a situation with RTAs as observed in 2006 with a counterfactual situation without any RTAs, i.e., we counterfactually set RTA_{ij2006} to 0. Second, we evaluate the U.S.-Australia Free Trade Agreement. Finally, we evaluate a hypothetical improvement of labor market institutions in the United States.

3.4.1 Evaluating the effects of RTAs

Our first counterfactual experiment evaluates the effects of introducing RTAs as observed in 2006 compared to a counterfactual situation in which there are no RTAs.[36] While this is an ex-post evaluation, our framework can also be applied to ex-ante evaluate the potential trade, welfare, and employment effects of any currently negotiated free trade agreement. Note that even for the ex-post evaluation of abandoning all RTAs as observed in 2006 as studied in the following, using a reduced form approach would neglect the general equilibrium effects of this large scale policy change. We base our counterfactual analysis

[36] This scenario assumes the same partial effect for all regional trade agreements in place in 2006, irrespective of their depth or when they were concluded. This is obviously a very strong assumption, but helps to focus on the mechanics of the model. Additionally, it allows a direct comparison with the results of **?**, who make the same assumption and also investigate the effects of switching on all RTAs while controlling for endogeneity as we do.

on parameter estimates from column (4) of Table 2 as they control for the heteroscedasticity of trade flows using PPML and include simple tariff averages which do not suffer from the downward aggregation bias as the weighted tariff average using trade values. PPML estimates for the tariff line average (column (6)) are quite similar to column (4).

For our counterfactual simulations, we use a generalized version of our model which also allows for trade imbalances as well as takes into account the tariff revenue generated by the effectively applied average tariff rate, i.e., we use the model described in detail in Section A of the Online Appendix. In Sections F and G of the Online Appendix, we present results of our counterfactual simulations imposing zero tariff rates for all country pairs and balanced trade, respectively. Results remain similar.

The results are shown in Table 3.[37] It is organized as follows. Column (1), "PLM $\%Y$", gives the percentage change in nominal total sales for the case of perfect labor markets. Column (2), "SMF $\%Y$", gives the same change within our search and matching framework. Columns (3) and (4) use Equation (14) and decompose the log change in total sales of Column (2) into log price and log employment changes. Column (5) reports the percentage change in the employment share for the case of imperfect labor markets, whereas Column (6) reports unemployment changes in percentage points. Finally, Columns (7) and (8) report the equivalent variation (EV) for the case of perfect and imperfect labor markets, respectively. Note that all changes are expressed as changes from the counterfactual scenario without any RTA to the observed scenario with RTAs as observed in 2006. For the baseline, we use observed GDPs from 2006 as our measure for total sales, while the changes in total sales are endogenously determined in the counterfactual.

Table 3 reveals that introducing RTAs as observed in 2006 has quite heterogeneous effects on total sales. Some countries gain substantially more than the average, for example Canada with a gain of 10.95 percent, whereas other countries such as Japan experience a smaller increase of 2.38 percent. Please

[37] In the Online Appendix, we additionally provide results concerning the changes in trade flows across countries.

note, however, that these changes can only be interpreted relative to each other, as their absolute level depends on the numéraire chosen.[38] The decomposition of the change in (log) sales into (log) price and (log) employment changes highlights that for many of our sample countries, roughly 15 percent of the increase in sales is driven by the increase in employment. Countries with only slight increases in sales may even see negative employment effects, as can be seen in Column (5) of Table 3. As explained in Section 2.3.1, welfare effects are typically magnified when taking into account employment effects as both trade openness and employment effects depend positively on the relative price p_j/P_j. For example, the standard welfare estimate for Canada is about 3 percent larger when taking into account labor markets imperfections.

To assess the fit of our model, we first compare the implied changes in both openness (measured as imports plus exports over GDP) and in unemployment rates predicted by our model with actually observed data for our sample. While it is straightforward to calculate these changes for our model, we cannot, of course, observe "real-world" counterfactual openness and unemployment rates. Thus, to compare model predictions with observed data, we take a simple and admittedly very crude approach: we calculate the observed change in openness and the unemployment rate as the change between the first year for which unemployment rate data are available and 2006.[39] Note that we

[38]Note that levels and changes of nominal variables like total sales can only be solved up to scale, see Costinot and Rodríguez-Clare (2014), pages 201 and 204, respectively. As mentioned in footnote 12 in Anderson and van Wincoop (2003), the solution of the multilateral resistance terms (MRTs) adopts a particular normalization. In general, this applied normalization may vary between the baseline MRTs and the counterfactual MRTs. In order to ensure a common numéraire, we normalize $\Pi_{United\,States} = \Pi^c_{United\,States} = 1$, i.e., changes in total sales are in terms of the outward multilateral resistance term of the United States.

[39]The first year is 1955 for the United States and Japan, 1956 for New Zealand, Ireland, France, and Canada, 1958 for Finland, 1959 for Italy, 1960 for Denmark and Turkey, 1961 for Greece, 1962 for Germany, 1964 for Australia and Austria, 1970 for Sweden, 1972 for Norway, Spain, and the United Kingdom, 1975 for Switzerland, 1983 for Belgium and the Netherlands, 1984 for Portugal, 1989 for Korea, 1990 for Poland, 1991 for Iceland, 1992 for Hungary, 1993 for the Czech Republic, and 1994 for the Slovak Republic. Note that all countries either had no or only a few RTAs in place for the first year in which we observe the unemployment rate, but all of them had experienced a tremendous increase in RTAs by 2006.

standardize changes for comparison reasons. As can be seen from Figure 1, our model replicates the average negative correlation between openness and unemployment.

[Figure 1 about here.]

[Figure 2 about here.]

As an additional validation of our results, we conducted another counterfactual exercise, where we shut down all RTAs which were signed between 1988, the first year of our data set, and 2006. We then compute the predicted counterfactual unemployment rates and compare them to the observed unemployment rates in 1988 for those countries where unemployment rates are available. Figure 2 shows the scatterplot of the counterfactual versus observed unemployment rates. The correlation between the observed and predicted counterfactual unemployment rate is 0.34 which is tantamount to explaining 12 percent of the variation in the observed unemployment rate. Thus, although there is room for improving the model fit, we are the first to explain any of the observed variation in unemployment rates by changes in international trade policy changes using a structural gravity model.

As in every quantitative trade model, the resulting magnitudes of policy changes crucially depend on the exact values of the elasticities. We therefore test the sensitivity of our results to different values of the elasticity of substitution σ and the elasticity of the matching function μ. In the interest of brevity, we present only average effects in Table 4. The total sales, employment, and EV effects crucially depend on the values of σ and μ. When the elasticity of substitution increases, total sales, employment, and EV changes become smaller. This is because varieties are better substitutes, making trade less important. Hence, switching on the RTA dummy leads to smaller predicted gains in terms of total sales, employment, and welfare. Changes in the elasticity of the matching function μ also show a clear pattern. Lower values of μ indicate higher total sales, employment, and welfare changes. A lower μ corresponds to larger labor market imperfections. When μ approaches 1 we end up in the case of perfect labor markets. The reason for this is that larger frictions on the labor market imply that firms have to post more vacancies in order to find a worker, effectively increasing recruiting costs. As trade liberalization decreases the overall price level, it also lessens a firm's recruiting costs. This reduction of recruiting costs is more important in labor markets with higher frictions, making trade liberalization more attractive. Overall, Table 4 highlights that the extent of labor market frictions plays a crucial role in assessing the quantitative impact of regional trade agreements.

[Table 3 about here.]

[Table 4 about here.]

3.4.2 Evaluating the effects of the U.S.-Australia Free Trade Agreement

Our first counterfactual exercise has evaluated the combined effect of abolishing all RTAs signed between the 28 OECD countries in our data set simultaneously. Hence positive welfare effects for member countries of one RTA are partly offset by negative welfare effects of other RTAs if a country is a non-signatory party.

To illustrate how allowing for imperfect labor markets affects the evaluation of a specific RTA, we analyze the U.S.-Australia Free Trade Agreement (FTA). It entered into force on January 1, 2005.[40] It is the second RTA between the United States and a developed country after the U.S.-Canada FTA in 1988. The RTA between the U.S. and Australia is far reaching, as it not only liberalizes 99 percent of U.S. manufactured goods exports, but also leads to harmonization in the areas of intellectual property rights, services trade, government procurement, e-commerce and investment.[41] This agreement is

[40] `https://ustr.gov/trade-agreements/free-trade-agreements/australian-fta`, accessed May 15, 2015.

[41] `https://ustr.gov/archive/Document_Library/Press_Releases/2004/February/US_Australia_Complete_Free_Trade_Agreement.html`, accessed May 15, 2015.

therefore interesting to investigate in the context of our framework, which is very suitable to study trade liberalization between developed countries.[42]

Additionally, the welfare effects of this agreement have not yet been intensively analyzed. **?** provides a qualitative assessment of the agreement to the Parliament of Australia, while **?** comments the results of a study commissioned by the Australian Department of Foreign Affairs and Trade. **?** uses the point estimates from a gravity model to assess the trade effects of the agreement. **?** and **?** provide a historical and political view on the U.S.-Australia FTA. Closest to our welfare analysis, **?** uses the Global Trade Analysis Project (GTAP) multi-sector, multi-country general equilibrium model to evaluate the welfare effects of the U.S.-Australia FTA.

To implement the counterfactual scenario, i.e., a world without the U.S.-Australia FTA, we 1.) set the RTA dummy between Australia and the U.S. to 0 and 2.) set bilateral tariffs between Australia and the U.S. to their level in 2004, i.e., before the FTA entered into force.

We report results from this exercise in Table 5. We find that the U.S.-Australia FTA increases Australia's welfare substantially by 5.95 percent, whereas U.S. welfare increases only slightly by 0.28 percent if assuming perfect labor markets. Accounting for imperfect labor markets increases welfare effects by 6 and 7 percent to 6.30 and 0.30 percent, respectively. Most non-member countries are hardly affected except the direct neighboring countries

[42] Alternatively, we could have investigated the U.S.-Canada Free Trade Agreement. However, this agreement was superseded by the North American Free Trade Agreement (NAFTA) in 1994, which included Mexico. As this is a developing country and we do not have (un)employment data for Mexico, we did not analyze NAFTA. Concerning the U.S.-Australia FTA, note that recently the Transpacific Partnership (TPP) has been negotiated. TPP is an expansion of the Trans-Pacific Strategic Economic Partnership Agreement, which is an RTA between Brunei, Chile, Singapore, and New Zealand concluded in 2006. In September 2008, the United States announced its intention to join the TPP negotiations. Since 2008, additional countries joined and by now TPP has twelve participating countries: Australia, Brunei, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, the United States, and Vietnam (see `https://ustr.gov/tpp/`, accessed January 13, 2016). On October 5th, 2015, TPP was successfully concluded (see `http://www.state.gov/secretary/remarks/2015/10/247870.htm`, accessed January 13, 2016) and therefore the U.S.-Australia FTA overlaps with TPP. As we have only parts of the involved countries in our data set, we focus on the U.S.-Australia FTA to highlight the working of our framework for a single agreement.

like New Zealand and, to a lesser extent, Canada. Interestingly, the negative change in total sales in New Zealand is driven by negative employment effects which overcompensate the price increase (indicated by the -19.71 percent in column (3)), as can be inferred from comparing columns (3) and (4) in combination with columns (2) and (5). Concerning unemployment, our model predicts that Australia's unemployment rate is 0.39 percentage points lower due to the U.S.-Australia FTA.

Our results are comparatively larger than those from **?**. He finds that the U.S.-Australia FTA increases real GDP by only 0.13 percent in Australia and 0.02 percent in the U.S. While these differences are substantial, note that the difference between the GTAP approach by **?** and ours does not stem from our modeling of the labor market, as becomes clear from comparing columns (7) and (8), but rather from the fact that **?** models the U.S.-Australia FTA as tariff reductions only. Thereby he abstracts from modeling the reduction of non-tariff barriers by RTAs as we do by changing the RTA dummy.[43]

[Table 5 about here.]

3.4.3 Evaluating the effects of a hypothetical labor market reform

In our third counterfactual experiment, we evaluate the effects of a hypothetical labor market reform which improves U.S. labor market institutions. We implement this by a 5.4 percent increase in $\hat{\kappa}_j$ for the United States, i.e., we set $\hat{\kappa}_{U.S.}$ to 1.054. Given our estimate of the matching elasticity of $\mu = 0.933$, this change in $\hat{\kappa}_{U.S.}$ corresponds to either an increase of exactly 5 percent in the overall matching efficiency m_j or a 51 percent reduction of recruiting costs in the United States. Note that within our framework we do not necessarily have to specify the explicit source of changes in labor market institutions. The results of this experiment are set out in Table 6.[44]

[Table 6 about here.]

[43] Welfare effects of RTAs are sensitive to these modeling choices. For a more detailed discussion, see **?**.

[44] Again, detailed results on the heterogeneous trade effects can be found in the Online Appendix.

In all countries, unemployment falls when U.S. labor market institutions improve. This highlights the positive spillover effects, recently theorized by **?** and Felbermayr et al. (2013), and documented empirically in a reduced-form setting in Felbermayr et al. (2013). Of course, when perfect labor markets are assumed, it is not possible to evaluate any change in them. Therefore, Columns (1) and (7) are uninformative. The decomposition of (log) total sales into (log) price and (log) employment changes highlights that in the United States prices fall and all increases in expenditure are due to increases in employment. This result can be understood when looking at the changes in the relative price p_j/P_j. When the U.S. labor market becomes more efficient, U.S. output will increase leading to a fall in prices of U.S. goods relative to its imports. This deterioration of the relative price in the U.S. mitigates the increases in total sales due to the improvement in their labor-market institutions. For the trading partners of the United States, the effects on total sales are quite heterogeneous but, compared to the effect in the U.S., rather small, with the exception of Canada.

Concerning welfare, obviously the United States profit the most from the improvement in its labor market institutions, with an increase in welfare of 4.68 percent. However and importantly, all other countries also gain, with the highest gains for Canada at 2.72 percent.

4 Conclusion

State of the art frameworks for quantitative analyses of international trade policies to evaluate the trade and welfare implications of trade liberalization all assume perfect labor markets. However, net employment effects are at the heart of the political debate on trade integration. Accordingly, recent developments in international trade theory have highlighted the link between trade liberalization and labor market outcomes.

We build on these theoretical contributions to develop a quantitative framework of bilateral trade flows which takes into account labor market frictions within a search and matching framework. Our model allows counterfactual analyses of changes in trade costs and labor market reforms on total sales, trade flows, employment, and welfare.

We apply our structural model to a sample of 28 OECD countries from 1988 to 2006 to evaluate the effects of regional trade agreements (RTAs) and a hypothetical labor market reform in the United States. We find that introducing RTAs as observed in 2006 leads to greater welfare increases when accounting for aggregate employment effects for most countries. Countries with only slight increases in total sales see negative employment effects. As our second counterfactual, we analyze the U.S.-Australian Free Trade Agreement and find that it increases welfare in the United States by 0.30 percent and by 6.30 percent in Australia, while all other countries see slight negative welfare effects. Our third counterfactual analysis assumes a hypothetical improvement of labor market institutions in the United States. Typically, average welfare effects are substantially magnified when taking into account employment effects. While the United States profits the most from improvements of its labor market institutions with an equivalent variation of 4.68 percent, all of its trading partners also experience an increase in welfare due to positive spillover effects.

As our approach does not require any information about the labor market except for the elasticity of the matching function, it can be easily applied to any other field in which the gravity equation is employed.

The single sector nature of our homogeneous firm framework abstracts from short-run reallocation frictions across firms and sectors. Even though these effects might well be important, see **?**, we leave these for future research.

Appendix

Introduction to the Appendix

In this Appendix, we present further results and derivations.

In Section A we discuss the implications of a more general vacancy posting cost function for our quantitative framework.

In Section B, we derive the solution of the system of asymmetric multilateral resistance equations.

In Section C, we derive sufficient statistics for welfare with imperfect labor markets and show that in the case of imperfect labor markets, the welfare statistics presented in Arkolakis et al. (2012) are augmented by the net employment change.

A A more general vacancy posting cost function

In the main text, we assume that vacancy posting costs are denoted in terms of the final good, $c_j P_j$. This implies that the firm has to buy all the goods and services needed to open a vacancy on the market for a price of P_j. For example, the firm has to pay for advertisements or worker screenings like assessment centers etc. In reality, a firm may be able to produce at least some of these services within the firm. As the firm has to devote workers to do so who could otherwise produce a good which can be sold at price p_j, using in-house labor to produce the vacancy posting costs implies an opportunity cost for the firm of p_j. Hence, we can generalize our vacancy posting cost function by assuming that vacancy posting costs are a weighted average of the following Cobb-Douglas form:

$$c_j p_j^{\eta} P_j^{1-\eta}, \tag{19}$$

where η is the cost share of internally produced vacancy posting services in terms of firm output.[45]

Equalizing expected profits of a firm from employing an additional worker, $(p_j - w_j)m_j\vartheta_j^{-\mu}$, with the new vacancy posting cost function leads to the job creation curve:

$$w_j = p_j \left(1 - \frac{c_j \left(\frac{p_j}{P_j}\right)^{\eta-1}}{m_j \vartheta_j^{-\mu}}\right). \tag{20}$$

Combining the job creation curve with the wage curve, which is still given by $w_j = p_j\xi_j/(1 + \gamma_j\xi_j - \gamma_j)$, we can solve for the labor market tightness ϑ_j:

$$\vartheta_j = \left(\frac{p_j}{P_j}\right)^{\frac{1-\eta}{\mu}} \left(\frac{c_j}{m_j}\Omega_j\right)^{-\frac{1}{\mu}}. \tag{21}$$

Counterfactual employment effects for constant labor market institutions are given by $\hat{e}_j = [(p_j^c/P_j^c)/(p_j/P_j)]^{[(1-\eta)(1-\mu)/\mu]}$. The total differential of the exponent of the expression for the employment effect implies $d\mu/d\eta = -(1-\mu)\mu/(1-\eta) < 0$, i.e., for a given counterfactual change in the relative price p_j/P_j, μ and η act as substitutes: given the multiplicative form of the exponent, μ and η are not separately identified. In other words, for a given change in the relative price, our framework allows for different combinations of μ and η for a given μ estimated under the assumption $\eta = 0$ as we do in the main text and will still imply the same employment effects: one may choose a combination of μ and η according to whether one believes that labor market frictions are severe (implying low values of μ) and vacancy posting costs are predominantly payed in domestic goods (implying high values of η), or vice versa. Both a lower μ or a lower η will imply a larger impact of trade liberalization on the labor market. In this sense, μ and η are interchangeable.

We can redo the steps described in Section 3.2.2 to come up with an alternative estimator for μ: using Equation (8), i.e., $u_j = 1 - m_j\vartheta_j^{1-\mu}$, and Equation

[45] We thank one of the referees for this suggestion.

(21) and defining $\Xi_j \equiv m_j \left(\frac{c_j}{m_j}\Omega_j\right)^{\frac{\mu-1}{\mu}}$, we can write

$$1 - u_j = m_j \vartheta_j^{1-\mu} = m_j \left(\frac{p_j}{P_j}\right)^{\frac{(1-\eta)(1-\mu)}{\mu}} \left(\frac{c_j}{m_j}\Omega_j\right)^{-\frac{1-\mu}{\mu}} = \Xi_j \left(\frac{p_j}{P_j}\right)^{\frac{(1-\eta)(1-\mu)}{\mu}}.$$

As we observe u_j in the baseline, we may take ratios for two countries and the log of this ratio to obtain:

$$\ln\left(\frac{1-u_j}{1-u_m}\right) = \frac{(1-\eta)(1-\mu)}{\mu}\left[\ln\left(\frac{p_j}{P_j}\frac{P_m}{p_m}\right)\right] + \frac{\mu-1}{\mu}\left[\ln\left(\frac{c_j\Omega_j}{c_m\Omega_m}\right)\right] + \frac{1}{\mu}\ln\left(\frac{m_j}{m_m}\right).$$

Assuming $m_j = m_m$ and defining $\mu' = (1-\mu)/\mu$, we end up with

$$\ln\left(\frac{1-u_j}{1-u_m}\right) = \mu'(1-\eta)\left[\ln\left(\frac{p_j}{P_j}\frac{P_m}{p_m}\right)\right] + \mu'\left[-\ln\left(\frac{c_j\Omega_j}{c_m\Omega_m}\right)\right].$$

This expression can be solved for μ':

$$\mu' = \frac{\ln\left(\frac{1-u_j}{1-u_m}\right)}{(1-\eta)\ln\left(\frac{p_j}{P_j}\frac{P_m}{p_m}\right) - \ln\left(\frac{c_j\Omega_j}{c_m\Omega_m}\right)}. \tag{22}$$

As one can see from this expression, the value of μ' (and therefore μ) cannot be uniquely determined without knowing the value of η. With $\eta = 0$, we are back in our simplified model where vacancy posting costs are entirely paid in terms of the final good. With $\eta = 1$ we are in the other extreme case where vacancy posting costs are entirely paid in terms of firm's own goods. In this case, prices do no longer affect the estimate of μ'. Plausibly, η is somewhere between zero and one, so that prices will affect μ' , but less so than in the case where vacancy posting costs are fully paid in terms of the final good.

Deriving μ' from Equation (22) with respect to η and plugging in $u_j = 1 - m_j\vartheta_j^{1-\mu}$ while replacing ϑ_j by Equation (21), one can show that $\partial\mu/\partial\eta = (\partial\mu/\partial\mu')(\partial\mu'/\partial\eta) = -(1-\mu)\mu/(1-\eta) < 0$ if labor market institutions are identical across countries, i.e., $m_j = m_m$, $c_j = c_m$ and $\Omega_j = \Omega_m$. Note that this does not imply that unemployment rates are identical across countries, as labor market tightness depends on prices which differ across countries. This implies that our estimates under the assumption of $\eta = 0$ may well be an upper bound on the actual value of μ. This may explain why we find very high values of μ in our estimation in the main text if one considers labor market institutions across OECD countries to be relatively similar. Therefore, allowing for $\eta > 0$ if the researcher has data about the value of η implies a lower value of μ and hence implies higher labor market frictions as long as labor market institutons are sufficiently similar.

B Solution of asymmetric multilateral resistance equations

Using Equation (6), we can write $\Pi_i^{1-\sigma} = \sum_{j=1}^{n} t_{ij}^{1-\sigma} P_j^{\sigma-1} \frac{Y_j}{Y^W}$. Defining $\mathbb{P}_j \equiv \frac{Y_j}{Y^W} P_j^{\sigma-1}$ leads to $\Pi_i^{1-\sigma} = \sum_{j=1}^{n} t_{ij}^{1-\sigma} \mathbb{P}_j$. Similarly, P_j can be written as $P_j^{1-\sigma} = \sum_{i=1}^{n} t_{ij}^{1-\sigma} \Pi_i^{\sigma-1} \frac{Y_i}{Y^W}$. Defining $\mathbb{\Pi}_i \equiv \frac{Y_i}{Y^W} \Pi_i^{\sigma-1}$ leads to $P_j^{1-\sigma} = \sum_{i=1}^{n} t_{ij}^{1-\sigma} \mathbb{\Pi}_i$. Now dividing $\Pi_i^{1-\sigma} = \sum_{j=1}^{n} t_{ij}^{1-\sigma} \mathbb{P}_j$ by $\Pi_i^{1-\sigma}$ and using again $\mathbb{\Pi}_i = \frac{Y_i}{Y^W} \Pi_i^{\sigma-1}$ leads to $\frac{Y_i}{Y^W} = \mathbb{\Pi}_i \sum_{j=1}^{n} t_{ij}^{1-\sigma} \mathbb{P}_j$. Similarly, dividing $P_j^{1-\sigma} = \sum_{i=1}^{n} t_{ij}^{1-\sigma} \mathbb{\Pi}_i$ by $P_j^{1-\sigma}$ and using again $\mathbb{P}_j = \frac{Y_j}{Y^W} P_j^{\sigma-1}$ leads to $\frac{Y_j}{Y^W} = \mathbb{P}_j \sum_{i=1}^{n} t_{ij}^{1-\sigma} \mathbb{\Pi}_i$. $\frac{Y_i}{Y^W} = \mathbb{\Pi}_i \sum_{j=1}^{n} t_{ij}^{1-\sigma} \mathbb{P}_j$ and $\frac{Y_j}{Y^W} = \mathbb{P}_j \sum_{i=1}^{n} t_{ij}^{1-\sigma} \mathbb{\Pi}_i$ define a system of $2n$ equations that can be solved for the $2n$ unknowns $\mathbb{\Pi}_i$ and $\mathbb{P}_j$ in the observed baseline scenario.

To solve for the counterfactual $\mathbb{\Pi}_i^c$s and $\mathbb{P}_j^c$s, we take into account the changes in Y_j^c according to Implication 4 when solving for the $2n$ $\mathbb{\Pi}_i^c$s and $\mathbb{P}_j^c$s. Finally, we can compute P_j, Π_i, P_j^c, and Π_i^c from the solutions $\mathbb{P}_j$, $\mathbb{\Pi}_i$, $\mathbb{P}_j^c$, and $\mathbb{\Pi}_i^c$ using their definitions above.

C Sufficient statistics for welfare with imperfect labor markets

We follow Arkolakis et al. (2012) in the following derivations. Using $Y_j = p_j(1-u_j)L_j$, we can write $d\ln Y_j = d\ln p_j - u_j/(1-u_j)d\ln u_j = -u_j/(1-u_j)d\ln u_j$ assuming that the labor force remains constant. The second expression on the right-hand side uses the wage curve $w_j = p_j\xi_j/(1+\gamma_j\xi_j-\gamma_j)$, implying $d\ln w_j = d\ln p_j$ as we hold constant all labor market parameters and choose the wage of the particular country j under study as our numéraire (in this section). Defining real wages as $W_j \equiv w_j(1-u_j)L_j/P_j$ and taking logs, the total differential is given by $d\ln W_j = -u_j/(1-u_j)d\ln u_j - d\ln P_j$.

The total differential of $\ln P_j = \ln\left\{\left[\sum_{i=1}^{n}(\beta_i p_i t_{ij})^{1-\sigma}\right]^{\frac{1}{1-\sigma}}\right\}$ is given by

$$d\ln P_j = \sum_{i=1}^{n}\left(\left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{1-\sigma} d\ln p_i + \left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{1-\sigma} d\ln t_{ij}\right).$$

Using $X_{ij} = ((\beta_i p_i t_{ij})/P_j)^{1-\sigma}\, Y_j$ and defining $\lambda_{ij} = X_{ij}/Y_j = ((\beta_i p_i t_{ij})/P_j)^{1-\sigma}$, yields

$$d\ln P_j = \sum_{i=1}^{n}\lambda_{ij}\left(d\ln p_i + d\ln t_{ij}\right). \tag{23}$$

Noting again that $d\ln p_i = d\ln w_i$ holds, we can also write: $d\ln P_j = \sum_{i=1}^{n}\lambda_{ij}\left(d\ln w_i + d\ln t_{ij}\right)$. Combining terms leads to $d\ln W_j = d\ln Y_j - d\ln P_j = -\frac{u_j}{1-u_j}d\ln u_j - \sum_{i=1}^{n}\lambda_{ij}\left(d\ln w_i + d\ln t_{ij}\right)$. Taking the ratio of λ_{ij} and λ_{jj} we can write $\lambda_{ij}/\lambda_{jj} = \left[(\beta_i p_i t_{ij})/(\beta_j p_j t_{jj})\right]^{1-\sigma}$. Assuming that $dt_{jj} = 0$, i.e., internal trade costs of country j do not change, and that w_j is the numéraire, so that $dw_j = dp_j = 0$, the log-change of this ratio is given by $d\ln\lambda_{ij} - d\ln\lambda_{jj} = (1-\sigma)\left(d\ln p_i + d\ln t_{ij}\right)$. Combining this with Equation (23) leads to:

$$d\ln P_j = \frac{1}{1-\sigma}\left(\sum_{i=1}^{n}\lambda_{ij}d\ln\lambda_{ij} - d\ln\lambda_{jj}\sum_{i=1}^{n}\lambda_{ij}\right).$$

Noting that $Y_j = \sum_{i=1}^{n} X_{ij}$, it follows that $\sum_{i=1}^{n} \lambda_{ij} = 1$ and $d \sum_{i=1}^{n} \lambda_{ij} = \sum_{i=1}^{n} d\lambda_{ij} = 0$. Hence, $\sum_{i=1}^{n} \lambda_{ij} d \ln \lambda_{ij} = \sum_{i=1}^{n} d\lambda_{ij} = 0$. Using these facts, the above expression simplifies to $d \ln P_j = -\frac{1}{1-\sigma} d \ln \lambda_{jj}$. The welfare change can then be expressed as $d \ln W_j = -\frac{u_j}{1-u_j} d \ln u_j + \frac{1}{1-\sigma} d \ln \lambda_{jj}$. Integrating between the initial and the counterfactual situation we get $\ln \hat{W}_j = \ln \hat{e}_j + \frac{1}{1-\sigma} \ln \hat{\lambda}_{jj}$, where $e_j = 1 - u_j$ is the share of employed workers. Taking exponents leads to $\hat{W}_j = \hat{e}_j \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}$. Note that $\hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}$ can be expressed as $\hat{\lambda}_{jj}^{\frac{1}{1-\sigma}} = \widehat{\left(\frac{p_j}{P_j}\right)}$ using $\lambda_{jj} = ((\beta_j p_j t_{jj})/P_j)^{1-\sigma}$ and recalling that β_j and t_{jj} are constant. Moving from any observed level of trade to autarky, i.e., $\lambda_{jj}^c = 1$, yields $\hat{W}_j = \hat{e}_j \left(\lambda_{jj}\right)^{-\frac{1}{1-\sigma}}$. Note, however, that in contrast to the case with perfect labor markets considered in Arkolakis et al. (2012), even this expression needs information about employment changes.

D List of included RTAs

For our RTA dummy, we use Mario Larch's RTA database which can be accessed at `http://www.ewf.uni-bayreuth.de/en/research/RTA-data/index.html`. It includes the following RTAs: Australia New Zealand Closer Economic Agreement (CER), European Free Trade Association (EFTA), Protocol on Trade Negotiations (PTN), European Community/Union and Turkey, European Community/Union and Slovak Republic, European Community/Union and Austria, European Community/Union and Poland, EFTA and Hungary, Finland and Hungary, Turkey and Poland, European Community/Union and Switzerland, EFTA and Turkey, South Pacific Regional Trade and Economic Cooperation Agreement (SPARTECA), EFTA and Korea, European Community/Union and Czechoslovakia, Canada United States Free Trade Agreement, European Community/Union and Czech Republic and Slovak Republic, European Community/Union and Sweden, EFTA and Poland, Finland and Poland, European Community/Union, European Community/Union and Iceland, EFTA and Iceland, North American Free Trade Agreement (NAFTA), European Community/Union and Hungary, Czech Republic and Slovak Republic, European Community/Union and Finland, EFTA and Slovak Republic, Hungary and Turkey, Central European Free Trade Agreement (CEFTA), European Community/Union and Norway, European Economic Area (EEA), U.S.-Australia Free Trade Agreement, Czech Republic and Turkey, EFTA and Switzerland, Finland and Germany, Slovak Republic and Turkey.

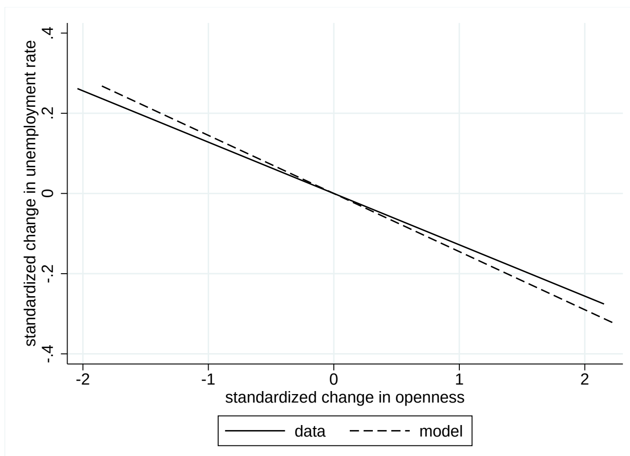

Figure 1: Implied regression lines of changes in openness and unemployment rates for both model and data.

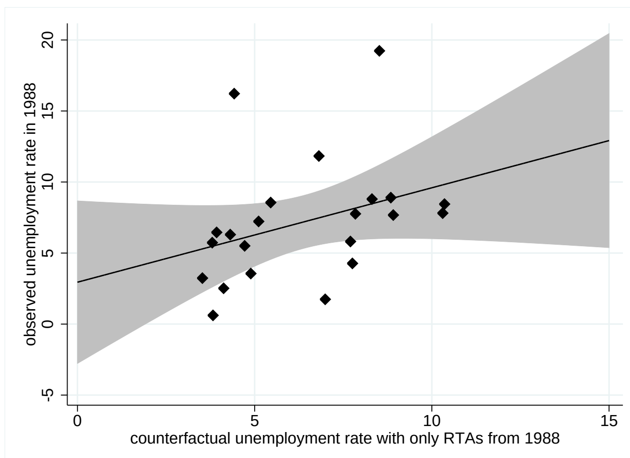

Figure 2: Graph depicts the implied regression line and the according 95% confidence interval of the regression of observed unemployment rates in 1988 on the counterfactual unemployment rates implied by the model with RTAs signed until 1988 only as well as the according scatterplot.

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.
X_{ijs} (current million US$)	5367.178	15340.135	0.061	348420.6
GDP_{is} (current million US$)	933259.51	1888767.495	5588.502	13201819
GDP_{js} (current million US$)	1018788.019	1940871.763	6127.601	13201819
RTA_{ijs}	0.586	0.493	0	1
$\ln(1 + simpleaveragetariffAPPLIED)_{ijs}$	0.032	0.034	0	0.341
$\ln(1 + simpletarifflineaveragetariffAPPLIED)_{ijs}$	0.037	0.038	0	0.77
$\ln(1 + weightedaveragetariffAPPLIED)_{ijs}$	0.027	0.036	0	0.452
$\ln DIST_{ij}$	7.987	1.127	5.081	9.880
$CONTIG_{ij}$	0.079	0.27	0	1
$COMLANG_{ij}$	0.084	0.277	0	1
N		10956		

Notes: Summary statistics for the OECD regression sample from 1988 to 2006. The 28 countries included are Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. Data are taken from **?**, Mario Larch's RTA data base, and WITS. As bilateral tariff rates are not available as a balanced panel, the summary statistics for GDP_{is} and GDP_{js} are different.

Table 2: Estimation results for OECD sample, 1988-2006

	(1) OLS $\ln Z_{ijs}$	(2) PPML Z_{ijs}	(3) OLS $\ln Z_{ijs}$	(4) PPML Z_{ijs}	(5) OLS $\ln Z_{ijs}$	(6) PPML Z_{ijs}	(7) OLS $\ln Z_{ijs}$	(8) PPML Z_{ijs}
First stage								
RTA_{ijs}	0.222***	0.182**	0.188***	0.160**	0.199***	0.159**	0.203***	0.161**
	(0.036)	(0.073)	(0.036)	(0.071)	(0.036)	(0.071)	(0.036)	(0.071)
Second stage								
$\ln DIST_{ij}$	-1.080***	-1.077***	-1.071***	-1.065***	-1.075***	-1.066***	-1.075***	-1.072***
	(0.016)	(0.015)	(0.016)	(0.015)	(0.016)	(0.015)	(0.016)	(0.015)
$CONTIG_{ij}$	0.297***	0.512***	0.301***	0.519***	0.300***	0.519***	0.296***	0.513***
	(0.031)	(0.034)	(0.031)	(0.035)	(0.031)	(0.035)	(0.031)	(0.035)
$COMLANG_{ij}$	0.145***	-0.113***	0.147***	-0.112***	0.146***	-0.114***	0.151***	-0.111***
	(0.027)	(0.037)	(0.027)	(0.037)	(0.027)	(0.037)	(0.027)	(0.037)
Estimated elasticities								
σ using method from Section 3.2.1	1.089***	1.064***						
	(0.014)	(0.005)						
σ using $\ln(1+simpleaverageAPPLIED_{ijs})$			1.673***	1.765***				
			(0.254)	(0.356)				
σ using $\ln(1+simpletarifflineaverageAPPLIED_{ijs})$					0.954***	1.515***		
					(0.192)	(0.320)		
σ using $\ln(1+weightedaverageAPPLIED_{ijs})$							1.351***	1.276***
							(0.171)	(0.289)
μ using method from Section 3.2.2	0.981***	0.989***	0.930***	0.933***	0.992***	0.946***	0.946***	0.964***
	(0.004)	(0.003)	(0.011)	(0.015)	(0.019)	(0.017)	(0.017)	(0.022)
N	10956	10956	10956	10956	10956	10956	10956	10956

Notes: Results for trade flows between 28 OECD countries between 1988 and 2006 (unbalanced panel) estimated by ordinary least squares (OLS) and Poisson pseudo-maximum-likelihood (PPML). Z_{ijs} are trade flows standardized by importer and exporter GDPs. RTA_{ijs} is an indicator variable equal to 1 if there exists a regional trade agreement between exporting country i and importing country j in year s, $\ln DIST_{ij}$ is the logarithm of the distance between exporting and importing country, $CONTIG_{ij}$ is an indicator variable equal to 1 if the exporting and importing countries share a common border, and $COMLANG_{ij}$ is an indicator variable equal to 1 if the exporting and importing country share a common official language. $\ln(1+simpleaverageAPPLIED_{ijs})$ is the logarithm of 1 plus the simple average of the effectively applied tariff rate for imports from i in j calculated at the HS 6-digit level, $\ln(1+simpletarifflineaverageAPPLIED_{ijs})$ is the logarithm of 1 plus the simple average of the effectively applied tariff rate for imports from i in j calculated at the tariff line level, and $\ln(1+weightedaverageAPPLIED_{ijs})$ is 1 plus the logarithm of the weighted average of the effectively applied tariff rate with weights given by the corresponding trade value. All regressions control for multilateral resistance terms (MRTs) via time-varying exporter and importer fixed effects. To control for the potential endogeneity of RTA_{ijs} and the tariff variables, all first stage regressions additionally include directional bilateral time-invariant fixed effects. Standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors for μ in all columns as well as σ in columns (1) and (2) are bootstrapped. Remaining standard errors are analytic heteroscedasticity-robust standard errors.

Table 3: Comparative static effects of RTA inception controlling for trade imbalances and tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share $\%Y$ SMF		SMF	SMF	PLM	SMF
	$\%Y$	$\%Y$	$\%\ln(\hat{p})$	$\%\ln(\hat{e})$	$\%\hat{e}$	Δu	$\%EV$	$\%EV$
Australia	4.04	4.57	92.09	7.91	0.35	-0.34	4.91	5.23
Austria	7.89	9.03	84.50	15.50	1.35	-1.27	20.43	21.68
Belgium	7.87	9.00	84.71	15.29	1.33	-1.20	20.03	21.29
Canada	9.80	10.95	84.43	15.57	1.63	-1.50	25.86	26.65
Czech Republic	8.29	9.47	84.29	15.71	1.43	-1.31	21.85	23.07
Denmark	7.56	8.65	84.80	15.20	1.27	-1.20	19.09	20.24
Finland	6.42	7.37	85.58	14.42	1.03	-0.94	15.16	16.03
France	6.98	8.01	85.08	14.92	1.16	-1.04	17.20	18.31
Germany	6.26	7.20	86.18	13.82	0.97	-0.86	14.06	15.06
Greece	6.02	6.94	85.59	14.41	0.97	-0.88	14.23	15.15
Hungary	7.67	8.78	84.67	15.33	1.30	-1.19	19.56	20.66
Iceland	5.95	6.82	85.99	14.01	0.93	-0.89	13.61	14.32
Ireland	7.68	8.74	84.95	15.05	1.27	-1.20	19.14	20.09
Italy	6.13	7.06	86.00	14.00	0.96	-0.89	13.99	14.95
Japan	2.07	2.38	101.06	-1.06	-0.02	0.02	-0.47	-0.49
Korea	2.13	2.45	100.50	-0.50	-0.01	0.01	-0.30	-0.30
Netherlands	7.60	8.67	85.27	14.73	1.23	-1.16	18.45	19.58
New Zealand	3.68	4.20	92.12	7.88	0.33	-0.31	4.43	4.61
Norway	7.24	8.27	85.26	14.74	1.18	-1.12	17.65	18.79
Poland	7.53	8.62	84.69	15.31	1.27	-1.08	19.18	20.29
Portugal	6.99	8.00	85.07	14.93	1.16	-1.06	17.25	18.25
Slovak Republic	8.10	9.26	84.38	15.62	1.39	-1.19	21.16	22.33
Spain	6.07	6.99	85.74	14.26	0.97	-0.88	14.14	15.07
Sweden	6.97	7.98	85.17	14.83	1.15	-1.05	17.02	18.00
Switzerland	7.97	9.12	84.47	15.53	1.36	-1.30	20.75	22.15
Turkey	6.09	7.00	85.88	14.12	0.96	-0.85	14.08	14.97
United Kingdom	4.94	5.73	87.03	12.97	0.73	-0.68	10.32	11.11
United States	2.44	2.82	97.49	2.51	0.07	-0.07	0.76	0.91
Average	4.39	5.04	92.41	7.59	0.53	-0.48	7.71	8.23

Notes: Counterfactual analysis is based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table 4: Average comparative static effects of RTA inception for various parameter values

μ	σ	PLM %Y	SMF %Y	SMF %$\hat{e}$	SMF Δu	PLM %EV	SMF %EV
	5	0.75	6.83	5.77	-4.85	1.40	7.30
0.2	10	0.33	2.91	2.51	-2.21	0.62	3.16
	15	0.21	1.84	1.60	-1.44	0.40	2.01
	5	0.75	2.24	1.40	-1.26	1.40	2.84
0.5	10	0.33	0.96	0.62	-0.56	0.62	1.24
	15	0.21	0.61	0.40	-0.36	0.40	0.80
	5	0.75	1.25	0.46	-0.42	1.40	1.88
0.75	10	0.33	0.54	0.21	-0.19	0.62	0.83
	15	0.21	0.34	0.13	-0.12	0.40	0.53
	5	0.75	0.92	0.15	-0.14	1.40	1.56
0.9	10	0.33	0.40	0.07	-0.06	0.62	0.69
	15	0.21	0.25	0.04	-0.04	0.40	0.44
	5	0.75	0.77	0.01	-0.01	1.40	1.42
0.99	10	0.33	0.33	0.01	-0.01	0.62	0.62
	15	0.21	0.21	0.00	-0.00	0.40	0.40

Notes: Table reports average changes in total sales, employment, unemployment, and the equivalent variation in percent assuming either a perfect labor market (PLM) or using a search and matching framework (SMF) for the labor market assuming balanced trade and setting tariffs to 0 with varying elasticity of substitution σ and elasticity of the matching function μ. The remaining parameters are set to values from column (4) of Table 2.

Table 5: Comparative static effects of the U.S.-Australia Free Trade Agreement controlling for trade imbalances and tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share %Y SMF		SMF	SMF	PLM	SMF
	%Y	%Y	% $\ln(\hat{p})$	% $\ln(\hat{e})$	%$\hat{e}$	Δu	%EV	%EV
Australia	2.28	2.51	83.43	16.57	0.41	-0.39	5.95	6.30
Austria	-0.04	-0.04	97.07	2.93	-0.00	0.00	-0.01	-0.01
Belgium	-0.04	-0.04	97.95	2.05	-0.00	0.00	-0.01	-0.01
Canada	-0.09	-0.09	91.75	8.25	-0.01	0.01	-0.11	-0.10
Czech Republic	-0.04	-0.04	97.04	2.96	-0.00	0.00	-0.01	-0.01
Denmark	-0.04	-0.04	96.68	3.32	-0.00	0.00	-0.02	-0.02
Finland	-0.05	-0.04	94.09	5.91	-0.00	0.00	-0.04	-0.04
France	-0.04	-0.04	97.12	2.88	-0.00	0.00	-0.01	-0.01
Germany	-0.04	-0.04	97.25	2.75	-0.00	0.00	-0.01	-0.01
Greece	-0.04	-0.04	94.53	5.47	-0.00	0.00	-0.03	-0.03
Hungary	-0.04	-0.04	95.75	4.25	-0.00	0.00	-0.02	-0.02
Iceland	-0.06	-0.05	92.42	7.58	-0.00	0.00	-0.06	-0.06
Ireland	-0.04	-0.04	96.70	3.30	-0.00	0.00	-0.02	-0.02
Italy	-0.04	-0.04	96.12	3.88	-0.00	0.00	-0.02	-0.02
Japan	-0.02	-0.02	83.82	16.18	-0.00	0.00	-0.04	-0.04
Korea	-0.02	-0.02	83.70	16.30	-0.00	0.00	-0.04	-0.04
Netherlands	-0.04	-0.04	97.87	2.13	-0.00	0.00	-0.01	-0.01
New Zealand	-0.03	-0.03	-19.71	119.71	-0.03	0.03	-0.54	-0.50
Norway	-0.04	-0.04	94.95	5.05	-0.00	0.00	-0.03	-0.03
Poland	-0.04	-0.04	95.99	4.01	-0.00	0.00	-0.02	-0.02
Portugal	-0.04	-0.04	95.05	4.95	-0.00	0.00	-0.03	-0.03
Slovak Republic	-0.04	-0.04	96.15	3.85	-0.00	0.00	-0.02	-0.02
Spain	-0.04	-0.04	95.45	4.55	-0.00	0.00	-0.03	-0.03
Sweden	-0.04	-0.04	95.24	4.76	-0.00	0.00	-0.03	-0.03
Switzerland	-0.04	-0.04	97.58	2.42	-0.00	0.00	-0.01	-0.01
Turkey	-0.04	-0.04	92.56	7.44	-0.00	0.00	-0.04	-0.04
United Kingdom	-0.04	-0.04	97.16	2.84	-0.00	0.00	-0.01	-0.01
United States	0.02	0.03	40.61	59.39	0.02	-0.02	0.28	0.30
Average	0.03	0.05	73.26	26.74	0.01	-0.01	0.21	0.23

Notes: Counterfactual analysis is based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table 6: Comparative static effects of $\hat{\kappa}_{U.S.} = 1.054$ controlling for trade imbalances and tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share %Y SMF		SMF	SMF	PLM	SMF
	%Y	%Y	$\%\ln(\hat{p})$	$\%\ln(\hat{e})$	$\%\hat{e}$	Δu	%EV	%EV
Australia	0.00	0.14	73.01	26.99	0.04	-0.04	-0.00	0.60
Austria	0.00	-0.01	267.65	-167.65	0.01	-0.01	0.00	0.21
Belgium	0.00	-0.02	139.88	-39.88	0.01	-0.01	-0.00	0.16
Canada	0.00	0.81	77.53	22.47	0.18	-0.17	-0.00	2.72
Czech Republic	0.00	-0.00	615.17	-515.17	0.01	-0.01	0.00	0.22
Denmark	0.00	0.01	-11.89	111.89	0.01	-0.01	0.00	0.26
Finland	0.00	0.08	66.90	33.10	0.03	-0.02	0.00	0.46
France	-0.00	-0.00	993.89	-893.89	0.01	-0.01	-0.00	0.22
Germany	-0.00	-0.01	302.57	-202.57	0.01	-0.01	-0.00	0.21
Greece	0.00	0.03	37.06	62.94	0.02	-0.02	0.00	0.33
Hungary	0.00	0.02	31.43	68.57	0.02	-0.01	0.00	0.30
Iceland	-0.00	0.23	75.04	24.96	0.06	-0.06	-0.00	0.92
Ireland	0.00	0.02	26.63	73.37	0.02	-0.02	0.00	0.31
Italy	-0.00	0.01	-7.07	107.07	0.01	-0.01	-0.00	0.27
Japan	0.00	0.03	57.94	42.06	0.01	-0.01	-0.00	0.25
Korea	0.00	0.03	54.60	45.40	0.01	-0.01	0.00	0.27
Netherlands	-0.00	-0.02	149.87	-49.87	0.01	-0.01	-0.00	0.18
New Zealand	0.00	0.16	73.52	26.48	0.04	-0.04	0.00	0.70
Norway	0.00	0.07	64.47	35.53	0.02	-0.02	0.00	0.41
Poland	0.00	0.02	31.04	68.96	0.02	-0.01	0.00	0.29
Portugal	0.00	0.06	59.63	40.37	0.03	-0.02	0.00	0.44
Slovak Republic	0.00	0.01	1.50	98.50	0.01	-0.01	0.00	0.27
Spain	-0.00	0.05	52.67	47.33	0.02	-0.02	-0.00	0.38
Sweden	0.00	0.05	59.78	40.22	0.02	-0.02	0.00	0.38
Switzerland	0.00	-0.02	152.95	-52.95	0.01	-0.01	0.00	0.17
Turkey	0.00	0.07	63.23	36.77	0.03	-0.02	-0.00	0.45
United Kingdom	-0.00	0.00	-338.74	438.74	0.01	-0.01	-0.00	0.24
United States	0.00	2.92	-80.16	180.16	5.32	-5.08	0.00	4.68
Average	0.00	1.12	63.25	36.75	1.98	-1.89	0.00	1.99

Notes: Counterfactual analysis is based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Gravity with Unemployment
Online Appendix

Benedikt Heid and Mario Larch*

*Heid: University of Bayreuth, CESifo, Universitätsstraße 30, 95447 Bayreuth, Germany, benedikt.heid@uni-bayreuth.de. Larch: University of Bayreuth, CESifo, ifo Institute, and GEP at University of Nottingham, Universitätsstraße 30, 95447 Bayreuth, Germany, mario.larch@uni-bayreuth.de. A previous version of this paper has been circulated under the title "International Trade and Unemployment: A Quantitative Framework". Funding from the DFG under project 592405 is gratefully acknowledged. We thank Daniel Bernhofen, Hartmut Egger, Christian Holzner, Kala Krishna, John McLaren, Marc-Andreas Muendler, Emanuel Ornelas, Yoto Yotov, participants at the GEP Postgraduate Conference 2012, the CESifo Area Conference on Global Economy 2012, the European Trade Study Group 2012, the Annual Meeting of the European Society of Population Economics 2012, the Annual Meeting of the Verein für Socialpolitik 2013, the Annual Congress of the European Economic Association 2013, the CAGE International Trade Research Day 2013, research seminars at the Universities of Trier and Innsbruck, and the 7th FIW-Research Conference on International Economics 2014, for helpful comments. As always, we have a property right on any remaining errors.

Introduction to the Online Appendix

In this Online Appendix, we present further results and robustness checks for the paper "Gravity with Unemployment".

In Section A, we extend our basic model to allow for tariff revenues and trade imbalances.

In Section B, we present a variant of our model where wages are determined by a binding minimum wage instead of bargaining once the match between a worker and firm is established. We derive counterfactual changes in employment and show that for constant labor market institutions, calculated employment changes are identical to the ones assuming wage bargaining as in the main text.

In Section C, we assume that the wage setting process is determined within an efficiency wage framework. Again, when labor market institutions remain unchanged, calculated changes in employment and total sales are identical to the model presented in the main text.

In Section D, we present an alternative model setup in the vein of the Ricardian model of international trade by Eaton and Kortum (2002) and show that our results from the main text hold when reinterpreting the elasticity of substitution as the technology dispersion parameter used in Eaton and Kortum (2002).

Section E presents further results on trade flow and employment changes for the evaluation of RTAs and the hypothetical labor market reform in the United States.

Section F presents results from the evaluation of RTAs with tariff rates set to 0, i.e., without tariff income.

Section G presents results for the counterfactual analyses in Section 3.4 from the main text under the assumption of balanced trade.

Section H provides additional details concerning the tariff data.

Section I presents the full distributions of the estimated elasticities when using the estimation methods described in Section 3.2 from the main text.

Finally, Section J derives an alternative, more robust estimation method for the elasticity of the matching function, μ, if a panel of both trade flows and labor market data is available.

A A quantitative framework for trade and unemployment with trade imbalances and tariffs

A.1 Goods market

The representative consumer in country j is characterized by the utility function U_j. We assume that goods are differentiated by country of origin, i.e., we use the simplest possible way to provide a rationale for bilateral trade between similar countries based on preferences à la Armington (1969).[1] In Section D of this Online Appendix, we demonstrate that our framework and counterfactual analysis are isomorphic to a Ricardian model of international trade along the lines of Eaton and Kortum (2002). Country j purchases quantity q_{ij} of goods from country i, leading to the utility function

$$U_j = \left[\sum_{i=1}^{n} \beta_i^{\frac{1-\sigma}{\sigma}} q_{ij}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{24}$$

where n is the number of countries, σ is the elasticity of substitution in consumption, and β_i is a positive preference parameter measuring the product appeal for goods from country i.

Trade of goods from i to j imposes iceberg trade costs $t_{ij} \geq 1$ and ad-valorem tariffs τ_{ij}, defined as 1 plus the tariff rate. Assuming factory-gate pricing implies that $p_{ij} = p_i t_{ij} \tau_{ij}$, where p_i denotes the factory gate price of the good in country i.

The representative consumer maximizes Equation (24) subject to the bud-

[1] Consequently, we deliberately abstract from distinguishing between the intensive and extensive margin of international trade as for example in Chaney (2008) or Helpman et al. (2008).

get constraint $E_j = \sum_{i=1}^n p_i t_{ij} \tau_{ij} q_{ij}$, where her expenditure E_j is given by $E_j = Y_j(1+d_j) + T_j$, with Y_j denoting total sales in country j, d_j the share of the exogenously given trade deficit (if $d_j > 0$) or surplus (if $d_j < 0$) of country j in terms of total sales, following Dekle et al. (2007) and Costinot and Rodríguez-Clare (2014), and T_j are tariff revenues of country j. Trade deficits are calculated as the difference between a country's imports and exports from the trade flow matrix between all countries in our data set. This ensures that trade deficits are lump-sum transfers across countries, i.e., $\sum_{i=1}^n d_i Y_i = 0$. It also implies that trade is balanced at the world level. The value of aggregate sales of goods from country i to country j before tariffs are levied can then be expressed as

$$X_{ij} \;=\; p_i t_{ij} q_{ij} = \left(\frac{\beta_i p_i t_{ij}}{P_j}\right)^{1-\sigma} \tau_{ij}^{-\sigma} E_j, \tag{25}$$

and P_j is the standard CES price index given by $P_j = [\sum_{i=1}^n (\beta_i p_i t_{ij} \tau_{ij})^{1-\sigma}]^{1/(1-\sigma)}$. Tariff revenues are given by the sum of all tariffs levied on all imports, i.e., $T_i = \sum_{j=1}^n (\tau_{ji} - 1) X_{ji}$.

In general equilibrium, total sales correspond to the sum of all exports, i.e., $Y_i = \sum_{j=1}^n X_{ij}$. Assuming labor to be the only factor of production which produces one unit of output per worker, total sales in a world with imperfect labor markets is given by total production of the final output good multiplied with its price, i.e., $Y_i = p_i(1-u_i)L_i$.

This setup implies a gravity equation for bilateral trade flows. Using

$$\begin{aligned} Y_i &= \sum_{j=1}^n X_{ij} = \sum_{j=1}^n \left(\frac{\beta_i t_{ij} p_i}{P_j}\right)^{1-\sigma} \tau_{ij}^{-\sigma} E_j \\ &= (\beta_i p_i)^{1-\sigma} \sum_{j=1}^n \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \tau_{ij}^{-\sigma} E_j, \end{aligned} \tag{26}$$

and solving for scaled prices $\beta_i p_i$ and defining $Y^W \equiv \sum_j Y_j$, we can write bilateral trade flows as given in Equation (25) as

$$X_{ij} = \frac{Y_i E_j}{Y^W} \left(\frac{t_{ij}}{\Pi_i P_j} \right)^{1-\sigma} \tau_{ij}^{-\sigma}, \quad \text{where} \tag{27}$$

$$\Pi_i = \left(\sum_{j=1}^{n} \left(\frac{t_{ij}}{P_j} \right)^{1-\sigma} \tau_{ij}^{-\sigma} \frac{E_j}{Y^W} \right)^{1/(1-\sigma)}, \quad P_j = \left(\sum_{i=1}^{n} \left(\frac{t_{ij}\tau_{ij}}{\Pi_i} \right)^{1-\sigma} \frac{Y_i}{Y^W} \right)^{1/(1-\sigma)}, \tag{28}$$

while we substituted equilibrium scaled prices into the definition of the price index to obtain the multilateral resistance terms P_j.

Note that this system of equations exactly corresponds to the system given in Equations (9)-(11) in Anderson and van Wincoop (2003) or Equations (5.32) and (5.35) in Feenstra (2004) assuming balanced trade, $d_i = 0$ for all i, and no tariffs, i.e., $\tau_{ij} = 1$ between all i and j (i.e., $Y_i{=}E_i$), even when labor markets are imperfect.

By adding a stochastic error term, Equation (27) can be written as

$$Z_{ij} \equiv \frac{X_{ij}}{Y_i E_j} = \exp\left[k - (1-\sigma)\ln t_{ij} - \sigma \ln \tau_{ij} - \ln \Pi_i^{1-\sigma} - \ln P_j^{1-\sigma} + \varepsilon_{ij} \right], \tag{29}$$

where ε_{ij} is a random disturbance term or measurement error, assumed to be identically distributed and mean-independent of the remaining terms on the right-hand side of Equation (29), and k is a constant capturing the logarithm of world sales. Importer and exporter fixed effects can be used to control for the outward and inward multilateral resistance terms Π_i and P_j, respectively, as suggested by Anderson and van Wincoop (2003) and Feenstra (2004). Hence, even with labor market frictions, we can use established methods to estimate trade costs using the gravity equation, independently of the underlying labor market model. We summarize this result in Implication 5:

Implication 5 *The estimation of trade costs is unchanged when allowing for imperfect labor markets, even when allowing for trade imbalances and tariffs.*

To evaluate ex ante welfare effects of changes in trade policies, we need the counterfactual changes in employment and total sales in addition to trade cost parameter estimates. To derive these, we have to take a stance on how to model the labor market, to which we turn in the next section.

A.2 Labor market

We model the labor market using a one-shot version of the search and matching framework (SMF, see Mortensen and Pissarides, 1994 and Pissarides, 2000) which is closely related to Felbermayr et al. (2013).[2] Search-theoretic frameworks fit stylized facts of labor markets in developed economies as they explain why some workers are unemployed even if firms cannot fill all their vacancies.[3]

The labor market is characterized by frictions. All potential workers in country j, L_j, have to search for a job, and firms post vacancies V_j in order to find workers. The number of successful matches between an employer and a worker, M_j, is given by $M_j = m_j L_j^{\mu} V_j^{1-\mu}$, where $\mu \in (0,1)$ is the elasticity of the matching function with respect to the unemployed and m_j measures the overall efficiency of the labor market.[4] Only a fraction of open vacancies will be filled, $M_j/V_j = m_j \left(V_j/L_j\right)^{-\mu} = m_j \vartheta_j^{-\mu}$, and only a fraction of all workers will find a job, $M_j/L_j = m_j \left(V_j/L_j\right)^{1-\mu} = m_j \vartheta_j^{1-\mu}$, where $\vartheta_j \equiv V_j/L_j$ denotes the degree of labor market tightness in country j.[5] This implies that

[2]See Rogerson et al. (2005) for a survey of search and matching models, including an exposition of a simplified one-shot (directed) search model. For other recent trade models using a similar static framework without directed search, see for example Keuschnigg and Ribi (2009), Helpman and Itskhoki (2010), and Heid et al. (2013). We use the labor market setup from Felbermayr et al. (2013). However, they do not investigate its implications for the estimation of gravity equations nor do they structurally estimate it or use it for a counterfactual quantitative analysis. They also do not present labor market setups with minimum and efficiency wages nor do they consider alternative trade models such as the Eaton and Kortum (2002) framework as we do in our Online Appendix.

[3]They are less successful in explaining the cyclical behavior of unemployment and vacancies, see Shimer (2005). This deficiency is not crucial in our case as we purposely focus on the steady state.

[4]Note that we assume a constant returns to scale matching function in line with empirical studies, see Petrongolo and Pissarides (2001).

[5]We assume that the matching efficiency is sufficiently low to ensure that M_j/V_j and M_j/L_j lie between 0 and 1.

the unemployment rate is given by

$$u_j = 1 - m_j \vartheta_j^{1-\mu}. \tag{30}$$

As is standard in search models, we assume that every firm employs one worker. Similar to Helpman and Itskhoki (2010), this assumption does not lead to any loss of generality as long as the firm operates under perfect competition and constant returns to scale. In addition, we assume that all firms have the same productivity and produce a homogeneous good. In order to employ a worker (i.e., to enter the market), the firm has to post a vacancy at a cost of $c_j P_j$, i.e., in units of the final output good.[6] After paying these costs, a firm finds a worker with probability $m_j \vartheta_j^{-\mu}$. When a match between a worker and a firm has been established, we assume that they bargain over the total match surplus. Alternatively, we consider minimum and efficiency wages in Sections B and C of this Online Appendix as mechanisms for wage determination. All three approaches are observationally equivalent in our setting.

In the bargaining case, the match gain of the firm is given by its revenue from sales of one unit of the homogeneous product minus wage costs, $p_j - w_j$, as the firm's outside option is zero. The match surplus of a worker is given by $w_j - b_j$, where b_j is the outside option of the worker, i.e., the unemployment benefits (b_j) she receives when she is unemployed.[7]

As is standard in the literature, we use a generalized Nash bargaining solution to determine the surplus splitting rule. Hence, wages w_j are chosen to maximize $(w_j - b_j)^{\xi_j}(p_j - w_j)^{1-\xi_j}$, where the bargaining power of the worker is given by $\xi_j \in (0, 1)$. The unemployment benefits are expressed as a fraction γ_j of the market wage rate. Note that both the worker and the firm neglect the

[6] This implies that not all of total sales are available for final consumption (and hence welfare) of workers.

[7] Unemployment benefits are financed via lump-sum transfers from employed workers to the unemployed. As we assume homothetic preferences, which are identical across employed and unemployed workers, this does not show up in the economy-wide budget constraint Y_j, see Equation (26). Hence, demand can be fully described by aggregate expenditure. We also assume costless redistribution of the lump-sum transfer to the unemployed. These assumptions allow us to abstract from modeling the government more explicitly.

fact that in general equilibrium, higher wages lead to higher unemployment benefits, i.e., they both treat the level of unemployment benefits as exogenous (see Pissarides 2000). The first order conditions of the bargaining problem yield $w_j - \gamma_j w_j = (p_j - w_j)\, \xi_j/(1-\xi_j)$. Solving for w_j results in the **wage curve** $w_j = p_j \xi_j/(1+\gamma_j\xi_j - \gamma_j)$. Due to the one-shot matching, the wage curve does not depend on ϑ_j.

Given wages w_j, profits of a firm π_j are given by $\pi_j = p_j - w_j$. As we assume one worker firms and the probability of filling an open vacancy is $m_j \vartheta_j^{-\mu}$, expected profits are equal to $(p_j - w_j) m_j \vartheta_j^{-\mu}$. Firms enter the market until these expected profits cover the entry costs $c_j P_j$. This condition can be used to yield the **job creation curve** $w_j = p_j - P_j c_j/(m_j \vartheta_j^{-\mu})$.

As pointed out by Felbermayr et al. (2013), combining the job creation and wage curves determines the equilibrium labor market tightness as

$$\vartheta_j = \left(\frac{p_j}{P_j}\right)^{1/\mu} \left(\frac{c_j}{m_j}\Omega_j\right)^{-1/\mu}. \tag{31}$$

$\Omega_j \equiv \frac{1-\gamma_j+\gamma_j\xi_j}{1-\gamma_j+\gamma_j\xi_j-\xi_j} \geq 1$ is a summary measure for the impact of the worker's bargaining power ξ_j and the replacement rate γ_j on labor market tightness.[8]

A.3 Counterfactual analysis

In the following, we derive and discuss in turn counterfactual welfare along the lines of Arkolakis et al. (2012), (un)employment, total sales, and trade flows as functions of the multilateral resistance terms in the baseline and counterfactual scenario.

A.3.1 Counterfactual welfare

We can now consider the welfare consequences of a counterfactual change in trade costs that leaves the ability to serve the own market, t_{jj}, unchanged as in Arkolakis et al. (2012). Additionally, we follow their normalization and take

[8]The replacement rate is the percentage of the equilibrium wage a worker receives as unemployment benefits when she is unemployed.

labor in the considered country j as our numéraire, leading to $w_j = 1$. In our economy, total sales are given by total production of the final output good multiplied with its price, i.e., $Y_i = p_i(1-u_i)L_i$, whereas consumer expenditure is given by $(1-u_j)w_jL_j + d_jY_j + T_j$.[9] We then come up with the following sufficient statistics:

Implication 6 *Welfare effects of trade liberalization in our model with imperfect labor markets, tariffs, and trade imbalances can be expressed as*

$$\hat{W}_j = \hat{\psi}_j \hat{e}_j \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}},$$

where ψ_j is a tariff multiplier defined below.

To prove this implication, we follow Arkolakis et al. (2012). We use total consumer expenditure of country j as our starting point, given by $CE_j = (1-u_j)w_jL_j + d_jY_j + T_j$. In order to be able to derive sufficient statistics with tariffs and trade imbalances, we follow Felbermayr et al. (2015) and write

$$\begin{aligned} CE_j &= (1-u_j)w_jL_j + d_jY_j + T_j \\ &= \frac{\xi_j}{(1+\gamma_j\xi_j-\gamma_j)}(1-u_j)p_jL_j + d_jY_j + T_j \\ &= \frac{\xi_j}{1+\gamma_j\xi_j-\gamma_j}Y_j + d_jY_j + T_j \\ &= \psi_j\left(\frac{\xi_j}{1+\gamma_j\xi_j-\gamma_j} + d_j\right)Y_j, \end{aligned} \tag{32}$$

where ψ_j is a tariff multiplier defined as

$$\psi_j \equiv \left(1 + \frac{T_j}{\left(\frac{\xi_j}{1+\gamma_j\xi_j-\gamma_j} + d_j\right)Y_j}\right) = \left(1 - \frac{T_j}{CE_j}\right)^{-1} \geq 1,$$

[9] Total consumer expenditure consists of the income of employed workers $(1-u_j)w_jL_j + d_jY_j + T_j - B_j$, and the income of unemployed workers B_j where $B_j = u_jL_jb_j$. The total sum of unemployment benefits is financed by a lump-sum transfer from employed workers to the unemployed.

and where we used $Y_j = p_j(1-u_j)L_j$ and $w_j = p_j\xi_j/(1+\gamma_j\xi_j-\gamma_j)$. Using again $Y_j = p_j(1-u_j)L_j$, we can write $d\ln CE_j = d\ln\psi_j + d\ln p_j - u_j/(1-u_j)d\ln u_j = d\ln\psi_j - u_j/(1-u_j)d\ln u_j$ assuming that the labor force L_j and trade imbalances d_j remain constant. The second expression on the right-hand side uses the wage curve $w_j = p_j\xi_j/(1+\gamma_j\xi_j-\gamma_j)$, implying $d\ln w_j = d\ln p_j$ holding all labor market parameters constant and the choice of numéraire w_j. Defining real consumer expenditure as $W_j \equiv CE_j/P_j = \left[\psi_j\left(\frac{\xi_j}{1+\gamma_j\xi_j-\gamma_j}+d_j\right)Y_j\right]/P_j$ and taking logs, the total differential is given by $d\ln W_j = d\ln\psi_j + d\ln Y_j - d\ln P_j$, where we again assume d_j and labor market parameters to be constant.

The total differential of $\ln P_j = \ln\left\{\left[\sum_{i=1}^n\left(\beta_i p_i t_{ij}\tau_{ij}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}\right\}$ is given by

$$\begin{aligned} d\ln P_j &= \sum_{i=1}^n\left(\left(\frac{\beta_i p_i t_{ij}\tau_{ij}}{P_j}\right)^{1-\sigma} d\ln p_i + \left(\frac{\beta_i p_i t_{ij}\tau_{ij}}{P_j}\right)^{1-\sigma} d\ln t_{ij}\right. \\ &\quad \left. + \left(\frac{\beta_i p_i t_{ij}\tau_{ij}}{P_j}\right)^{1-\sigma} d\ln\tau_{ij}\right). \end{aligned}$$

Using $\tau_{ij}X_{ij} = \left((\beta_i p_i t_{ij}\tau_{ij})/P_j\right)^{1-\sigma}E_j$ and defining $\lambda_{ij} \equiv \tau_{ij}X_{ij}/E_j = \left((\beta_i p_i t_{ij}\tau_{ij})/P_j\right)^{1-\sigma}$, yields

$$d\ln P_j = \sum_{i=1}^n \lambda_{ij}\left(d\ln p_i + d\ln t_{ij} + d\ln\tau_{ij}\right). \tag{33}$$

Noting again that $d\ln p_i = d\ln w_i$ holds, we can also write $d\ln P_j = \sum_{i=1}^n \lambda_{ij}(d\ln w_i + d\ln t_{ij} + d\ln\tau_{ij})$. Combining terms leads to $d\ln W_j = d\ln\psi_j + d\ln Y_j - d\ln P_j = d\ln\psi_j - \frac{u_j}{1-u_j}d\ln u_j - \sum_{i=1}^n\lambda_{ij}(d\ln w_i + d\ln t_{ij} + d\ln\tau_{ij})$. Taking the ratio of λ_{ij} and λ_{jj} we can write $\lambda_{ij}/\lambda_{jj} = [(\beta_i p_i t_{ij}\tau_{ij})/(\beta_j p_j t_{jj}\tau_{jj})]^{1-\sigma}$. Noting that $dt_{jj} = d\tau_{jj} = 0$ by assumption and that w_j is the numéraire, so that $dw_j = dp_j = 0$, the log-change of this ratio is given by $d\ln\lambda_{ij} - d\ln\lambda_{jj} = (1-\sigma)\left(d\ln p_i + d\ln t_{ij} + d\ln\tau_{ij}\right)$. Combining this with Equation (33) leads to:

$$d\ln P_j = \frac{1}{1-\sigma}\left(\sum_{i=1}^n \lambda_{ij} d\ln\lambda_{ij} - d\ln\lambda_{jj}\sum_{i=1}^n\lambda_{ij}\right).$$

Noting that $E_j = \sum_{i=1}^{n} \tau_{ij} X_{ij}$, it follows that $\sum_{i=1}^{n} \lambda_{ij} = 1$ and $d \sum_{i=1}^{n} \lambda_{ij} = \sum_{i=1}^{n} d\lambda_{ij} = 0$. Hence, $\sum_{i=1}^{n} \lambda_{ij} d \ln \lambda_{ij} = \sum_{i=1}^{n} d\lambda_{ij} = 0$. Using these facts, the above expression simplifies to $d \ln P_j = -\frac{1}{1-\sigma} d \ln \lambda_{jj}$. The welfare change can then be expressed as $d \ln W_j = d \ln \psi_j - \frac{u_j}{1-u_j} d \ln u_j + \frac{1}{1-\sigma} d \ln \lambda_{jj}$. Integrating between the initial and the counterfactual situation we get $\ln \hat{W}_j = \ln \hat{\psi}_j + \ln \hat{e}_j + \frac{1}{1-\sigma} \ln \hat{\lambda}_{jj}$, where $e_j = 1 - u_j$ is the share of employed workers. Taking exponents leads to $\hat{W}_j = \hat{\psi}_j \hat{e}_j \hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}$. Note that $\hat{\lambda}_{jj}^{\frac{1}{1-\sigma}}$ can be expressed as $\hat{\lambda}_{jj}^{\frac{1}{1-\sigma}} = \widehat{\left(\frac{p_j}{P_j}\right)}$ using $\lambda_{jj} = \left((\beta_j p_j t_{jj} \tau_{jj})/P_j\right)^{1-\sigma}$ and recalling that β_j, t_{jj} and τ_{jj} are constant. Moving from any observed level of trade to autarky, i.e., $\lambda_{jj}^c = 1$ and $\psi_j^c = 1$, yields $\hat{W}_j = \psi_j \hat{e}_j \left(\lambda_{jj}\right)^{-\frac{1}{1-\sigma}}$. Note, however, that in contrast to the case with perfect labor markets considered in Arkolakis et al. (2012), even this expression needs information about employment changes.

Hence, welfare depends on the change in the tariff multiplier, $\hat{\psi}_j$, the employment change, $\hat{e}_j$, the change in the share of domestic expenditures, $\hat{\lambda}_{jj}$, and the partial elasticity of imports with respect to variable trade costs, given in our case by $(1 - \sigma)$. Note that in the case of perfect labor markets $\hat{e}_j = 1$ and $\hat{W}_j = \hat{\psi}_j \hat{\lambda}_{jj}^{1/(1-\sigma)}$, which extends Equation (6) in Arkolakis et al. (2012) to account for tariff revenues.

When $\hat{\lambda}_{jj}$ and $\hat{\psi}_j$ are observed, assuming imperfect or perfect labor markets leads to different welfare predictions. The difference in the welfare change is given by $\hat{e}_j$. Hence, assuming perfect labor markets neglects the effects on employment and the corresponding welfare effects. Whether welfare increases or decreases in a particular country depends on the magnitude of relative price change p_j/P_j.

While Implication 6 already describes how to calculate welfare within our framework with tariff revenues and allowing for trade imbalances, we can equivalently express the change in welfare as a function of the multilateral resistance terms by using the equivalent variation, i.e., the amount of income the representative consumer would need to make her as well off under current prices P_j as in the counterfactual situation with price level P_j^c. Using the definition for consumer expenditure CE_j as given in Equation (32), and defining $v_j = \psi_j \left(\frac{\xi_j}{1+\gamma_j \xi_j - \gamma_j} + d_j \right)$ and $\hat{v}_j \equiv v_j^c / v_j$, we can express the change in consumer expenditure as a function of the change in total sales and $\hat{v}_j$, $\hat{v}_j \hat{Y}_j$. We can then express the equivalent variation in percent as follows:

$$EV_j \;=\; \frac{v_j^c Y_j^c \frac{P_j}{P_j^c} - v_j Y_j}{v_j Y_j} = \frac{v_j^c Y_j^c}{v_j Y_j} \frac{P_j}{P_j^c} - 1 = \hat{v}_j \hat{Y}_j \frac{P_j}{P_j^c} - 1. \tag{34}$$

Hence welfare can be calculated by using the expressions for the price indices (which can be derived from the multilateral resistance terms) and the counterfactual change in total sales. To derive the counterfactual change in total sales, it turns out to be useful to first derive an expression for the counterfactual change in (un)employment.

A.3.2 Counterfactual (un)employment

We follow Anderson and van Wincoop (2003) and use Equation (26) to solve for scaled prices as follows:

$$(\beta_j p_j)^{1-\sigma} = \frac{Y_j}{\sum_{i=1}^{n} \left(\frac{t_{ji}}{P_i} \right)^{1-\sigma} \tau_{ij}^{-\sigma} E_i} = \frac{Y_j}{Y^W} \Pi_j^{\sigma-1} = \mathbb{\Pi}_j, \tag{35}$$

where $\mathbb{\Pi}_j \equiv \frac{Y_j}{Y^W} \Pi_j^{\sigma-1}$. We then use the definition of u_j given in Equation (30), replacing ϑ_j by the expression given in Equation (31) and defining $\Xi_j \equiv m_j \left(\frac{c_j}{m_j} \Omega_j \right)^{\frac{\mu-1}{\mu}}$ and $\hat{\kappa}_j \equiv \Xi_j^c / \Xi_j$, where superscript c denotes counterfactual values:

$$\frac{e_j^c}{e_j} \equiv \frac{1-u_j^c}{1-u_j} = \hat{\kappa}_j \left(\frac{p_j^c}{p_j} \right)^{\frac{1-\mu}{\mu}} \left(\frac{P_j}{P_j^c} \right)^{\frac{1-\mu}{\mu}}, \tag{36}$$

where e_j denotes the employment rate. Noting the derivation of Equation (26) and remembering that $P_j^{1-\sigma} = \sum_i (t_{ij}\tau_{ij})^{1-\sigma} \mathbb{\Pi}_i$ (see the definition of the price index and (35)), we can express the ratios of the prices and price indices as functions of $\mathbb{\Pi}_i$ and $(t_{ij}\tau_{ij})^{1-\sigma}$ to end up with counterfactual (un)employment levels summarized in the following implication:

Implication 7 *Whereas in the setting with perfect labor markets (un)employment effects are zero by assumption, the (un)employment effects in our gravity system with imperfections on the labor market, taking into account tariff revenues and allowing for trade imbalances, are given by:*

$$\begin{aligned}\hat{e}_j &\equiv \frac{e_j^c}{e_j} = \hat{\kappa}_j \left(\frac{\Pi_j^c}{\Pi_j}\right)^{\frac{1-\mu}{\mu(1-\sigma)}} \left(\frac{\sum_i \left(t_{ij}\tau_{ij}\right)^{1-\sigma} \Pi_i}{\sum_i \left(t_{ij}^c \tau_{ij}^c\right)^{1-\sigma} \Pi_i^c}\right)^{\frac{1-\mu}{\mu(1-\sigma)}}, \\ \Delta u_j &\equiv u_j^c - u_j = (1-u_j)(1-\hat{e}_j).\end{aligned}$$

Implication 7 reveals that a country can directly affect its (un)employment level by changes in its labor market institutions, as reflected by changes in $\hat{\kappa}_j$.[10] In addition, all trading partners are affected by such a labor market reform due to changes in prices as reflected by Π_i. Direct effects are scaled by changes in relative prices p_j/P_j which are proportional to $\left(\Pi_j / \sum_i \left(t_{ij}\tau_{ij}\right)^{1-\sigma} \Pi_i\right)^{1/(1-\sigma)}$, reflecting the spillovers of labor market reforms to other countries. Changes of relative prices due to trade liberalization therefore provide the link to the labor market.

A.3.3 Counterfactual total sales

We next derive counterfactual total sales. Using the definition of total sales, $Y_j = p_j(1-u_j)L_j = p_j e_j L_j$, and taking the ratio of counterfactual total sales, Y_j^c, and observed sales, Y_j, we can use Implication 7 and Equation (26) to come up with the following implication:

Implication 8 *Counterfactual total sales allowing for tariff revenues and trade imbalances are given by:*

$$\begin{aligned}&\textit{imperfect labor markets:} \quad \hat{Y}_j = \hat{\kappa}_j \left(\tfrac{\Pi_j^c}{\Pi_j}\right)^{\frac{1}{\mu(1-\sigma)}} \left(\tfrac{\sum_i (t_{ij}\tau_{ij})^{1-\sigma} \Pi_i}{\sum_i \left(t_{ij}^c \tau_{ij}^c\right)^{1-\sigma} \Pi_i^c}\right)^{\frac{1-\mu}{\mu(1-\sigma)}}, \\ &\textit{perfect labor markets:} \quad \hat{Y}_j = \left(\tfrac{\Pi_j^c}{\Pi_j}\right)^{\frac{1}{1-\sigma}}.\end{aligned}$$

[10] Note that employment changes are homogeneous of degree zero in prices, implying that a normalization does not matter for the employment effects.

If we assume $\mu = 1$, balanced trade, and zero tariffs, we end up with the case of perfect labor markets which is identical to the model employed by Anderson and van Wincoop (2003).

It is illuminating to decompose the change in total sales as follows:

$$\hat{Y}_j = \underbrace{\left(\frac{\sqcap_j^c}{\sqcap_j}\right)^{\frac{1}{1-\sigma}}}_{\text{price change}} \underbrace{\hat{\kappa}_j \left(\frac{\sqcap_j^c}{\sqcap_j}\right)^{\frac{1-\mu}{\mu(1-\sigma)}} \left(\frac{\sum_i \left(t_{ij}\tau_{ij}\right)^{1-\sigma} \sqcap_i}{\sum_i \left(t_{ij}^c \tau_{ij}^c\right)^{1-\sigma} \sqcap_i^c}\right)^{\frac{1-\mu}{\mu(1-\sigma)}}}_{\text{employment change}}, \tag{37}$$

with the price change defined as implied by Equation (35) and the employment change as defined in Implication 7.

Taking logs, we can attribute the share of log change in total sales due to changes in prices and employment as follows:

$$1 = \frac{\ln \hat{p}_j}{\ln \hat{Y}_j} + \frac{\ln \hat{e}_j}{\ln \hat{Y}_j}. \tag{38}$$

Alongside changes in total sales, we will report this decomposition in all our counterfactual exercises.

A.3.4 Counterfactual trade flows

Finally, given estimates of $t_{ij}^{1-\sigma}$, data on Y_i, and a value for σ, we can calculate (scaled) baseline trade flows as $X_{ij}Y^W/(Y_iE_j) = (t_{ij}/(\Pi_i P_j))^{1-\sigma}\tau_{ij}^{-\sigma}$, where Π_i and P_j are given by Equation (28). With counterfactual total sales given by Implication 8, we can calculate counterfactual trade flows as $X_{ij}^c Y^{W,c}/(Y_i^c E_j^c) = (t_{ij}^c/(\Pi_i^c P_j^c))^{1-\sigma} \left(\tau_{ij}^c\right)^{-\sigma}$, where Π_i^c and P_j^c are defined analogously to their counterparts in the baseline scenario given in Equation (28).[11] Due to direct effects of changes in trade costs via t_{ij}, tariffs via τ_{ij}, and non-trivial changes in Π_i and P_j, trade may change more or less when assuming

[11] Note that P_j and P_j^c are homogeneous of degree one in prices while Π_i and Π_i^c are homogeneous of degree minus one. Hence, scaled trade flows $X_{ij}Y^W/(Y_iE_j)$ and $X_{ij}^c Y^{W,c}/(Y_i^c E_j^c)$ are homogeneous of degree zero in prices. In other words, they do not depend on the normalization chosen.

imperfect labor markets in comparison with the baseline case of perfect labor markets.

A.3.5 Tariff revenues

The last missing part to determine changes in consumable income and welfare are the tariff revenues. Tariff revenues are given by $T_i = \sum_{j=1}^{n} (\tau_{ji} - 1) X_{ji}$. In the baseline we take observed GDP as our measure of total sales. When solving for the baseline MRTs, we simultaneously solve for implied tariff revenues using predicted trade flows and observed tariff rates. In the counterfactual, we simultaneously solve for counterfactual MRTs and counterfactual $T_i^c = \sum_{j=1}^{n} (\tau_{ji}^c - 1) X_{ji}^c$.

B Minimum wages within the search and matching framework

In this section, we introduce minimum wages in our search and matching framework. The binding minimum wage replaces the bargaining of workers and firms that are matched. We then show that this leads to expressions for counterfactual changes in total sales, employment, trade flows, and welfare which are isomorphic to those in the main text.

We assume balanced trade and do not consider revenue-generating tariffs for the following derivations. Let us first consider the bounds for a binding minimum wage. If the minimum wage is below the wage that a firm and a worker agree upon, it is not binding and hence not relevant. The lower bound for a binding minimum wage, denoted by $\underline{w}_j$, is therefore given by the **wage curve** from the main text

$$\underline{w}_j = w_j = \frac{\xi_j}{1 + \gamma_j \xi_j - \gamma_j} p_j. \tag{39}$$

The upper bound for a minimum wage, denoted by $\overline{w}_j$, is given by the job's output, as firms would not be able to recover recruiting costs. Hence, $\overline{w}_j = p_j$.

A well defined equilibrium with a binding minimum wage $\breve{w}_j$ exists if $\underline{w}_j < \breve{w}_j < \overline{w}_j$. With a given binding minimum wage, the wage curve is no longer relevant. ϑ_j can be solved by using the **job creation curve** given in the main text

$$\breve{w}_j = p_j - \frac{P_j c_j}{m_j \vartheta_j^{-\mu}} \Rightarrow$$
$$\vartheta_j = \left(\frac{p_j - \breve{w}_j}{P_j}\right)^{1/\mu} \left(\frac{c_j}{m_j}\right)^{-1/\mu}, \tag{40}$$

which corresponds to Equation (9) in the main text. By replacing u_j by Equation (8) from the main text and using Equation (40), total sales in country j can be written as:

$$Y_j = p_j(1-u_j)L_j = p_j m_j \left(\frac{p_j - \breve{w}_j}{P_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{c_j}{m_j}\right)^{\frac{\mu-1}{\mu}} L_j. \tag{41}$$

Assuming that the nominal minimum wage is indexed to prices, we can express it as a share of prices, i.e., $\breve{w}_j = \xi_j p_j$. This allows us to express total sales solely as a function of prices and parameters. Similarly, (counterfactual) employment can be rewritten using Equation (8) in the main text and Equation (40). Then, defining $\breve{\Xi}_j = m_j \left(\frac{c_j}{m_j}\right)^{\frac{\mu-1}{\mu}}$ and $\hat{\breve{\kappa}}_j = \breve{\Xi}_j^c / \breve{\Xi}_j$, we get

$$\frac{1-u_j^c}{1-u_j} = \hat{\breve{\kappa}}_j \left(\frac{p_j^c - \breve{w}_j}{p_j - \breve{w}_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{P_j}{P_j^c}\right)^{\frac{1-\mu}{\mu}}. \tag{42}$$

Using again that $\breve{w}_j = \xi_j p_j$, the last expression simplifies to

$$\frac{1-u_j^c}{1-u_j} = \hat{\breve{\kappa}}_j^* \left(\frac{p_j^c}{p_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{P_j}{P_j^c}\right)^{\frac{1-\mu}{\mu}}, \tag{43}$$

where $\hat{\breve{\kappa}}_j^* = \hat{\breve{\kappa}}_j((1-\xi_j^c)/(1-\xi_j))^{(1-\mu)/\mu}$. Equation (43) exactly corresponds to Equation (12) in the main text except for the replacement of $\hat{\kappa}_j$ by $\hat{\breve{\kappa}}_j^*$. Hence, when assuming that labor market institutions (here: minimum wage levels) do not change, we can proceed as with bargained wages to calculate employment effects.

Note that in the case of binding minimum wages, all changes in total sales are due to employment changes. Hence, counterfactual sales changes correspond to employment changes.

Counterfactual trade flows and welfare can be calculated as in the case of bargained wages.

C Efficiency wages within the search and matching framework

In this section, we show how efficiency wages in the spirit of Stiglitz and Shapiro (1984) can be introduced into our search and matching framework by replacing the bargaining of workers and firms with the no-shirking condition. Note that we assume balanced trade, do not consider revenue-generating tariffs and assume risk neutral workers in the following.

We first derive the utility for a shirker, s, and a non-shirker, ns. The non-shirker ns earns wage w_j while exerting effort e_j. Hence, her utility in our one-shot framework is given by

$$E_j^{ns} = w_j - e_j. \tag{44}$$

A shirker s also earns wage w_j but does not exert any effort e_j. However, a share α_j of shirkers is detected by firms and gets fired, which leads to unemployment. When the worker is unemployed she earns $\gamma_j w_j$, and hence the expected utility for a shirker can be written as

$$E_j^s = (1 - \alpha_j)w_j + \alpha_j \gamma_j w_j. \tag{45}$$

The no-shirking condition $E^{ns} \geq E^s$ leads to $E^{ns} = E^s$ in equilibrium. Hence, using Equations (44) and (45), the wage can be written as:

$$w_j = \frac{1}{\alpha_j(1-\gamma_j)} e_j. \tag{46}$$

As in the case of bargaining, wages can be solved without knowledge of ϑ_j. ϑ_j can be solved by using the **job creation curve** given in the main text:

$$\begin{aligned} \frac{1}{\alpha_j(1-\gamma_j)} e_j &= p_j - \frac{P_j c_j}{m_j \vartheta_j^{-\mu}} \Rightarrow \\ \vartheta_j^{\mu} &= \left(\frac{m_j}{P_j c_j}\right)\left(p_j - \frac{1}{\alpha_j(1-\gamma_j)} e_j\right). \end{aligned} \tag{47}$$

Now assume that effort e_j can be expressed in terms of prices p_j as $e_j = \xi_j p_j$. Then we can simplify Equation (47) to:

$$\vartheta_j = \left(\frac{p_j}{P_j}\right)^{1/\mu} \left(\frac{c_j}{m_j}\check{\Omega}_j\right)^{-1/\mu}, \tag{48}$$

with $\check{\Omega}_j = \frac{\alpha_j(1-\gamma_j)}{\alpha_j(1-\gamma_j)-\xi_j}$, which corresponds to Equation (9).

Counterfactual employment can be calculated using the definition of u_j given in Equation (8) in the main text, replacing ϑ_j by the expression given in Equation (48) and defining $\check{\Xi}_j = m_j \left(\frac{c_j}{m_j}\check{\Omega}_j\right)^{\frac{\mu-1}{\mu}}$ and $\hat{\check{\kappa}}_j = \check{\Xi}_j^c / \check{\Xi}_j$:

$$\frac{1-u_j^c}{1-u_j} = \hat{\check{\kappa}}_j \left(\frac{p_j^c}{p_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{P_j}{P_j^c}\right)^{\frac{1-\mu}{\mu}}, \tag{49}$$

which exactly corresponds to Equation (12) in the main text except for the replacement of $\hat{\kappa}_j$ by $\hat{\check{\kappa}}_j$. Hence, when assuming that labor market institutions do not change, we can proceed as with bargained wages to calculate employment effects.

Using the definition of $\check{\Xi}_j$, total sales can be expressed as:

$$Y_j = p_j e_j L_j = p_j m_j \left(\frac{p_j}{P_j}\right)^{\frac{1-\mu}{\mu}} \left(\frac{c_j}{m_j}\check{\Omega}_j\right)^{\frac{\mu-1}{\mu}} L_j = p_j \left(\frac{p_j}{P_j}\right)^{\frac{1-\mu}{\mu}} \check{\Xi}_j L_j. \tag{50}$$

Now take the ratio of counterfactual total sales, Y_j^c, and observed total sales, Y_j, and note that the labor force, L_j, stays constant:

$$Y_j^c = \hat{\check{\kappa}}_j \frac{p_j^c \left(\frac{p_j^c}{P_j^c}\right)^{\frac{1-\mu}{\mu}}}{p_j \left(\frac{p_j}{P_j}\right)^{\frac{1-\mu}{\mu}}} = \hat{\check{\kappa}}_j \left(\frac{p_j^c}{p_j}\right)^{\frac{1}{\mu}} \left(\frac{P_j}{P_j^c}\right)^{\frac{1-\mu}{\mu}} Y_j, \tag{51}$$

where $\hat{\check{\kappa}}_j = \check{\Xi}_j^c / \check{\Xi}_j$. Then, using Equation (11) from the main text and the fact that $P_j^{1-\sigma} = \sum_i t_{ij}^{1-\sigma} \frac{Y_i}{Y^W} \Pi_i^{\sigma-1}$, we end up with exactly the same expression as given in the result in Implication 4 in the main text except for the replacement of $\hat{\kappa}_j$ by $\hat{\check{\kappa}}_j$. Hence, we can calculate counterfactual total sales as in the case of bargained wages. Similarly, counterfactual trade flows and welfare can be calculated as in the case with bargained wages.

D A Ricardian trade model with imperfect labor markets following Eaton and Kortum (2002)

In the following, we introduce search and matching frictions in the Ricardian model of international trade by Eaton and Kortum (2002) and show that this leads to expressions for counterfactual changes in total sales, employment, trade flows, and welfare which are isomorphic to those in the main text. Note that in the following we assume balanced trade and abstract from revenue-generating tariffs.

The representative consumer in country j is again characterized by the utility function U_j. As in Eaton and Kortum (2002), we assume a continuum of goods $k \in [0, 1]$. Consumption of individual goods is denoted by $q(k)$, leading to the following utility function

$$U_j = \left[\int_0^1 q(k)^{\frac{\sigma-1}{\sigma}} dk\right]^{\frac{\sigma}{\sigma-1}}, \tag{52}$$

where σ is the elasticity of substitution in consumption. Again, trade of goods from i to j imposes iceberg trade costs $t_{ij} > 1$.

Countries differ in the efficiency with which they can produce goods. We denote country i's efficiency in producing good $k \in [0, 1]$ as $\mathfrak{z}_i(k)$. Denoting input costs in country i as $\mathfrak{c}_i$, the cost of producing a unit of good k in country i is then $\mathfrak{c}_i / \mathfrak{z}_i(k)$.

Taking trade barriers into account, delivering a unit of good k produced in country i to country j costs

$$p_{ij}(k) = \left(\frac{\mathfrak{c}_i}{\mathfrak{z}_i(k)} \right) t_{ij}. \tag{53}$$

Assuming perfect competition, $p_{ij}(k)$ is the price which consumers in country j would pay if they bought good k from country i. With international trade, consumers can choose from which country to buy a good. Hence, the price they actually pay for good k is $\underline{p}_j(k)$, the lowest price across all sources i:

$$\underline{p}_j(k) = \min \left\{ p_{ij}(k); i = 1, \cdots, n \right\}, \tag{54}$$

where n denotes the number of countries.

Let country i's efficiency in producing good k be the realization of an independently drawn Fréchet random variable with distribution $F_i(\mathfrak{z}) = e^{-T_i \mathfrak{z}^{-\theta}}$, where T_i is the location parameter (also called "state of technology" by Eaton and Kortum, 2002) and θ governs the variance of the distribution and thereby also the comparative advantage within the continuum of goods.

Plugging Equation (53) in $F_i(\mathfrak{z})$ leads to $G_{ij}(p) = Pr[P_{ij} \leq p] = 1 - e^{-[T_i(\mathfrak{c}_i t_{ij})^{-\theta}] p^{\theta}}$. Noting that the distribution of prices for which a country j buys is given by $G_j(p) = Pr[P_j \leq p] = 1 - \prod_{i=1}^{n} [1 - G_{ij}(p)]$ leads to:

$$G_j(p) = 1 - e^{-\Phi_j p^{\theta}}, \tag{55}$$

where $\Phi_j = \sum_{i=1}^{n} T_i \left(\mathfrak{c}_i t_{ij} \right)^{-\theta}$.

The probability that country i provides good k at the lowest price to country j is given by (see Eaton and Kortum 2002, page 1748):

$$\pi_{ij} = \frac{T_i \left(\mathfrak{c}_i t_{ij}\right)^{-\theta}}{\Phi_j}. \tag{56}$$

With a continuum of goods between zero and one this is also the fraction of goods that country j buys from country i. Eaton and Kortum (2002) show that the price of a good that country j actually buys from any country i is also distributed $G_j(p)$, and that the exact price index is given by $P_j = \breve{\Gamma}\Phi_j^{-1/\theta}$ with $\breve{\Gamma} = \left[\Gamma\left(\frac{\theta+1-\sigma}{\theta}\right)\right]^{\frac{1}{1-\sigma}}$ where Γ is the Gamma function.

The fraction of goods that country j buys from country i, π_{ij}, is also the fraction of its expenditures on goods from country i, X_{ij}, due to the fact that the average expenditures per good do not vary by source. Hence,

$$X_{ij} = \frac{T_i(\mathfrak{c}_i t_{ij})^{-\theta}}{\Phi_j} Y_j = \frac{T_i(\mathfrak{c}_i t_{ij})^{-\theta}}{\sum_{k=1}^{n} T_k(\mathfrak{c}_k t_{kj})^{-\theta}} Y_j, \tag{57}$$

where Y_j is country j's total spending.

Assuming balanced trade, exporters' total sales (including home sales) are equal to total expenditure and are given by:

$$Y_i = \sum_{j=1}^{n} X_{ij} = T_i \mathfrak{c}_i^{-\theta} \sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\Phi_j} Y_j. \tag{58}$$

Solving for $T_i \mathfrak{c}_i^{-\theta}$ leads to:

$$T_i \mathfrak{c}_i^{-\theta} = \frac{Y_i}{\sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\Phi_j} Y_j}. \tag{59}$$

Replacing $T_i \mathfrak{c}_i^{-\theta}$ in Equation (57) with this expression leads to:

$$X_{ij} = \frac{t_{ij}^{-\theta}}{\Phi_j \left(\sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\Phi_j} Y_j\right)} Y_i Y_j.$$

Using $P_j = \breve{\Gamma}\Phi_j^{-\frac{1}{\theta}}$ to replace Φ_j in both terms of the denominator leads to:

$$X_{ij} = \frac{t_{ij}^{-\theta}}{\breve{\Gamma}^{\theta} P_j^{-\theta}\left(\sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\breve{\Gamma}^{\theta} P_j^{-\theta}} Y_j\right)} Y_i Y_j.$$

Define

$$\Pi_i = \left(\sum_{j=1}^{n} \left(\frac{t_{ij}}{P_j}\right)^{-\theta} \frac{Y_j}{Y^W}\right)^{-\frac{1}{\theta}},$$

and note that we can express P_j also as follows:

$$\begin{aligned} P_j &= \left(\breve{\Gamma}^{-\theta}\Phi_j\right)^{-\frac{1}{\theta}} = \left(\breve{\Gamma}^{-\theta}\sum_{i=1}^{n} T_i(\mathfrak{c}_i t_{ij})^{-\theta}\right)^{-\frac{1}{\theta}} = \left(\breve{\Gamma}^{-\theta}\sum_{i=1}^{n} \frac{t_{ij}^{-\theta} Y_i}{\sum_{l=1}^{n} \frac{t_{il}^{-\theta}}{\Phi_l} Y_l}\right)^{-\frac{1}{\theta}}, \\ &= \left(\sum_{i=1}^{n} \left(\frac{t_{ij}}{\Pi_i}\right)^{-\theta} \frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}}, \end{aligned}$$

where $Y^W = \sum_j Y_j$. Then we can write:

$$X_{ij} = \frac{Y_i Y_j}{Y^W}\left(\frac{t_{ij}}{\Pi_i P_j}\right)^{-\theta}.$$

Replacing $-\theta$ by $1-\sigma$ we end up with exactly the same system as in the model by Anderson and van Wincoop (2003).

Hence, our approach can be applied to both worlds with the only difference that the interpretation differs and the roles of θ and σ have to be exchanged.

D.1 Counterfactual expenditure in the Eaton and Kortum (2002) framework with perfect labor markets

We assume that there are no intermediates and $\mathfrak{z}_i$ units of the final good are produced with one unit of labor, hence $\mathfrak{c}_i = w_i$. Equation (59) can be written as

$$T_i w_i^{-\theta} = \frac{Y_i}{\sum_{j=1}^{n} \frac{t_{ij}^{-\theta}}{\Phi_j} Y_j} = \frac{\frac{Y_i}{Y^W}}{\sum_{j=1}^{n} \breve{\Gamma}^{-\theta} \left(\frac{t_{ij}}{P_j}\right)^{-\theta} \frac{Y_j}{Y^W}} = \breve{\Gamma}^{\theta} \frac{Y_i}{Y^W} \Pi_i^{\theta}.$$

Solving for w_i leads to:

$$w_i = \breve{\Gamma}^{-1} T_i^{\frac{1}{\theta}} \left(\frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}} \Pi_i^{-1}.$$

As $Y_i = w_i L_i$, the change in expenditure is given by $Y_i^c / Y_i = w_i^c / w_i$. Hence,

$$\frac{Y_i^c}{Y_i} = \frac{\breve{\Gamma} T_i^{\frac{1}{\theta}} \left(\frac{Y_i^c}{Y^{W,c}}\right)^{-\frac{1}{\theta}} (\Pi_i^c)^{-1}}{\breve{\Gamma} T_i^{\frac{1}{\theta}} \left(\frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}} \Pi_i^{-1}} = \frac{\left(\frac{Y_i^c}{Y^{W,c}}\right)^{-\frac{1}{\theta}} (\Pi_i^c)^{-1}}{\left(\frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}} \Pi_i^{-1}} = \left(\frac{\sqcap_i^c}{\sqcap_i}\right)^{-\frac{1}{\theta}},$$

where $\sqcap_i = \frac{Y_i}{Y^W} \Pi_i^{\theta}$.

D.2 Counterfactuals in the Eaton and Kortum (2002) framework with imperfect labor markets

We assume that there are no intermediates and $\mathfrak{z}_i$ units of the final good k are produced using one unit of labor. For simplicity, we omit the product index k in the following. Denoting the net price earned by the producer by $p_i = p_{ij}/t_{ij}$, the total surplus of a successful match is given by $\mathfrak{z}_i p_i - b_i$, while the firm's rent is given by $\mathfrak{z}_i p_i - w_i$ and the worker's by $w_i - b_i$. Nash bargaining leads to $w_i - b_i = (\mathfrak{z}_i p_i - w_i)\xi_i/(1 - \xi_i)$. Using $b_i = \gamma_i w_i$ and combining leads to

$$w_i = \frac{\xi_i}{1 - \gamma_i + \xi_i \gamma_i} \mathfrak{z}_i p_i = \frac{\xi_i}{1 - \gamma_i + \xi_i \gamma_i} \mathfrak{c}_i, \tag{60}$$

as firms create vacancies until all rents are dissipated. The free entry (zero profit) condition is given by $(\mathfrak{z}_i p_i - w_i) M_i / V_i = P_i c_i$. Rewriting leads to the job creation curve

$$w_i = \mathfrak{z}_i p_i - \frac{P_i c_i}{m_i \vartheta_i^{-\mu}} = \mathfrak{c}_i - \frac{P_i c_i}{m_i \vartheta_i^{-\mu}}. \tag{61}$$

We can combine Equations (60) and (61) to write the wage paid by a firm as

$$w_i = \frac{\xi_i}{1 - \gamma_i + \gamma_i \xi_i - \xi_i} \frac{P_i c_i}{m_i \vartheta^{-\mu}}. \tag{62}$$

The wage paid by a firm producing variety k is solely determined by parameters and aggregate variables and does neither depend on its variety-specific price nor on productivity. Hence, as wages are equalized across firms, Equation (61) then implies that also $\mathfrak{c}_i$ is the same across firms, irrespective of the variety they produce. Hence the job creation and wage curve are the same for all firms and we can thus determine aggregate labor market tightness ϑ_i as the locus of intersection of both curves:

$$\vartheta_i = \left(\frac{\mathfrak{c}_i}{P_i}\right)^{1/\mu} \left(\frac{c_i}{m_i}\Omega_i\right)^{-1/\mu}. \tag{63}$$

Equation (59) can be written as

$$T_i \mathfrak{c}_i^{-\theta} \quad = \quad \frac{Y_i}{\sum_{j=1}^n \frac{t_{ij}^{-\theta}}{\Phi_j} Y_j} = \frac{\frac{Y_i}{Y^W}}{\sum_{j=1}^n \breve{\Gamma}^{-\theta} \left(\frac{t_{ij}}{P_j}\right)^{-\theta} \frac{Y_j}{Y^W}} = \breve{\Gamma}^{\theta} \frac{Y_i}{Y^W} \Pi_i^{\theta}.$$

Solving for $\mathfrak{c}_i$ leads to:

$$\mathfrak{c}_i = \breve{\Gamma}^{-1} T_i^{\frac{1}{\theta}} {\frac{Y_i}{Y^W}}^{-\frac{1}{\theta}} \Pi_i^{-1}. \tag{64}$$

As $Y_i = \mathfrak{c}_i(1-u_i)L_i$, assuming a constant labor force the change in expenditure is given by $Y_i^c/Y_i = (1-u_i^c)\mathfrak{c}_i^c/[(1-u_i)\mathfrak{c}_i]$ leading to

$$
\begin{aligned}
\frac{Y_i^c}{Y_i} &= \frac{(1-u_i^c)\breve{\Gamma} T_i^{\frac{1}{\theta}} \left(\frac{Y_i^c}{Y^{W,c}}\right)^{-\frac{1}{\theta}} (\Pi_i^c)^{-1}}{(1-u_i)\breve{\Gamma} T_i^{\frac{1}{\theta}} \left(\frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}} \Pi_i^{-1}} \\
&= \frac{(1-u_i^c) \left(\frac{Y_i^c}{Y^{W,c}}\right)^{-\frac{1}{\theta}} (\Pi_i^c)^{-1}}{(1-u_i) \left(\frac{Y_i}{Y^W}\right)^{-\frac{1}{\theta}} \Pi_i^{-1}} \\
&= \frac{(1-u_i^c)}{(1-u_i)} \left(\frac{\mathbb{\Pi}_i^c}{\mathbb{\Pi}_i}\right)^{-\frac{1}{\theta}}, \qquad (65)
\end{aligned}
$$

where $\mathbb{\Pi}_i = \frac{Y_i}{Y^W}\Pi_i^{\theta}$.

For the change in employment (the first fraction on the right-hand side of Equation (65)) the same relationship holds as is given in the main text in Equation (12) when we remember once more that $-\theta = 1-\sigma$. Hence, we end up with

$$
\frac{Y_i^c}{Y_i} = \hat{\kappa}_i \left(\frac{\mathbb{\Pi}_i^c}{\mathbb{\Pi}_i}\right)^{-\frac{1}{\mu\theta}} \left(\frac{\sum_i t_{ij}^{-\theta}\mathbb{\Pi}_i}{\sum_i \left(t_{ij}^c\right)^{-\theta}\mathbb{\Pi}_i^c}\right)^{-\frac{1-\mu}{\mu\theta}}, \qquad (66)
$$

which is the same relationship as given in Implication 4 in the main text when we again replace $1-\sigma$ by $-\theta$.

Besides counterfactual employment, also counterfactual trade flows and welfare can be calculated as in the main text.

E Further results for counterfactual analyses

E.1 Further results for introducing RTAs as observed in 2006

This section reports additional results for the counterfactual analysis presented in Section 3.4.1 in the main text.

Tables A.1 and A.2 report goods trade changes for perfect and imperfect labor markets, respectively. Trade changes are heterogeneous across importers and exporters. To summarize this heterogeneity, we present quantiles of calculated trade flow changes across all destination countries for all exporters. Both tables report the minimum and maximum changes, along with the 0.025, 0.25, 0.5, 0.75, and 0.975 quantiles. Comparing numbers across columns for each row reveals the heterogeneity across importers, while comparing numbers across rows for each column highlights the heterogeneity across exporters.

Table A.1 reveals that every country experiences both positive and negative bilateral trade flow changes. For example, the introduction of RTAs as observed in 2006 implies that the change in trade flows for the United Kingdom is larger than 5.54% for 25% of all countries importing goods from the United Kingdom. Turning to the trade flow results of our model with imperfect labor markets (Table A.2), we find a similar pattern for trade flow changes. Again, changes are heterogeneous across importers and exporters and, again, small and remote countries experience larger changes. The implied trade flow changes differ from the case with perfect labor markets but are of similar magnitude.

[Table A.1 about here.]

[Table A.2 about here.]

[Table A.3 about here.]

The employment effects of incepting RTAs from column (5) of Table 3 in the main text are illustrated graphically in Figure A.1.

[Figure A.1 about here.]

E.2 Further results for the labor market reform in the U.S.

Table A.3 summarizes the trade effects of the hypothetical labor market reform in the U.S. presented in Section 3.4.3 in the main text. A labor market reform in the United States spurs trade changes across the whole sample. The effects of exports by the United States range between -1.46% and -0.14%. Effects across other exporters range from -1.45% for Canada to 1.05% for Belgium, the Netherlands, and Switzerland. On average, 50% of trade flow changes are larger than 0.81%. The size pattern of the spillover effects of labor market reforms in the United States clearly depends on the bilateral distance and the trade volume of the corresponding country with the United States.

The employment effects of the counterfactual U.S. labor market reform from column (5) of Table 6 are graphically illustrated in Figure A.2.

[Figure A.2 about here.]

F Results without tariff income

Table A.4 presents results for introducing all RTAs observed in 2006 taking into account trade imbalances but without taking into account tariff income, i.e., with tariff rates equal to zero for all country pairs in both the baseline and the counterfactual scenario.

[Table A.4 about here.]

G Results with balanced trade

The following tables present the results for the same counterfactual experiments as presented in Section 3.4 in the main text but we assume balanced trade throughout, i.e., $E_j = Y_j$. Results basically remain the same, both qualitatively and quantitatively. For comparison reasons, we keep the trade cost parameter estimates as well as the elasticities from column (4) of Table 2 in the main text.

G.1 Introducing RTAs as observed in 2006

Table A.5 presents the results from switching on RTAs as observed in 2006 starting from a counterfactual situation without any RTAs assuming balanced trade. Tables A.6 and A.7 present the changes in trade flows for both perfect and imperfect labor markets, similar to Tables A.1 and A.2.

[Table A.5 about here.]

[Table A.6 about here.]

[Table A.7 about here.]

G.2 Evaluating the effects of the U.S.-Australia Free Trade Agreement

Table A.8 presents the results for the evaluation of the U.S.-Australia Free Trade Agreement assuming balanced trade but controlling for tariff revenues.

[Table A.8 about here.]

G.3 Evaluating the effects of a labor market reform in the U.S.

Tables A.9 and A.10 present the results from the counterfactual labor market reform in the U.S. assuming balanced trade but controlling for tariff revenues.

[Table A.9 about here.]

[Table A.10 about here.]

H Additional details concerning tariff data

In this section, we present additional details concerning the tariff measures we use in the main text.

We use data from the World Integrated Trade Solution (WITS), the most comprehensive database on bilateral tariff data compiled by the World Bank in collaboration with the United Nations Conference on Trade and Development (UNCTAD) and the World Trade Organization (WTO).[12] Specifically, we use data from the UNCTAD Trade Analysis Information System (TRAINS), which is part of WITS. TRAINS contains tariff data beginning only in 1988. This implies that including tariff rates as an additional regressor substantially reduces the time dimension of our data set. In addition, data even for the countries in our sample are not available for all years beginning in 1988. In the end, our sample for which tariff information is available consists of 10,916 observations, down from around 37,000 observations when compared to the working paper version of this paper, Heid and Larch (2012), where we use the years 1950 to 2006 but do not consider tariff rates.[13]

Specifically, we have used three average tariff rates: the simple average at the HS 6 digit level of the effectively applied tariff rate, the simple average of the effectively applied tariff rate at the tariff line level, as well as the weighted average of the effectively applied tariff rate with the weights given by the corresponding trade value.

Whereas trade-weighted tariff rates underestimate the actual level of protection, simple averages may overestimate the actual level of protection. We therefore included several tariff rates in our regressions.[14] Figure A.3 shows a histogram of the prevailing tariff rates for the simple average of effectively applied tariffs in our sample. We also calculated the according yearly tar-

[12] The data as well as a detailed user guide can be downloaded at `http://wits.worldbank.org/default.aspx`, accessed 2015/03/13.

[13] We set effectively applied tariffs within the EU equal to zero. We also excluded nine observations for which the availability of tariff data does not allow us to identify the according exporter-year effect as we only observe the tariff rate for the exporter in one year.

[14] Technically, we include the log of one plus the tariff rate, as implied by the model structure.

iff revenue as a share of GDP using the simple average for our data set. A histogram of these tariff revenue shares can be seen in Figure A.4.

[Figure A.3 about here.]

[Figure A.4 about here.]

All averages are calculated from the effectively applied tariff rate. It equals either the most favored nation (MFN) rate or, if there is a preferential trade agreement between the two countries, the according preferential tariff rate. In principle, all firms have access to the lower preferential tariff rate. However, preferential tariff rates may be tied to strict rules of origin for which some firms do not qualify. Also, documenting that intermediates used for production are in line with those rules of origin in itself implies a cost which may be higher than the gain from using the lower preferential tariff rate, see Demidova and Krishna (2008). In addition, given that we use aggregate trade data, we abstract from product lines which may have preferential access and those which do only get MFN tariff rates. As Carpenter and Lendle (2010) document, about 27 percent of North-North trade consists of non-preferential imports, and hence it is not clear whether one should use effectively applied or MFN tariff rates for aggregate trade flows. As by definition the MFN tariff rate is the same for all import source countries, and our analysis includes importer-year effects, our regression results can be interpreted as being conditional on the MFN tariff rate of a country.

I Distribution of elasticity estimates

In this section, we present the full distribution of the estimates of σ and μ when using the estimation methods described in Section 3.2 in the main text.

I.1 Distribution of μ

In the main text, we calculate all $n(n-1)/2$ possible values for μ and then take the mean of those values which lie in the admissible range, i.e., between zero and one. Figure A.5 shows the unrestricted distribution of the calculated values using the trade cost parameter and σ estimates from column (4) of Table 2 in the main text to calculate the price indices necessary to calculate μ. The vertical bars indicate the admissible range. Note that we have dropped one outlier value of $\mu = 67.891$ to ensure the readability of the histogram. In total, 58 percent of the calculated values for μ lie within the admissible range.

[Figure A.5 about here.]

I.2 Distribution of σ

If tariff data are not available to estimate σ, we propose an alternative estimator of σ in Section 3.2. We use this estimator for the estimates of σ in columns (1) and (2) of Table 2. Specifically, we calculate all $n^2(n-1)$ possible values for σ and then take the median of those values, following Bergstrand et al. (2013). Figure A.6 shows the unrestricted distribution of the calculated values using the trade cost parameter estimates from column (2) of Table 2 in the main text to calculate the price indices necessary to calculate σ. The vertical bar indicates the limit of the admissible range, i.e., $\sigma > 1$. Note that we have dropped about 2 percent of outliers of the calculated values ($|\sigma| > 100$) to ensure the readability of the histogram. In total, 51 percent of the calculated values for σ lie within the admissible range.

[Figure A.6 about here.]

J A more robust estimation method for the matching elasticity

When panel data on the trade cost variables like RTAs etc. as well as for the unemployment and replacement rates are available, we can relax the assumption of time-invariant and equal matching efficiencies, m_j, across countries when using a different estimation method for μ. To illustrate our approach, we add time indices s to Equation (18) from the main text to receive the following Equation:

$$\ln\left(\frac{1-u_{js}}{1-u_{ms}}\right)=\frac{1-\mu}{\mu}\left[\ln\left(\frac{p_{js}}{p_{ms}}\frac{P_{ms}}{P_{js}}\right)-\ln\left(\frac{c_{js}\Omega_{js}}{c_{ms}\Omega_{ms}}\right)\right]+\frac{1}{\mu}\ln\left(\frac{m_{js}}{m_{ms}}\right), \quad (67)$$

where we have assumed that the matching elasticity, μ, is time-invariant. Assuming that the vacancy posting cost may vary over time but is the same across countries, and adding a well behaved stochastic error term, ε_{jms}, we can rewrite this expression as

$$\ln\left(\frac{1-u_{js}}{1-u_{ms}}\right)=\frac{1-\mu}{\mu}\left[\ln\left(\frac{p_{js}}{p_{ms}}\frac{P_{ms}}{P_{js}}\right)-\ln\left(\frac{\Omega_{js}}{\Omega_{ms}}\right)\right]+\tilde{\nu}_{js}+\tilde{\upsilon}_{ms}+\varepsilon_{jms}, \quad (68)$$

where $\tilde{\nu}_{js}$ and $\tilde{\upsilon}_{ms}$ are time-varying country fixed effects to capture the variation in the term $1/\mu\ln(m_{js}/m_{ms})=1/\mu\ln(m_{js})-1/\mu\ln(m_{ms})$.

As in the main text, p_{js} can be replaced again by $p_{js}=Y_{js}/[(1-u_{js})L_{js}]$ and the price indices P_{js} by $P_{js}^{1-\sigma}=\sum_{i=1}^{n}t_{ijs}^{1-\sigma}\frac{Y_{is}}{Y_s^W}\Pi_{is}^{\sigma-1}$ from the solution of the multilateral resistance terms system of Equation (6) from the main text. Ω_{js} is in principle observable, as the dependent variable, the log employment ratio. Then, Equation (68) can be estimated via OLS to get an estimate of $(1-\mu)/\mu$. Importantly, the time-varying country fixed effects control for other time-varying determinants of the unemployment rate such as business cycles which may be correlated with both the measure of labor market institutions, Ω_{js}, and the real price ratio.

We present results from this regression in Table A.11. For these estimations, we only use data from 1994 to 2006 due to patchy labor market data before 1994. We also neglect tariffs and tariff income as the tariff data are not balanced for all years between 1994 and 2006. We use parameter estimates from the corresponding column of Table 2 in the main text to solve for the baseline price levels. We calculate the standard error of μ by the delta method.

[Table A.11 about here.]

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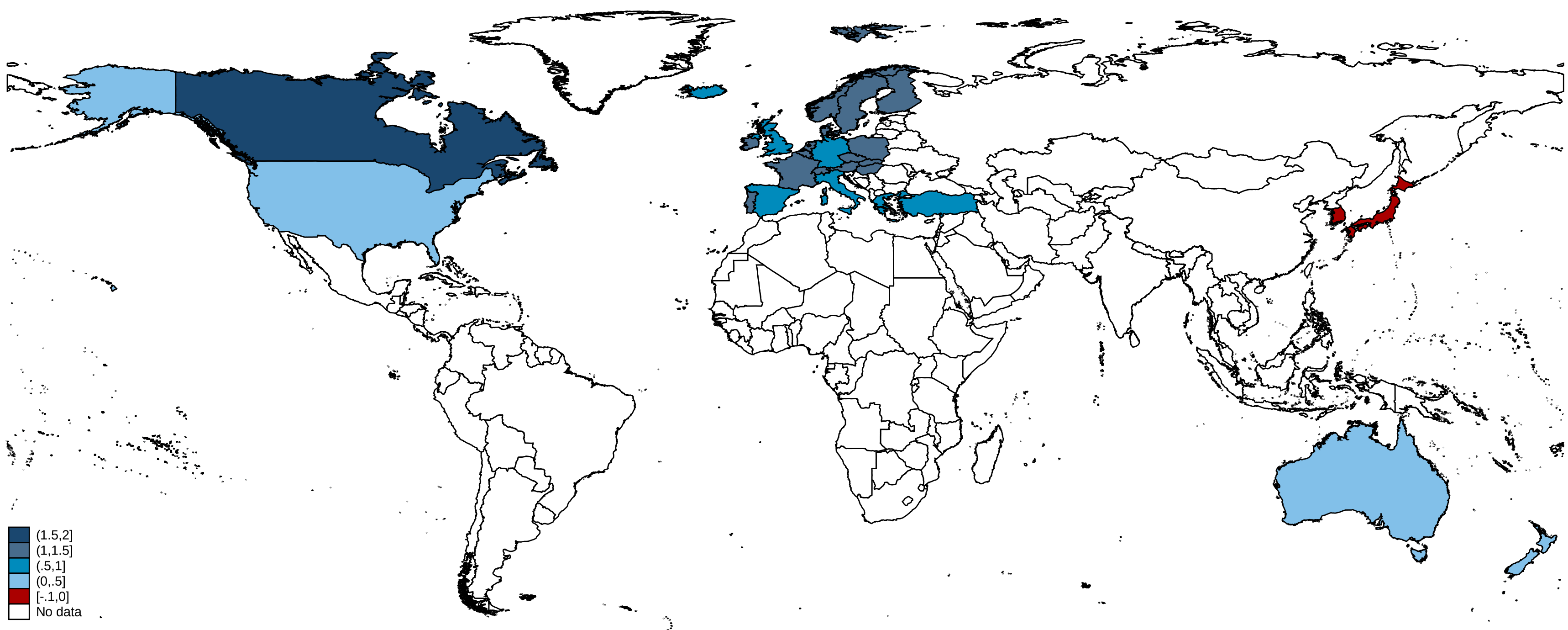

Figure A.1: Employment effects of incepting RTAs as observed in 2006.

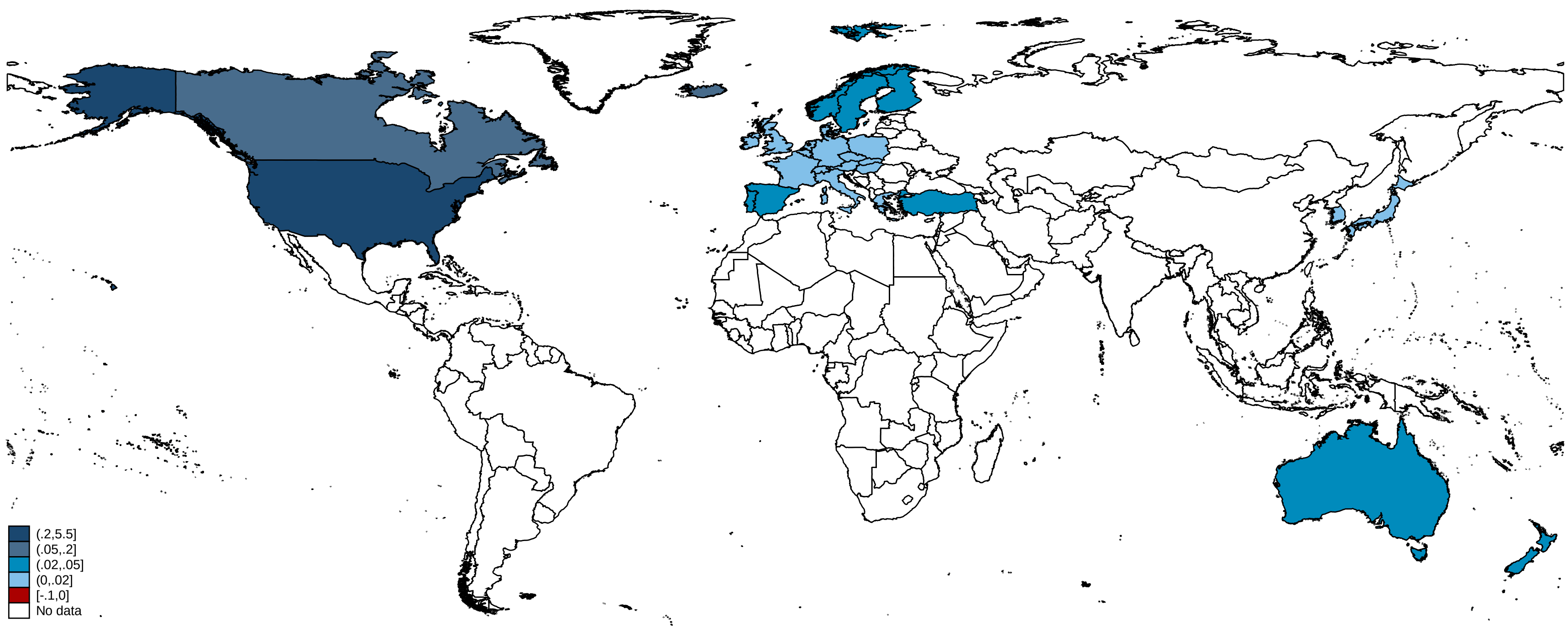

Figure A.2: Employment effects of a hypothetical labor market reform in the United States ($\hat{\kappa}_{US} = 1.054$).

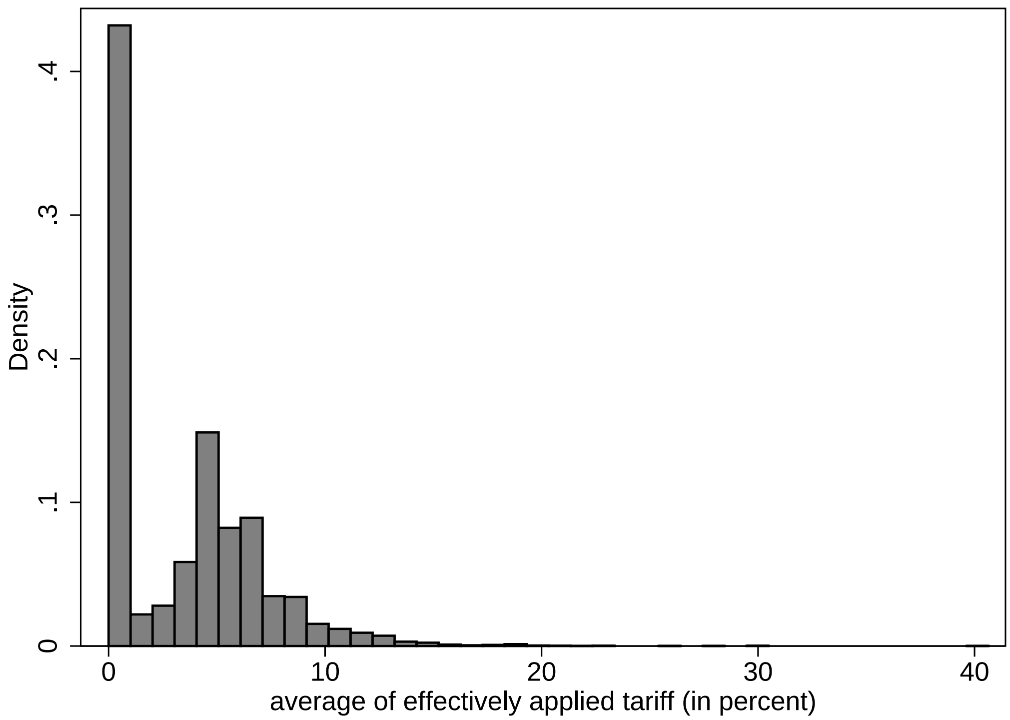

Figure A.3: Histogram of the bilateral simple average of effectively applied tariff rates for the tariff sample

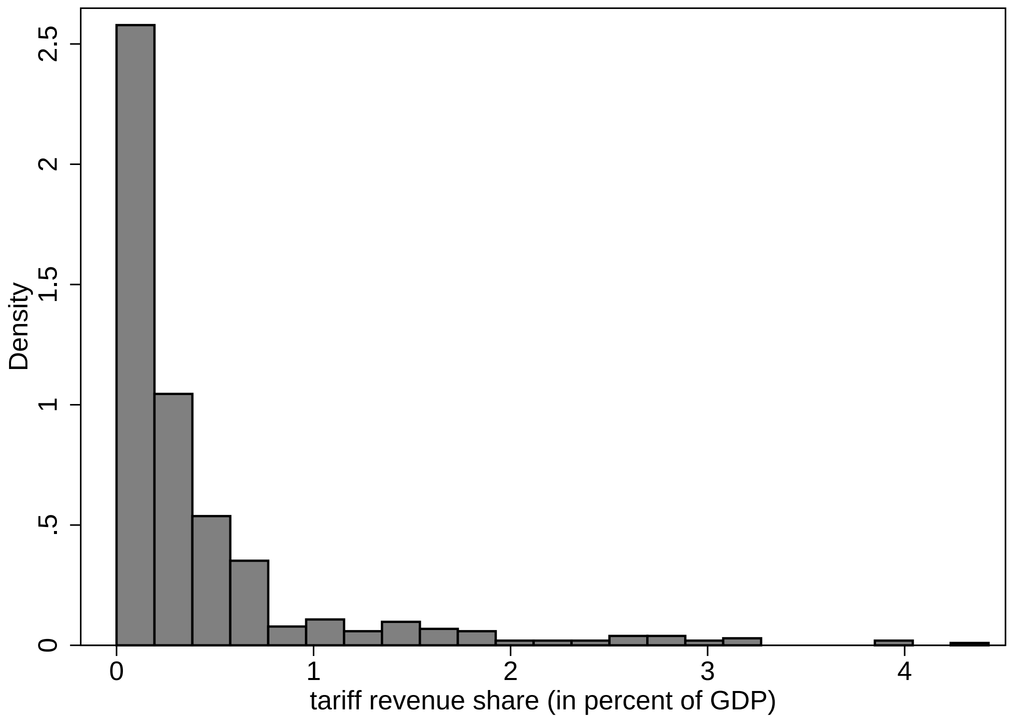

Figure A.4: Histogram of the calculated tariff revenue as a share of GDP using the bilateral simple average of effectively applied tariff rates for the tariff sample

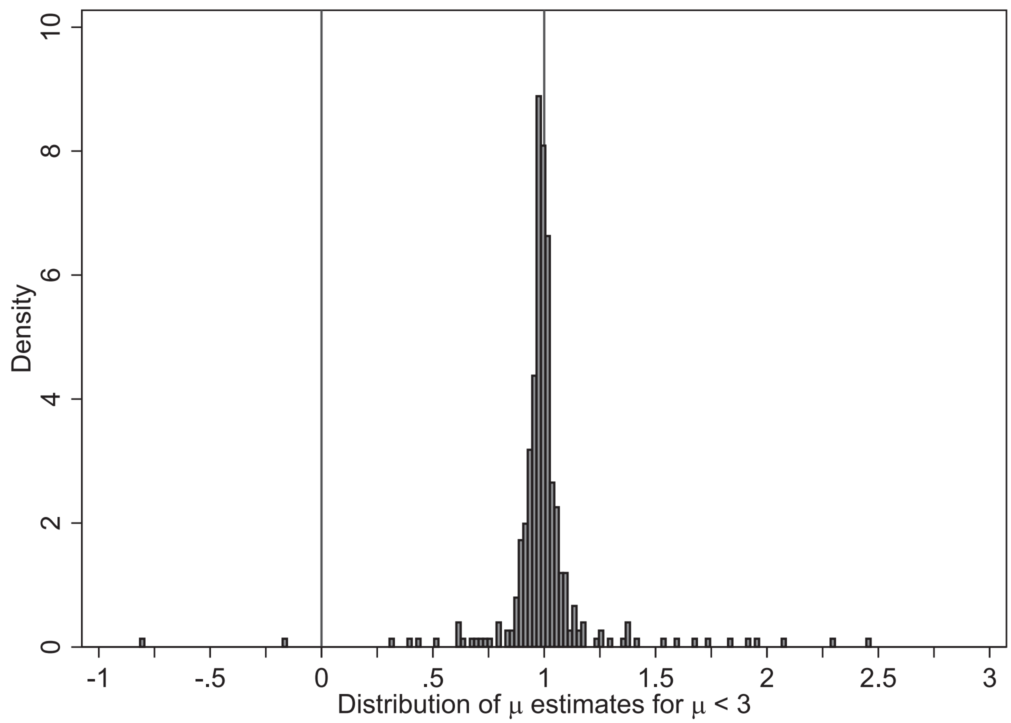

Figure A.5: Histogram of the different values of μ

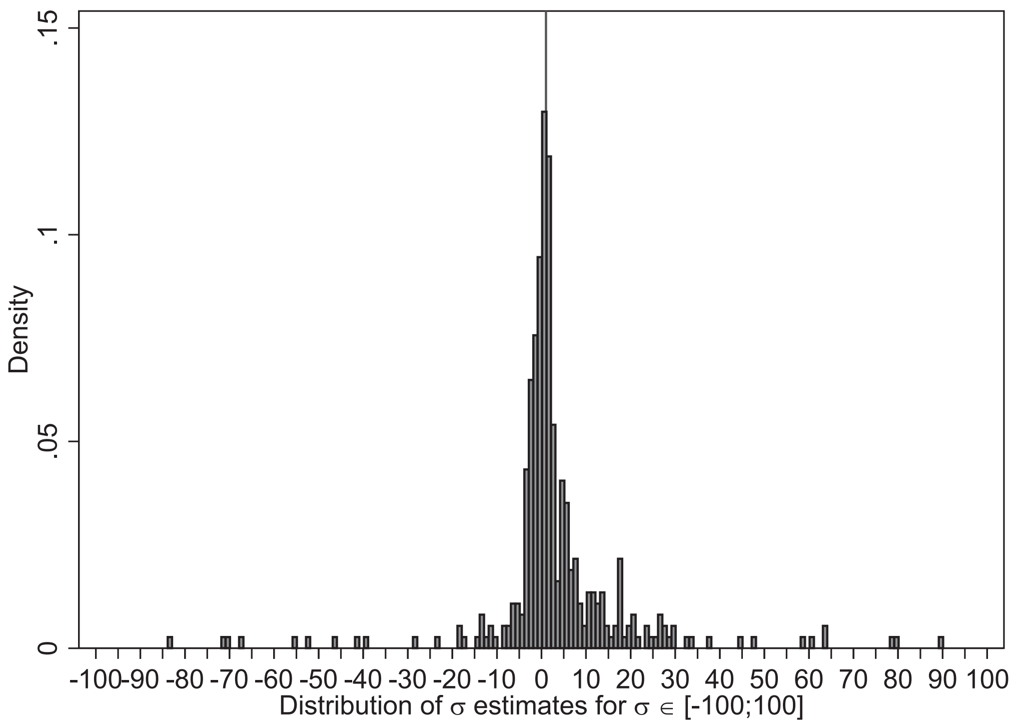

Figure A.6: Histogram of the different values of σ

Table A.1: Heterogeneity of comparative static trade effects of RTA inception with perfect labor markets and controlling for trade imbalances and tariff revenues in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-12.45	-12.23	-10.26	-9.35	-7.93	15.20	15.57
Austria	-17.89	-16.41	-2.17	-0.99	0.98	2.72	3.00
Belgium	-17.87	-16.38	-2.14	-0.96	1.01	2.76	3.04
Canada	-19.25	-19.21	-18.30	-17.51	-16.25	2.46	5.08
Czech Republic	-18.43	-16.95	-2.54	-1.64	0.32	2.05	2.33
Denmark	-17.45	-15.96	-1.64	-0.46	1.52	3.27	3.55
Finland	-15.88	-14.36	0.23	1.40	3.24	5.24	5.52
France	-16.65	-15.14	-0.69	0.47	2.50	4.28	4.56
Germany	-15.66	-14.13	0.50	1.67	3.24	5.52	5.81
Greece	-15.32	-13.79	0.90	2.08	3.65	5.94	6.23
Hungary	-17.60	-16.11	-1.82	-0.63	1.34	3.09	3.37
Iceland	-15.23	-13.69	1.29	2.23	4.26	11.48	12.56
Ireland	-17.60	-16.11	-1.83	-0.68	1.33	3.08	3.36
Italy	-15.48	-13.95	0.71	1.88	3.46	5.75	6.03
Japan	-9.45	-9.22	-7.18	-6.24	-4.77	2.33	2.44
Korea	-9.55	-9.32	-7.16	-5.48	-0.15	11.69	11.72
Netherlands	-17.49	-16.00	-1.69	-0.55	1.47	3.22	3.50
New Zealand	-11.92	-11.70	-9.72	-8.80	-7.37	11.56	14.07
Norway	-17.01	-15.51	-0.85	0.07	2.22	9.13	10.19
Poland	-17.41	-15.92	-1.60	-0.41	1.57	3.33	3.60
Portugal	-16.67	-15.16	-0.71	0.45	2.48	4.25	4.54
Slovak Republic	-18.18	-16.70	-2.45	-1.33	0.63	2.37	2.65
Spain	-15.38	-13.85	0.82	2.00	3.57	5.87	6.15
Sweden	-16.64	-15.13	-0.68	0.48	2.52	4.29	4.58
Switzerland	-18.00	-16.52	-2.01	-0.72	1.00	7.82	8.87
Turkey	-15.42	-13.89	1.05	1.99	4.02	11.22	12.30
United Kingdom	-13.77	-12.21	2.74	3.94	5.54	6.49	6.50
United States	-8.76	-8.71	-7.68	-6.78	-5.36	14.59	16.50
Average	-15.66	-14.44	-2.67	-1.57	0.36	6.11	6.70

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2 in the main text. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.2: Heterogeneity of comparative static trade effects of RTA inception with imperfect labor markets and controlling for trade imbalances and tariff revenues in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-12.33	-12.15	-10.35	-9.43	-8.02	15.33	15.71
Austria	-17.94	-16.46	-2.46	-1.24	0.72	2.48	2.75
Belgium	-17.91	-16.43	-2.43	-1.21	0.75	2.51	2.78
Canada	-19.30	-19.26	-18.34	-17.54	-16.23	2.64	5.25
Czech Republic	-18.47	-17.00	-2.83	-1.88	0.07	1.81	2.08
Denmark	-17.48	-16.00	-1.92	-0.69	1.28	3.05	3.32
Finland	-15.89	-14.38	-0.02	1.16	3.02	5.04	5.31
France	-16.68	-15.18	-0.97	0.20	2.26	4.05	4.32
Germany	-15.70	-14.18	0.20	1.39	2.98	5.28	5.55
Greece	-15.34	-13.81	0.64	1.83	3.42	5.73	6.01
Hungary	-17.64	-16.15	-2.10	-0.88	1.09	2.86	3.13
Iceland	-15.19	-13.66	1.09	2.07	4.10	11.54	12.68
Ireland	-17.61	-16.12	-2.07	-0.91	1.13	2.89	3.16
Italy	-15.51	-13.99	0.43	1.62	3.21	5.51	5.79
Japan	-9.26	-9.07	-7.21	-6.26	-4.80	2.59	2.71
Korea	-9.36	-9.17	-7.18	-5.47	0.02	11.75	11.80
Netherlands	-17.53	-16.05	-1.98	-0.82	1.22	2.98	3.25
New Zealand	-11.80	-11.61	-9.80	-8.88	-7.46	11.69	14.19
Norway	-17.03	-15.53	-1.10	-0.14	1.99	9.12	10.23
Poland	-17.44	-15.96	-1.87	-0.65	1.33	3.10	3.37
Portugal	-16.68	-15.18	-0.96	0.21	2.26	4.05	4.32
Slovak Republic	-18.22	-16.75	-2.74	-1.58	0.37	2.12	2.39
Spain	-15.40	-13.88	0.56	1.75	3.34	5.65	5.92
Sweden	-16.66	-15.16	-0.94	0.23	2.29	4.08	4.35
Switzerland	-18.05	-16.57	-2.30	-1.02	0.73	7.77	8.87
Turkey	-15.42	-13.90	0.81	1.79	3.81	11.23	12.36
United Kingdom	-13.78	-12.22	2.49	3.70	5.32	6.32	6.35
United States	-8.82	-8.78	-7.73	-6.83	-5.36	14.74	16.65
Average	-15.66	-14.45	-2.90	-1.77	0.17	6.00	6.59

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2 in the main text. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.3: Heterogeneity of comparative static trade effects of $\hat{\kappa}_{U.S.} = 1.054$ controlling for trade imbalances and tariff revenues with imperfect labor markets in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-0.54	-0.51	0.66	0.74	0.77	0.79	0.79
Austria	-0.30	-0.27	0.89	0.97	1.00	1.03	1.03
Belgium	-0.28	-0.25	0.92	0.99	1.03	1.05	1.05
Canada	-1.45	-1.30	-0.40	-0.33	-0.30	-0.27	-0.27
Czech Republic	-0.31	-0.28	0.89	0.96	1.00	1.03	1.03
Denmark	-0.33	-0.31	0.86	0.94	0.98	1.00	1.00
Finland	-0.44	-0.41	0.76	0.83	0.87	0.89	0.89
France	-0.31	-0.28	0.89	0.96	1.00	1.02	1.02
Germany	-0.30	-0.28	0.89	0.97	1.00	1.03	1.03
Greece	-0.36	-0.33	0.84	0.92	0.95	0.97	0.98
Hungary	-0.35	-0.32	0.85	0.93	0.96	0.98	0.98
Iceland	-0.68	-0.66	0.51	0.59	0.62	0.65	0.65
Ireland	-0.35	-0.32	0.85	0.93	0.96	0.99	0.99
Italy	-0.33	-0.31	0.86	0.94	0.98	1.00	1.00
Japan	-0.37	-0.34	0.83	0.91	0.94	0.97	0.97
Korea	-0.36	-0.34	0.83	0.91	0.94	0.97	0.97
Netherlands	-0.28	-0.26	0.91	0.99	1.02	1.05	1.05
New Zealand	-0.57	-0.55	0.62	0.70	0.73	0.76	0.76
Norway	-0.42	-0.40	0.77	0.85	0.88	0.91	0.91
Poland	-0.35	-0.32	0.85	0.92	0.96	0.98	0.98
Portugal	-0.41	-0.39	0.79	0.86	0.89	0.92	0.92
Slovak Republic	-0.33	-0.31	0.86	0.94	0.97	1.00	1.00
Spain	-0.38	-0.36	0.81	0.89	0.92	0.95	0.95
Sweden	-0.40	-0.37	0.80	0.88	0.91	0.94	0.94
Switzerland	-0.28	-0.26	0.91	0.99	1.02	1.05	1.05
Turkey	-0.42	-0.40	0.77	0.85	0.88	0.91	0.91
United Kingdom	-0.31	-0.29	0.88	0.96	0.99	1.02	1.02
United States	-1.46	-1.29	-0.27	-0.20	-0.17	-0.14	-0.14
Average	-0.45	-0.42	0.74	0.81	0.85	0.87	0.87

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2 in the main text. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.4: Comparative static effects of RTA inception controlling for trade imbalances but with zero tariff rates for all country pairs in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share $\%Y$ SMF		SMF	SMF	PLM	SMF
	$\%Y$	$\%Y$	$\%\ln(\hat{p})$	$\%\ln(\hat{e})$	$\%\hat{e}$	Δu	$\%EV$	$\%EV$
Australia	3.93	4.47	91.82	8.18	0.36	-0.34	5.03	5.40
Austria	7.95	9.09	84.67	15.33	1.34	-1.26	20.43	21.80
Belgium	7.93	9.06	84.87	15.13	1.32	-1.20	20.05	21.42
Canada	9.72	10.86	84.34	15.66	1.63	-1.50	25.96	26.99
Czech Republic	8.37	9.55	84.47	15.53	1.43	-1.31	21.87	23.30
Denmark	7.61	8.70	84.97	15.03	1.26	-1.20	19.09	20.37
Finland	6.47	7.42	85.80	14.20	1.02	-0.93	15.13	16.20
France	7.03	8.06	85.26	14.74	1.15	-1.04	17.20	18.41
Germany	6.32	7.27	86.35	13.65	0.96	-0.86	14.08	15.20
Greece	6.06	6.99	85.78	14.22	0.96	-0.87	14.21	15.24
Hungary	7.73	8.84	84.86	15.14	1.29	-1.18	19.55	20.88
Iceland	5.97	6.85	86.26	13.74	0.91	-0.88	13.46	14.40
Ireland	7.72	8.79	85.13	14.87	1.26	-1.19	19.14	20.36
Italy	6.19	7.12	86.18	13.82	0.95	-0.88	14.00	15.07
Japan	2.04	2.36	101.12	-1.12	-0.03	0.03	-0.45	-0.44
Korea	2.10	2.43	100.55	-0.55	-0.01	0.01	-0.27	-0.24
Netherlands	7.66	8.74	85.43	14.57	1.23	-1.16	18.48	19.77
New Zealand	3.59	4.11	92.16	7.84	0.32	-0.30	4.40	4.73
Norway	7.30	8.33	85.42	14.58	1.17	-1.12	17.65	18.84
Poland	7.59	8.69	84.88	15.12	1.27	-1.08	19.17	20.47
Portugal	7.00	8.01	85.24	14.76	1.14	-1.04	17.16	18.30
Slovak Republic	8.16	9.32	84.56	15.44	1.39	-1.18	21.15	22.56
Spain	6.11	7.04	85.95	14.05	0.96	-0.87	14.12	15.17
Sweden	7.01	8.03	85.37	14.63	1.14	-1.05	17.00	18.17
Switzerland	8.04	9.19	84.60	15.40	1.36	-1.29	20.77	22.17
Turkey	6.15	7.06	86.07	13.93	0.95	-0.85	14.06	15.06
United Kingdom	5.00	5.80	87.23	12.77	0.72	-0.68	10.33	11.20
United States	2.44	2.83	97.53	2.47	0.07	-0.07	0.80	0.98
Average	4.41	5.06	92.50	7.50	0.52	-0.48	7.74	8.32

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table A.5: Comparative static effects of RTA inception assuming balanced trade but controlling for tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share $\%Y$ SMF		SMF	SMF	PLM	SMF
	$\%Y$	$\%Y$	$\%\ln(\hat{p})$	$\%\ln(\hat{e})$	$\%\hat{e}$	Δu	$\%EV$	$\%EV$
Australia	3.89	4.42	91.80	8.20	0.36	-0.34	4.98	5.31
Austria	8.12	9.25	84.84	15.16	1.35	-1.27	20.50	21.74
Belgium	8.00	9.12	84.93	15.07	1.32	-1.20	20.07	21.35
Canada	9.73	10.87	84.33	15.67	1.63	-1.50	25.91	26.74
Czech Republic	8.48	9.65	84.59	15.41	1.43	-1.31	21.87	23.12
Denmark	7.75	8.84	85.11	14.89	1.27	-1.20	19.15	20.31
Finland	6.66	7.61	86.01	13.99	1.03	-0.94	15.21	16.08
France	7.23	8.26	85.51	14.49	1.16	-1.04	17.27	18.37
Germany	6.33	7.27	86.35	13.65	0.96	-0.86	14.05	15.07
Greece	6.42	7.34	86.31	13.69	0.97	-0.88	14.31	15.18
Hungary	7.86	8.96	85.00	15.00	1.30	-1.18	19.56	20.68
Iceland	6.20	7.06	86.51	13.49	0.92	-0.89	13.59	14.25
Ireland	7.70	8.76	85.16	14.84	1.25	-1.18	18.95	20.01
Italy	6.31	7.23	86.40	13.60	0.95	-0.88	13.95	14.91
Japan	2.14	2.44	101.09	-1.09	-0.03	0.03	-0.45	-0.45
Korea	2.20	2.51	100.53	-0.53	-0.01	0.01	-0.27	-0.26
Netherlands	7.54	8.60	85.26	14.74	1.22	-1.16	18.38	19.57
New Zealand	3.69	4.19	92.12	7.88	0.32	-0.31	4.47	4.65
Norway	7.29	8.31	85.48	14.52	1.17	-1.11	17.51	18.67
Poland	7.78	8.86	85.07	14.93	1.28	-1.09	19.26	20.35
Portugal	7.26	8.27	85.56	14.44	1.15	-1.05	17.25	18.20
Slovak Republic	8.30	9.45	84.72	15.28	1.39	-1.19	21.16	22.36
Spain	6.37	7.29	86.34	13.66	0.97	-0.87	14.15	15.05
Sweden	7.18	8.20	85.54	14.46	1.15	-1.05	17.08	18.08
Switzerland	8.20	9.34	84.83	15.17	1.36	-1.29	20.79	22.20
Turkey	6.35	7.25	86.38	13.62	0.96	-0.85	14.08	14.94
United Kingdom	5.31	6.10	87.71	12.29	0.73	-0.69	10.44	11.23
United States	2.50	2.88	97.49	2.51	0.07	-0.07	0.83	0.98
Average	4.51	5.15	92.57	7.43	0.53	-0.48	7.75	8.27

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table A.6: Heterogeneity of comparative static trade effects of RTA inception with perfect labor markets assuming balanced trade but controlling for tariff revenues in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-12.18	-11.93	-9.80	-8.87	-7.47	15.64	16.01
Austria	-18.15	-16.68	-2.27	-1.07	0.95	2.67	2.95
Belgium	-17.99	-16.52	-2.09	-0.88	1.15	2.87	3.15
Canada	-18.95	-18.90	-17.99	-17.19	-15.89	2.73	5.35
Czech Republic	-18.63	-17.16	-2.56	-1.65	0.36	2.07	2.35
Denmark	-17.66	-16.18	-1.69	-0.48	1.56	3.29	3.57
Finland	-16.16	-14.66	0.10	1.24	3.18	5.16	5.45
France	-16.95	-15.46	-0.85	0.29	2.43	4.17	4.45
Germany	-15.71	-14.19	0.64	1.79	3.40	5.73	6.02
Greece	-15.83	-14.32	0.49	1.64	3.24	5.57	5.86
Hungary	-17.80	-16.32	-1.86	-0.65	1.38	3.11	3.39
Iceland	-15.52	-14.01	1.15	2.10	4.19	11.23	12.29
Ireland	-17.59	-16.10	-1.60	-0.48	1.65	3.38	3.66
Italy	-15.67	-14.16	0.68	1.83	3.44	5.78	6.06
Japan	-9.51	-9.25	-7.05	-6.09	-4.66	2.37	2.48
Korea	-9.60	-9.34	-7.03	-5.32	-0.18	11.92	11.96
Netherlands	-17.36	-15.88	-1.34	-0.21	1.92	3.66	3.93
New Zealand	-11.87	-11.62	-9.48	-8.54	-7.15	11.58	14.06
Norway	-17.03	-15.54	-0.65	0.28	2.50	9.25	10.29
Poland	-17.69	-16.21	-1.72	-0.51	1.52	3.25	3.53
Portugal	-16.99	-15.50	-0.89	0.24	2.38	4.13	4.41
Slovak Republic	-18.39	-16.92	-2.51	-1.36	0.66	2.37	2.65
Spain	-15.76	-14.24	0.58	1.73	3.34	5.67	5.96
Sweden	-16.88	-15.39	-0.76	0.37	2.51	4.26	4.54
Switzerland	-18.25	-16.79	-2.10	-0.93	0.99	7.64	8.66
Turkey	-15.72	-14.21	0.91	1.86	3.94	10.97	12.03
United Kingdom	-14.25	-12.71	2.38	3.55	5.18	6.17	6.20
United States	-8.62	-8.57	-7.54	-6.64	-5.17	14.47	16.36
Average	-15.81	-14.60	-2.67	-1.57	0.41	6.11	6.70

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.7: Heterogeneity of comparative static effects of RTA inception with imperfect labor markets and assuming balanced trade but controlling for tariff revenues in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-12.06	-11.85	-9.88	-8.92	-7.54	15.77	16.16
Austria	-18.19	-16.73	-2.56	-1.32	0.70	2.43	2.70
Belgium	-18.04	-16.57	-2.38	-1.13	0.89	2.62	2.89
Canada	-19.00	-18.95	-18.03	-17.22	-15.87	2.91	5.52
Czech Republic	-18.67	-17.21	-2.85	-1.89	0.11	1.83	2.10
Denmark	-17.69	-16.22	-1.96	-0.71	1.32	3.06	3.33
Finland	-16.17	-14.67	-0.16	1.00	2.96	4.96	5.23
France	-16.99	-15.50	-1.12	0.02	2.18	3.94	4.21
Germany	-15.75	-14.24	0.35	1.51	3.13	5.49	5.76
Greece	-15.85	-14.34	0.23	1.39	3.01	5.36	5.64
Hungary	-17.84	-16.37	-2.14	-0.89	1.13	2.87	3.14
Iceland	-15.49	-13.98	0.95	1.95	4.03	11.29	12.39
Ireland	-17.60	-16.12	-1.85	-0.71	1.43	3.18	3.45
Italy	-15.71	-14.20	0.40	1.57	3.19	5.54	5.82
Japan	-9.30	-9.08	-7.05	-6.06	-4.64	2.64	2.76
Korea	-9.39	-9.17	-7.03	-5.30	0.01	12.01	12.06
Netherlands	-17.41	-15.93	-1.62	-0.48	1.66	3.41	3.68
New Zealand	-11.74	-11.53	-9.55	-8.59	-7.21	11.72	14.18
Norway	-17.05	-15.56	-0.92	0.06	2.27	9.23	10.32
Poland	-17.72	-16.25	-2.00	-0.75	1.28	3.02	3.29
Portugal	-17.00	-15.52	-1.14	0.01	2.17	3.92	4.19
Slovak Republic	-18.43	-16.97	-2.80	-1.61	0.40	2.13	2.39
Spain	-15.78	-14.27	0.32	1.48	3.10	5.46	5.73
Sweden	-16.91	-15.42	-1.03	0.12	2.28	4.04	4.31
Switzerland	-18.30	-16.84	-2.39	-1.22	0.72	7.59	8.65
Turkey	-15.72	-14.22	0.67	1.66	3.74	10.98	12.08
United Kingdom	-14.25	-12.72	2.13	3.31	4.97	6.00	6.04
United States	-8.69	-8.64	-7.60	-6.69	-5.17	14.61	16.50
Average	-15.81	-14.61	-2.89	-1.76	0.22	6.00	6.59

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.8: Comparative static effects of the U.S.-Australia Free Trade Agreement assuming balanced trade but controlling for tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share %Y SMF		SMF	SMF	PLM	SMF
	%Y	%Y	$\% \ln(\hat{p})$	$\% \ln(\hat{e})$	$\%\hat{e}$	Δu	%EV	%EV
Australia	2.03	2.27	81.54	18.46	0.41	-0.39	5.99	6.34
Austria	-0.06	-0.06	98.28	1.72	-0.00	0.00	-0.01	-0.02
Belgium	-0.06	-0.06	98.81	1.19	-0.00	0.00	-0.01	-0.01
Canada	-0.11	-0.10	93.16	6.84	-0.01	0.01	-0.11	-0.10
Czech Republic	-0.06	-0.06	98.25	1.75	-0.00	0.00	-0.02	-0.02
Denmark	-0.06	-0.06	98.01	1.99	-0.00	0.00	-0.02	-0.02
Finland	-0.07	-0.06	96.32	3.68	-0.00	0.00	-0.04	-0.04
France	-0.06	-0.06	98.30	1.70	-0.00	0.00	-0.01	-0.02
Germany	-0.06	-0.06	98.38	1.62	-0.00	0.00	-0.01	-0.01
Greece	-0.07	-0.06	96.80	3.20	-0.00	0.00	-0.03	-0.03
Hungary	-0.07	-0.06	97.45	2.55	-0.00	0.00	-0.02	-0.02
Iceland	-0.08	-0.07	94.83	5.17	-0.00	0.00	-0.06	-0.06
Ireland	-0.06	-0.06	98.00	2.00	-0.00	0.00	-0.02	-0.02
Italy	-0.06	-0.06	97.69	2.31	-0.00	0.00	-0.02	-0.02
Japan	-0.05	-0.05	94.57	5.43	-0.00	0.00	-0.04	-0.04
Korea	-0.05	-0.05	94.51	5.49	-0.00	0.00	-0.04	-0.04
Netherlands	-0.06	-0.06	98.76	1.24	-0.00	0.00	-0.01	-0.01
New Zealand	-0.13	-0.12	72.28	27.72	-0.03	0.03	-0.54	-0.50
Norway	-0.07	-0.06	96.86	3.14	-0.00	0.00	-0.03	-0.03
Poland	-0.07	-0.06	97.59	2.41	-0.00	0.00	-0.02	-0.02
Portugal	-0.07	-0.06	96.93	3.07	-0.00	0.00	-0.03	-0.03
Slovak Republic	-0.06	-0.06	97.71	2.29	-0.00	0.00	-0.02	-0.02
Spain	-0.07	-0.06	97.20	2.80	-0.00	0.00	-0.03	-0.03
Sweden	-0.07	-0.06	97.07	2.93	-0.00	0.00	-0.03	-0.03
Switzerland	-0.06	-0.06	98.59	1.41	-0.00	0.00	-0.01	-0.01
Turkey	-0.07	-0.07	95.52	4.48	-0.00	0.00	-0.05	-0.05
United Kingdom	-0.06	-0.06	98.31	1.69	-0.00	0.00	-0.01	-0.02
United States	0.00	0.02	-6.34	106.34	0.02	-0.02	0.28	0.30
Average	0.01	0.02	58.36	41.64	0.01	-0.01	0.21	0.23

Notes: Counterfactual analysis is based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table A.9: Comparative static effects of $\hat{\kappa}_{U.S.} = 1.054$ assuming balanced trade but controlling for tariff revenues in 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PLM	SMF	share %Y SMF		SMF	SMF	PLM	SMF
	$\%Y$	$\%Y$	$\% \ln(\hat{p})$	$\% \ln(\hat{e})$	$\%\hat{e}$	Δu	$\%EV$	$\%EV$
Australia	0.00	0.17	76.76	23.24	0.04	-0.04	-0.00	0.58
Austria	0.00	0.04	73.08	26.92	0.01	-0.01	0.00	0.18
Belgium	0.00	0.03	70.80	29.20	0.01	-0.01	-0.00	0.14
Canada	0.00	0.83	78.00	22.00	0.18	-0.17	0.00	2.70
Czech Republic	0.00	0.05	74.17	25.83	0.01	-0.01	0.00	0.19
Denmark	0.00	0.06	74.36	25.64	0.01	-0.01	0.00	0.23
Finland	0.00	0.12	76.54	23.46	0.03	-0.03	0.00	0.43
France	-0.00	0.05	73.59	26.41	0.01	-0.01	-0.00	0.20
Germany	-0.00	0.04	73.07	26.93	0.01	-0.01	-0.00	0.18
Greece	0.00	0.08	75.27	24.73	0.02	-0.02	0.00	0.31
Hungary	0.00	0.07	75.57	24.43	0.02	-0.02	0.00	0.27
Iceland	-0.00	0.26	77.61	22.39	0.06	-0.06	-0.00	0.90
Ireland	0.00	0.07	75.03	24.97	0.02	-0.02	0.00	0.27
Italy	0.00	0.06	74.66	25.34	0.02	-0.01	-0.00	0.25
Japan	0.00	0.06	74.35	25.65	0.01	-0.01	-0.00	0.22
Korea	0.00	0.06	74.13	25.87	0.01	-0.01	0.00	0.25
Netherlands	0.00	0.03	71.35	28.65	0.01	-0.01	-0.00	0.14
New Zealand	0.00	0.19	76.73	23.27	0.04	-0.04	0.00	0.68
Norway	0.00	0.11	76.17	23.83	0.03	-0.02	0.00	0.38
Poland	0.00	0.07	75.60	24.40	0.02	-0.01	0.00	0.27
Portugal	0.00	0.11	75.86	24.14	0.03	-0.03	0.00	0.43
Slovak Republic	0.00	0.06	75.10	24.90	0.02	-0.01	0.00	0.25
Spain	0.00	0.09	75.79	24.21	0.02	-0.02	-0.00	0.36
Sweden	0.00	0.09	75.87	24.13	0.02	-0.02	0.00	0.35
Switzerland	0.00	0.03	70.87	29.13	0.01	-0.01	0.00	0.14
Turkey	0.00	0.12	76.49	23.51	0.03	-0.02	-0.00	0.44
United Kingdom	-0.00	0.05	73.97	26.03	0.01	-0.01	-0.00	0.22
United States	0.00	2.94	-79.04	179.04	5.32	-5.08	-0.00	4.65
Average	0.00	1.15	17.76	82.24	1.98	-1.89	0.00	1.96

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. PLM gives results assuming perfect labor markets. SMF gives results using a search and matching framework for the labor market. Averages are weighted averages using country GDP as weight.

Table A.10: Heterogeneity of comparative static trade effects of $\hat{\kappa}_{U.S.} = 1.054$ with imperfect labor markets and assuming balanced trade but controlling for tariff revenues in 2006

	Changes in exports in percent by importer quantiles						
Exporting country	Min.	0.025	0.25	0.5	0.75	0.975	Max.
Australia	-0.55	-0.52	0.67	0.75	0.77	0.81	0.81
Austria	-0.35	-0.32	0.86	0.94	0.97	1.01	1.01
Belgium	-0.33	-0.30	0.88	0.96	0.99	1.02	1.03
Canada	-1.44	-1.30	-0.39	-0.31	-0.28	-0.25	-0.25
Czech Republic	-0.35	-0.33	0.86	0.94	0.96	1.00	1.00
Denmark	-0.37	-0.35	0.84	0.92	0.95	0.98	0.99
Finland	-0.47	-0.44	0.74	0.83	0.85	0.89	0.89
France	-0.36	-0.33	0.85	0.93	0.96	1.00	1.00
Germany	-0.35	-0.32	0.86	0.94	0.97	1.01	1.01
Greece	-0.41	-0.38	0.80	0.89	0.92	0.95	0.95
Hungary	-0.39	-0.37	0.82	0.90	0.93	0.96	0.96
Iceland	-0.70	-0.67	0.51	0.59	0.62	0.65	0.65
Ireland	-0.39	-0.36	0.82	0.91	0.93	0.97	0.97
Italy	-0.38	-0.35	0.83	0.91	0.94	0.98	0.98
Japan	-0.37	-0.34	0.84	0.92	0.95	0.99	0.99
Korea	-0.37	-0.35	0.84	0.92	0.95	0.98	0.98
Netherlands	-0.33	-0.30	0.88	0.96	0.99	1.02	1.03
New Zealand	-0.58	-0.56	0.63	0.71	0.74	0.77	0.77
Norway	-0.45	-0.42	0.76	0.84	0.87	0.90	0.90
Poland	-0.39	-0.36	0.82	0.90	0.93	0.97	0.97
Portugal	-0.46	-0.43	0.75	0.83	0.86	0.89	0.90
Slovak Republic	-0.38	-0.35	0.83	0.91	0.94	0.98	0.98
Spain	-0.43	-0.40	0.78	0.86	0.89	0.92	0.93
Sweden	-0.43	-0.40	0.78	0.87	0.90	0.93	0.93
Switzerland	-0.33	-0.31	0.88	0.96	0.98	1.02	1.02
Turkey	-0.46	-0.44	0.75	0.83	0.86	0.89	0.89
United Kingdom	-0.36	-0.34	0.85	0.93	0.96	0.99	0.99
United States	-1.45	-1.29	-0.25	-0.17	-0.15	-0.11	-0.11
Average	-0.49	-0.45	0.72	0.80	0.83	0.86	0.86

Notes: Counterfactual analysis based on parameter estimates from column (4) of Table 2. Table depicts changes in normalized exports, i.e., exports divided by source and origin GDPs.

Table A.11: Estimates of the matching elasticity using panel data regressions, 1994-2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
time-varying country fixed effects								
μ	.966	.966	.986	.985	1.000	.991	.994	.996
	(.001)	(.001)	(.001)	(.001)	(.000)	(.001)	(.000)	(.000)
country fixed effects								
μ	.971	.971	.99	.99	1.000	.994	.997	.999
	(.001)	(.001)	(.001)	(.001)	(.000)	(.001)	(.000)	(.000)
N	4675							

Notes: Estimates of μ based on Equation (68) and the trade cost parameter estimates and corresponding σ estimates from columns (1) to (8) of Table 2. Unbalanced panel from 1994 to 2006. Standard errors calculated by the delta method.