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TRADE AND FRICTIONAL UNEMPLOYMENT IN THE GLOBAL ECONOMY

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Abstract

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15 November 2019

Abstract

We develop a multi-country, multi-sector trade model featuring risk-averse workers, labor market frictions, unemployment benefits, and equilibrium unemployment. Trade opening leads to a reduction in unemployment when it simultaneously raises welfare and reallocates labor towards sectors with lower-than-average labor market frictions. We then estimate and calibrate the model using employment data from 31 OECD countries and worldwide trade data. Finally, we quantify the potential unemployment, real wage, and welfare effects of repealing NAFTA and raising bilateral tariffs between the US and Mexico to 20 percent. This policy would increase unemployment by 2.4 percent in the US and 48 percent in Mexico.

1. Introduction

Until fairly recently, the proposition whereby openness to international trade usually raises real incomes was uncontentious. But does trade create jobs? The former US administration seemed to believe so, in sharp contrast to the current one, which blames trade in general and the North American Free

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Trade Agreement (NAFTA) in particular for many of the evils cursing American workers.[1] By contrast, many economists used to reject the very idea that trade has any long run aggregate impact on overall unemployment.

In the first part of this paper (Section 3), we put forth a parsimonious quantitative framework to evaluate trade reforms when workers care about both income and unemployment. Specifically, we design a multi-sector, multi-country general equilibrium trade model featuring labor market frictions and equilibrium unemployment. Workers are risk-averse and acquire costly sector-specific skills. Accordingly, our welfare criterion is a certainty-equivalent real wage that accounts for the probability of losing one's job and for the costs of acquiring skills. In equilibrium, welfare is equalized across sectors and workers search for jobs in any sector indifferently.

Trade regime changes affect the aggregate unemployment rate of a country via two channels in our model. First, the *reallocation* effect of a trade reform leads to an increase in unemployment if it reallocates labor into sectors with higher-than-average labor market frictions. Second, the *expansion* effect is a general equilibrium effect whereby a trade reform, by boosting allocative efficiency, may spur aggregate job creation, which in turn raises welfare and reduces unemployment in all sectors. As the theory makes clear, the expansion effect and welfare move in tandem (one is a positive iso-elastic transformation of the other) but the reallocation effect may go in either direction. The multi-sector, multi-country design of our model emphasizes that the combination of the reallocation and expansion effects of a preferential trade agreement on the unemployment rate of a country depends on the set of countries and sectors included in the agreement. It also opens the possibility that trade simultaneously raises real GDP per capita and unemployment. Our welfare criterion accounts for both effects and hence provides a way to resolve such ambiguity.[2]

In the second part of the paper (Section 4), we structurally estimate the parameters of the model using world trade data for over 60 importing and 207 exporting countries, as well as sectoral employment and production data for 31 OECD countries (henceforth OECD-31), 34 ISIC Rev 3 sectors, and years 2001 to 2008.[3] We then run several counterfactual exercises (Section 5). Our first

1. On September 26, 2016, then candidate Donald Trump said, referring to the decline of US manufacturing: "NAFTA is the worst trade deal maybe ever signed anywhere, but certainly ever signed in this country."

2. Some authors propose alternative mechanisms that could lead to a simultaneous increase of both real wages and unemployment, such as fair wages (Egger and Kreickemeier, 2009), screening (Helpman, Itskhoki, and Redding, 2010), or binding minimum wages (Kreickemeier, 2005). Heid (2016) introduces an informal sector in order to study the labor market consequences of preferential trade agreements in developing countries.

3. OECD and ISIC Rev 3 stand for the Organisation for Economic Co-operation and for the Development for International Standard Industrial Classification Revision 3, respectively. The list of OECD-31 countries appears in Tables 3 to E.2. The list of ISIC Rev 3 sectors appears

counterfactual scenario, which we refer to as the "Wall", involves the repeal of NAFTA and the imposition of 20 percent bilateral tariffs between the US and Mexico in all sectors, as well as the reintroduction of some of the non tariff barriers (NTBs) that were eliminated by NAFTA. We motivate these choices in Section 5.1. We find that this trade regime would raise the unemployment rate from 3.9 percent to 5.78 percent in Mexico and from 5.8 percent to 5.94 percent in the US. Welfare is expected to fall by 0.31 percent in the US and by 6.6 percent in Mexico; changes in real GDP per capita are similar but their magnitude is smaller. Unlike their Mexican and US counterparts, Canadian workers would be better off by any metric but changes are tiny.[4] The welfare and real GDP per capita losses in Mexico and the US are larger than Caliendo and Parro's (2015) mirror-image estimates of welfare gains from NAFTA. Part of the reason for these larger effects is that such a bold policy reform would go beyond undoing NAFTA (average bilateral tariff rates were lower than 20 percent prior to 1993), that we account for NTBs, that inter-sectoral linkages are more important nowadays than back then, and, last but not least, that our welfare criterion accounts for risk aversion: workers care about the risk of being in unemployment over and above the earnings loss that it entails.

We also compute some counterfactual analysis using a short run version of our model, in which the sector choices of workers are given at the moment of the policy change. The short run employment losses are larger than the long run ones in both Mexico and the US, with heterogeneous employment responses across sectors. Differences between the short run and long run outcomes of our model capture some transitory dynamics which are absent from our static model.

Whereas in our first scenario the US is raising trade barriers in all sectors against two countries, in our second scenario the US is raising trade barriers in one sector (Motor Vehicles) against imports from all countries bar Mexico and Canada. The main provisions of the US-Mexico-Canada Agreement (USMCA), signed on 30 November 2018, include changes in the rules of origin for automakers and other regulations. These provisions are likely to lead to a surge in the production costs and prices of motor vehicles imported from Mexico and, in turn, of imports from Asia and Europe. As we explain in Section 5.2, we assume that the White House would then react by raising tariffs on Motor Vehicle imports from third countries to 20 percent. We refer to this scenario as the "USMCA Citadel." We find that long run welfare and employment would fall in both Mexico and the US as well as in major car producing countries. In a rare

in Table 1. The sample we use to estimate the trade elasticity in Section 4.3 includes 60 importing and 207 exporting countries and captures 65 percent of the World trade over 2000-2009. We perform the counterfactual exercises in Section 5 using 100 percent of the available trade data in 2008. See Appendices C and D.

4. Unless we specify otherwise, all the changes mentioned in the text are statistically significant at the five percent confidence level.

vindication of the protectionist instincts of President Trump, US employment would rise in the sector of interest in the short run.[5]

In the final part of the paper (Section 6), we use US census data to show that two distinctive features of our model – frictions to labor mobility across sectors, and sector-specific labor market search and matching frictions – are supported by the data over the period 1990-2008. In this Section, we show that frictions to labor mobility across sectors lead to sector-specific fluctuations of the employment rates in the "short run" (defined as the years following the implementation of NAFTA or China's accession to the GATT/WTO) while sector-specific labor market search and matching frictions lead to heterogeneous employment rates across sectors in the "long run."

Designing a multi-country, multi-sector general equilibrium model of trade and equilibrium unemployment with risk-averse workers is important for several reasons. First, policymakers and the public at large tend to voice concerns and support for trade agreements in terms of jobs gained or lost over and above wage concerns.[6] We take these concerns seriously by explicitly including search-and-matching labor market frictions and risk-aversion in an otherwise standard quantitative trade model. Specifically, we introduce sector-specific Diamond-Mortensen-Pissarides (henceforth DMP) search-and-matching frictions, as modeled in the static model of Helpman and Itskhoki (2010) (henceforth HI), into a multi-country Ricardian trade model à-la Eaton and Kortum (2002) and Costinot, Donaldson, and Komunjer (2012). As a result, equilibrium trade patterns have non-trivial effects on equilibrium unemployment.

Second, we show that welfare, real GDP per capita, and unemployment effects are closely – but only imperfectly – correlated. Both the distinctions and the similarities among these criteria are important. First, risk-averse workers put a higher negative weight on the penalty of not finding a job than does the arithmetic average of individual real earnings. Our welfare criterion accounts for that. Second, the unemployment rate may vary for two conceptually different reasons. On the one hand, any reform that raises aggregate demand boosts job creation, which reduces unemployment and raises wages in all sectors, and thus raises welfare in turn. On its own, this *expansion effect* suggests that focusing on aggregate unemployment, as policymakers tend to do, or on real earnings, as economists used to do, is looking at the same issue from two different angles.

5. In an earlier version of our paper (Carrère, Grujovic, and Robert-Nicoud, 2015), we also estimate the welfare and unemployment effects the Transatlantic Trade and Investment Partnership (TTIP), which aims at eliminating trade barriers between the US and the EU (the Trump Administration initially halted the negotiations, which resumed in July 2018). In that 2015 version of the paper, we also consider the removal of trade imbalances as in Dekle, Eaton and Kortum (2007).

6. See e.g. Lü, Scheve, and Slaughter (2012) for evidence that labor market outcomes shape attitudes towards trade in China and the US.

But this view misses the other half of the story whereby trade reforms reallocate resources across sectors. This *reallocation effect*, which features in HI's two-country model, has an impact on the unemployment rate of a country if sectors exhibit heterogeneous labor market frictions and heterogeneous unemployment rates, as US sectors do. Indeed, Figure 1 reports that differences in US sectoral unemployment rates are highly persistent as these rates increase and decrease in parallel fashion during the financial crisis. These variations of employment rates across sectors motivate our modeling of sector-specific labor market frictions. Under some conditions that we detail in Appendix A, these sector-specific labor market frictions can be defined as as convex combinations of occupation-specific or occupation-sector-specific labor market frictions. We work with sector-specific frictions in the body of the paper for the sake of parsimony and to match the level of aggregation of our data.[7]

2. Contributions to Extant Literature

We further contribute to the existing literature on five accounts. First, the normative contribution of the paper is to provide a rationale for the interests of the public in the employment effects of trade. In our (Ricardian) model, all workers are *ex-ante* identical but some end up in involuntary unemployment *ex-post*. If they are risk-adverse, the possibility not to find a job (or lose one) is costly over and above the lost income. If society is averse to inequality, then we can assess the welfare effects of equilibrium allocations using a social welfare function as in Atkinson (1970). Here, we use individual risk aversion to provide a microeconomic foundation for societal aversion to inequality.[8] In this way, our paper complements the literature on trade-induced inequality.[9] Our

7. In Appendix A, we assume that each sector is a specific combination of occupations and that labor market frictions are occupation-sector-specific. Such a framework encompasses the framework with sector-specific labor market frictions of the main text and an alternative with occupation-specific labor market frictions as special cases. Appendix A then establishes conditions under which the sector-specific frictions in the body of the text are isomorphic to a convex combination of occupation-specific or occupation-sector-specific labor market frictions.

8. Risk aversion is a standard but controversial way to provide microeconomic foundations to societal inequality aversion (Fleurbaey, 2010, 2018). In an earlier version of this paper (Carrère, Grujovic, and Robert-Nicoud, 2015), we explicitly distinguish between the two and show that, under some conditions, changes in welfare as measured by a social welfare function à-la Atkinson (1970) is identical to a convex combination of changes in real wages and in the unemployment rate.

9. See e.g. Antràs, de Gortari, and Itskhoki (2017), Burstein and Vogel (2017), Burstein, Cravino and Vogel (2013), Cravino and Sotelo (2019), Faber and Fally (2017), Galle, Rodríguez-Clare, and Yi (2017), Helpman, Itskhoki, and Redding (2010), Helpman, Itskhoki, Muendler, and Redding (2017), Krishna, Pool, and Senses (2012), Lee (2018), Parro (2013), and Verhoogen (2008); Goldberg and Pavcnik (2007) provide a review of the empirical literature on developing countries.

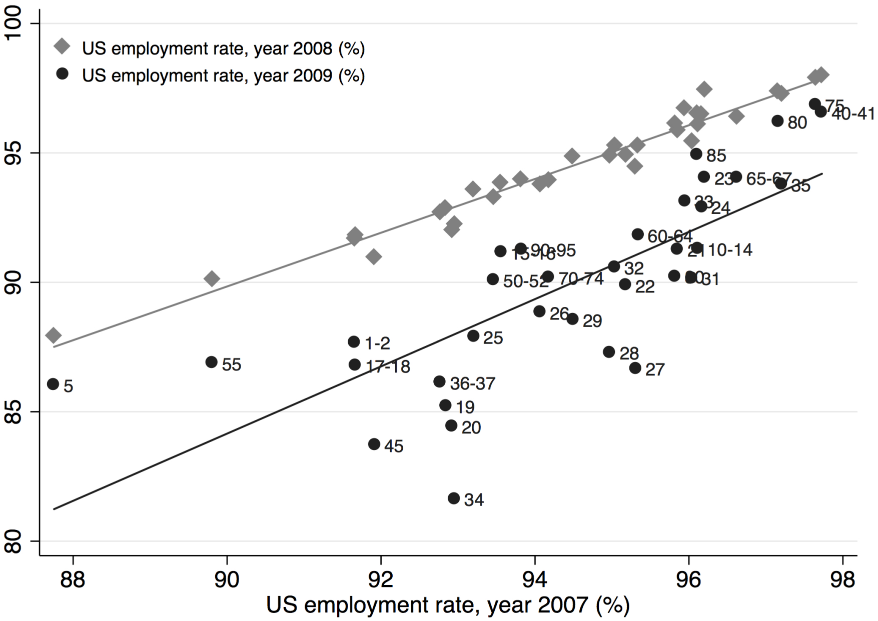


FIGURE 1. Correlation of US Employment Rates for 34 sectors, 2007-2009. The Figure plots the linear fit between the observed US sectoral employment rates for years 2007, 2008 and 2009. Labels indicate ISIC Rev 3 sector classifications (see Table 1). Data on sectoral employment rates is sourced from US census data. We define sectoral employment as the share of employed workers in the industry over the sum of employed workers in the industry and unemployed workers that were previously employed in the industry. The mean unemployment rate in year 2008 is 0.94 and the standard deviation is 0.024. Source: US census data and authors calculations.

paper also contributes to the recent debate on the gains from trade sparked by the seminal work of Arkolakis, Costinot, and Rodríguez-Clare (2012).[10] We generalize their formula to our multi-sector environment with labor market frictions and individual risk aversion.

Second, we complement theoretical papers that study labor market outcomes of various trade regimes (see Helpman, Itskhoki, and Redding, 2013,

10. See in particular Atkeson and Burstein (2010), Head, Mayer, and Thoenig (2014), Melitz and Redding (2015), Edmond, Midrigan, and Xu (2015), Ossa (2015), Heid and Larch (2016), and Tombe and Zhu (2019).

for a review).[11] Our contribution to this literature is to develop a multi-sector, multi-country trade model with trade in intermediates featuring DMP labor market frictions, unemployment benefits, and risk-averse workers. Several features of such a framework are noteworthy: (*i*) it generalizes the central theoretical predictions of two-country and/or two-sector trade models to a more realistic environment, which (*ii*) allows us to study the consequences of discriminatory trade liberalization; (*iii*) its key parameters can be structurally estimated using trade and unemployment data, which (*iv*) we can then use to run counterfactual experiments and characterize the equilibrium in relative changes using the "hat algebra" that is by now standard in much of the quantitative trade literature (Costinot and Rodríguez-Clare, 2014). Felbermayr, Prat, and Schmerer (2011), Helpman, Itskhoki, and Redding (2013), and Coşar, Guner, and Tybout (2016) extend this literature to "new trade models" with monopolistic competition and heterogeneous firms. As these works make clear, this important extension comes at the cost of analytical tractability because these models do not easily lend themselves to generalizations to settings featuring large and asymmetric open economies and/or income effects (as our paper does).

Third, we complement empirical papers that use microeconomic data in order to study labor market outcomes of a given trade reform or trade shock in a single country or in a handful of countries. These papers focus on the moving costs that inhibit movement across sectors and occupations; they either ignore unemployment or treat it as a residual sector (Artuç, Chaudhuri, and McLaren 2010, Caliendo, Dvorkin, and Parro 2019, Dix-Carneiro 2014, Fajgelbaum 2013, Menezes-Filho and Muendler 2011, Tombe and Zhu 2019). Costs of switching sectors and occupations are high (McLaren, 2017), and reallocating labor across sectors and firms takes time and several workers become temporarily unemployed, some for a substantial amount of time. Our static framework complements such studies by looking at the long run effects of trade on frictional unemployment in a multi-sector, multi-country trade model. We also compute all counterfactual analyses using a short run version of our model, in which the sector choices of workers are given at the moment of the policy change. Differences between the short run and long run outcomes of our model can be seen as a shortcut to transitory dynamics. Caliendo, Dvorkin, and Parro (2019) and Pessoa (2018) account for both transition and steady-state unemployment

11. Brecher (1974) and Davis (1998) set up two-country Heckscher-Ohlin models in which the patterns of trade interact with minimum wages. Davidson, Martin, and Matusz (1988, 1999), Costinot (2009), Helpman and Itskhoki (2010), and Carrère, Fugazza, Olarreaga, and Robert-Nicoud (2014, 2016) embed DMP labor market frictions into two-country or small-open-economy homogeneous-firm trade models. Heid and Larch (2016) embed labor market frictions into many-country Armington (1969) and Eaton and Kortum (2002) trade models. Another important strand of this literature considers the impact of trade on unemployment caused by "efficient" or "fair wages", as in Davis and Harrigan (2011), Egger and Kreickemeier (2012), and Kreickemeier and Nelson (2006).

effects of the China shock using Eaton-Kortum (2002) Ricardian trade models and household level data.[12] Their works complement the work of Autor, Dorn, and Hanson (2013), who find permanent and substantial relative declines in manufacturing employment and participation rates in markets most exposed to Chinese import competition.

Fourth, our paper recognizes that labor-market frictions can be a source of comparative advantage like Cuñat and Melitz (2012), Davidson, Martin, and Matusz (1988), and HI.

Finally, our paper contributes to the voluminous and lively policy and academic literatures on the economic effects of major preferential trade agreements.[13] Most of these papers, including Heid and Larch (2016), display the expansion effect but only HI features a reallocation effect.[14]

3. Model

3.1. Technology and Production

Consider a world comprising a set $\mathcal{C} \equiv \{1, ..., C\}$ of countries, labeled with subscripts c when considering a specific country, or i (for origin) and j (for destination) when considering trade flows, and a set $\mathcal{K} \equiv \{1, ..., K\}$ of sectors, labeled with subscripts k, s, that combine a single primary factor of production, labor L, as well as intermediates from other sectors for

12. Pessoa (2018) evaluate the China shock in the US and UK labor markets. His rich model is fully dynamic and it allows for job destruction as well as costs of switching sectors. On the theory side, our parsimonious, static version of labor market frictions enables us to allow for risk aversion (so that the utility cost of not finding a job is larger than lost income) and a richer input-output structure. On the empirical side, we can work with more countries as well as with more disaggregated and more numerous sectors. Last but not least, following Dekle, Eaton, and Kortum (2007) and others, we can readily use the "hat algebra" and compute the equilibrium in relative changes. Caliendo, Dvorkin, and Parro (2019) elegantly solve many of the difficulties posed by dynamic models by using the "hat algebra" for transitory effects. They study the impact of the China shock on households across 1150 local US labor markets and estimate that the China shock accounted for 16 percent of the decline in manufacturing employment from 2000 to 2007.

13. Caliendo and Parro (2015) estimate the trade volume and welfare effects of NAFTA. Dhingra, Huang, Ottaviano, Pessoa, Sampson, and Van Reenen (2017) estimate the costs and benefits of Brexit. Head and Mayer (2016) estimate how TTIP, TPP, Brexit, and the repeal of NAFTA influence the location decisions of multinational corporations. Hsieh, Li, Ossa, and Yang (2018) estimate and decompose the welfare effects of CUFSTA. Pessoa (2018) analyzes the labor market consequences of the China shock using individual data from the US and the UK.

14. Like us, Heid and Larch (2016) develop a microeconomically founded gravity trade model with labor market frictions. The key difference between their work and ours is that our model features an arbitrary number of sectors in all countries, which generates new theoretical predictions that we test in our empirical section. Ours also features trade in intermediates and risk-averse workers.

production, which include machinery and equipment. Each sector produces a differentiated good consisting of a unit mass of differentiated varieties, $x \in [0,1]$. Technology exhibits constant returns to scale and is variety- and country-specific. Specifically, let the output level of the representative firm producing variety x in sector k, country c, be defined as

$$\mathbb{Q}_{ck}(x) = \varphi_{ck}(x) \left(\frac{H_{ck}(x)}{1-\gamma_{ck}} \right)^{1-\gamma_{ck}} \prod_{s \in \mathcal{K}} \left(\frac{\mathbb{M}_{csk}(x)}{\gamma_{csk}} \right)^{\gamma_{csk}}. \tag{1}$$

Above, $H_{ck}(x)$ is the number of (hired) employees supplying labor to this firm, $1-\gamma_{ck}$ is the share of value added (labor) in sector k, $\mathbb{M}_{csk}(x)$ is the amount of materials or inputs purchased from sector s, $\gamma_{csk} \in [0,1)$ is the Cobb-Douglas share of input supplied by sector s to sector k, with $\gamma_{ck} \equiv \sum_{s \in \mathcal{K}} \gamma_{csk} \in (0,1]$, and $\varphi_{ck}(x)$ is a variety-specific productivity shifter (TFP). This technology parameter has a deterministic component, φ_{ck}, which is country- and sector-specific, and a stochastic component, which is the outcome of a random process such that productivity differs across varieties. Specifically, we assume that $\varphi_{ck}(x)$ is drawn independently for all (c,k,x) from a Fréchet distribution with scale parameter $\varphi_{ck} > 0$ and shape parameter $\theta_k > 1$ such that

$$F_{ck}(\varphi) = \exp\left[- \left(\frac{\varphi}{\varphi_{ck}} \right)^{-\theta_k} \right].$$

The scale parameter φ_{ck} governs absolute productivity levels and the shape parameter θ_k is negatively related to the scope for comparative advantage across varieties: the lower θ_k, the higher the dispersion of the φ_{ck}'s.

Following Caliendo and Parros (2015), producers of composite intermediate goods in sector k, country c purchase intermediate varieties $Q_{ck}(x)$ and assemble them into the usual Dixit-Stiglitz-Spence/Ethier aggregate

$$\mathbb{Q}_{ck} = \left[\int_0^1 \left(Q_{ck}(x) \right)^{1-1/\sigma_k} \mathrm{d}x \right]^{\frac{1}{1-1/\sigma_k}}.$$

$Q_{ck}(x)$ is the quantity of variety x sourced from the lowest cost suppliers across the world (we postpone further discussions pertaining to trade to Section 3.4 below) and σ_k is the common elasticity of substitution between any pair of varieties. We henceforth impose $0 < \sigma_k < 1 + \theta_k$ so that the price index of k, as defined in (3) below, is finite.

3.2. Preferences and Demand

We assume that consumers hold Constant Relative Risk Aversion (CRRA) preferences and spend a constant share α_{ck} of their earnings on the composite good produced by sector k:

$$\mathbb{U}_c = \frac{(\mathbb{C}_c)^{1-a}}{1-a}, \qquad \mathbb{C}_c \equiv \prod_{k \in \mathcal{K}} (\mathbb{C}_{ck})^{\alpha_{ck}}, \qquad \sum_{k \in \mathcal{K}} \alpha_{ck} = 1. \tag{2}$$

Above, $a \geq 0$ is the constant rate of relative risk aversion, with $a = 0$ for risk neutral agents.[15] The various $\mathbb{C}$'s stand for quantities consumed.

It follows from (2) that expenditure in any country c on variety x of good k is given by

$$E_{ck}(x) = \left[\frac{p_{ck}(x)}{p_{ck}}\right]^{1-\sigma_k} E_{ck},$$

where E_{ck} is the aggregate expenditure on good k in country c, p denotes prices, and

$$p_{ck} \equiv \left[\int_0^1 (p_{ck}(x))^{1-\sigma_k}\right]^{\frac{1}{1-\sigma_k}} \tag{3}$$

is the price index for good k in country c (i.e. it is the dual of $\mathbb{Q}_{ck}$) and $p_{ck}(x)$ is the purchasing price of $Q_{ck}(x)$. It follows from (2) that the unit price of the bundle $\mathbb{Q}_c$ is equal to the geometric weighted average of the sectoral prices:

$$\mathbb{P}_c = \prod_{k \in \mathcal{K}} (p_{ck})^{\alpha_{ck}}.$$

3.3. Labor Market Frictions, Wage Bargaining, and Equilibrium (Un)Employment

Each country is endowed with an inelastic labor force $\bar{L}_c$. An infinitely elastic supply of potential firms may enter the labor market by opening vacancies at a cost. Search-and-matching frictions in the labor market generate matching rents over which the firm and the employee bargain, as we explain in detail below.

Labor market frictions are country-sector specific. That is, each sector is also a segmented labor market (Barnichon and Figura, 2015). An alternative, equally plausible hypothesis, is that labor market frictions are country-occupation specific. We develop this point in Section 3.3.4 below and in Appendix A.

3.3.1. Matching Frictions. Firms open vacancies and workers search for jobs. Firms compete on output prices before they post vacancies. Let V_{ck} denote the endogenous number of open vacancies and let L_{ck} denote the endogenous mass of workers who seek employment in sector k, country c. We denote the subset of workers who are actually hired in sector k by H_{ck}.

15. Note that CRRA preferences over the composite good are usually defined as $\frac{(\mathbb{C}_c)^{1-a}-1}{1-a}$. This equation holds for $a \neq 1$. In the limiting case $a = 1$, $\lim_{a \to 1} \frac{(\mathbb{C}_c)^{1-a}-1}{1-a} = \ln \mathbb{C}_c$. We henceforth work under the assumption $a \neq 1$ and use the monotonic transformation of the standard formulation of CRRA preferences in (2). This transformation enables us to use the "hat" analysis of counterfactual scenarios that is now widespread in the trade literature.

We assume a Cobb-Douglas matching technology, so that the number of successful matches (and thus of hired workers) in each sector equals

$$H_{ck} = \tilde{\mu}_{ck} \left(V_{ck}\right)^{1-\lambda} \left(L_{ck}\right)^{\lambda}, \tag{4}$$

where the TFP of the matching process, $\tilde{\mu}_{ck}$, varies across countries and sectors and where $\lambda \in (0,1)$ is the labor share in the matching process. There is sectoral equilibrium unemployment whenever $H_{ck} < L_{ck}$. We define the employment rate in sector k as

$$\ell_{ck} \equiv \frac{H_{ck}}{L_{ck}}. \tag{5}$$

HI refer to ℓ_{ck} as the tightness of the labor market in sector k, country c. It is also the equilibrium probability of finding a job in sector k conditional on searching in this sector.

Let the parameter ν_{ck} denote the unit vacancy cost. In our setting, this vacancy cost can be thought of as including sector-specific training costs borne out by the employer. For simplicity, we assume that ν is paid in units of the domestic consumption bundle $\mathbb{C}$ only; Appendix B works out a more general case in which ν is paid in terms of a Cobb-Douglas combination of labor and $\mathbb{C}$ and establishes that all qualitative results and most quantitative results go through unaltered.[16] For each worker actually hired, V_{ck}/H_{ck} vacancies need be open. Thus the per worker hiring cost is equal to $\mathbb{P}_c \nu_{ck} V_{ck}/H_{ck}$. Using (4) and (5), this cost is equal to

$$c_{ck} \equiv \mathbb{P}_c \left[\frac{\left(\ell_{ck}\right)^{\lambda}}{\mu_{ck}}\right]^{\frac{1}{1-\lambda}}, \tag{6}$$

where

$$\mu_{ck} \equiv \frac{\tilde{\mu}_{ck}}{\left(\nu_{ck}\right)^{1-\lambda}} \tag{7}$$

is the sector-specific matching TFP adjusted for vacancy costs, henceforth "matching efficiency" for short; in other words, μ is the inverse of all labor market frictions. Thus, the sector-specific cost of hiring a worker in (6) depends on the tightness of, and on the frictions in, the labor submarket.

16. In Appendix B the per worker hiring cost is equal to $(\mathbb{P}_c)^{\rho}(w_{ck})^{1-\rho}\nu_{ck}V_{ck}/H_{ck}$, some $\rho \in [0,1]$. We set $\rho = 1$ in the main text; we show in Appendix B that all qualitative results go through unaltered for any $\rho \in (0,1]$. The polar case $\rho = 0$ implies that search costs are proportional to wages so that trade has no impact on the relative cost of labor; we emphasize the consequences of this assumption in the relevant sections below. As we show in Appendix B, λ and ρ jointly enter some key relationships such as (18) and (38) below. In Appendix E, we run some sensitivity analysis for our central scenario for different values of λ around our central value of $\lambda = 0.6$ under the maintained assumption $\rho = 1$. An alternative interpretation of the material contained in Appendix E is that we let ρ vary between $\rho \approx 0.05$ and $\rho = 1$. We find that most qualitative results of our baseline specification are robust across the various parameter configurations, though some quantitative results are sensitive (Helpman, 2010).

Upon forming a match, the firm and the worker bargain over the wage. We turn to this topic next.

3.3.2. Wage Bargaining. Revenue of firms in the triple (c, k, x) is defined as $E_{ck}(x) \equiv p_{ck}(x)\mathbb{Q}_{ck}(x)$. Let

$$r_{ck}(x) \equiv \frac{\partial E_{ck}(x)}{\partial H_{ck}(x)}$$

define the revenue generated by the marginal worker of the representative firm. Once matched, the firm and the worker bargain over the firm-specific wage $w_{ck}(x)$ in a cooperative fashion. They take all other prices as given. Disagreeing and breaking the match has an opportunity cost because it implies searching for another partner. Thus, upon matching, the worker and the firm enjoy bilateral monopoly power and $r_{ck}(x)$ is a rent over which they bargain. Here, as in Pissarides (2000, Chapter 1), intermediates are purchased on spot markets and it is natural to assume that they can be resold at the same price in these markets if the worker and the firm fail to come to an agreement. Therefore, the worker cannot hold the firm that has committed itself to a certain level of intermediaries. The outside option of firms is zero, whereas the outside option of the worker is b_{ck}, the unemployment benefit that she gets if unemployed. For simplicity, we assume equal bargaining weights so that the firm and the worker set $w_{ck}(x)$ so as to maximize the geometric average of the firm and the worker surplus:

$$\max_{w} \left[r_{ck}(x) - w\right]^{1/2} \left[\frac{w^{1-a} - (b_{ck})^{1-a}}{1-a}\right]^{1/2}.$$

This formula encapsulates the solution put forth by Stole and Zwiebel (1996) and used by HI in a similar context.[17] Here, we generalize it for worker risk aversion and the existence of unemployment benefits.[18]

17. It is straightforward to generalize the solution of the problem to arbitrary bargaining weights. Let $\Xi_c \in (0,1)$ denote the bargaining weight of workers in country c. Then the solution to the cooperative bargaining gain retains the same form as in (9) below, with B_c being redefined as

$$B_c = \frac{\Xi_c}{1-\Xi_c}\frac{1-a}{1-(b_c)^{1-a}}.$$

A higher bargaining weight and higher employment benefits both strengthen the bargaining position of the worker, which results in higher equilibrium wages and production costs.

18. We may write the first order condition to this problem as

$$[w_{ck}(x)]^{1-a} = (b_{ck})^{1-a} + \frac{1}{[w_{ck}(x)]^{a}}(1-a)\left[r_{ck}(x) - w_{ck}(x)\right],$$

which boils down to the well-know solution $w_{ck}(x) = b_{ck} + [r_{ck}(x) - b_{ck}]/2$ if $a = 0$. In that case of risk neutral parties, each of the firm and the worker gets their outside option plus half of the surplus. With concave utility, the firm extracts a higher share of the surplus

From the point of view of the firm, replacing a worker entails the sector- and country-specific search cost c_{ck} defined in (6), which is exogenous to the individual firm x. Any firm finds it optimal to open vacancies until the surplus generated by the marginal worker, $r_{ck}(x) - w_{ck}(x)$, is equal to the cost of replacing a worker, c_{ck}. Together with the expression above, this fact implies that the solution to the first-order condition of the bargaining problem yields an identical wage for all firms in a given sector and country, which we denote by w_{ck}. Following Ljungqvist and Sargent (1998), Boeri (2011) and much of the labor macroeconomics literature, we assume that unemployment benefits take the form of a flat income replacement scheme:

$$b_{ck} = b_c w_{ck}, \qquad b_c \in [0, 1). \tag{8}$$

That is to say, unemployed workers receive a fraction of the wage prevailing in the sector in which they are searching for a job (the outcome of this scheme is similar to that which would give workers a fraction of the wage they used to earn before loosing their job in a dynamic setting).[19] The extent of the unemployment shield may vary across countries. Together, this fact and assumption yield an explicit solution to the first order condition of the Nash Bargaining problem:

$$w_{ck}(x) = w_{ck} = c_{ck} B_c, \qquad B_c \equiv \frac{1-a}{1-(b_c)^{1-a}}. \tag{9}$$

Hence, from the point of view of the firm, the cost of employing one unit of labor is $c_{ck} + w_{ck} = (1 + 1/B_c)\, w_{ck}$, i.e. it includes the wage and the hiring cost. Wages are common across all varieties within a sector but production costs and prices reflect heterogeneous productivity levels across varieties within each sector. Let z_{ck} define an index of the unit cost pertaining in sector k, country c, and let $z_{ck}(x)$ be the unit cost of production of firm x. The producer price, which is the dual of (1), may then be written as

$$p_{ck}(x) = z_{ck}(x) = \frac{z_{ck}}{\varphi_{ck}(x)}, \qquad z_{ck} \equiv \left[\left(1 + \frac{1}{B_c}\right) w_{ck}\right]^{1-\gamma_{ck}} \prod_{s \in \mathcal{K}} (p_{cs})^{\gamma_{csk}}, \tag{10}$$

where $p_{ck}(x) = z_{ck}(x)$ holds by perfect competition.

Let ω_{ck} denote the real wage of workers employed in sector k, country c. It is also the dual of the consumption index $\mathbb{C}_{ck}$ in (2), i.e. $\mathbb{C}_{ck} = \omega_{ck}$. Combining

because it insures the worker against the less desirable outcome of being unemployed (Roth 1979; Kihlstrom, Roth, and Schmeidler 1981).

19. To see this point using our framework, consider the scheme $b_{ck}(x) = b_c w_{ck}(x)$. Maximizing $[r(x) - w]^{1/2} (1-a)^{-1/2} [w^{1-a} - (b_c w)^{1-a}]^{1/2}$ with respect to w, solving and letting $r_{ck}(x) - w = c_{ck}$, any x, yields $w_{ck}(x) = w_{ck} = c_{ck} B_c$, where $B_c = (1-a)$. Both scheme yield an equilibrium wage that is proportional to c_{ck}, as in (9).

(6) and (9) yields

$$\omega_{ck} \equiv \frac{w_{ck}}{\mathbb{P}_c} = B_c \left[\frac{(\ell_{ck})^{\lambda}}{\mu_{ck}} \right]^{\frac{1}{1-\lambda}}. \tag{11}$$

3.3.3. Sector Choice. All workers in the workforce actively look for employment, such that the full-participation condition reads as

$$\bar{L}_c = \sum_{k \in \mathcal{K}} L_{ck}. \tag{12}$$

Let $\tilde{w}_{ck}$ denote the certainty-equivalent expected earnings for workers seeking employment in sector k, country c (that is, workers would be indifferent between obtaining $\tilde{w}_{ck}$ with probability one, or getting w_{ck} with probability ℓ_{ck} and getting $b_{ck} w_{ck}$ with the complementary probability):

$$\begin{aligned} \tilde{w}_{ck} \equiv & \left[\ell_{ck} (w_{ck})^{1-a} + (1-\ell_{ck}) (b_{ck})^{1-a} \right]^{\frac{1}{1-a}} \\ = & w_{ck} \left[\ell_{ck} + (1-\ell_{ck}) (b_c)^{1-a} \right]^{\frac{1}{1-a}}, \end{aligned} \tag{13}$$

where the second equality follows from (8). The term in the square parenthesis of (13) is the wedge between actual and the certainty-equivalent earnings in sector k, country c; it follows from $a \geq 0$, $b \in (0,1)$, and $\ell_{ck} \in (0,1)$ that certainty-equivalent expected earnings are lower than actual earnings, $\tilde{w}_{ck} < w_{ck}$. This term appears frequently, so it is useful to define it as

$$\beta_{ck} \equiv \left[\ell_{ck} + (1-\ell_{ck}) (b_c)^{1-a} \right]^{\frac{1}{1-a}}, \tag{14}$$

which is increasing in both ℓ_{ck} and b_c.[20] We may also define the certainty-equivalent expected real earning for the country-sector pair (c,k):

$$\tilde{\omega}_{ck} \equiv \frac{\tilde{w}_{ck}}{\mathbb{P}_c} = \omega_{ck} \beta_{ck}, \tag{15}$$

where the second equality follows from (9) and (14).

Henceforth we assume that workers can freely choose the sector in which they search for a job and that this choice is irreversible, as in HI.[21] Acquiring the skills pertaining to sector k is costly. We denote by f_{ck} these costs of acquiring skills (or "education costs" for short), and assume that they take an

20. It obeys $\beta_{ck} \in (b_c, 1)$, with $\beta_{ck} = b_c$ in the limiting case $\ell_{ck} = 0$ (in which case the job seeker in (c,k) gets the unemployment benefit for sure) and with $\beta_{ck} = 1$ in the polar case $\ell_{ck} = 1$ (in which case the job seeker in (c,k) gets the labor compensation for sure).

21. Another way to formalize this assumption is the following. All workers have one unit of learning time and one unit of working time. They use the former to acquire the skills specific to the sector of their choosing. This choice is sunk.

iceberg form. If sector k in country c attracts a positive number of job seekers in equilibrium ($L_{ik} > 0$), then

$$\forall k \in \mathcal{K}: \quad \tilde{\omega}_c = \frac{\tilde{\omega}_{ck}}{f_{ck}} = \frac{\omega_{ck}\beta_{ck}}{f_{ck}}, \tag{16}$$

some $\tilde{\omega}_c > 0$, where the second equality follows from (15). Workers search indifferently in any of the active sectors: $\tilde{\omega}_c$ is the common certainty-equivalent real earnings net of education costs that workers get in any active sector of the economy. With risk-averse homogeneous workers, $\tilde{\omega}_c$ is a natural metric to assess welfare. If workers are risk-neutral ($a = 0$), then $\tilde{\omega}_c$ is equal to the average real labor earning in the economy net of education costs, which we denote by $\bar{\omega}_c$ below.

It is useful to perform the following change of variable. Let $\tilde{\ell}_{ck} \equiv (\ell_{ck})^{\lambda} (\beta_{ck})^{1-\lambda}$ define a theory-consistent measure of the employment rate in sector k, country c, that corrects for unemployment benefits and risk aversion: if $a = b = 0$, then it is equal to the actual employment rate, $\tilde{\ell}_{ck} = \ell_{ck}$, by the definition of β_{ck} in (14). Together, (11) and (16) yield

$$\tilde{\ell}_{ck} \equiv (\ell_{ck})^{\lambda} (\beta_{ck})^{1-\lambda} = \left(\frac{\tilde{\omega}_c}{B_c}\right)^{1-\lambda} (f_{ck})^{1-\lambda} \mu_{ck}. \tag{17}$$

Let also $\tilde{\ell}_c \equiv \sum_{k\in\mathcal{K}} (L_{ck}/\bar{L}_c)\tilde{\ell}_{ck}$ define the average theory-consistent employment rate in country c. Then, using (17), the average employment rate is given by

$$\tilde{\ell}_c \equiv \sum_{k\in\mathcal{K}} \frac{L_{ck}}{\bar{L}_c}\tilde{\ell}_{ck} = \left(\frac{\tilde{\omega}_c}{B_c}\right)^{1-\lambda} \sum_{k\in\mathcal{K}} \frac{L_{ck}}{\bar{L}_c} (f_{ck})^{1-\lambda} \mu_{ck}. \tag{18}$$

Three properties of this expression are noteworthy. First, in equilibrium, the overall employment rate in country c and the average certainty-equivalent real wage are monotonically increasing in one another. Thus, if any shock shifts aggregate demand out in this economy, then both real wages and employment rise. In effect, labor market frictions make the *employment* supply curve somewhat elastic, even as the *labor* supply curve is vertical. Second, the allocation of labor across sectors also has an impact on $\tilde{\ell}_c$: ceteris paribus, an economy that specializes in sectors with high education costs – which we interpret as sectors using high-skill occupations intensively – or high matching efficiency enjoys a relatively high employment rate. These two components of the employment rate play an important role in the quantitative analysis below. Finally, countries with high unemployment benefits (high B_c) enjoy lower employment rates. As usual in models with matching frictions in the labor markets, high unemployment benefits make job creation more expensive and thence dearer in equilibrium.

3.3.4. Occupations. The quantitative sections of the paper work with data at the sector level. In order to keep the link between the theoretical and quantitative parts of the paper as tight as possible, we work with sector-specific labor market frictions in the main text. This assumption is consistent with the empirical evidence documenting frictions to mobility across sectors. However, the model is silent about mobility frictions across occupations. For this reason, in Appendix A we develop a framework with occupation-sector-specific frictions that encompasses the model of the main text featuring sector-specific frictions only, as well as an alternative framework featuring occupation-specific frictions only. In particular, we develop conditions under which sector-specific labor market frictions in the body of the paper can be thought of as convex combinations of sector-occupation-specific (or of occupation-specific) labor market frictions.

Importantly, Appendix A shows that the maintained assumption of sector-specific frictions is an equilibrium outcome in the special case $a = b_c = 0$ and a *second*-order approximation under the empirical distributions of ℓ_{ck} and b_c and for $a = 2$.[22]

3.4. Trade

Following Caliendo and Parro (2015), we assume that output $\mathbb{Q}$ may be turned into consumption goods $\mathbb{C}$ or materials $\mathbb{M}$.

All markets are perfectly competitive and there are heterogeneous costs to trade. These costs take the standard iceberg form (Samuelson 1954), such that only a fraction $1/\tau_{ijk}$ of the goods shipped from country i to country j reach their destination. We impose *(i)* $\tau_{ijk} > \tau_{iik}$ for all (i, j, k) with $i \neq j$, and *(ii)* $\tau_{ilk} \leq \tau_{ijk}\tau_{jlk}$. Here, *(i)* states that trade across international borders is costlier than trade within countries; and *(ii)* is a technical condition that rules out that triangular trade be cheaper than direct trade. In the Estimation Section (4.3), τ_{ijk} encapsulates tariff and non tariff barriers as well as other frictions related to physical or cultural distance that impede bilateral trade flows. The model also accounts for non-traded goods and services, for which $\tau_{ijk} \to \infty$.

Under these assumptions, the all-inclusive cost of delivering variety x in industry k produced in country i and consumed in country j is equal to

$$z_{ijk}(x) = \tau_{ijk} \frac{z_{ik}}{\varphi_{ik}(x)}.$$

Countries consume goods from the lowest cost source by virtue of perfect competition. As a result, the equilibrium price of a variety x of good k in

22. That is, we show formally that some key equilibrium conditions are quantitatively very similar under two very different parameter combinations – one with $a = b_c = 0$ and one with $a = 2$ and $b_c \in [0.13, 0.83]$. In the former model, assuming that labor market frictions vary across sectors only is without additional loss of generality. In the latter, it is a very precise approximation.

country j is such that

$$p_{jk}(x) = \min_i \{z_{ijk}(x)\}. \tag{19}$$

Let also

$$t_{ijk} \equiv \frac{\tau_{ijk}}{\varphi_{ik}} z_{ik} \tag{20}$$

define the delivery cost of all varieties of sector k that are actually shipped from country i to country j, and let T_{jk} define the "remoteness" of country j in sector k (Head and Mayer, 2014):

$$T_{jk} \equiv \left[\sum_{i\in\mathcal{C}} (t_{ijk})^{-\theta_k}\right]^{-\frac{1}{\theta_k}} = \left[\Gamma\left(1 - \frac{1-\sigma_k}{\theta_k}\right)\right]^{-\frac{1}{1-\sigma_k}} p_{jk}, \tag{21}$$

where $\Gamma(\cdot)$ is the Gamma function. Observe that T_{jk}, which is a destination-sector specific term, is proportional to the price index p_{jk} in (3). Next, denote the size of market k in country j (in monetary units) by E_{jk}, and denote the value of total exports from country i to country j in sector k by $E_{ijk} \equiv \sum_{x\in\mathbb{X}_{ijk}} E_{ijk}(x)$, where $\mathbb{X}_{ijk} \equiv \{x \in \mathbb{X} \mid z_{ijk}(x) = \min_{i'} z_{i'jk}(x)\}$ is the set of varieties exported by country i to country j in industry k. Finally, let π_{ijk} define the market share of origin country i in market k of destination country j. It then follows from (9), (19), (20), and (21) that bilateral trade flows (in value) at the industry level obey the following gravity equation:

$$E_{ijk} = \pi_{ijk} E_{jk}, \qquad \pi_{ijk} \equiv \left(\frac{t_{ijk}}{T_{jk}}\right)^{-\theta_k}. \tag{22}$$

It follows from (1) and (2) that expenditure on good k in origin country c is equal to

$$E_{ck} = \alpha_{ck} I_c + \sum_{s\in\mathcal{K}} \gamma_{cks} \sum_{j\in\mathcal{C}} \pi_{cjs} E_{js}, \qquad I_c = \left(1 + \frac{1}{B_c}\right) \sum_{k\in\mathcal{K}} w_{ck} H_{ck}, \tag{23}$$

where I_c denotes income and final absorption in country c.

Three aspects of (20) and (22) are noteworthy. First, the elasticity of trade volumes with respect to trade costs is governed by the structural parameter θ_k. It varies across sectors: the largest the scope for comparative advantage (the lower θ_k), the least sensitive are trade volumes to cost variations. Second, country i's volume of exports of good k to country j is increasing in the destination market size, E_{jk}. Finally, country i's market share is decreasing in its delivery cost to destination j relative to the delivery cost of all alternative partners. This delivery cost is increasing in trade and transportation costs τ_{ijk} and in the input cost z_{ik}, and it is decreasing in the production TFP's and labor matching efficiencies – recall that wages w_{ik} are decreasing in μ_{ik} by (11). The novelty with respect to the Ricardian models of Eaton and Kortum (2002) and Costinot, Donaldson and Komunjer (2012) is twofold. First, the overall TFP of a sector is a combination of production TFP φ_{ik} and labor matching efficiency μ_{ik}. Second, wages do not enter labor costs linearly because the matching technology exhibits decreasing returns to labor by $\lambda < 1$. This gives rise to the expansion effect as any increase in sales translates into a less-that-proportional increase in wages, the remainder of the effect being partially absorbed by the tightening of labor markets.

We denote by Y_{ck} the value added in sector k, country c. It is equal to

$$Y_{ck} \equiv (1 - \gamma_{ck}) E_{ck} = \left(1 + \frac{1}{B_c}\right) H_{ck} w_{ck}. \tag{24}$$

Finally, trade is balanced for country $c \in \mathcal{C}$ if and only if the aggregate value of production is equal to aggregate expenditure:

$$0 = \sum_{j \in \mathcal{C}} \sum_{k \in \mathcal{K}} \pi_{cjk} E_{jk} - \sum_{i \in \mathcal{C}} \sum_{k \in \mathcal{K}} \pi_{ick} E_{ck}. \tag{25}$$

In the quantitative section we add trade deficits to the definition of income in (23) and to the left-hand side of (25) in order to account for trade imbalances. It is also straightforward to generalize this expression to account for tariff revenues. For computational purposes, we assume that tariff revenues are so small in our sample that they are dissipated (the OECD average of customs and import duties as a share of GDP is 0.1 percent; its maximum is 0.3 percent in Mexico).

3.5. Government

The government taxes the earnings of workers to finance unemployment benefits. Assume a constant income tax rate $\iota_c \in [0, 1)$. The budget is balanced if and only if the pair (b_c, ι_c) solves:

$$\begin{aligned} 0 &= \iota_c \sum_{k \in \mathcal{K}} L_{ck} w_{ck} \left[\ell_{ck} + b_c (1 - \ell_{ck})\right] - b_c \sum_{k \in \mathcal{K}} L_{ck} w_{ck} (1 - \ell_{ck}) \\ &= \iota_c \sum_{k \in \mathcal{K}} H_{ck} w_{ck} - (1 - \iota_c) b_c \sum_{k \in \mathcal{K}} (L_{ck} - H_{ck}) w_{ck}, \end{aligned} \tag{26}$$

where the second equality follows from (5). Two remarks are in order. Note first that we assume that the government taxes labor income of the employed and unemployed at the same rate. This assumption is without loss of generality because one can always redefine b_c to allow the effective tax rate on unemployment benefits to be the same as the tax rate on nominal income.[23] Second, this constant tax rate changes neither the nature nor the solution of the

23. At some substantial additional analytical cost, we could extend the model to allow for progressive taxes. We leave this extension for further work.

wage bargaining cooperative game of Section (3.3.2) and of the sector choice of Section (3.3.3). Therefore, we impose (26) and work with gross nominal and real wages throughout.

In the quantitative section we add trade deficits to the right-hand side of (26). It is also straightforward to generalize this expression to account for tariff revenues.

3.6. Equilibrium

Let us define the equilibrium as follows. Given a, b_c, $\bar{L}_c$, α_{ck}, γ_{csk}, φ_{ck}, c_{ck}, μ_{ck}, and τ_{ijk}, an equilibrium comprises income taxes ι_c, wages w_{ck}, prices p_{ck}, labor shares $L_{ck}/\bar{L}_c$, and employment rates ℓ_{ck} that satisfy conditions (10), (11), (12), (16), (21), (22), (23), (25), and (26).

Following Dekle, Eaton, and Kortum (2007), Caliendo and Parro (2015), Aichele, Felbermayr, and Heiland (2016) and many others, we solve for equilibrium changes of outcomes – in particular, in prices, wages, and employment rates – following policy changes. The policy changes we consider involve changes in trade barriers.[24] Let τ_{ijk} denote the current trade barrier pertaining to bilateral trade between exporting country i and importing country j in sector k, and let τ'_{ijk} denote the counterfactual trade policy scenario. Then $\hat{x} \equiv x'/x$ denotes the equilibrium relative change in variable x for any variable $x \in \iota_c, w_{ck}, p_{ck}, L_{ck}/\bar{L}_c, \ell_{ck}$.

The model comprises two major blocks: the labor market block, the trade block, as well as a third part that does not play much role in our model – the government budget constraint. For the trade part, we closely follow Caliendo and Parro's (2015) structure of the characterization of the equilibrium. Using conditions (10), (21), (22), (23), and (25), the equilibrium conditions in relative changes satisfy:

- Unit cost:
$$\hat{z}_{ck} \equiv (\hat{w}_{ck})^{1-\gamma_{ck}} \prod_{s\in\mathcal{K}} (\hat{p}_{cs})^{\gamma_{csk}} . \tag{27}$$

- Price index:
$$\hat{\mathbb{P}}_c = \prod_{k\in\mathcal{K}} (\hat{p}_{ck})^{\alpha_{ck}}, \qquad \hat{p}_{ck} = \left[\sum_{i\in\mathcal{C}} \pi_{ick} \left(\hat{\tau}_{ick}\hat{z}_{ik}\right)^{-\theta_k}\right]^{-\frac{1}{\theta_k}} . \tag{28}$$

- Bilateral trade shares:
$$\hat{\pi}_{ijk} \equiv \left(\frac{\hat{\tau}_{ijk}\hat{z}_{ik}}{\hat{p}_{jk}}\right)^{-\theta_k} . \tag{29}$$

24. Our framework is also suitable to quantify the consequences of changes in unemployment benefits.

- Expenditure:
$$E'_{ck} = \alpha_{ck} I'_c + \sum_{s\in\mathcal{K}} \gamma_{cks} \sum_{j\in\mathcal{C}} \pi'_{cjs} E'_{js}, \tag{30}$$
where $\pi'_{cjk} = \hat{\pi}_{cjk}\pi_{cjk}$, $E'_{jk} = \hat{E}_{jk}E_{jk}$, and
$$I'_c = \hat{I}_c I_c = \sum_{k\in\mathcal{K}} (1-\gamma_{ck}) \sum_{j\in\mathcal{C}} \pi'_{cjk} E'_{jk}.$$

- Trade balance:
$$0 = \sum_{j\in\mathcal{C}} \sum_{k\in\mathcal{K}} \pi'_{cjk} E'_{jk} - \sum_{i\in\mathcal{C}} \sum_{k\in\mathcal{K}} \pi'_{ick} E'_{ck}. \tag{31}$$

Given $\hat{w}_{ck}$ and initial conditions on observable variables, we can solve for all the endogenous variables of the trade block. Thus, wages are the link between the trade and labor market blocks.

Using conditions (11), (12), and (16) for the labor market block, the equilibrium conditions in relative changes satisfy:

- Value added:
$$\hat{E}_{ck} = \hat{Y}_{ck} = \hat{w}_{ck}\hat{\ell}_{ck}\hat{L}_{ck}, \tag{32}$$
where the second equality follows from (24).
- Real wage:
$$\hat{\omega}_{ck} \equiv \frac{\hat{w}_{ck}}{\hat{\mathbb{P}}_c} = \left(\hat{\ell}_{ck}\right)^{\frac{\lambda}{1-\lambda}}. \tag{33}$$

- Indifference condition:
$$\hat{\bar{\omega}}_c = \hat{\omega}_{ck}\hat{\beta}_{ck}, \qquad \hat{\beta}_{ck} = \left[\frac{\ell'_{ck} + (1-\ell'_{ck})(b_c)^{1-a}}{\ell_{ck} + (1-\ell_{ck})(b_c)^{1-a}}\right]^{\frac{1}{1-a}}, \tag{34}$$
where $\ell'_{ck} = \hat{\ell}_{ck}\ell_{ck}$.
- Full participation:
$$0 = \sum_{k\in\mathcal{K}} L_{ck}\left(\hat{L}_{ck} - 1\right). \tag{35}$$

The model is block recursive in the trade and employment blocks, on the one hand, and in the budget constraint of the government (26) on the other: the counterfactual tax rate is set so as to balance the budget of the government and, because preferences are homothetic, it does not affect any of the other endogenous variables: it simply transfers money among agents in the national economy.

- Fiscal balance:
$$0 = \iota'_c \sum_{k\in\mathcal{K}} H'_{ck} w'_{ck} - \left(1-\iota'_c\right) \sum_{k\in\mathcal{K}} \left(L'_{ck} - H'_{ck}\right) w'_{ck}, \tag{36}$$

where $H'_{ck} = \hat{H}_{ck} H_{ck}$ and $L'_{ck} = \hat{L}_{ck} L_{ck}$.

It follows by inspection of the system of equations (27)-(36) that studying counterfactual scenarios in relative changes (relative to the actual configuration) is parsimonious: estimates of the overall trade costs τ_{ijk}, total factor productivity φ_{ck}, and matching efficiency μ_{ck} are not needed. We elaborate on our estimation strategy in Section 4. Appendix D provides a detailed explanation of the methodology we use to generate counterfactual equilibrium changes following any trade policy regime change $\hat{\tau}_{ijk}$.

3.7. Gains from Trade and Equilibrium (Un)Employment

This section develops several comparative statics results in order to get a clearer understanding of the interaction between trade and labor market outcomes that are at work in the model. Two variables are of special interest: the certainty-equivalent economy-wide real wage $\tilde{\omega}_c$, which is the proper metric for individual welfare in our Ricardian model with risk-adverse, ex ante homogeneous, workers, and the employment rate $\tilde{\ell}_c$. The reader interested in the quantitative implementation of the model may safely skip this material and go directly to Section 3.8.[25]

The policy counterfactual scenarios that we consider in Section 5 involve trade regime changes.

3.7.1. Trade, Welfare, and Employment. Let us start with the relationship between relative changes in employment and welfare. For this purpose, it is useful to collect parameters and define the matching efficiency adjusted for education costs at the country-sector level as well as its countrywide average:

$$\mu^*_{ck} \equiv (f_{ck})^{1-\lambda} \mu_{ck}, \qquad \bar{\mu}^*_c \equiv \frac{L_{ck}}{\bar{L}_c} \mu^*_{ck}. \tag{37}$$

Let also define the covariance between labor reallocation across sectors and sectoral matching efficiencies adjusted for education costs:

$$\mathrm{Cov}\left(\frac{L'_{ck} - L_{ck}}{\bar{L}_c}, \mu^*_{ck}\right) \equiv \sum_{k \in \mathcal{K}} \frac{L'_{ck} - L_{ck}}{\bar{L}_c} \left(\mu^*_{ck} - \bar{\mu}^*_c\right).$$

25. In Section 5, we report changes in welfare ($\tilde{\omega}_c$), as motivated by our theory, as well as changes in unemployment, $u_c \equiv 1 - \ell_c$, and real GDP per capita, as motivated by the current debate on trade and unemployment. The model would suggest focusing on $\tilde{\ell}_c$ and $\tilde{\omega}_c$ only; in any case, as we explain there, with risk neutral workers and some additional parameter restrictions, changes in $\tilde{\ell}_c$ and $\tilde{\omega}_c$ coincide with changes in ℓ_c and real GDP per capita, respectively.

Then, using (18), changes in $\tilde{\ell}_c$ and $\tilde{\omega}_c$ are related by:

$$\hat{\tilde{\ell}}_c = \left(\hat{\tilde{\omega}}_c\right)^{1-\lambda} \hat{\bar{\mu}}_c^* = \underbrace{\left(\hat{\tilde{\omega}}_c\right)^{1-\lambda}}_{\text{Expansion}} \left[1 + \underbrace{\frac{1}{\bar{\mu}_c^*} \text{Cov}\left(\frac{L'_{ck} - L_{ck}}{\bar{L}_c}, \mu_{ck}^*\right)}_{\text{Reallocation}}\right]. \quad (38)$$

Inspection of (38) reveals that two effects compete in the determination of the overall impact of a trade reform on the equilibrium employment rate in the open economy. First, an increase in welfare has a positive effect on the employment rate. This *expansion effect* affects all sectors in the same way: when a trade reform results in efficiency gains from trade, then such gains are associated with increased job creation, higher welfare, and lower equilibrium unemployment rates. Second, for a given level of welfare, any reform that reallocates resources towards sectors featuring a combination of high labor market efficiency and education costs relative to the domestic average (i.e. sectors such that $\mu_{ck}^* > \bar{\mu}_c^*$) results in a rise of employment – and vice-versa. This *reallocation effect* occurs because labor market frictions differ across labor sub-markets.

We can then establish the following:

PROPOSITION 1. *(Gains From Trade and Unemployment). Let* $a = b_c = 0$ *so that* $\tilde{\omega}_c = \omega_c$ *and* $\tilde{\ell}_c = \ell_c$.[26]

(i) *Let* α_{ck}^0 *denote the autarky labor share of sector k, country c.*[27] *The trade equilibrium employment rate,* ℓ_c*, is greater than the autarky employment rate,* ℓ_c^0*, if country c has a revealed comparative advantage in sectors with a combination of relatively high matching efficiency and education costs:*

$$\text{Cov}\left(\frac{L_{ck}}{\bar{L}_{ck}} - \alpha_{ck}^0, \mu_{ck}^*\right) > 0 \quad \Rightarrow \quad \frac{\ell_c}{\ell_c^0} > 1.$$

(ii) *Consider two long-run equilibrium allocations, the "actual" and "counterfactual" allocations, where the latter is the consequence of some trade regime change. The counterfactual equilibrium employment rate in country c,* ℓ'_c*, is greater than its current employment rate,* ℓ_c*, if the trade regime change yields higher real wages and if it reallocates labor towards sectors with a combination of relatively high matching efficiency and education costs:*

$$\hat{\omega}_c > 1 \quad \textit{and} \quad \text{Cov}\left(\frac{L'_{ck} - L_{ck}}{\bar{L}_c}, \mu_{ck}^*\right) > 0 \quad \Rightarrow \quad \hat{\ell}_c > 1.$$

26. We only impose this restriction in order to simplify the interpretation of the results and to ease comparison with extant work on the gains from trade.

27. With Cobb-Douglas preferences and production functions, α_{ck}^0 is a linear combination of all the consumer expenditure shares, α_{ck}, and of all the input-output expenditure shares, γ_{csk}, with $\alpha_{ck}^0 = \alpha_{ck}$ if $\gamma_{ck} = 0$ for all (c, k).

Proof. The proof of *(**ii**)* is by inspection of (38); *(**i**)* is a corollary of *(**ii**)* and follows from $\omega_c/\omega_c^0 > 1$, which holds by Samuelson (1962) and Kemp's (1962) Gains From Trade theorems; in our model, an exact, parsimonious formula for this ratio is available in equation (41) below. *QED.* □

The second part of *(**ii**)* above generalizes Proposition 6 *(iii)* of HI to a multi-sector environment with comparative advantage. Of course, this Proposition leaves open a situation in which the counterfactual allocation is associated with both a higher level of average real wages and a higher unemployment rate. A necessary condition for this to occur is that resources be reallocated towards sectors with low (adjusted) matching efficiencies.

This finding has important implications for trade policy and its accompanying measures. Though more open trade may result in the overall growth of national purchasing power, individual effects are heterogeneous. To the extent that gains from trade are not fully redistributed through unemployment benefits, there are winners and losers in terms of employment. But are there overall gains from trade, namely, does $\hat{\bar{\omega}}_c > 1$ hold? We turn to this issue next.

3.7.2. Gains From Trade with Risk-Averse Workers and Labor Matching Frictions. Here we generalize the Gains-From-Trade formula of Arkolakis, Costinot, and Rodríguez-Clare (2012), henceforth ACR, to our environment with risk-adverse workers and labor matching frictions. To simplify algebra and notation, we rule out input-output linkages, i.e. let $\gamma_{cks} = 0$ for all (c, k, s).[28] We also let $a \in [0, 1)$ and $b_c = 0$ so that $\tilde{\ell}_{ck} = (\ell_{ck})^{\frac{1-a\lambda}{1-a}}$, which allows for neat closed form solutions.[29] Let $\bar{\theta}_c$ define the harmonic weighted average of trade elasticities,

$$\bar{\theta}_c \equiv \left[\sum_{k \in \mathcal{K}} \alpha_{ck} \left(\theta_k \right)^{-1} \right]^{-1},$$

and let us operate the following change of variables for the trade shares:

$$\tilde{\pi}_{cjk} \equiv \left(\pi_{cjk} \right)^{\frac{\bar{\theta}_c}{\theta_k}}. \tag{39}$$

28. See footnote 31 for the more general case.

29. In this case, we can rewrite (38) for changes in ℓ_c and thus in the unemployment rate by $u_c \equiv 1 - \ell_c$. Let

$$\Lambda \equiv 1 - \frac{(1-\lambda)(1-a)}{1-a\lambda}, \qquad \mu_{ck}^{**} \equiv \left(\mu_{ck}^{*} \right)^{\frac{1-\Lambda}{1-\lambda}}$$

collect parameters. Then (38) becomes

$$\hat{\ell}_c \equiv \frac{\ell_c'}{\ell_c} = \left(\hat{\omega}_c \right)^{1-\lambda} \hat{\bar{\mu}}_c^{**}.$$

Then, using (10), (20), (21), and (22), we obtain the following generalized ACR formula:

$$\hat{\tilde{\omega}}_c = \left[\prod_{k\in\mathcal{K}} \left(\hat{\pi}_{cck}\right)^{\frac{\alpha_{ck}}{\theta_k}}\right]^{-\frac{1-a\lambda}{\lambda(1-a)}} = \left(\hat{\bar{\pi}}_{cc}\right)^{-\frac{1-a\lambda}{\bar{\theta}_c\lambda(1-a)}}, \quad \bar{\pi}_{cc} \equiv \prod_{k\in\mathcal{K}} \left(\tilde{\pi}_{cck}\right)^{\alpha_{ck}}. \quad (40)$$

Above, $\bar{\pi}_{cc} \in (0,1)$ is the geometric weighted average of country c's sector-level modified "autarkiness ratios" defined for $j = c$ in (39). The welfare cost of returning to autarky, expressed as a proportion of current real per capita GDP, can be parsimoniously computed as as a special case of the expression above:

$$\frac{\tilde{\omega}_c}{\tilde{\omega}_c^0} = \left(\frac{1}{\bar{\pi}_{cc}}\right)^{\frac{1}{\bar{\theta}_c}\frac{1-a\lambda}{\lambda(1-a)}}. \quad (41)$$

Only three parameters and K statistics are required to compute this measure. Both formulas above encompass the generalizations to multiple sectors due to Ossa (2015), who also allows for input-output linkages, and to endogenous employment due to Heid and Larch (2016). Observe in particular that ACR's gains from trade measure is magnified by a factor $(1-a\lambda)/[\lambda(1-a)] > 1$, which is increasing in the elasticity of employment supply, $1-\lambda$, and in the extent of risk aversion, a. Thus, as in Arkolakis, and Esposito (2015), but with a different mechanism, gains from trade are always higher with an endogenous employment response than in models with inelastic labor and employment supplies.[30] To the best of our knowledge, the extension of the ACR formula of the gains from trade to risk-averse workers is novel.[31]

30. If vacancy costs are paid in units of labor only ($\rho = 0$ in Appendix B) then the expansion effect disappears. In turn, since employment no longer reacts to aggregate changes in prices, the magnification effect disappears from (41), which collapses to Ossa's (2015) generalization of the ACR formula, $\left(\tilde{\omega}_c/\tilde{\omega}_c^0\right) = (1/\bar{\pi}_{cc})^{1/\bar{\theta}_c}$. For any $\rho \in (0,1)$ the ACR formula is a convex combination of the former expression and of (41); Appendix B provides details.

31. In this footnote we briefly sketch the case with input-output linkages. First, using (10), (20), and (21) yields

$$\begin{aligned} p_{ck} &= \frac{\Gamma_k}{\varphi_{ck}} \left(w_{ck}\right)^{1-\gamma_{ik}} \prod_{s\in\mathcal{K}} \left(p_{cs}\right)^{\gamma_{csk}} \left(\pi_{cck}\right)^{\frac{1}{\theta_k}} \\ &= \prod_{s\in\mathcal{K}} \left[\frac{\Gamma_s}{\varphi_{cs}} \left(w_{cs}\right)^{1-\gamma_{cs}} \left(\pi_{ccs}\right)^{\frac{1}{\theta_s}}\right]^{\delta_{csk}}, \end{aligned}$$

where δ_{csk} is the (s,k) element of $(\mathbf{I}-\mathbf{G_c})^{-\mathbf{1}}$, $\mathbf{G}$ is the input-output matrix with (s,k) element γ_{csk}, and

$$\Gamma_k \equiv \left[\Gamma\left(1 - \frac{1-\sigma_k}{\theta_k}\right)\right]^{-\frac{1}{1-\sigma_k}}.$$

Using (10) to substitute for w_{ck} in the expression above, and rearranging, yields

$$\tilde{\omega}_c = \left\{\prod_{k\in\mathcal{K}} \left[\prod_{s\in\mathcal{K}} \left(\frac{\Gamma_s}{\varphi_{cs}}\right)^{\delta_{csk}} \left(\pi_{ccs}\right)^{\frac{\delta_{csk}}{\theta_s}}\right]^{\alpha_{ck}}\right\}^{-\frac{1-a\lambda}{\lambda(1-a)}}$$

In the quantitative work that follows, we work with the general model featuring input-output linkages and unemployment benefits, unless otherwise specified. Additional interactions among the effects that we have uncovered emerge and preclude closed form solutions, but the mechanisms and interactions between trade and labor markets that feature in this Section of course continue to hold in our general environment.

3.8. Short Run

Trade regime changes displace people and destroy jobs and it takes time for workers to change occupations, sectors, or locations. To capture the idea that these shocks are especially disruptive in the short run, we also run counterfactual scenarios keeping labor shares L_{ck} constant, assuming that the indifference condition only holds in the "long run."

In our "short run" counterfactual scenarios, we replace (34) in the system of equations (27)-(36) characterizing the equilibrium conditions in relative changes by

$$\hat{L}_{ck} = 1 \quad \forall c, k. \tag{42}$$

Firms may still open vacancies as they please. Therefore, L_{ck} becomes a sector-specific factor and the short run version of our model is a Specific Factor model.

A final comment is in order. As we explain in the introduction, we use Helpman and Itshoki's (2010) static version of the DMP dynamic model of labor market frictions and equilibrium unemployment for the sake of parsimony. In particular, this approach enables us to use the "hat algebra" and thereby makes our model directly comparable to extant quantitative trade models. A long run equilibrium in our static framework is thus the equivalent of a steady state in a dynamic one. We have explored a dynamic version of our framework using the standard Pissarides (2000) textbook model. In steady state, the continuation values for employed workers are proportional to a linear combination of $\tilde{\omega}_{ck}$ and $\tilde{\omega}_c$ and, for the unemployed workers, of $b_c\tilde{\omega}_{ck}$ and $\tilde{\omega}_c$. As a result, the steady state of this model and the long run equilibrium of our static model share many qualitative properties. Such an equivalence does not hold out of steady state.

4. Data and Estimation Methodology

In this section we take our model to the data. The advantage of characterizing the equilibrium in changes using the "hat notation" is that we only need a

---

so that

$$\hat{\tilde{\omega}}_c = \left\{ \prod_{k\in\mathcal{K}} \left[\prod_{s\in\mathcal{K}} \left(\hat{\pi}_{ccs}\right)^{\frac{\delta_{csk}}{\theta_s}} \right]^{\alpha_{ck}} \right\}^{-\frac{1-a\lambda}{\lambda(1-a)}},$$

of which (40) is a special case.

limited and readily available set of variables (see Section 3.6). As in Caliendo and Parro (2015), we need data on bilateral trade flows π_{ijk}, consumption expenditure shares α_{ck}, the share of value added in production $1 - \gamma_{ck}$, value added Y_{ck}, and input-output linkages γ_{csk}. Turning to trade costs, we also need to compute the ad valorem tariff equivalent of trade barriers impacted in our counterfactuals, namely, applied bilateral tariffs and non tariff barriers (NTB's) removed by the implementation of an RTA. We estimate the ad valorem tariff equivalent of NTB's and the parameter governing comparative advantage within sectors θ_k using a panel gravity equation, as described in Section 4.3. Relative to Caliendo and Parro, we additionally need data on wages by sector w_{ck}, unemployment benefits b_c, and employment rates, ℓ_{ck}. Sectoral employment rates by country are not available for manufacturing sectors; we describe our methodology for estimating these in Section 4.2. Finally, we borrow the value for the parameter governing risk aversion a and for the labor share in the matching process λ from the literature. We describe data sources for each variable and our choices for parameter values in Section 4.1 below.

4.1. Data

Our data have a time dimension but we omit the time subscript to lighten the notation.

4.1.1. Goods and Services . Let us start with goods and services markets. We require data on value added Y_{ik}, gross production E_{ik}, and the intermediary input shares γ_{iks} for all goods and service sectors. Additionally, we also require bilateral trade flows E_{ijk} and trade costs τ_{ijk} for goods sectors. (*i*) We source sector-level bilateral trade flows from the BACI data base assembled by the CEPII. We compute the bilateral trade shares π_{ijk} defined in (22) as $\pi_{ijk} \equiv E_{ijk} / \sum_{i \in \mathcal{C}} E_{ijk}$ and the domestic sales E_{iik} as the difference between gross output and total exports in sector k, $E_{iik} = E_{ik} - \sum_{i' \in \mathcal{C},\, i' \neq i} E_{i'ik}$. (*ii*) Bilateral trade costs τ_{ijk} consist in tariff and non tariff barriers to trade. We source data on tariffs from United Nations Conference on Trade and Development's Trade Analysis Information System (UNCTAD-TRAINS). We use applied bilateral tariffs, namely, preferential applied tariffs when relevant or "Most Favored Nation" (MFN) tariffs when no preferential tariff applies to the exporter-importer-sector-year tuple.[32] To compute an ad valorem tariff equivalent for non tariff barriers removed by the implementation of an RTA, we use an RTA dummy variable that we set to unity if and when both countries belong to the same regional trade agreement. We extract this information from the Word Trade Organization (WTO) database. (*iii*) We define the share of

32. The MFN principle requires that tariff rates applied to members of the Word Trade Organization be non-discriminatory.

value added in production of sector k as $(1-\gamma_{ck}) = Y_{ck}/E_{ck}$ and we source information on value added Y_{ck} and gross production E_{ck} from OECD input-output tables. Input-output tables provide the share of spending in sector k on goods from sector s, γ_{cks}, which are computed as the share of intermediate consumption of goods from sector s by sector k in country c. We compute consumption expenditure shares as $\alpha_{ck} = \left(Y_{ck} + D_{ck} - \sum_{s\in\mathcal{K}} \gamma_{cks} Y_{cs}\right)/I_c$, where the numerator is total expenditure on goods from sector k net of expenditure on intermediate goods, the denominator is total final absorption, and D_{ck} are country-sector trade deficits, which we compute as $D_{ck} = \sum_{j\in\mathcal{C}} E_{cjk} - \sum_{i\in\mathcal{C}} E_{ick}$. *(iv)* For the gravity estimation of trade elasticities in Section 4.3, we use a sample of 60 importer countries (for which the necessary production data was available for imputation of domestic trade), 207 exporter countries, 23 tradables sectors (2-digit ISIC Revision 3) and 10 years (2000-2009). For the counterfactual exercises in Section 5, we use a balanced sample of $C = 61$ countries made of 60 actual countries and a constructed rest of the world for year 2008. Appendix C provides further details on the computation of variables in case of missing observations and for the rest of the world.

4.1.2. Labor Markets. The labor market part of the model requires using data on sectoral employment rates ℓ_{ck}. When available, we compute country-specific sectoral employment rates using annual data on sectoral employment and unemployment levels reported in the Key Indicators of the Labor Market (KILM) database of the International Labor Office (ILO).[33] Data on both sector-specific unemployment and sectoral production are available over the period 2001-2008 (eight years) for a set of 31 OECD countries, henceforth "OECD-31".[34] Data for the employment rates ℓ_{ck} are only available for 14 non-manufacturing sectors. We thus need to estimate ℓ_{ck} for the remaining 20 (manufacturing) sectors.[35] For this purpose, as we explain in Section 4.2 below, we compute country-sector wages w_{ck} as the total sectoral labor bill divided by number of employees, both of which we source from the OECD STAN database. The OECD STAN database also provides a measure of average unemployment benefits at the

33. Specifically, we define the employment rate in sector k as $\ell_{ckt} = H_{ckt}/(U_{ckt} + H_{ckt})$, where H_{ckt} is the number of workers currently employed in sector k and U_{ckt} is the number of workers who are currently unemployed and whose last job was in sector k. This definition of sectoral unemployment is the exact empirical counterpart of ℓ_{ckt} in our static model. We also compute the sector-specific unemployment rates u_{ckt} as the fraction of workers searching for a job in sector k but unable to form a match, i.e. $u_{ckt} = 1 - \ell_{ckt}$.

34. The set of 31 OECD countries is Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italia, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, and United States of America.

35. The US census reports employment rates for all 34 sectors; we use the 20 manufacturing sectors in the US to compare our empirical predictions with actual data as an external validity check (see Section 4.2).

country level, b_c. We define b_c as the initial unemployment benefits as a share of the last wage for a single person without children who was previously earning the average national wage. We proxy education costs f_{ck} using the average share of high-school graduates per sector that we source from the US census. We set the matching elasticity at the midpoint of Petrongolo and Pissarides' (2001) plausible range, $\lambda = 0.6$; we test the robustness of our results for a range of values of λ in $[0.3, 0.9]$ in Appendix E. Finally, we set the parameter for risk aversion at $a = 2$, as is standard in the Macroeconomics literature (Appendix E reports results for risk-neutral workers, $a = 0$).

4.2. Sectoral Employment Rates

Computing counterfactual scenarios requires values for the baseline β_{ck} defined in (14), which we recall here for convenience:

$$\beta_{ck} = \left[\ell_{ck} + (1 - \ell_{ck})\,(b_c)^{1-a}\right]^{\frac{1}{1-a}}.$$

We need a measure of ℓ_{ck} for each sector and country, but such a measure is available for 14 non-manufacturing sectors only. We thus estimate β_{ck} for the remaining 20 manufacturing sectors.

We start with the 14 sectors for which sector-specific unemployment rates ℓ_{ck}, and therefore β_{ck}, are available (Table 1 provides a list). Taking logs of (15) and of the indifference condition (16), and rearranging, yields:

$$\ln \beta_{ck} = \ln \tilde{\omega}_c - \ln \omega_{ck} + \ln f_{ck},$$

which can be estimated by running the fixed effect regression:

$$\ln \beta_{ck} = FE_c + \delta^w \ln w_{ck} + \delta^f \ln \text{skill}_k + \text{error}_{ck}, \tag{43}$$

where error_{ck} is measurement error in β_{ck}, skill_k is the US skill composition by sector, which we use as a proxy for f_{ck}, w_{ck} is the wage bill per worker in country c, sector k, and FE_c is a country fixed effect that lumps together $\ln \tilde{\omega}_c + \ln \mathbb{P}_c$ and any country-specific systematic component of f_{ck}/f_k. We use the average values of β_{ck}, skill_k, and w_{ck} over 2001-2008 in order to purge short-term fluctuations. We then run this regression for these 14 sectors in our OECD-31 sample of countries. In line with the qualitative predictions of the model, the estimated wage coefficient is statistically negative at $\delta^w = -0.18$ (with a standard error, clustered at the country level, of 0.0048) and the estimated coefficient on the sector-specific education costs is statistically positive and equal to $\delta^f = 0.24$ (with a clustered standard error of 0.032). The adjusted R^2 is 0.71.

We then use the regression above to predict the β_{ck} for the 20 manufacturing sectors for which employment rates are not available for our OECD-31 sample of countries for the period 2001-2008. Data for w_{ck} and skill_k are available for all 34 sectors and we assume the estimated coefficients to be constant across sectors and countries. We report the median of the relative predicted β_{ck}'s by sector and the associated standard errors in Table 1.[36] The reference sector within each country is "80 Education." The use of the reference sector allows us to compare the within-country ranking of β_{ck}'s without the interference of the country fixed-effect in (43) (i.e. the country-specific real certainty equivalent wage). This ranking is also the relevant measure that governs the within-country reallocation effect in our quantitative exercises in Section 5. We also plot the distribution of the associated relative ℓ_{ck}'s for each sector in Figure 2.[37]

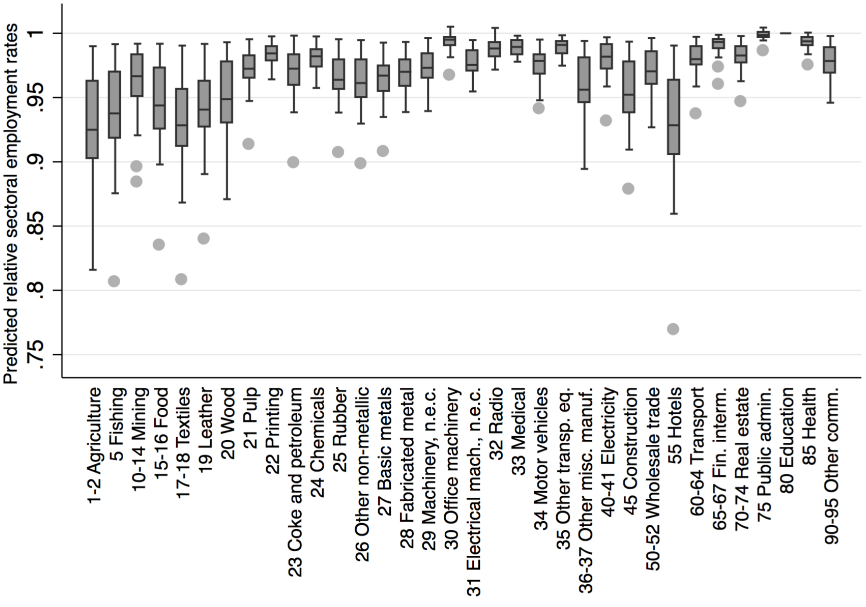


FIGURE 2. Estimated Relative ℓ_{ck}, 31 OECD Countries, 2001-2008. The Figure reports the estimated relative sectoral employment rates (estimated using sectoral data on OECD wages and US educational costs as described in Section 4.2), averaged over the period 2001-2008. For each sector the figure reports the "box" with the median, the 25th and 75th percentiles, the "whiskers" report the upper and lower adjacent values and the points correspond to outside values (i.e. not within the "whiskers") of the estimated ℓ_{ck}, relative to the reference sector, namely "80 Education". Source: Authors' calculations.

36. These estimates are within-sample predictions for the 14 non-manufacturing sectors and out-of-sample predictions for the 20 manufacturing sectors. There are $C = 31$ estimates per sector and Table 1 reports the median value for each $k \in \mathcal{K}$.

37. Fewer than 2 percent of estimated ℓ_{ck} (in levels) are larger than 1, but none of them are significantly different from 1. We set these values to 1. We report statistics on the distribution of ℓ_{ck} in Appendix A.

Table 1. Measures and Estimates of Median β_{ck}

ISIC Sectors	Measured β_{ck}	*sd error*	Estimated β_{ck}	*sd error*
1-2 Agriculture, hunting and forestry	0.9954	0.0275	0.9518	0.0039
5 Fishing	0.9855	0.0566	0.9575	0.0039
10-14 Mining and quarrying	0.9839	0.0240	0.9733	0.0083
15-16 Food, beverages and tabacco products			0.9623	0.0021
17-18 Textiles, wearing apparel, dressing and dyeing of fur			0.9539	0.0023
19 Leather, leather products and footwear			0.9611	0.0023
20 Wood and products of wood and cork			0.9657	0.0026
21 Pulp, paper and paper products			0.9835	0.0025
22 Printing and publishing			0.9898	0.0021
23 Coke, refined petroleum products and nuclear fuel			0.9795	0.0046
24 Chemicals and chemical products			0.9865	0.0025
25 Rubber and plastics products			0.9764	0.0016
26 Other non-metallic mineral products			0.9736	0.0018
27 Basic metals			0.9781	0.0024
28 Fabricated metal products, except machinery and equipment			0.9805	0.0018
29 Machinery and equipment, n.e.c.			0.9821	0.0017
30 Office, accounting and computing machinery			0.9961	0.0034
31 Electrical machinery and apparatus, n.e.c.			0.9853	0.0018
32 Radio, television and communication equipment			0.9920	0.0033
33 Medical, precision and optical instruments			0.9929	0.0020
34 Motor vehicles, trailers and semi-trailers			0.9848	0.0023
35 Other transport equipment			0.9935	0.0022
36-37 Other miscellaneous manufacturing			0.9715	0.0021
40-41 Electricity, gas and water supply	0.9983	0.0118	0.9858	0.0023
45 Construction	0.9704	0.0312	0.9682	0.0018
50-52 Wholesale and retail trade - repairs	0.9815	0.0261	0.9804	0.0019
55 Hotels and restaurants	0.9545	0.0467	0.9519	0.0022
60-64 Transport, storage and communications	0.9900	0.0190	0.9860	0.0017
65-67 Financial intermediation	0.9975	0.0143	0.9936	0.0021
70-74 Real estate, renting and business activities	0.9818	0.0232	0.9868	0.0023
75 Public admin. and defense - compulsory social security	1.0009	0.0139	0.9986	0.0020
80 Education	1	-	1	-
85 Health and social work	0.9961	0.0075	0.9947	0.0013
90-95 Other community, social and personal services	0.9708	0.0250	0.9829	0.0032

Note: The table displays measurement and estimates of relative β_{ck} for 14 and 34 ISIC Rev 3 sectors respectively. The relative sector within each country is "80 Education". Column (1) reports the ISIC Rev 3 classication code and sector description. Columns (2) and (3) report the median relative β_{ck} measured for the 14 sectors for which ℓ_{ik} is available, and the associated standard error. Columns (4) and (5) report the median relative β_{ck} estimated for the 34 sectors according to (43) (within sample prediction for the 14 non-manufacturing sectors / out-of-sample prediction for the 20 manufacturing sectors), and the associated standard error. The median values for the relative β_{ck}'s are taken over the country dimension, $c \in \mathcal{C}_{\mathrm{OECD}-31}$. Source: Authors' calculations.

The sectors with the lowest median relative employment rates are Sectors "1-2 Agriculture, Hunting and Forestry" and "55 Hotels and Restaurants"; the sector with the highest employment rate is "80 Education" (the reference sector). Among manufacturing sectors, the lowest estimated ℓ_{ck} is in "17-18 Textiles and Textile Products" and the highest one is in "30 Office, Accounting and Computing Machinery."

As an external validity test, consider Figure 3, which plots the estimated levels of ℓ_{ck}'s for the US against their observed counterparts, which we compute as per footnote 33 using data from the US census on average over 2001-2008. The advantage of using these data for validation is that we observe unemployment rates for manufacturing sectors as well. The correlation between predicted and observed employment rates is reassuringly high (0.75 for all sectors, and 0.62 for manufacturing sectors).

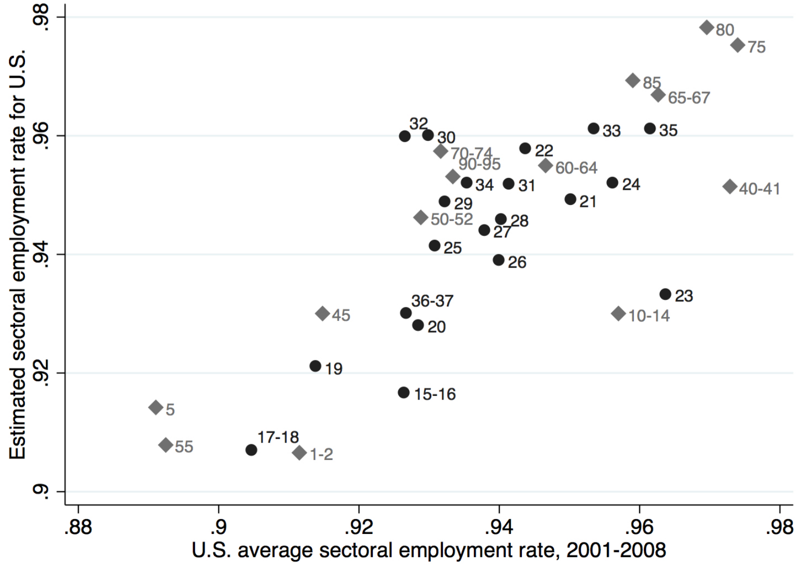


FIGURE 3. Correlation Between Estimated ℓ_{ck} and US Sectoral Employment Rates. The Figure reports the correlation between the estimated sectoral employment rates for the US (estimation described in Section 4.2) and the observed sectoral employment rates in the US, averaged over the period 2001-2008. Labels indicate ISIC Rev 3 sector classifications (see Table 1). Manufacturing sectors are shown in black dots, non-manufacturing sectors in gray diamonds. We calculate the employment rate from US census data as the share of employed workers in the industry over the sum of employed workers in the industry and unemployed workers that were previously employed in the industry. Source: US census data and authors calculations.

4.3. Trade Elasticities

We use a gravity equation to estimate the elasticity of trade with respect to bilateral trade costs. Using expressions (20), (21), and (22), taking logs and explicitly allowing for time variation yields:

$$\ln E_{ijkt} = -\theta_k \ln \tau_{ijkt} - \theta_k \ln \frac{z_{ikt}}{\varphi_{ikt}} + \theta_k \ln T_{jkt} + \ln E_{jkt},$$

where E_{ijkt} is the value of imports of country j from country i in sector k and year t. We assume that bilateral trade frictions obey:

$$\tau_{ijkt} \equiv (1 + \text{tariff}_{ijkt}) \left(d_{ij}\right)^{\delta^d} \times \exp\left(\delta^{rta}\text{rta}_{ijt} + \delta^{other}\text{other}_{ij}\right),$$

where tariff_{ijkt} is the ad valorem tariff rate that country j imposes on sector k imports from country i in year t, rta_{ijt} is a dummy variable equal to one if a regional agreement is in force between i and j in year t. Other components of the bilateral trade friction such as the distance between countries i and j (d_{ij}) or the vector other_{ij} (which includes traditional gravity dummies such as contiguity, common language or past colonial relationship) are country-pair specific and time invariant, and are thus captured by country-pair fixed effects. Plugging this expression for τ_{ijkt} into the expression for E_{ijkt} above, and adding an error term, we may write the resulting expression as the following gravity equation:

$$\ln E_{ijkt} = -\theta_k \ln (1 + \text{tariff}_{ijkt}) + \upsilon_k \text{rta}_{ijt} + FE_{ij} + FE_{ikt} + FE_{jkt} + \varepsilon_{ijkt}, \tag{44}$$

where $FE_{ikt} = -\theta_k \ln(z_{ikt}/\varphi_{ikt})$, $FE_{jkt} = \theta_k \ln T_{jkt} + \ln E_{jkt}$, and $FE_{ij} = -\theta_k \delta^d \ln d_{ij} - \theta_k \delta^{other}\text{other}_{ij}$ are exporter-sector-year, importer-sector-year, and country-pair fixed effects, respectively, $\upsilon_k = -\theta_k \delta^{rta}$ collects parameters, and ε_{ijkt} is measurement error in E_{ijkt}.

We estimate the coefficients of this gravity equation using a balanced sample of 60 importer countries, 207 exporter countries, 23 tradable sectors and 10 years from 2000 to 2009 (2,856,600 observations). Table 2 reports estimates for θ_k, which are in the range $[0.73, 25.38]$.[38] Our results are in line with those of Caliendo and Parro (2015), who use a similar level of sector aggregation. The correlation between our set of estimates and theirs (Table 1, Column 1, in Caliendo and Parro, 2015) is 0.78. See also Ossa (2015) for a more disaggregated set of estimates. Not allowing for sector specific coefficients for the RTA dummy gives a coefficient of 0.34, which is in line with the mean value of 0.36 reported in the meta-analysis of Head and Mayer (Table 3.4 of Head and Mayer, 2014, mean coefficient for structural gravity).

38. In order to be consistent with the model we set a value of 1 to the only sector, “36-37 Other miscellaneous manufacturing”, whose θ_k is lower than, but not significantly different from, unity (see Table 2).

TABLE 2. Estimates of Trade Elasticities and Ad Valorem Tariff Equivalent for Non Tariff Barriers, Per Sector

ISIC Sectors	θ_k	*sd error*	v_k	*sd error*	ave_{ijk}
1-2 Agriculture, hunting and forestry	4.00	*0.30*	0.09	*0.08*	0.02
5 Fishing	7.41	*0.79*	0.08	*0.10*	0.01
10-14 Mining and quarrying	12.51	*3.11*	1.08	*0.09*	0.09
15-16 Food, beverages and tabacco products	1.64	*0.19*	0.16	*0.07*	0.11
17-18 Textiles, wearing apparel, dressing and dyeing of fur	3.02	*0.45*	0	-	0
19 Leather, leather products and footwear	5.91	*0.69*	0.13	*0.07*	0.02
20 Wood and products of wood and cork	12.25	*0.84*	0.26	*0.07*	0.02
21 Pulp, paper and paper products	3.94	*0.94*	0.86	*0.06*	0.24
22 Printing and publishing	9.62	*0.97*	0.32	*0.06*	0.03
23 Coke, refined petroleum products and nuclear fuel	25.38	*2.27*	1.13	*0.10*	0.05
24 Chemicals and chemical products	6.55	*1.06*	0.27	*0.06*	0.04
25 Rubber and plastics products	4.63	*0.58*	0.42	*0.05*	0.10
26 Other non-metallic mineral products	5.20	*0.64*	0.24	*0.06*	0.05
27 Basic metals	15.71	*1.29*	1.02	*0.07*	0.07
28 Fabricated metal products, except machinery and equipment	8.30	*0.65*	0.21	*0.05*	0.03
29 Machinery and equipment, n.e.c.	3.02	*0.89*	0	-	0
30 Office, accounting and computing machinery	19.76	*2.24*	0	-	0
31 Electrical machinery and apparatus, n.e.c.	4.39	*0.80*	0	-	0
32 Radio, television and communication equipment	2.94	*0.90*	0	-	0
33 Medical, precision and optical instruments	2.73	*1.33*	0	-	0
34 Motor vehicles, trailers and semi-trailers	4.59	*0.54*	0.74	*0.07*	0.17
35 Other transport equipment	2.76	*0.71*	0.55	*0.07*	0.22
36-37 Other miscellaneous manufacturing	1	-	0.22	*0.06*	0.24

Note: The table displays estimates of coefficients for 23 tradable sectors classified according to ISIC Rev 3 (adjusted $R^2 = 0.8$). Column (1) reports the ISIC Rev 3 classication code and sector description. Columns (2) and (3) report the coefficient estimates on tariff (θ_k) and the clustered (country-pair) standard errors, respectively. We set a value of 1 to the only sector, "Other miscellaneous manufacturing," whose θ_k is lower than (but not significantly different from) 1. Columns (4), (5) and (6) report the coefficient estimates on the RTA dummy ($v_k = -\theta_k \delta^{rta}$), the clustered (country-pair) standard errors, and the associated ad valorem tariff equivalent (ave_{ijk}), respectively. We impute a value of zero for non significant estimates of v_k. We estimate equation (44) using a balanced sample of 60 importing countries, 207 exporting countries, 23 tradable sectors and 10 years from 2000 to 2009 (2,856,600 observations). Sections 4.1 and 4.2 provide details. Source: Authors' calculations.

We compute the ad valorem tariff equivalent for NTB's removed by the implementation of an RTA as follows:[39]

$$\text{ave}_{ijk} \equiv \exp\left(\frac{\hat{v}_k}{\hat{\theta}_k}\text{rta}_{ijt}\right) - 1.$$

Table 2 reports the estimates for ave_{ijk}. They are in the range $[0, 0.24]$. Finally we compute τ_{ijk} as

$$\tau_{ijkt} = (1 + \text{tariff}_{ijkt})\,(1 + \text{ave}_{ijkt})\,.$$

5. Unemployment and Welfare Effects of Trade Policy Regime Changes: Quantification

In this section we compute two counterfactual scenarios. We explain the procedure that we implement in Appendix D. Sections 5.1 and 5.2 respectively report the counterfactual long run unemployment and welfare effects of repealing NAFTA and of implementing the US-Mexico-Canada Agreement (USMCA) with collateral damages on the car industry. In each case, we decompose changes in the unemployment rate into the expansion and reallocation effects, and we also report changes in real GDP per capita to facilitate comparison with the outcomes of alternative quantitative trade models. We also compute the short run unemployment and welfare effects for each scenario. Appendix F explains how we compute standard errors and reports them in Table F.1.

5.1. The Wall Scenario

The forty-fifth president of the United States, after his election to the White House, has repeated his intention to repeal NAFTA – the "worst trade deal ever" – and impose duties on imports from Mexico. What would be the real wage, unemployment, and welfare consequences of such a bold move? In order to provide a quantitative answer to this question, one needs to make three specific sets of assumptions. First, what tariff rate would the US administration impose on imports from Mexico? Several rates have been mused about, from 16 percent, which corresponds to the rate of the value added tax in Mexico and which is rebated to Mexican firms upon exporting (and thus amounts to an "unfair" export subsidy, according to the former Commerce Secretary Willbur Ross) to 35 percent, which would apply to companies that move jobs to Mexico (Head and Mayer, 2016). We use the median value of 20 percent, which was touted by the then White House Press Secretary Sean Spicer on January 26,

39. We impute a value of zero for non significant estimates of v_k, see Table 2.

2017, as a way to pay for the wall that President Trump intends to complete along the Mexico-US land border. Repealing NAFTA amounts to more than raising tariff barriers. We thus add to bilateral trade frictions the ad valorem tariff equivalent of NTB's that were removed by the implementation of the RTA between Mexico and the US as estimated in our gravity regression in Section 4.3.

Second, what should we assume about Mexico's response? We follow Head and Mayer (2016) and take the then Secretary of Economy Ildefonso Guajardo's threat "to retaliate right away" seriously by assuming that Mexico would match the 20 percent tariff rate. Third, what would happen to Canada's bilateral relationships with Mexico and the US? We assume that CUFTA would remain in place and that Mexico and Canada would retain a NAFTA-light between them by setting the Canada-US and the Canada-Mexico RTA dummies to unity and leaving their bilateral tariffs unchanged.

Finally, what are the consequences for the multilateral trading system? Indeed, imposing a 20 percent tariff rate on Mexican imports violates the General Agreements on Tariffs and Trade (GATT) MFN principle, for this level is much higher than current US MFN tariffs. Here, we assume that the WTO would allow Mexico to retaliate and impose 20 percent tariffs on US imports.

Table 3 reports the results of this scenario that we refer to as the Wall Counterfactual.[40] All values are in percent. The top panel of Table 3 reports results for NAFTA members; the bottom panel reports results for the remaining countries of our OECD-31 sample. Column (1) displays the unemployment rate of the base year (2008); all other columns report predicted changes under the Wall counterfactual relative to the actual values in the base year, with Columns (2) to (5) and Columns (6) and (7) referring to the long run and short run versions of the scenario, respectively.

Column (2) reports the overall impact on the unemployment rates in the long run in percentage changes, $(\hat{u} - 1) \times 100$, which is decomposed into the welfare and reallocation effects in Columns (3) and (4), respectively.[41] Column (3) reports the welfare change measured as $(\hat{\tilde{\omega}}_c - 1) \times 100$. We compute the reallocation effect as a residual and we report the results in Column (4).[42]

40. With apologies to Roger Waters and Pink Floyd fans.

41. Recall from Section 3.3 that our measure of welfare is the certainty-equivalent expected real wage. Recall also from equation (38) that $(\hat{\tilde{\omega}}_c)^{1-\lambda}$ corresponds to the expansion effect; we do not explicitly report $[(\tilde{\omega}_c)^{1-\lambda} - 1] \times 100$ in order to avoid a proliferation of columns. Finally, recall that the reallocation effect arises as a result of the reallocation of workers across sectors characterized by heterogeneous matching frictions.

42. Specifically, we use (18) to compute this effect as

$$\frac{1}{\bar{\mu}_c^*} \operatorname{Cov}\left(\frac{L'_{ck} - L_{ck}}{\bar{L}_c}, \mu_{ck}^*\right) \times 100 = \left[\frac{\hat{\tilde{\ell}}_c}{\left(\hat{\tilde{\omega}}_c\right)^{1-\lambda}} - 1\right] \times 100.$$

Table 3. Changes in Welfare and Unemployment Rates under the Wall Counterfactual (in Percent)

		Long Run (in percent)				**Short Run** (in percent)	
Country	u_c^{2008}	$\hat{u}_c - 1$ Unemployment	$\hat{\hat{\omega}}_c - 1$ Welfare	$\frac{1}{\bar{\mu}_c^*}\text{Cov}\left(\frac{L'_{ck}-L_{ck}}{L_c}, \mu^*_{ck}\right)$ Reallocation	$\hat{\bar{\omega}}_c - 1$ Real GDP P.C.	$\hat{u}_c{}^{SR} - 1$ Unemployment	$\hat{\hat{\omega}}_c^{SR} - 1$ Average Welfare
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NAFTA members							
Canada	6.1	-0.487	0.044	0.008	0.038	-2.728	0.290
Mexico	3.9	48.337	-6.637	-0.214	-3.801	126.393	-12.459
USA	5.8	2.389	-0.306	-0.003	-0.273	3.501	-0.179
Other OECD members							
Australia	4.2	-0.110	0.000	0.007	-0.010	-1.181	0.195
Austria	4.1	-0.120	0.010	0.001	0.008	-0.349	0.016
Belgium	7.0	-0.040	0.006	0.000	0.005	-0.197	0.018
Czech Rep.	4.4	-0.067	0.006	0.001	0.005	-0.290	0.013
Denmark	3.4	-0.049	0.002	0.001	0.002	-0.388	0.014
Estonia	5.5	0.025	-0.004	0.000	-0.004	-0.302	0.013
Finland	6.4	-0.059	0.008	0.000	0.007	-0.071	0.004
France	7.1	0.050	-0.007	0.000	-0.008	0.031	-0.036
Germany	7.5	-0.093	0.014	0.001	0.012	-0.276	0.017
Greece	7.8	0.024	-0.009	0.000	-0.006	-0.721	0.164
Hungary	7.8	-0.067	0.013	0.001	0.009	-0.337	0.036
Iceland	3.0	-0.335	0.021	0.005	0.011	-0.710	0.074
Ireland	6.8	0.213	-0.062	0.004	-0.042	-0.047	0.013
Israel	7.7	-0.226	0.025	0.005	0.022	-0.664	0.058
Italy	6.7	-0.052	0.006	0.001	0.005	-0.246	0.014
Japan	4.0	-0.195	0.021	-0.001	0.018	-1.163	0.049
Netherlands	2.8	-0.214	0.010	0.001	0.009	-0.672	0.019
New Zealand	4.2	-0.299	0.017	0.012	-0.003	-1.426	0.221
Norway	2.6	0.171	-0.010	0.001	-0.010	-0.145	0.006
Poland	7.1	-0.081	0.012	0.002	0.007	-0.376	0.065
Portugal	7.6	0.209	-0.001	-0.011	-0.005	0.341	-0.088
Slovakia	9.5	-0.051	0.008	0.001	0.008	-0.131	0.007
Slovenia	4.4	-0.124	0.009	0.001	0.008	-0.409	0.012
South Korea	3.2	-0.791	0.063	0.001	0.050	-1.954	0.085
Spain	11.3	-0.099	0.024	0.001	0.022	-0.396	0.046
Sweden	6.2	0.025	-0.004	0.000	-0.004	-0.170	0.007
Switzerland	3.4	-0.001	0.007	-0.003	0.002	-0.048	-0.005
United Kingdom	5.6	-0.145	0.040	0.005	0.005	-0.924	0.311

Note: All values are in percent. Column (1) reports the national unemployment rate in 2008 (source: ILO). Columns (2)-(5) report long run results of a simulation based on 60 countries and a constructed rest of the world for which sufficient data is available in year 2008. We set the matching elasticity to $\lambda = 0.6$. Column (2) reports the relative change in the unemployment rate calculated according to equation (38). Column (3) reports the change in the welfare as per equation (34). Column (4) reports the "reallocation effect" calculated as $[\hat{\hat{\ell}}_c/(\hat{\bar{\omega}}_c)^{1-\lambda} - 1] \times 100$, where $\hat{\hat{\ell}}_c$ is a theory-consistent measure of the employment rate defined in equation (18) (values not reported in the Table); Column (5) reports the change in real GDP per capita (net of education costs), calculated as $\left(\sum_{k\in\mathcal{K}} L'_{ck}\bar{\omega}'_{ck}\right) / \left(\sum_{k\in\mathcal{K}} L_{ck}\bar{\omega}_{ck}\right)$. Columns (6) and (7) report short run changes in average welfare and national unemployment rate, where $\hat{\hat{\omega}}_c^{SR} = \sum_{k\in\mathcal{K}} L_{ck}\hat{\hat{\omega}}_c^{SR}$. Source: Authors' calculations.

Let

$$\bar{\omega}_{ck} \equiv \frac{\omega_{ck}\left[\ell_{ck} + (1-\ell_{ck})\, b_c\right]}{f_{ck}}$$

define sector-specific average real earnings net of skill acquisition costs and let

$$\bar{\omega}_c \equiv \sum_{k\in\mathcal{K}} L_{ck}\bar{\omega}_{ck} \tag{45}$$

define real GDP per capita. It is an alternative metric to assess the normative implications of policy changes. The outcome of this criterion is readily comparable to those of quantitative trade models that do not feature labor market frictions, skill acquisition costs, unemployment benefits, or risk-averse workers. Note that real GDP per capita and welfare are identical when workers are neutral towards risk (i.e. $a = 0$ implies $\bar{\omega}_c = \tilde{\omega}_c$ and $\bar{\omega}_{ck} = \tilde{\omega}_{ck}$ for all k). Column (5) reports the estimated changes in real GDP per capita in percents, $(\hat{\bar{\omega}}_c - 1) \times 100$, where

$$\hat{\bar{\omega}}_c \equiv \frac{\bar{\omega}'_c}{\bar{\omega}_c} = \frac{\sum_{k\in\mathcal{K}} L'_{ck}\bar{\omega}'_{ck}}{\sum_{k\in\mathcal{K}} L_{ck}\bar{\omega}_{ck}}. \tag{46}$$

When workers are risk-averse, sector-specific average real earnings are not equalized across sectors in equilibrium because workers put a higher weight on the probability of finding a job than if they are risk-neutral; it is then entirely conceivable that some shock may pull welfare $\tilde{\omega}_c$ and real GDP per capita $\bar{\omega}_c$ in opposite directions.[43] This case is not purely theoretical: in New Zealand welfare increases even as real GDP per capita falls. How can that be? This outcome arises because unemployment falls sufficiently to compensate risk-averse workers for the reduction in average real earnings. In the case of NAFTA countries, the unemployment and welfare effects work in opposite directions, which implies that changes in real GDP per capita are smaller in absolute value than changes in welfare. Finally, Columns (6) and (7) report the impact on the unemployment rates in the short run $(\hat{u}_c^{SR} - 1) \times 100$ and the associated average welfare effect $(\hat{\tilde{\omega}}_c^{SR} - 1) \times 100$. Note that the short run scenario does not display any reallocation effect by construction.

Five results are noteworthy. First, this policy hurts Mexico badly. In the long run, unemployment would increase by 48 percent (from 3.9 percent to

43. For instance, assume that a shock raises welfare by the same fraction in all sectors, i.e. $\hat{\tilde{\omega}}_c = \hat{\tilde{\omega}}_{ck} = 1 + \varepsilon$, some $\varepsilon > 0$. Assume also that this shock lowers average real earnings in all sectors in the same proportion, i.e. assume $\hat{\bar{\omega}}_{ck} = 1 - \varphi$, some $\varphi > 0$. As a result of the equiproportional change in welfare, no worker switches sectors so that $\hat{\bar{\omega}}_c = 1 - \varphi$ by (46), namely, real GDP per capita falls. By (16), $\hat{\bar{\omega}}_c = \hat{\bar{\omega}}_{ck} = 1 - \varphi$ and $\hat{\tilde{\omega}}_c = \hat{\tilde{\omega}}_{ck} = 1 + \varepsilon$ together imply that sectoral employment rates increase in a heterogeneous fashion. To see this point, note that $\bar{\omega}_{ck} = \tilde{\omega}_{ck}\psi_{ck}$, where $\psi_{ck} \equiv [\ell_{ck} + (1 - \ell_{ck})b_c][\ell_{ck} + (1 - \ell_{ck})/b_c]$ if $a = 2$, hence $\hat{\psi}_{ck} = 1 - \varphi + \varepsilon$; since ψ_{ck} is a second-order polynomial transformation of ℓ_{ck}, the result immediately follows. To summarize, we have constructed a case in which welfare and real GDP per capita move in opposite directions because of risk aversion only (there is no reallocation of workers across sectors in this example by construction).

5.8 percent of the workforce), while welfare and real GDP per capita would fall by 6.6 percent and 3.8 percent, respectively.[44] Second, as far as the American worker is concerned, this policy backfires. In the US, welfare and real GDP per capita would fall by 0.31 percent and 0.27 percent respectively, and unemployment would actually increase by 2.4 percent. Third, trade diversion would actually help Canadian workers somewhat – not the natural Trump constituency – by lowering unemployment in Canada by 0.49 percent. Fourth, the long run impacts on employment in third countries are very small and mainly positive (the unemployment rate falls in majority of the countries).[45] Finally, the short run and long run effects on welfare and unemployment are qualitatively similar. In terms of unemployment, in the short run this policy hurts both Mexican and US workers more than in the long run.[46]

In the long run we are all dead, goes the famous Keynesian quip, and all US Presidents leave office after eight years at most. The current US President may also have his eyes on some specific sectors only. For these reasons, we plot short run and long run employment changes by sector for the US (panel A) and Mexico (panel B) in Figure 4. In each panel, the horizontal axis reports changes in the employment rates in percent, $(\hat{\ell}_{ck} - 1) \times 100$, and the vertical axis lists sectors by ISIC Rev 3 number. Short run changes are reported in black dots and sectors are identified with their ISIC Rev 3 label; long run changes are reported in gray diamonds. In the long run, workers are mobile and welfare and employment

44. All results that we discuss are statistically significant at the five percent confidence level unless specified otherwise. In order not to clutter the main Tables, we report bootstrapped standard errors for the member countries of each scenario in Appendix Table F.1. See Appendix F for details.

45. Note that, except for Mexico, the magnitude of the predicted changes in real GDP per capita is small. One reason for this result has to do with our using of trade data at a fine level of disaggregation, which tends to produce smaller quantitative effects than when using more aggregated data (Costinot and Rodríguez-Clare, 2014). For instance, Costinot and Rodríguez-Clare (2014) simulate the real wage effect of the imposition of a unilateral US tariff of 40 percent across the board assuming that all tariffs are zero in the initial equilibrium. They find a world average real GDP per capita effect of -0.2 percent in the one sector framework and -0.14 percent when allowing for multiple sectors. We also include non-tradable sectors, which further reduces the estimates of changes.

46. This result is the outcome of a composition effect. In the short run, employment rates grow proportionally to production. Insofar as the sectors that receive the largest shocks are also the biggest sectors in terms of labor shares, then short run effects can be larger than long run effects, and vice versa. There is no such composition effect in the long run because labor moves freely across sectors and all sectoral employment rates are affected in the same proportion.

shift proportionately in all sectors.[47] In the short run, workers are stuck in the sector they had chosen prior to the shock and employment rates may vary widely across sectors. Ironically, in the US employment falls the most in one of the most sensitive sectors, "Motor Vehicles, Trailers and Semi-Trailers" (Sector 34 in ISIC Rev 3). Sectors "Basic metals" and "Fabricated metals" (Sectors 27 and 28, respectively, in ISIC Rev 3) are also negatively affected in terms of employment, which is further ironic given President Trump's vows to protect US steel workers through the repeal of NAFTA. Employment changes are much larger on average in Mexico (from −23% to +5%) than in the US (from −1.9% to +0.2%), reflecting the fact that the US is a more important trading partner to Mexico than the other way around.

We report a series of sensitivity analyses in Appendix E. The qualitative results of the Wall scenario on welfare and unemployment are robust to plausible alternative choices of parameter values. The quantitative results are also fairly stable. First, we study the sensitivity of our results to the parameterization of λ within the range $[0.3, 0.9]$ (Petrongolo and Pissarides, 2001). Most of our quantitative results are robust to these changes. The quantitative results for Mexico are the most sensitive; even then, the magnitude changes by a factor 1.7 at most. Second, we assume that workers are risk-neutral and we set unemployment benefits to zero ($a = b_c = 0$); our results are remarkably stable here (see Appendix A for a quantitative explanation). Third, we additionally impose skill acquisition costs to be homogeneous across sectors (we set $a = b_c = 0$, $f_{ck} = f_c$) and we take the limiting case $\lambda = 1$, which leads to zero equilibrium unemployment; such a model closely resembles Caliendo and Parro's (2015).[48] Comparing the different sensitivity analyses it becomes apparent that not accounting for unemployment effects underestimates the welfare effects of trade for some countries.

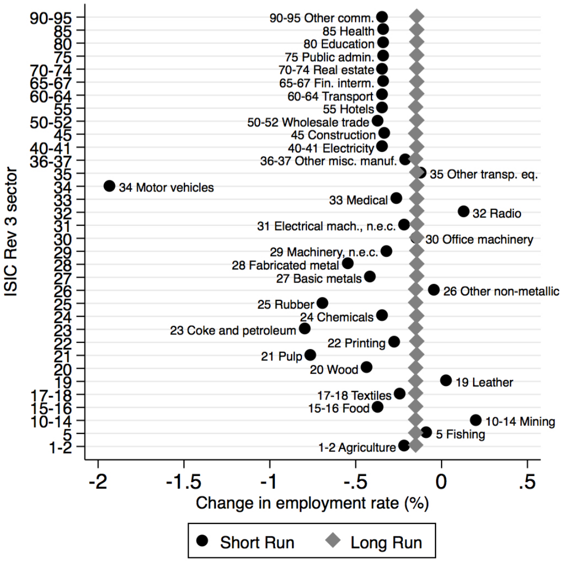
47. To see this point, note that $\hat{\tilde{\omega}}_{ck} = \hat{\tilde{\omega}}_c$ by the indifference condition (34). From (17), equilibrium changes in our theory-consistent sector-specific employment rates are equal to

$$\forall k: \qquad \hat{\tilde{\ell}}_{ck} = \left(\hat{\tilde{\omega}}_c\right)^{1-\lambda},$$

which are invariant across sectors. When sector-specific employment rates are close to unity to start with (empirically they are typically well above 0.5), and when λ is large enough (our benchmark, at $\lambda = 0.6$, is above 0.5), then the actual and theory consistent rates evolve closely, $\hat{\tilde{\ell}}_{ck} \approx \hat{\ell}_{ck}$, as can be seen from Figure 4. Hence, employment shifts (almost) proportionately in all sectors.

48. Our results in this scenario are slightly larger in magnitude than those of Caliendo and Parro (2015). These larger effects are easily explained by the fact that such a bold policy reform would go beyond undoing NAFTA (average bilateral tariff rates were lower than 20 percent prior to 1993), we account for NTBs, inter-sectoral linkages are more important nowadays than back then, and, last but not least, our welfare criterion accounts for risk aversion: workers care about the risk of being in unemployment over and above the earnings loss that it entails.

(A) Changes in Employment Rates for US under the Wall Scenario



(B) Changes in Employment Rates for Mexico under the Wall Scenario

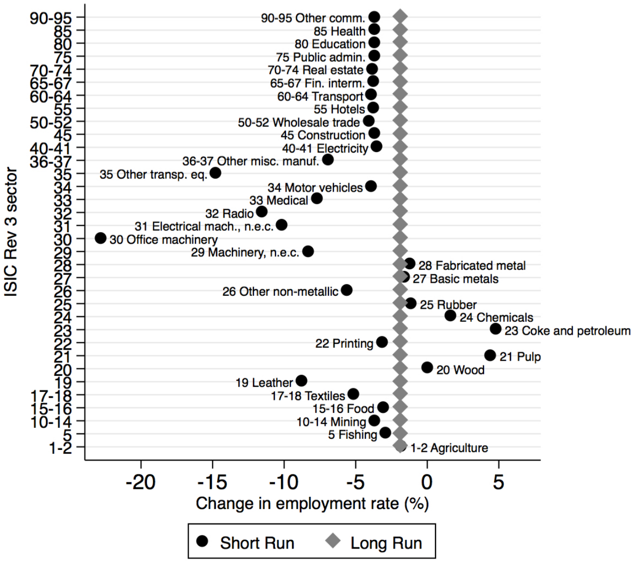


FIGURE 4. Short Run and Long Run Changes for the Wall Scenario. The Figure reports short run (black dots) and long run (gray diamonds) changes in sectoral employment rates for US (upper panel) and Mexico (lower panel). The vertical axis reports the ISIC Rev 3 sector classification and short sector descriptions are also shown as labels on short run markers. The horizontal axis reports the change in sectoral employment rate calculated as $(\hat{\ell}_k - 1) \times 100$. Source: Authors' calculations.

5.2. *The* USMCA *Citadel*

Several commentators refer to the US-Mexico-Canada Agreement (USMCA), signed on 30 November 2018, as NAFTA 2.0, with reason: the main differences include changes in the rules of origin for automakers (a higher share of intermediates has to be sourced from North America to qualify for zero tariff), labor and environmental standards (a minimum fraction of the value added of a car must be produced by workers earning above a certain wage), intellectual property protections, and some digital trade provisions. The legislatures in Canada and in the US have yet to ratify the agreement (Mexico's legislature has ratified it on June 19th 2019). If USMCA is not ratified by all member countries, the Wall scenario remains the likely alternative. If USMCA is ratified, then the new provisions listed above are likely to lead to a surge in the production costs and prices of motor vehicles imported by the US from Mexico. In this event, North American consumers are likely to substitute away from more expensive cars built in North America towards cheaper brands imported from Asia and Europe. According to our quantitative model, an increase of the NTB's faced by Mexico from zero to half of what the other exporters have to face when exporting "Motor Vehicles, Trailers and Semi-Trailers" (Sector 34 in ISIC Rev 3) to the US leads to a significant 3.2 percent increase in US imports in this sector from the rest of the world (i.e. non Mexican imports). This policy is likely to benefit car producers from the rest of the world more than US car producers (and workers): we estimate that the market share of the rest of the world would increase by 2.9 percent, whereas the domestic market share of US producers would increase by 2.0 percent only. In light of President Trump's past behavior in similar trade contexts, such a surge in imports from Asia and Europe is likely to trigger further protectionist outbursts.

The scenario we develop in this Section, which we refer to as the USMCA Citadel, accounts for such a likely response by setting MFN tariffs on Motor Vehicules to 20 percent in addition to increasing NTB's from Mexico to the US.[49] As described by Chad Bown, a trade policy expert, "a surge in German-built Volkswagens and Japanese-assembled Nissans would seem likely to push Trump to follow through on his threats to raise tariffs on such vehicles from 2.5 percent to 20 percent or 25 percent".[50] We maintain the assumption of zero tariffs on imports from Mexico and Canada, since a side agreement protects

49. More precisely, we assume that the ad valorem equivalent of NTB's increases from zero to 8.5 percent for "Motor Vehicles, Trailers and Semi-Trailers" (Sector 34 in ISIC Rev 3). This rate, which we report in Table 2, is equal to half of the ad valorem equivalent tariff, ave_{ijk}, associated to an RTA for this sector. We leave all other bilateral trade barriers among USMCA members unchanged. In particular, we assume that NTB's between the US and Canada are unaffected because Canadian wages are above the threshold required by USMCA, thereby already complying with provisions on labor standards.

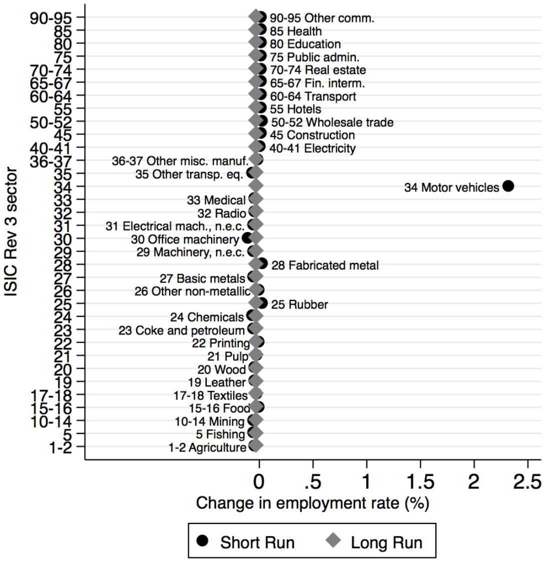
50. See https://voxeu.org/content/five-surprising-things-about-new-usmca-trade-agreement.

TABLE 4. Changes in Welfare and Unemployment Rates under the USMCA Citadel Counterfactual (in Percent)

		Long Run (in percent)				**Short Run** (in percent)	
Country	u_c^{2008}	$\hat{u}_c - 1$ Unemployment	$\hat{\bar{\omega}}_c - 1$ Welfare	$\frac{1}{\bar{\mu}_c^*}\text{Cov}\left(\frac{L'_{ck}-L_{ck}}{L_c}, \mu_{ck}^*\right)$ Reallocation	$\hat{\bar{\omega}}_c - 1$ Real GDP P.C.	$\hat{u}_c^{SR} - 1$ Unemployment	$\hat{\bar{\omega}}_c^{SR} - 1$ Average Welfare
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
USMCA members							
Canada	6.1	0.045	-0.003	-0.001	-0.002	-0.254	-0.037
Mexico	3.9	0.667	-0.102	0.000	-0.060	0.465	-0.076
USA	5.8	0.405	-0.058	0.002	-0.052	0.276	-0.101
Other OECD members							
Australia	4.2	-0.009	-0.003	0.002	-0.004	-0.033	0.008
Austria	4.1	0.089	-0.009	0.000	-0.008	0.326	-0.019
Belgium	7.0	0.019	-0.004	0.000	-0.003	0.200	-0.016
Czech Rep.	4.4	0.019	-0.003	0.000	-0.002	0.155	-0.009
Denmark	3.4	-0.034	0.001	0.000	0.001	0.103	-0.004
Estonia	5.5	-0.008	0.002	0.000	0.000	0.066	-0.003
Finland	6.4	0.019	-0.011	0.003	-0.003	0.067	-0.006
France	7.1	0.032	-0.004	0.000	0.007	-0.026	0.013
Germany	7.5	0.129	-0.021	0.000	-0.020	0.312	-0.030
Greece	7.8	-0.020	0.002	0.002	0.002	-0.040	0.010
Hungary	7.8	0.006	-0.002	0.000	-0.001	0.115	-0.008
Iceland	3.0	0.104	-0.012	0.001	-0.008	0.097	-0.014
Ireland	6.8	-0.051	0.014	-0.001	0.010	-0.045	0.010
Israel	7.7	0.033	-0.004	0.000	-0.004	0.223	-0.037
Italy	6.7	0.011	-0.002	0.000	-0.004	0.097	-0.007
Japan	4.0	0.260	-0.025	0.000	-0.021	1.389	-0.062
Netherlands	2.8	0.028	-0.005	0.001	-0.002	0.251	-0.007
New Zealand	4.2	0.019	-0.008	0.002	-0.007	0.462	-0.072
Norway	2.6	-0.038	0.000	0.001	0.000	-0.214	0.011
Poland	7.1	0.023	-0.002	-0.001	0.001	0.037	-0.002
Portugal	7.6	0.058	-0.014	0.002	0.005	0.041	0.010
Slovakia	9.5	0.054	-0.011	0.000	-0.010	0.124	-0.011
Slovenia	4.4	0.022	0.005	-0.003	-0.001	0.154	-0.004
South Korea	3.2	0.355	-0.030	0.000	-0.024	1.006	-0.049
Spain	11.3	0.002	0.005	-0.002	-0.001	0.025	-0.003
Sweden	6.2	0.029	-0.005	0.000	-0.005	0.297	-0.020
Switzerland	3.4	0.008	-0.002	0.000	-0.001	0.142	-0.002
United Kingdom	5.6	0.019	-0.016	0.004	-0.012	0.497	-0.164

Note: All values are in percent. Column (1) reports the national unemployment rate in 2008 (source: ILO). Columns (2)-(5) report long run results of a simulation based on 60 countries and a constructed rest of the world for which sufficient data is available in year 2008. We set the matching elasticity to $\lambda = 0.6$. Column (2) reports the relative change in the unemployment rate calculated according to equation (38). Column (3) reports the change in the welfare as per equation (34). Column (4) reports the "reallocation effect" calculated as $[\hat{\hat{\ell}}_c/(\hat{\bar{\omega}}_c)^{1-\lambda} - 1] \times 100$, where $\hat{\hat{\ell}}_c$ is a theory-consistent measure of the employment rate defined in equation (18) (values not reported in the Table); Column (5) reports change in real GDP per capita (net of education costs), calculated as $\left(\sum_{k\in\mathcal{K}} L'_{ck}\bar{\omega}'_{ck}\right) / \left(\sum_{k\in\mathcal{K}} L_{ck}\bar{\omega}_{ck}\right)$. Columns (6) and (7) report short run changes in average welfare and national unemployment rate, where $\hat{\bar{\omega}}_c^{SR} = \sum_{k\in\mathcal{K}} L_{ck}\hat{\bar{\omega}}_c^{SR}$. Source: Authors' calculations.

(A) Changes in Employment Rates for US under the Citadel Scenario



(B) Changes in Employment Rates for Mexico under the Citadel Scenario

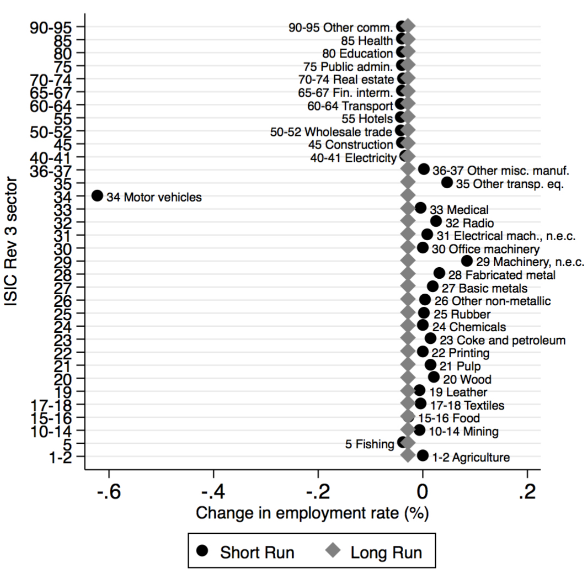


FIGURE 5. Short Run and Long Run for the USMCA Citadel Scenario. The Figure reports short run (black dots) and long run (gray diamonds) changes in sectoral employment rates for US (upper panel) and Mexico (lower panel). The vertical axis reports the ISIC Rev 3 sector classification and short sector descriptions are also shown as labels on short run markers. The horizontal axis reports the change in sectoral employment rate calculated as $(\hat{\ell}_k - 1) \times 100$. Source: Authors' calculations.

them from possible use of Section 232 Tariff Protection measures for the car industry.

Table 4 reports the results. We find insignificant effects for Canada. Unemployment would rise in both Mexico and the US by less than 1 percent and welfare would fall by about 0.1 percent. That even quite protectionist measures on only two sectors have small aggregate implications is not surprising. Figure 5 plots the short run and long run effects by sector for the US (panel A) and Mexico (panel B). The short run effects in the sector of interest, Motor Vehicles, are much larger than the long run ones, but still small. Interestingly, the employment rate in this sector rises by over 2 percent in the US but falls in Mexico, though by less than 1 percent. In terms of overall welfare and unemployment, large car producing countries such as Germany, Japan, and South Korea are negatively affected, both in the short and the long run.

6. Additional Evidence for Key Model Mechanisms

Our multi-country, multi-sector general equilibrium trade model differs from extent quantitative trade models in several ways, including by featuring, as in the HI two-country, two-sector model, (*i*) frictions to labor mobility across sectors, which give rise to sector-specific labor market outcomes, and (*ii*) sector-specific labor market search and matching frictions. To be sure, our model is not the first to include either (*i*) or (*ii*), but, to the best of our knowledge, it is unique among multi-country quantitative trade models to *simultaneously* feature (*i*) and (*ii*).

In this Section, we first show that (*i*) leads to sector-specific fluctuations of the employment rates in the "short run" that closely track sector-specific fluctuations of value-added, while (*ii*) leads to heterogeneous employment rates across sectors in the "long run." We then take advantage of the rich US census data over the period 1990-2008 to show that these distinctive features of our model are supported by the data. Note that unemployment rates cannot differ across sectors in models featuring an integrated labor market with free labor mobility across sectors. Note also that in search-and-matching models without heterogeneous matching frictions across sectors, sectoral unemployment rates may vary in the short run, but should converge to the same level in the long run.

Consider the characterization of the equilibrium in Section 3.6. In the long ru version of our model, agents can choose which sector to search for work so that the indifference condition (16) applies. Section 3.8 defines the short run equilibrium version of the model as an allocation in which, following an unexpected shock, workers are stuck in the sector they initially chose but wages, production, and employment rates may vary; hence (42) replaces (16) and all other equilibrium conditions hold.

In this Section we drop the country subscript for convenience ($c =$ US throughout). For simplicity and tractability, we also set $a = b = 0$. The algebra is much more straightforward in this case and we show in Appendix E that the main quantitative predictions of our model on unemployment changes are not sensitive to this simplification.

Using (11) and (24), our model predicts that employment rates for any arbitrary pair of sectors $k, r \in \mathcal{K}$ are related to value added per unit of labor as follows:[51]

$$\frac{\ell_k}{\ell_r} = \left(\frac{Y_k/L_k}{Y_r/L_r}\right)^{1-\lambda} \frac{\mu_k}{\mu_r}.$$

We get three useful results from these expressions. First, we use (16) to obtain the following long run relationships: relative value added is proportional to relative labor shares and to relative education costs, and relative employment rates are proportional to relative labor market efficiencies adjusted for education costs:

$$\frac{Y_k^{LR}}{Y_r^{LR}} = \frac{f_k}{f_r}\frac{L_k^{LR}}{L_r^{LR}}, \qquad \frac{\ell_k^{LR}}{\ell_r^{LR}} = \frac{\mu_k^*}{\mu_r^*}, \tag{47}$$

where the superscripts emphasize that these expressions refer to long-run equivalences. Second, using the hat algebra for equilibrium changes, we obtain the following relationship between relative changes in employment rates and relative changes in labor and value added:

$$\frac{\hat{\ell}_k}{\hat{\ell}_r} = \left(\frac{\hat{Y}_k/\hat{L}_k}{\hat{Y}_r/\hat{L}_r}\right)^{1-\lambda}, \tag{48}$$

which implies that deviations around the long-run relative employment rates are governed by shifts in production and labor shares. It then follows from (47) and (48) that relative changes in value added are proportional to relative changes in labor supply in the long run:

$$\frac{\hat{Y}_k^{LR}}{\hat{Y}_r^{LR}} = \frac{\hat{L}_k^{LR}}{\hat{L}_r^{LR}}, \qquad \frac{\hat{\ell}_k^{LR}}{\hat{\ell}_r^{LR}} = 1. \tag{49}$$

Finally, in the short run, labor is immobile and thence $\hat{L}_k = 1$. It then follows from (48) that short-run deviations of relative employment rates around their long-run levels are proportional to production shifts:

51. Together with $a = b = 0$, these conditions yield $\beta_k = \tilde{\ell}_k = \ell_k = (\tilde{\omega} f_k)^{1-\lambda} \mu_k$ and $Y_k = \tilde{\omega} f_k L_k/2$. The expression in the text then follows.

$$\frac{\hat{\ell}_k^{SR}}{\hat{\ell}_r^{SR}} = \left(\frac{\hat{Y}_k}{\hat{Y}_r}\right)^{1-\lambda}, \tag{50}$$

where the superscript "SR" stands for a short run equivalence.

In the following series of tests, we use OECD STAN data on US value added to compute $\hat{Y}_k$ and we use US census data to compute changes in labor shares $\hat{L}_k$.[52]

6.1. Short Run Variations in Employment Rates

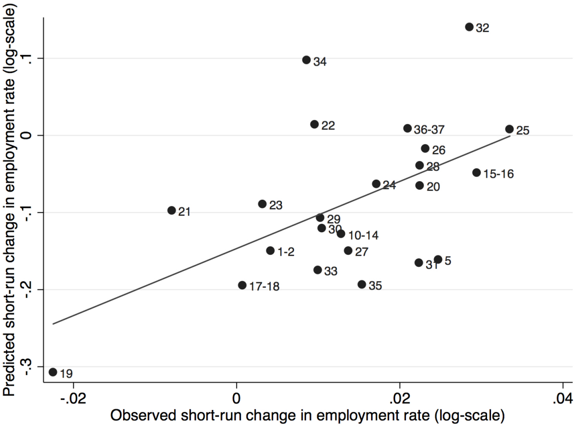
We first evaluate how well our model predicts short run variations in sectoral employment rates using changes in value added shares as per equation (50). In order to assess the validity of this short run relationship, we focus on years 1990 and 2000, which encompass the coming into force of NAFTA. We assume that the US economy was in a pre-NAFTA long run equilibrium in 1990, which is the last pre-NAFTA Census year, and that it has not yet fully adjusted to its new long run equilibrium by 2000, which is the first Census year following the implementation of NAFTA on 1 January 1994. Figure 6 (panel A) plots the actual change in employment rates between years 1990 and 2000 for 23 tradable sectors on the horizontal axis against changes predicted using the observed evolution of value-added as per equation (50) (logarithmic scale). All changes are relative to a reference sector "r"; we choose the non-tradable sector "80 Education" as the benchmark (results are not sensitive to this choice). The correlation between the natural logarithm of employment rate changes and the natural logarithm of value added changes, at 0.55, is large and statistically different from zero at the 1 percent significance level (p-value equal to 0.007).

We perform a similar exercise for the "China shock" by assuming that changes between years 2000 and 2002, which encompass China's accession to the GATT/WTO, are short term changes so that (50) applies here, too. Figure 6 (panel B) plots the results. The correlation between the natural logarithm of employment rate changes and the natural logarithm of value added changes, at 0.54, is again large and statistically different from zero at conventional confidence levels (p-value of 0.008).

These strong correlations imply that sectors that were most hit by (positive or negative) production shocks experienced the largest reactions in employment rates in the short run. This result is in turn consistent with one of the distinctive features of our model, namely, that the labor markets are segmented by sectors; this qualitative result may also be consistent with transitional employment in a fully dynamic DMP model and an integrated labor market. The patterns that we report in the next subsection are helpful in discriminating between the two

52. We compute L_k as the sum of workers employed in sector k and unemployed workers previously working in sector k. See also footnote (33).

(A) Changes between 1990 and 2000



(B) Changes between 2000 and 2002

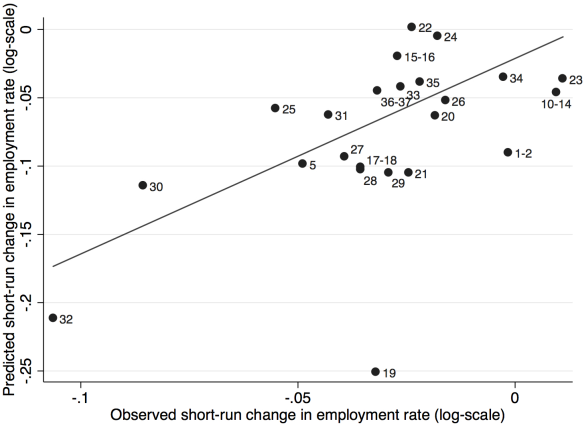


FIGURE 6. Observed vs. Short Run Predictions of Changes in Employment Rates. Panel (A) of the Figure reports predicted short run vs. observed changes in employment rate between 1990 and 2000 in natural logarithm, $\ln \hat{\ell}_{k,1990-2000} - \ln \hat{\ell}_{r,1990-2000}$, for tradable sectors. Predicted values are computed as $(1-\lambda)\left(\ln \hat{Y}_{k,1990-2000} - \ln \hat{Y}_{r,1990-2000}\right)$. Panel (B) of the Figure reports predicted short run vs. observed changes in employment rate between 2000 and 2002 in natural logarithm, $\ln \hat{\ell}_{k,2000-2002} - \ln \hat{\ell}_{r,2000-2002}$, for tradable sectors. Predicted values are computed as $(1-\lambda)\left(\ln \hat{Y}_{k,2000-2002} - \ln \hat{Y}_{r,2000-2002}\right)$. The reference sector r is "80 Education" and $\lambda = 0.6$. The lines show the linear fits. Labels indicate ISIC Rev 3 sector classifications (see Table 2 for tradable sectors). Source: Authors' calculations.

models because they cannot be rationalized with the plain vanilla one-labor-market DMP model.

6.2. Long Run Variations in Employment Rates

As shown in Figure 1 in the Introduction, US sectors exhibit highly persistent and heterogeneous unemployment rates in 2007-2009. Here we report a second piece of evidence consistent with the existence of sector-specific employment rates and labor market frictions. Over the time period 1990-2008, during which several shocks hit the US economy, relative sector-specific employment rates fluctuate and then converge back towards their original 1990 levels as per equation (47). Consider the correlation between the relative employment rates in each year relative to the base year, $\text{Corr}\left(\ln \ell_{k,1990} - \ln \ell_{r,1990}, \ln \ell_{k,t} - \ln \ell_{r,t}\right)$, for $t \in \{2000, ..., 2008\}$. Figure 7 reports results. The relative employment rates appear to be converging back to their original pre-NAFTA 1990 relative levels (the correlation converges to unity) by late 2000's. This result is striking, since the "dot.com" bubble and the accession of China to the GATT/WTO, among other shocks, hit the US economy over the first years of this century.

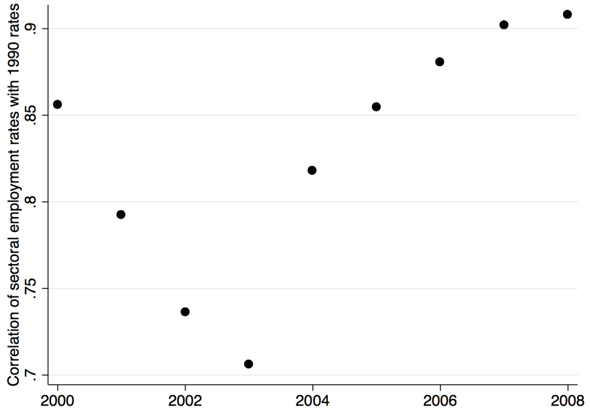


FIGURE 7. Correlation between Observed Relative Employment Rates and 1990 Relative Employment Rates. The Figure reports correlations between observed relative employment rates $(\ln \ell_{k,t} - \ln \ell_{r,t})$ in each year t, and the observed relative employment rates $(\ln \ell_{k,1990} - \ln \ell_{r,1990})$ in year 1990. The reference sector r is "80 Education." Source: Authors' calculations.

According to the empirical literature on the China shock, some sectors have been particularly impacted. Autor, Dorn, and Hanson (2016) identify that the most affected US manufacturing industries by net imports from China are "Textile/apparel/leather," "Machines/electrical" (including industrial machinery, office machinery, telecommunications equipment or electrical machinery), and "Toys/other manufactures." As reported in Figure 8, the relative employment rates of these sectors have also faced a major negative shock, but they converge back to their 1990 levels despite large deviations in 2000-2002.

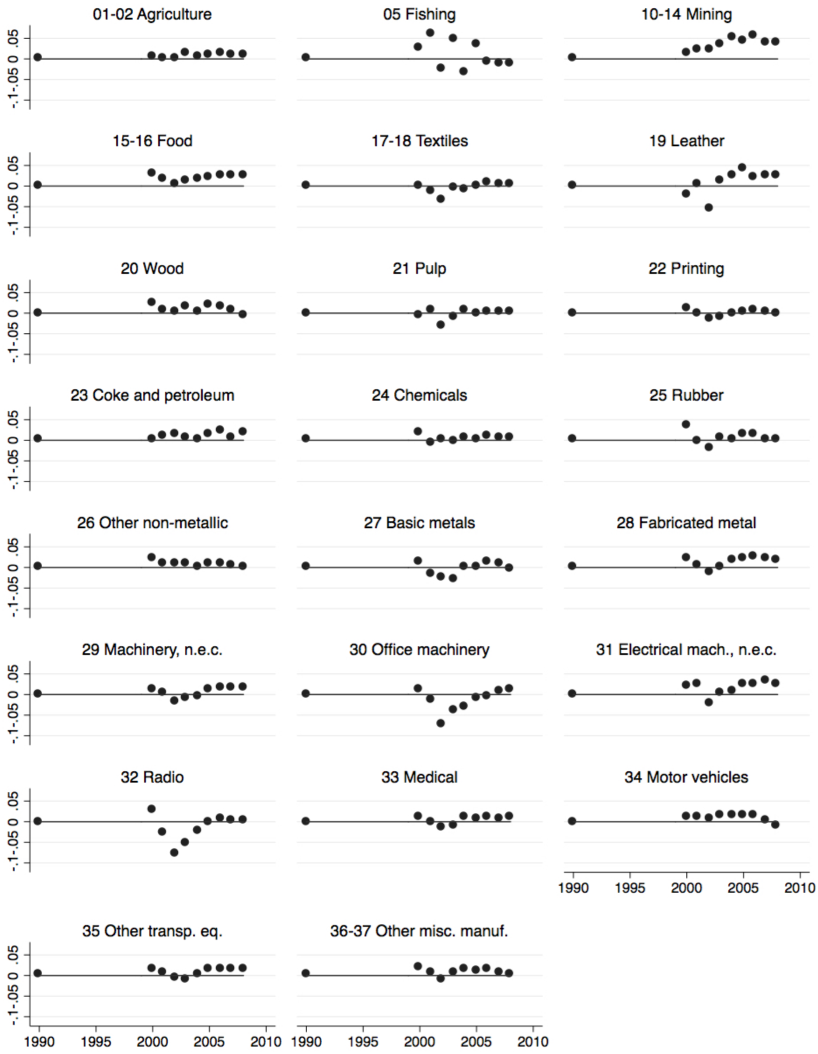


FIGURE 8. Changes in Relative Employment Rates by Sector, 1990-2008. The Figure reports deviations in the relative employment rates around their 1990 levels, for each tradable sector. Deviations are computed as $\ln \hat{\ell}_{k,1990-t} - \ln \hat{\ell}_{r,1990-t}$, where the reference sector r is "80 Education" and time runs from $t = 1990$ to $t = 2008$. The line shows the zero deviation level (i.e. the 1990 level of relative employment rates). Labels indicate ISIC Rev 3 sector classifications (see Table 1). Source: Authors' calculations.

Together, the patterns reported in Figures 1, 7, and 8 imply that there is considerable variation in employment rates across sectors and that these differences are persistent and stable in the long run. Our model of equilibrium unemployment with sector-specific labor market frictions is consistent with these patterns.

6.3. Long Run Labor Reallocation

Finally, we look for evidence that long run changes in relative employment rates, relative value added, and relative labor shares evolve according to equation (49) by treating the baseline year 1990 as an initial long run equilibrium and year 2008 as the last long run equilibrium year of our sample.[53] Figure 9 plots the predicted against actual 2000-2008 changes in labor shares for all tradable sectors (logarithmic scale). Though statistically different from unity at conventional confidence levels, the correlation, at 0.70, is high (the partial correlation, at 0.79, is higher still). Through the lenses of our model, this discrepancy between the actual correlation of 0.70 and the theoretical correlation of unity suggests that the economy was still adjusting to shocks in years 1990 and/or 2008.

FIGURE 9. Observed vs. Long Run Predictions of Changes in Employment Shares, 1990-2008. The Figure reports predicted long run vs. observed changes in relative labor shares $\left(\ln \hat{L}_k^{LR}\text{-}\ln \hat{L}_r^{LR}\right)$, for tradable sectors between 1990 and 2008. Predicted values are computed as $\left(\ln \hat{Y}_{k,1990-2008} - \ln \hat{Y}_{r,1990-2008}\right)$, where $\lambda = 0.6$ and the reference sector r is "80 Education." The line shows the linear fit. Labels indicate ISIC Rev 3 sector classifications (see Table 1). Source: Authors' calculations.

53. Production and employment rates drop in 2009. No meaningful changes are discernible prior to 2009 in yearly data.

To summarize, our model is able to replicate short run and long run movements of relative employment shares, value added, and employment rates. To the best of our knowledge, its combination of equilibrium unemployment and sector-specific labor market frictions is unique among quantitative trade models in accounting for all these facts simultaneously.

7. Conclusion

Trade affects incomes and (un)employment, even in the long run. This paper has put forth a quantitative trade model featuring inter-sectoral linkages, risk-averse workers, labor market frictions, and unemployment benefits. Trade regimes affect the equilibrium unemployment rates of countries in two ways: by changing the real cost of opening vacancies (the so-called *expansion* effect) and by reallocating labor across sectors featuring heterogeneous labor market frictions and unemployment rates (the so-called *reallocation* effect).

Though the model assembles a rich set of ingredients, it remains relatively parsimonious and is thus amenable to policy evaluation. We illustrate these properties to quantify the possible impacts of various trade regimes on unemployment, real GDP per capita, and welfare – which is a combination of the other two criteria. Other policy experiments are possible, including changes in labor market policies. For instance, we can use the model to study the consequences of labor market policies, both domestic, as in Ljungqvist and Sargent (1998), and foreign as channeled through trade, as in Davis (1998) or HI. We leave such experiments and other applications to further work.

Appendix A: Occupation-Sector-Specific Labor Market Frictions

The quantitative sections of the paper work with data at the sector level. In order to keep the link between the theoretical and quantitative parts of the paper as tight as possible, we work with sector-specific labor market frictions the main text. This assumption is consistent with the empirical evidence documenting frictions to mobility across sectors. However, the model is silent about mobility frictions across occupations. For this reason, this Appendix develops a framework with occupation-sector-specific frictions that encompasses the model of the main text featuring sector-specific frictions only, as well as an alternative framework featuring occupation-specific frictions only. In particular, we develop conditions under which sector-specific labor market frictions in the body of the paper can be thought of as convex combinations of sector-occupation-specific labor market frictions.

This Appendix does three things. First, it develops this encompassing framework and derives the key equilibrium results. Second, it shows that the maintained assumption of sector-specific frictions in the main text is an equilibrium outcome in a special case and a robustly precise approximation under the empirical distribution of a key variable of the model. Finally, it shows how the reallocation effect can be decomposed between a within-sector/across-occupation effect and a within-occupation/across sector effect.

A.1 Model and Equilibrium

Let $\mathcal{O} \equiv \{1, ..., O\}$ define the set of occupations in the economy. The production function of variety x in sector k is now given by

$$\mathbb{Q}_{ck}(x) = \varphi_{ck}(x) \left[\frac{1}{1-\gamma_{ck}} \prod_{o \in \mathcal{O}} \left(\frac{H_{cok}(x)}{\chi_{ok}} \right)^{\chi_{ok}} \right]^{1-\gamma_{ck}} \prod_{s \in \mathcal{K}} \left(\frac{\mathbb{M}_{csk}(x)}{\gamma_{csk}} \right)^{\gamma_{csk}}, \tag{A.1}$$

where $\sum_{o \in \mathcal{O}} \chi_{ok} \equiv 1$, $H_{cok}(x)$ is the mass of workers of occupation o implicated in the production of variety x in sector k, and χ_{ok} is the sector-occupation Cobb-Douglas coefficient. There are frictions to mobility across sectors and occupations, hence we consider $O \times S$ labor markets in the economy. The current framework encompasses the framework in the body of the text, in which case $ok-$labor markets are integrated across occupations at the sector level, as well as a framework in which there would be frictions to labor mobility across occupations only (but not across sectors), in which case labor markets are integrated across sectors at the occupation level.[54]

All variables and parameters of Subsection 3.3 are now defined at the occupation-sector level. In particular, the following expressions are affected:

- The employment rate in occupation o, sector k generalizes as

$$\ell_{cok} \equiv \frac{H_{cok}}{L_{cok}}. \tag{A.2}$$

- The unit cost index generalizing equation (10):

$$z_{ck} \equiv \left[(1 + B_c) \prod_{o \in \mathcal{O}} (w_{cok})^{\chi_{ok}} \right]^{1-\gamma_{ck}} \prod_{s \in \mathcal{K}} (p_{cs})^{\gamma_{csk}}. \tag{A.3}$$

- The full-participation condition generalizing equation (12):

$$\bar{L}_c = \sum_{o \in O} \sum_{k \in \mathcal{K}} L_{cok}. \tag{A.4}$$

54. If labor markets are integrated at the sector level, then $\mu_{cok} = \mu_{ck}$, $f_{cok} = f_{ck}$, $\ell_{cok} = \ell_{ck}$, and $w_{cok} = w_{ck}$, all $o \in \mathcal{O}$, some $w_{ck} > 0$ and some $\ell_{ck} \in (0, 1)$. By the same token, if labor markets are integrated at the occupation level, then $\mu_{cok} = \mu_{co}$, $f_{cok} = f_{co}$, $\ell_{cok} = \ell_{co}$, and $w_{cok} = w_{co}$, all $k \in \mathcal{K}$, some $w_{co} > 0$ and some $\ell_{co} \in (0, 1)$.

- The certainty-equivalent real wage $\tilde{\omega}_c$, which pertains to all occupations and sectors with a positive measure of job seekers, generalizes equation (16):
$$\forall o \in \mathcal{O}, \quad \forall k \in \mathcal{K}: \qquad \tilde{\omega}_c = \frac{\omega_{cok}\beta_{cok}}{f_{cok}}, \tag{A.5}$$
where
$$\beta_{cok} \equiv \left[\ell_{cok} + (1-\ell_{cok})\,(b_c)^{1-a}\right]^{\frac{1}{1-a}} \tag{A.6}$$
and
$$\omega_{cok} \equiv \frac{\tilde{w}_{cok}}{\mathbb{P}_c} \tag{A.7}$$
replace the definitions in (14) and (15), respectively.
- The average theory-consistent employment rate generalizing (18):
$$\tilde{\ell}_c \equiv \sum_{o\in\mathcal{O}}\sum_{k\in\mathcal{K}} \frac{L_{cok}}{\bar{L}_c}\tilde{\ell}_{cok} = \left(\frac{\tilde{\omega}_c}{B_c}\right)^{1-\lambda} \sum_{o\in\mathcal{O}}\sum_{k\in\mathcal{K}} \frac{L_{cok}}{\bar{L}_c}\,(f_{cok})^{1-\lambda}\,\mu_{cok}, \tag{A.8}$$
which we may rewrite as a weighted sum of sector-specific employment rates:
$$\tilde{\ell}_c = \sum_{k\in\mathcal{K}} \frac{L_{ck}}{\bar{L}_c}\tilde{\ell}_{ck}, \qquad \tilde{\ell}_{ck} \equiv \left(\frac{\tilde{\omega}_c}{B_c}\right)^{1-\lambda} \mu^*_{ck},$$
where
$$\mu^*_{ck} \equiv \sum_{o\in\mathcal{O}} \frac{L_{cok}}{L_{ck}}\mu^*_{cok}, \qquad \mu^*_{cok} \equiv (f_{cok})^{1-\lambda}\,\mu_{cok} \tag{A.9}$$
generalizes (37). For further references, let also
$$\bar{\mu}^*_c \equiv \sum_{o\in\mathcal{O}}\sum_{k\in\mathcal{K}} \frac{L_{cok}}{\bar{L}_c}\mu^*_{cok}.$$
- Value-added in occupation o, sector k, country c, which generalizes (24):
$$Y_{cok} \equiv \chi_{ok}\,(1-\gamma_{ck})\,E_{ck} = \left(1+\frac{1}{B_c}\right) H_{cok}w_{cok}. \tag{A.10}$$
For any pair of occupations $o, o' \in \mathcal{O}$ and for any sector $k \in \mathcal{K}$, this expression yields
$$\frac{Y_{co'k}}{Y_{cok}} = \frac{H_{co'k}w_{co'k}}{H_{cok}w_{cok}} = \frac{\chi_{o'k}}{\chi_{ok}}.$$

A.2 From Occupation-Sector-Specific to Sector-Specific Frictions

Together, the indifference condition in (A.5), the definition of ℓ in (A.2), and the identities in (A.7) and (A.10), yield
$$\frac{\ell_{co'k}}{\beta_{co'k}}\left(\frac{\ell_{cok}}{\beta_{cok}}\right)^{-1} \underbrace{\frac{L_{co'k}}{L_{cok}}}_{\text{Labor ratio}} = \frac{\chi_{o'k}}{\chi_{ok}}\left(\frac{f_{co'k}}{f_{cok}}\right)^{-1}. \tag{A.11}$$

The right-hand side of (A.11) contains parameters only. Its left-hand side contains the labor ratio of this pair of occupation, as well as a function of the employment rates of these occupations. In general, the term

$$\frac{\ell_{co'k}}{\beta_{co'k}}\left(\frac{\ell_{cok}}{\beta_{cok}}\right)^{-1}$$

is unwieldy, as inspection of (A.6) confirms. In two special cases, however, it boils down to a relatively simple expression.

First, if $a = b_c = 0$, then $\beta_{cok} = \ell_{cok}$ and (A.11) simplifies to

$$\frac{L_{co'k}}{L_{cok}} = \frac{\chi_{o'k}}{\chi_{ok}}\left(\frac{f_{co'k}}{f_{cok}}\right)^{-1}, \tag{A.12}$$

from which it follows that the occupation labor share

$$\frac{L_{cok}}{L_{ck}} = \frac{\chi_{ok}/f_{cok}}{\sum_{o'\in\mathcal{O}}\left(\chi_{o'k}/f_{co'k}\right)}$$

is a function of parameters of the model only. As a result, the adjusted sector-specific matching efficiency ("adjusted" for education costs), μ^*_{ck} in (A.9), is parametric. In this case, then, one can meaningfully refer to is as "the adjusted sector-specific" matching efficiency. In the main text, we work with constant relative rate of risk aversion of two and strictly positive unemployment benefits, so this result cannot hold exactly. But can it hold as an approximation? We turn to this question next.

Second, if $a = 2$ then, from (A.6), we may write

$$\frac{\ell_{cok}}{\beta_{cok}} = \left(1 - \frac{1}{b_c}\right)\left(\ell_{cok}\right)^2 + \frac{\ell_{cok}}{b_c}.$$

In our data, the average b among 31 countries in year 2005 was $0.52 \approx 1/2$. Thus, rewriting the expression above as deviations from $b_c = 1/2$ and rearranging terms, we get

$$\left(1 - \frac{\ell_{cok}}{\beta_{cok}}\right) = \left(1 - \ell_{cok}\right)^2 + \left(2 - \frac{1}{b_c}\right)\left(1 - \ell_{cok}\right)\ell_{cok}.$$

What are the quantitative implications of this expression for the gap between ℓ_{cok}/β_{cok} and unity and hence for the quality of the approximation in (A.12)? First, for $b_c = 1/2$, this gap is an order of magnitude smaller than the gap between ℓ_{cok} and unity; for $b_c \neq 1/2$, this gap is in the order of magnitude of the product of $(1 - \ell_{cok})\,\ell_{cok}$ and $(2 - 1/b_c)$.[55] The average value of ℓ_{ck}/β_{ck} in

55. The sample mean of ℓ_{ck} is 0.93 (minimum 0.73, median 0.95, maximum 1) and half of the observed and estimated values fall in the range $[0.91, 0.97]$. Thus, the maximum of the gap $(1 - \ell_{cok})^2$ is about 0.07. The sample mean of $1/b_c$ is 2.28 (minimum 1.2, median 1.72, maximum 7.58) and half of the observed and estimated values fall in the range $[1.56, 2.83]$.

our data is 0.99 (minimum 0.82, median 0.99, maximum 1.23) and half of the observations are between 0.966 and 1.001. Figure A.1 shows the distribution of ℓ_{ck}/β_{ck} in our sample. Given these empirical values, we may plug $\beta_{cok}/\ell_{cok} \approx 1$ into (A.11), which implies that (A.12) holds as a *second*-order approximation. In turn, the sector-average adjusted matching efficiency of country c in (A.9) is approximately constant across equilibrium allocations.

To summarize, under the maintained assumption $a = 2$ and given the values of b_c and ℓ_{ck} in the data, we find that the empirical values of ℓ_{ck}/β_{ck} are close to unity, which implies that the labor shares L_{cok}/L_{ck} are remarkably stable across equilibrium allocations. Hence, our assumption that frictions are sector-specific comes at a trivial additional loss of generality. This finding gets additional, indirect support from Appendix E, where we show that the quantitative findings under the alternative assumption $a = b_c = 0$ for the Wall scenario are similar to those in the main text.

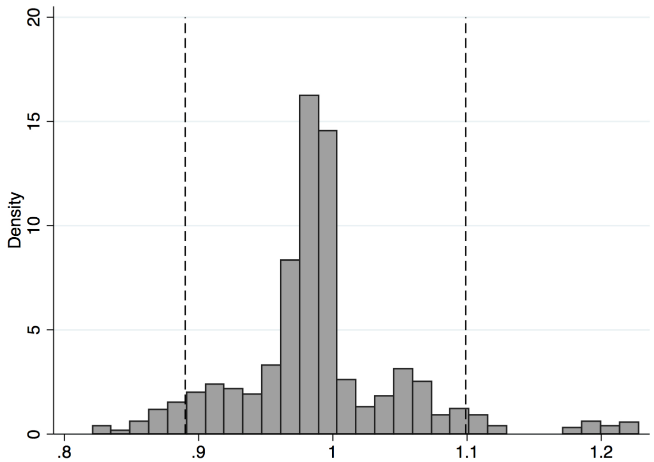


FIGURE A.1. Distribution of estimated ℓ_{ck}/β_{ck} for OECD-31. The Figure reports the density distribution (y-axis) of the estimated ℓ_{ck}/β_{ck} (x-axis) for our sample of OECD-31 countries and 34 sectors. The β_{ck}'s (and the corresponding ℓ_{ck}'s) are estimated using country- and sector-specific data on OECD wages and US educational costs, averaged over the period 2001-2008, as described in Section 4.2. Vertical dashed lines mark the 5^{th} and the 95^{th} percentiles, respectively. Source: Authors' calculations.

A.3 Equilibrium in Changes

Equilibrium changes obey:

- The indifference condition in changes replacing equation (34):

$$\hat{\tilde{\omega}}_c = \hat{\omega}_{cok}\hat{\beta}_{cok}, \qquad \hat{\beta}_{cok} \equiv \left[\frac{\ell'_{cok} + (1-\ell'_{cok})\,(b_c)^{1-a}}{\ell_{cok} + (1-\ell_{cok})\,(b_c)^{1-a}}\right]^{\frac{1}{1-a}}.$$

- Employment and welfare changes, which replace equation (38):

$$\hat{\hat{\ell}}_c = \left(\hat{\hat{\omega}}_c\right)^{1-\lambda} \hat{\bar{\mu}}^*_c$$

$$= \underbrace{\left(\hat{\hat{\omega}}_c\right)^{1-\lambda}}_{\text{Expansion}} \left[1 + \underbrace{\frac{1}{\bar{\mu}^*_c} \text{Cov}\left(\frac{L'_{cok} - L_{cok}}{\bar{L}_c}, \mu^*_{cok} \right)}_{\text{Reallocation}} \right], \tag{A.13}$$

where

$$\text{Cov}\left(\frac{L'_{cok} - L_{cok}}{\bar{L}_c}, \mu^*_{cok} \right) \equiv \sum_{o \in \mathcal{O}} \sum_{k \in \mathcal{K}} \frac{L'_{cok} - L_{cok}}{\bar{L}_c} \left(\mu^*_{cok} - \bar{\mu}^*_c \right).$$

Define employment at the sector level as

$$L_{ck} \equiv \sum_{o \in \mathcal{O}} L_{cok}, \qquad L'_{ck} \equiv \sum_{o \in \mathcal{O}} L'_{cok}$$

and the sector-averages of inverse labor market frictions:

$$\mu^*_{ck} \equiv \sum_{o \in \mathcal{O}} \frac{L_{cok}}{L_{ck}} \mu^*_{cok}, \qquad \mu^{*\prime}_{ck} \equiv \sum_{o \in \mathcal{O}} \frac{L'_{cok}}{L'_{ck}} \mu^*_{cok}.$$

We can then decompose the Reallocation Effect in (A.13) as follows:

$$\begin{aligned} \text{Cov}\left(\frac{L'_{cok} - L_{cok}}{\bar{L}_c}, \mu^*_{cok} \right) &= \text{Cov}\left(\frac{L'_{ck}}{\bar{L}_c} - \frac{L_{ck}}{\bar{L}_c}, \mu^*_{ck} \right) \\ &+ \sum_{k \in \mathcal{K}} \frac{L_{ck}}{\bar{L}_c} \text{Cov}\left(\frac{L'_{cok}}{L'_{ck}} - \frac{L_{cok}}{L_{ck}}, \mu^*_{cok} \right) \\ &+ \text{Cov}\left(\frac{L'_{ck}}{\bar{L}_c} - \frac{L_{ck}}{\bar{L}_c}, \mu^{*\prime}_{ck} - \mu^*_{ck} \right). \end{aligned} \tag{A.14}$$

Thus, the overall reallocation effect can be decomposed into three reallocation effects: *(i)* reallocation across sectors, *(ii)* reallocation across occupations within sectors, and *(iii)* the interaction term (or a covariance) between these inter- and intra- sectoral reallocation terms. Equivalently, the overall reallocation effect can be decomposed into reallocation across occupations, reallocation across sectors within occupations, and the interaction of the two:

$$\begin{aligned} \text{Cov}\left(\frac{L'_{cok} - L_{cok}}{\bar{L}_c}, \mu^*_{cok} \right) &= \text{Cov}\left(\frac{L'_{co}}{\bar{L}_c} - \frac{L_{co}}{\bar{L}_c}, \mu^*_{co} \right) \\ &+ \sum_{o \in \mathcal{O}} \frac{L_{co}}{\bar{L}_c} \text{Cov}\left(\frac{L'_{cok}}{L'_{co}} - \frac{L_{cok}}{L_{co}}, \mu^*_{cok} \right) \\ &+ \text{Cov}\left(\frac{L'_{co}}{L'_c} - \frac{L_{co}}{L_c}, \mu^{*\prime}_{co} - \mu^*_{co} \right), \end{aligned} \tag{A.15}$$

where the occupation-averages of adjusted labor market efficiencies are defined as

$$\mu_{co}^{*} \equiv \sum_{k\in\mathcal{K}} \frac{L_{cok}}{L_{co}} \mu_{cok}^{*}, \qquad \mu_{co}^{*\prime} \equiv \sum_{k\in\mathcal{K}} \frac{L'_{cok}}{L'_{co}} \mu_{cok}^{*}.$$

Hence, given the expansion effect, employment falls following some shock if labor is reallocated towards sectors and occupations with higher-than average labor market frictions.

Consider now two special cases of this framework with an arbitrary number of sectors and occupations.

1. Frictions are occupation-specific. If labor markets are integrated at the occupation level, then $\mu_{cok}^{*} = \mu_{co}^{*}$, hence $\mu_{co}^{*\prime} = \mu_{co}^{*}$, and $\ell_{cok} = \ell_{co}$, and $w_{cok} = w_{co}$, all $k \in \mathcal{K}$, some $w_{co} > 0$ and some $\ell_{co} \in (0,1)$. It then follows from (A.15) that the reallocation effect only operates across occupations:
$$\operatorname{Cov}\left(\frac{L'_{cok} - L_{cok}}{\bar{L}_c}, \mu_{cok}^{*}\right) = \operatorname{Cov}\left(\frac{L'_{co}}{\bar{L}_c} - \frac{L_{co}}{\bar{L}_c}, \mu_{co}^{*}\right).$$
2. Frictions are sector-specific. If labor markets are integrated at the sector level, then $\mu_{cok}^{*} = \mu_{ck}^{*}$, hence $\mu_{ck}^{*\prime} = \mu_{ck}^{*}$, and $\ell_{cok} = \ell_{ck}$, and $w_{cok} = w_{ck}$, all $k \in \mathcal{K}$, some $w_{ck} > 0$ and some $\ell_{ck} \in (0,1)$. It then follows from (A.14) that the reallocation effect only operates across sectors:
$$\operatorname{Cov}\left(\frac{L'_{cok} - L_{cok}}{\bar{L}_c}, \mu_{cok}^{*}\right) = \operatorname{Cov}\left(\frac{L'_{ck}}{\bar{L}_c} - \frac{L_{ck}}{\bar{L}_c}, \mu_{ck}^{*\prime}\right).$$

Appendix B: Vacancy Costs

In order to simplify the algebra and carry the main results in the most transparent and straightforward way, let us assume that workers are risk-neutral, unemployment benefits are zero, and skill acquisition costs are homogeneous and normalized to unity, namely, for all $c \in \mathcal{C}$ and all $k \in \mathcal{K}$, let $a = b_c = 0$ (so that $B_c = 1$) and $f_{ck} = 1$.

In this appendix we develop the model under the assumption that the unit vacancy cost v_{ck} is a Cobb-Douglas combination of the domestic consumption bundle $\mathbb{C}_c$ and labor such that the per worker hiring cost is equal to $(\mathbb{P}_c)^{\rho}(w_{ck})^{1-\rho}\nu_{ck}V_{ck}/H_{ck}$, some $\rho \in [0,1]$. The main text works with the special case $\rho = 1$, namely, vacancies use the final good only. As will become clear below, while some results are qualitatively altered in the polar case $\rho = 0$, all qualitative results and most quantitative results of the main text go through for any $\rho \in (0,1]$. Under this generalized assumption, and making use of (4), (5), (7), and(9), the sectors-specific wage and per-worker hiring cost in (6) and (9) become

$$c_{ck} = w_{ck} = \mathbb{P}_c \left[\frac{(\ell_{ck})^{\lambda}(\nu_{ck})^{1-\lambda}}{\tilde{\mu}_{ck}}\right]^{\frac{1}{1-\lambda-\zeta}}, \tag{B.1}$$

where $\zeta \equiv (1-\lambda)(1-\rho)$ is a convenient collection of parameters such that $\zeta = 0$ if $\rho = 1$ and $0 \leq \zeta \leq 1-\lambda$, $\forall \rho$. Combining this expression with the indifference condition (16), the expected/average real wage in (11) and the matching efficiency in (7) become

$$\omega_c \equiv \frac{w_c}{\mathbb{P}_c} = \left(\frac{\ell_{ck}}{\mu_{ck}}\right)^{\frac{1-\zeta}{1-\lambda-\zeta}} \quad \text{and} \quad \mu_{ck} \equiv \left[\frac{\tilde{\mu}_{ck}}{(\nu_{ck})^{1-\lambda}}\right]^{\frac{1}{1-\zeta}},$$

respectively, which simplify to the corresponding expressions in the main text under the assumption $\zeta = 0$. Solving for ℓ_{ck} and plugging the resulting expression into (B.1) yields $w_{ck} = c_c/\mu_{ck}$, where the expression for the equilibrium "input cost" in country c becomes

$$z_c = \left[(\mathbb{P}_c)^{1-\lambda-\zeta} (w_c)^{\lambda}\right]^{\frac{1}{1-\zeta}}.$$

The aggregate employment rate in (18) becomes

$$\ell_c = (\omega_c)^{\frac{1-\lambda-\zeta}{1-\zeta}} \bar{\mu}_c, \qquad \bar{\mu}_c \equiv \sum_{k \in \mathcal{K}} \frac{L_{ck}}{\bar{L}_c} \mu_{ck}. \tag{B.2}$$

The expansion effect, defined as $\partial \ell / \partial \omega$ in the expression above, is monotonically decreasing in ζ and disappears if vacancies are paid in labor only; indeed, we obtain $\lim_{\zeta \to 1-\lambda} \ell_c = \bar{\mu}_c$. In this case, any change in wages translates into an equivalent change in both the cost and the benefit of opening the vacancy, as such leaving hiring decisions unchanged. Importantly, for any $\rho \in (0,1]$, and with the exception of the expansion effect, all estimation steps and all quantitative results remain unaffected by this generalization. Appendix E reports a sensitivity analysis on the values of λ and ρ.

Finally, the generalization of the ACR formula for the gains from trade in (41) becomes

$$\frac{\omega_c}{\omega_c^0} = \left(\frac{1}{\bar{\pi}_{cc}}\right)^{\frac{\rho}{\lambda \theta_c} + \frac{1-\rho}{\theta_c}}. \tag{B.3}$$

Inspection of the expression above reveals that the magnification effect of the ACR gains from trade is a by-product of the expansion effect: if vacancies use labor only then $\rho = 0$ and the formula above collapses to Ossa's (2015) multi-sector extension of the ACR formula. At the other extreme, if $\rho = 1$ then (B.3) simplifies to (41) in the main text, which is itself a generalization of Heid and Larch's (2016) ACR formula. For any other $\rho \in (0,1)$ the generalized ACR formula in (B.3) is a convex combination of these two.

Appendix C: Data and Variable Construction

This appendix complements Section 4 and provides additional detail on the construction of variables for the counterfactual simulations, and particularly on our methodology for dealing with missing observations. We run the counterfactuals on a fully balanced dataset of 60 countries, a constructed rest of the world and a set of 34 ISIC Rev 3 sectors (for information on our sector classification see Table 1).[56] For the following variables, data was not available for all countries or all sectors in our sample. We explain our methodology for dealing with these caveats.

Intermediate Consumption Shares: We construct the share of intermediary consumption between each sector using combined data from four different Input-Output data sources: the OECD Input-Output Tables, 2017 and 2012 Editions; and the World Input-Output Database (WIOD) 2016 and 2013 Editions. Our main data source is the 2017 Edition of the OECD Input-Output Tables. This database provides input-output tables for 60 countries and for 29 aggregated ISIC Rev 3 sectors. We use the information available in the other IO tables to split these aggregated data-points into our sector classification. To disaggregate ISIC Rev 3 sectors 1-5 and 21-22 we use the respective shares in the WIOD 2016 Edition; for sectors 17-19 we use the shares from WIOD 2013 Edition; and for sectors 30-33 we use the shares from OECD IO Tables 2012 Edition. When performing the splits, we use country-specific shares where available, and sample averages otherwise. We always use the data for year 2008, which is the baseline year in our counterfactuals, except for OECD 2012 Edition where the closest data point is "mid-2000's." The resulting IO database contains fully balanced input-output coefficients for a set of 60 countries and a constructed rest of the world, and for 34 sectors according to our sector classification.

Value Added Shares: We source the share of value added in production from the OECD STAN database. This dataset contains information on value added and gross output for our sample of OECD-31 countries and the full set of sectors in our classification. For countries not available in this dataset, we rely on value added shares in the OECD IO Tables 2017 Edition. To perform the necessary sector disaggregation for this dataset (see paragraph above for list of aggregated sectors) we use the average shares in the OECD STAN database for each respective sector.

Employment Rates: Sectoral employment rates are available from the ILO KILM database for the period 2001-2008 for our OECD-31 sample of countries and a set of aggregated sectors. As explained in Section 4, we estimate employment rates for a full set of sectors in our classification using data on sectoral wages

56. The 60 countries are Argentina, Australia, Austria, Belgium-Luxembourg, Brazil, Brunei Darussalam, Bulgaria, Cambodia, Canada, Chile, China, China Hong Kong, Colombia, Costa Rica, Croatia, Cyprus, Czech Rep., Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Malaysia, Malta, Mexico, Morocco, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Rep. of Korea, Russian Federation, Saudi Arabia, Singapore, Slovakia, Slovenia, South African Customs Union, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, USA, United Kingdom, Vietnam. All other countries with available trade data are in the constructed rest of the world.

and a proxy for skill-investment by sector. Sectoral wages for each country are computed as value added per worker, obtained from the OECD STAN database. For a small number of country-sectors data on value added per worker are missing. In this case, we obtain an estimate of the employment rate by taking the average estimated relative employment rate in the sample for that sector and applying it to the estimated employment rate in the reference sector in that country. The result is a balanced sample of estimated employment rates for 31 countries and 34 sectors. For our methodology in computing counterfactuals for remaining 29 countries for which labor data is not available, see Appendix D.

Unemployment Benefits: We source data on unemployment benefits from the OECD dataset on Social Welfare. We opt to use unemployment benefits reported as the share of last wage earned, received immediately upon entering unemployment, for a single person without children whose last salary was at the level of the average national wage. Data on benefits is available for our full OECD-31 sample of countries except Mexico. We set the unemployment benefits for Mexico to 0.27. We obtain this value as follows. Since 2007, workers in Mexico City are eligible for 6 months of unemployment benefits at the level of Mexico's minimum wage. We thus proxy unemployment benefits in Mexico by the minimum wage divided by the average wage, both sourced from the ILOSTAT database.

Rest of the World Variables: For intermediate consumption and value added shares for the rest of the world, we use averages for each sector in our 60 country sample. Bilateral imports and exports are calculated as the sum of trade flows between countries included in the rest of the world and the 60 countries in our sample. In the same way, tariffs are the weighted averages of bilateral applied tariffs set by countries in the rest of the world to 60 countries in our sample, and vice versa. "Domestic" sales are approximated by import flows within the rest of the world - we do not have sectoral gross output for countries in this entity – and we do not assume zero tariffs or NTBS within the rest of the world; instead we take the weighted averages of these variables reported by countries included in the rest of the world. Our different scenarios never impact the intra-"rest of the world" trade costs. For deficits, we calibrate the deficits of the rest of the world such that the sum of all deficits in our sample is equal to zero.

Appendix D: Computational Procedure for Counterfactual Scenarios

Here we describe the iteration procedure we use to solve the model for any policy change. We use the characterization of the equilibrium in changes, namely, equations (27)-(36) in Section 3.6. We choose the aggregate value of global production as the numeraire.

Step 1 consists in plugging the values corresponding to the changes to the trade regime, $\hat{\tau}_{ijk}$ (changes in other regime types are also possible). We guess wage changes in Step 2; for instance, we set $\hat{w}_{ck} = 1$ for all countries and sectors. We obtain corresponding values for z'_{ck}, $\hat{\mathbb{P}}'_c$, π'_{ijk}, and E'_{ck} from conditions (27)-(30). In Step 3 we plug these new values into the trade balance equation (31), which we rewrite as

$$0 = D_c + \sum_{j\in\mathcal{I}}\sum_{k\in\mathcal{K}} \pi'_{cjk}E'_{jk} - \sum_{i\in\mathcal{I}}\sum_{k\in\mathcal{K}} \pi'_{ick}E'_{ck}, \tag{D.1}$$

where D_c is the trade deficit of country c; we hold D_c constant throughout. If this expression is violated, we update our initial guess for the vector of wages using equilibrium conditions of the labor block in Step 4: we solve simultaneously for $\hat{\ell}_{ck}$, $\hat{L}_{ck}$ and $\hat{w}_{ck}$ using (32)-(35).[57] We additionally impose the constraint $\hat{\ell}_{ck}\ell_{ck} \leq 1$. For countries for which data on labor markets are not available, we assume $\hat{\beta}_{ck} = \hat{\ell}_{ck}$, in which case $\hat{w}_{ck} = (\hat{Y}_c)^{\lambda}(\hat{\mathbb{P}}_c)^{1-\lambda}$, all k. Using updated values of $\hat{w}_{ck}$, we then repeat Steps 3 and 4 until the equilibrium trade balance condition (D.1) is satisfied. Iterations stop when the sum of the left-hand side residuals in equation (D.1) across all countries is below our tolerance level of 10^{-3}. We compute these iterations using Matlab.

Appendix E: Sensitivity Analysis for the Wall Scenario

In this Appendix we report a series of results for the Wall scenario under different assumptions on parameters λ, a, b_c, f_{ck}. First, we test the sensitivity of our results to the choice of the elasticity of the matching function with respect to labor, λ. Table E.1 reports unemployment and welfare results for values of the matching elasticity corresponding to the lower bound ($\lambda = 0.3$) and the upper bound ($\lambda = 0.9$) of this parameter as reported by Petrongolo and Pissarides (2001). These parameter values imply that the elasticity of the employment rate with respect to welfare in equation (18), $\mathcal{E}_{\ell,\omega}$, is equal to $\mathcal{E}_{\ell,\omega} = 1 - \lambda$ and is in the range $\mathcal{E}_{\ell,\omega} \in [0.1, 0.7]$.

In the original model, we set $\lambda = 0.6$ and vacancies use the final good only. We generalize the model in Appendix B by allowing vacancies to use any geometric average of the final good and labor as per equation (B.1), where ρ is the weight of the final good. In this case,

$$1 - \mathcal{E}_{\ell,\omega} = \frac{\lambda}{1 - (1-\lambda)(1-\rho)} \tag{E.1}$$

holds. Hence, an alternative interpretation of the sensitivity analysis that we run here is that we allow the ratio in the right-hand-side of the expression to

57. For the indifference condition (16) to hold, we impose that education costs are equal to $f_{ck} = \omega_{ck}\beta_{ck}$.

TABLE E.1. Changes in Welfare and Unemployment Rates under the Wall Counterfactual for Different Values of Matching Elasticity λ (in Percent)

	Long Run (in percent)				**Short Run** (in percent)			
Country	$\hat{u}_c - 1$		$\hat{\bar{\omega}}_c - 1$		$\hat{u_c}^{SR} - 1$		$\hat{\bar{\omega}}_c^{SR} - 1$	
	λ =0.3	λ =0.9	λ =0.3	λ =0.9	λ =0.3	λ =0.9	λ =0.3	λ =0.9
NAFTA members								
Canada	-0.846	-0.228	0.037	0.040	-4.367	-0.599	0.218	0.292
Mexico	155.019	10.824	-14.722	-3.365	318.477	25.231	-21.992	-7.067
USA	8.201	0.435	-0.533	-0.228	13.349	0.544	-0.625	-0.019
Other OECD members								
Australia	-0.277	-0.100	0.018	0.000	-3.689	-0.197	0.462	0.090
Austria	-0.382	-0.029	0.017	0.008	-0.660	-0.071	0.023	0.007
Belgium	-0.144	-0.006	0.010	0.005	-0.391	-0.039	0.022	0.013
Czech Rep.	-0.239	-0.017	0.012	0.004	-0.531	-0.059	0.022	0.004
Denmark	-0.275	-0.010	0.007	0.002	-0.828	-0.071	0.021	0.008
Estonia	-0.049	0.006	0.000	-0.004	-0.804	-0.054	0.033	0.004
Finland	-0.129	-0.013	0.008	0.007	0.045	-0.017	-0.007	0.003
France	0.082	0.016	-0.007	-0.007	0.287	-0.003	-0.038	-0.037
Germany	-0.202	-0.023	0.014	0.012	-0.406	-0.059	0.014	0.011
Greece	0.050	0.005	-0.013	-0.006	-1.882	-0.148	0.426	0.035
Hungary	-0.226	-0.019	0.030	0.008	-0.685	-0.069	0.076	0.005
Iceland	-0.722	-0.159	0.037	0.013	-1.267	-0.153	0.083	0.056
Ireland	0.627	-0.013	-0.112	-0.032	-0.311	-0.002	0.050	0.003
Israel	-0.535	-0.100	0.032	0.021	-1.367	-0.130	0.071	0.040
Italy	-0.174	-0.013	0.011	0.005	-0.457	-0.052	0.022	0.006
Japan	-0.460	-0.048	0.027	0.017	-2.186	-0.227	0.081	0.016
Netherlands	-0.555	-0.056	0.011	0.010	-1.160	-0.138	0.016	0.016
New Zealand	-0.650	-0.194	0.048	0.009	-3.801	-0.274	0.431	0.127
Norway	0.373	0.031	-0.012	-0.008	-2.114	0.035	0.050	-0.012
Poland	-0.259	-0.032	0.031	0.007	-0.783	-0.076	0.099	0.039
Portugal	0.173	0.227	0.002	-0.006	0.944	0.062	-0.094	-0.088
Slovakia	-0.184	-0.014	0.014	0.007	-0.292	-0.026	0.016	0.000
Slovenia	-0.408	-0.038	0.014	0.007	-0.920	-0.080	0.023	0.004
South Korea	-2.145	-0.165	0.099	0.046	-3.769	-0.401	0.133	0.037
Spain	-0.299	-0.021	0.036	0.019	-0.925	-0.083	0.079	0.026
Sweden	0.101	0.005	-0.009	-0.003	-0.053	-0.041	-0.002	0.005
Switzerland	-0.082	0.028	0.008	0.005	-0.046	-0.009	-0.003	-0.009
United Kingdom	-0.462	-0.043	0.126	0.011	-2.019	-0.181	0.606	0.113

Note: All values are in percent. The Table reports results of simulations for the Wall counterfactual using lower and upper bounds of lambda (0.3 and 0.9, respectively). The left panel reports long-run estimates of changes in national unemployment rate and welfare. The right panel reports short-run estimates of changes in national unemployment rate and national average welfare, where $\hat{\bar{\omega}}_c^{SR} = \sum_{k \in \mathcal{K}} L_{ck} \hat{\omega}_c^{SR}$. Source: Authors' calculations.

take on values in $\{0.3, 0.6, 0.9\}$, which implies that we allow ρ to vary between $\frac{1}{21} \approx 0.048$ and 1 in the various robustness checks.[58]

These results therefore provide bounds to the welfare and unemployment effects of our policy experiment. The qualitative results for NAFTA countries and most third countries are robust to these alternative assumptions about the value of λ. Some quantitative results, by contrast, are sensitive to the value of λ. That result is to be expected: in the limit $\lambda = 1$, vacancies are not required to create jobs and there is full employment; unemployment varies little when the trade regime changes. When λ is low, employment is relatively inelastic in the number of job seekers, and unemployment is high; unemployment is more sensitive to policy changes. To illustrate this point, consider the long run unemployment and welfare changes for Mexico, which features the largest swings among NAFTA countries. Relative to the corresponding benchmark figures reported in Table 3 (which pertain to $\lambda = 0.6$), unemployment changes are 1.7 times as large when $\lambda = 0.3$ and 0.75 as large when $\lambda = 0.9$. The corresponding figures for the US are 1.06 and 0.98, respectively. Turning to welfare changes for Mexico, these are 0.9 times as large when $\lambda = 0.3$ and 1.03 as large when $\lambda = 0.9$.[59] The corresponding figures for the US, at 0.998 and 1.001, respectively, are indistinguishable from 1 up to the second decimal at least. To summarize, the choice of the value of λ is not innocuous (which is why we choose the central value in Petrongolo and Pissarides' 2001 survey), but even the most sensitive meaningful outcome retains the same sign and stays within the same order of magnitude: going from the benchmark $\lambda = 0.6$ to the lower bound $\lambda = 0.3$ does not even double changes in the unemployment rate and it reduces the change in welfare by less than ten percent.

58. To see this result, invert (E.1) to write

$$\rho = \frac{\lambda \mathcal{E}_{\ell,\omega}}{(1-\lambda)\left(1-\mathcal{E}_{\ell,\omega}\right)}.$$

Using the range $\lambda \in [0.3, 0.9]$ from Petrongolo and Pissarides (2001) and $\mathcal{E}_{\ell,\omega} \in \{0.1, 0.4, 0.7\}$ in Tables 3 and E.1, we find that the results reported in these Tables cover values for ρ from $\frac{1}{21}$ when $\lambda = 0.3$ and $\mathcal{E}_{\ell,\omega} = 0.1$ to (above) unity when $\lambda = 0.9$ and $\mathcal{E}_{\ell,\omega} = 0.7$. That is to say, the quantitative analysis performed in this Appendix virtually covers the full range of admissible values for ρ.

59. We compute these figures as follows. First, consider relative changes in unemployment in Mexico:

$$\frac{\hat{u}^{(\lambda=0.3)}_{Mexico}}{\hat{u}^{(\lambda=0.6)}_{Mexico}} = \frac{255.019}{148.337} \approx 1.72, \qquad \frac{\hat{u}^{(\lambda=0.9)}_{Mexico}}{\hat{u}^{(\lambda=0.6)}_{Mexico}} = \frac{110.824}{148.337} \approx 0.75$$

Second, consider relative changes in Mexican welfare:

$$\frac{\hat{\hat{\omega}}^{(\lambda=0.3)}_{Mexico}}{\hat{\hat{\omega}}^{(\lambda=0.6)}_{Mexico}} = \frac{100-14.2}{100-6.6} \approx 0.91, \qquad \frac{\hat{\hat{\omega}}^{(\lambda=0.9)}_{Mexico}}{\hat{\hat{\omega}}^{(\lambda=0.6)}_{Mexico}} = \frac{100-3.4}{100-6.6} \approx 1.03.$$

The figures pertaining to the US that we report in the text are computed in the same way.

Table E.2. Changes in Welfare and Unemployment Rates under the Wall Counterfactual for $a = b_c = 0$ (in Percent)

Assumptions:	$a = b_c = 0$						$a = b_c = 0$, $f_{ck} = f_i \, \forall \, k$, $\lambda = 1$
	Long Run (in percent)				**Short Run** (in percent)		**Long Run** (in percent)
Country	$\hat{u}_c - 1$ Unemployment	$\hat{\bar{\omega}}_c - 1$ Welfare	$\frac{1}{\bar{\mu}_c^*} \text{Cov}\left(\frac{L'_{ck} - L_{ck}}{L_c}, \mu_{ck}^*\right)$ Reallocation	$\hat{\bar{\omega}}_c - 1$ Real GDP P.C.	$\hat{u}_c{}^{SR} - 1$ Unemployment	$\hat{\bar{\omega}}_c^{SR} - 1$ Av. Welfare	$\hat{\bar{\omega}}_c - 1$ Welfare
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NAFTA members							
Canada	-0.493	0.054	0.010	0.054	-2.728	0.369	0.008
Mexico	46.691	-4.354	-0.132	-4.354	126.393	-9.016	-2.609
USA	2.350	-0.353	-0.003	-0.353	3.501	-0.256	-0.216
Other OECD members							
Australia	-0.108	-0.001	0.005	-0.001	-1.181	0.120	-0.008
Austria	-0.122	0.011	0.001	0.011	-0.349	0.019	0.009
Belgium	-0.040	0.007	0.000	0.007	-0.197	0.023	0.002
Czech Rep.	-0.068	0.006	0.001	0.006	-0.290	0.015	0.006
Denmark	-0.050	0.003	0.001	0.003	-0.388	0.019	0.003
Estonia	0.025	-0.005	0.000	-0.005	-0.302	0.019	-0.003
Finland	-0.061	0.009	0.000	0.009	-0.071	0.005	0.010
France	0.050	-0.009	0.000	-0.009	0.031	-0.038	0.005
Germany	-0.094	0.017	0.001	0.017	-0.276	0.027	0.014
Greece	0.025	-0.006	0.000	-0.006	-0.721	0.065	-0.004
Hungary	-0.067	0.012	0.001	0.012	-0.337	0.026	0.011
Iceland	-0.337	0.017	0.004	0.017	-0.710	0.059	0.010
Ireland	0.187	-0.043	0.004	-0.043	-0.047	0.010	0.008
Israel	-0.227	0.032	0.006	0.032	-0.664	0.086	0.019
Italy	-0.053	0.008	0.001	0.008	-0.246	0.020	0.006
Japan	-0.195	0.023	-0.001	0.023	-1.163	0.057	0.020
Netherlands	-0.217	0.014	0.001	0.014	-0.672	0.030	0.012
New Zealand	-0.296	0.011	0.009	0.011	-1.426	0.146	-0.001
Norway	0.169	-0.013	0.001	-0.013	-0.145	0.009	-0.007
Poland	-0.078	0.010	0.002	0.010	-0.376	0.053	-0.001
Portugal	0.214	-0.005	-0.016	-0.005	0.341	-0.109	0.008
Slovakia	-0.052	0.011	0.001	0.011	-0.131	0.015	0.008
Slovenia	-0.125	0.011	0.001	0.011	-0.409	0.022	0.008
South Korea	-0.794	0.063	0.001	0.063	-1.954	0.083	0.040
Spain	-0.099	0.030	0.001	0.030	-0.396	0.068	0.016
Sweden	0.024	-0.005	0.000	-0.005	-0.170	0.012	-0.004
Switzerland	0.006	0.007	-0.003	0.007	-0.048	-0.004	0.011
United Kingdom	-0.138	0.015	0.002	0.015	-0.924	0.106	0.001

Note: All values are in percent. Columns (1)-(6) report the results of the Wall counterfactual for parameter values $a = b_c = 0$, while keeping $\lambda = 0.6$ and allowing for country-sector specific education costs f_{ck} as in the main text. Columns (1)-(4) report the long-run results, while columns (5)-(6) report the short-run results. Column (1) reports the relative change in the unemployment rate calculated according to equation (38). Column (2) reports the change in the welfare as per equation (34). Column (3) reports the 'reallocation effect' calculated as $[\hat{\ell}_c/(\hat{\bar{\omega}}_c)^{1-\lambda} - 1] \times 100$; Column (4) reports the changes in real GDP per capita (net of education costs), calculated as $\left(\sum_{k \in \mathcal{K}} L'_{ck} \bar{\omega}'_{ck}\right) / \left(\sum_{k \in \mathcal{K}} L_{ck} \bar{\omega}_{ck}\right)$. Columns (5) and (6) report short-run changes in average welfare and national unemployment rate, where $\hat{\bar{\omega}}_c^{SR} = \sum_{k \in \mathcal{K}} L_{ck} \hat{\bar{\omega}}_c^{SR}$. Notice that under the assumptions $a = b_c = 0$, welfare changes are equal to changes in real GDP per capita. In addition, Column (7) reports the long-run welfare changes (here equivalent to changes in real GDP per capita) for the Wall counterfactual under additional assumptions that education costs are constant across all sectors $f_{ck} = f_i \, \forall \, k$ and that the matching efficiency is set to unity, $\lambda = 1$, so that there is full employment. Source: Authors' calculations.

Next, we check the sensitivity of our results to parameter choice for a and b_c. Table E.2, Columns (1)-(6) report the results for the Wall counterfactual under the assumption that workers are risk-neutral and that there are no unemployment benefits, $a = b_c = 0$. Recall that welfare and real GDP per capita are identical in this case. We maintain our baseline value $\lambda = 0.6$ throughout. Our quantitative predictions on changes in unemployment, welfare and real GDP per capita are robust to this simplification. Unemployment changes are almost identical to our baseline results. Welfare changes are remarkably similar to the baseline changes, even though the values of the risk aversion parameter a differ markedly.

Finally, the last column of Table E.2 reports welfare changes for the Wall scenario under the following assumptions: risk aversion and unemployment benefits are zero as above, $a = b_c = 0$ (so that real GDP per capita and welfare are identical); education costs are equal across sectors, $f_{ik} = f_i$ for all k; and the elasticity of the matching function with respect to labor is set to unity, $\lambda = 1$, which implies full employment of labor. This version of the model is identical to Caliendo and Parro (2015). In most cases, not allowing for unemployment underestimates the magnitude of the welfare effects of trade. For instance, Mexico is worse off by 4.4 percent under the Wall scenario with matching frictions (Col. 2), but by only 2.6 percent under the same scenario without labor matching frictions (Col. 7).

Appendix F: Bootstrapped Standard Errors

Table F.1 reports bootstrapped standard errors for the main results shown in Tables 3 and 4. We bootstrapped the standard errors on 100 random draws from the estimated distributions of β_{ck} and θ_k. To save space, we report only the standard errors for the member countries in each counterfactual scenario. Unemployment and welfare results for all member countries are significant at 5 percent significance level, with the exception of Canada under the USMCA scenario. The latter is not surprising as Canada is not directly affected by trade barrier changes in this counterfactual.

TABLE F.1. Bootstrapped Results for The Wall and USMCA Citadel Counterfactuals

	Long Run (in percent)								**Short Run** (in percent)			
	$\hat{u}_c - 1$		$\hat{\bar{\omega}}_c - 1$		$\frac{1}{\bar{\mu}_c^*}\text{Cov}\left(\frac{L'_{ck}-L_{ck}}{\bar{L}_c}, \mu_{ck}^*\right)$		$\hat{\bar{\omega}}_c - 1$		$\hat{u}_c^{SR} - 1$		$\hat{\bar{\omega}}_c^{SR} - 1$	
Scenario Country	Unemployment		Welfare		Reallocation		Real GDP P.C.		Unemployment		Average Welfare	
	Coeff.	(St. Err.)	Coeff.	(St. Err.)	Coeff.	(St. Err.)	Coeff.	(St. Err.)	Coeff.	(St. Err.)	Coeff.	(St. Err.)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
The Wall												
Canada	-0.448	0.217	0.039	0.015	0.008^{ns}	0.008	0.033	0.012	-2.412	0.752	0.258	0.088
Mexico	48.140	1.604	-6.621	0.195	-0.210	0.037	-3.795	0.124	125.072	3.991	-12.317	0.533
USA	2.414	0.113	-0.310	0.012	-0.003^{ns}	0.002	-0.275	0.011	3.514	0.113	-0.181	0.012
The USMCA Citadel												
Canada	0.046^{ns}	0.050	-0.003^{ns}	0.003	-0.001^{ns}	0.002	-0.002^{ns}	0.003	-0.248	0.105	-0.036	0.013
Mexico	0.670	0.028	-0.103	0.003	0.000^{ns}	0.001	-0.060	0.002	0.468	0.058	-0.077	0.005
USA	0.405	0.038	-0.058	0.004	0.002^{ns}	0.001	-0.052	0.004	0.282	0.022	-0.102	0.003

Note: The Table reports bootstrapped standard errors of long run and short run results for relevant members of each counterfactual scenario. Odd-numbered columns show the average bootstrapped coefficient. All values are in percent. Even-numbered columns report the corresponding bootstrapped standard errors. Bootstrapping was performed using 100 random draws from the estimated distributions of β_{ck} and θ_k. All results shown, except the ones signaled by the ns superscript, are significant at 5 percent significance level. Source: Authors' calculations.

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