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Comparative advantage and equilibrium unemployment[☆]

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ABSTRACT

We embed a model of the labour market with sector-specific search-and-matching frictions into a Ricardian model with a continuum of goods to show that trade reduces unemployment in countries with comparative advantage in sectors with more efficient labour markets and leads to higher unemployment in countries with comparative advantage in sectors with less efficient labour markets. We test this prediction in a panel dataset of 107 countries covering the period 1995–2009 and find that the data support this theoretical prediction. Our results also help reconcile the apparently contradicting evidence in the empirical literature on the impact of trade on unemployment.

1. Introduction

Does international trade create or destroy jobs? We develop a model that introduces search-and-matching labour market frictions in a trade model with a continuum of sectors to address this question. Comparative advantage drives the patterns of trade, whereas labour market frictions generate equilibrium unemployment. In our model, labour market frictions are sector-specific and the aggregate unemployment rate of a country can be thought of as a weighted average of these sector-specific labour market frictions. As a result, patterns of trade and sector-specific labour market frictions interact in shaping aggregate unemployment. If a country has a comparative advantage in sectors that have less efficient labour markets, then trade

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reallocates resources towards these sectors, and thereby may increase aggregate unemployment. Conversely, if comparative advantage and sector-specific labour market efficiency are positively correlated, unemployment falls with trade. We find strong empirical support for this theoretical prediction in a panel of 107 countries that account for more than 95% of world trade over the period 1995–2009.

Integrating labour market frictions in trade models is important for at least three reasons. First, such a setting allows trade to destroy or create jobs, rather than assume away the impact of trade on unemployment. Until fairly recently, most economists would agree with Krugman (1992) that "it should be possible to emphasize to students that the level of employment is a macroeconomic issue... with microeconomic policies like tariffs having little net effect." Most international economics textbooks have no chapter on the impact of trade on unemployment. Our paper contributes to the filling of this gap. Second, the net impact of trade on unemployment is likely to be complex and ambiguous as illustrated in Helpman and Itskhoki (2010). It is therefore important to understand when to expect the adverse effects to dominate. Our paper provides an empirical test of the sector reallocation effect, a theoretical prediction we obtain building on Helpman and Itskhoki (2010) and Dornbusch et al. (1977).[1]

Third, the relationship between trade and unemployment is an important political issue. Policymakers are convinced that there is a link between the two, but they disagree on the direction to which unemployment moves with trade. Voters seem to be convinced about this link, too, as voting patterns in the recent US presidential election suggest (Autor et al., 2016b). Our model and empirical evidence claim that the answer depends on the correlation between patterns of trade and labour market frictions.

Bringing our theoretical predictions to the data requires three steps. First, we need a measure of comparative advantage and a measure of sectoral labour market efficiency. We measure the former using the fixed-effect gravity approached introduced by Costinot et al. (2012) and developed further by Hanson et al. (2015). We construct the latter building on the simple idea that observed country-level unemployment rates are a weighted-sum of sector-level unemployment rates, where weights are given by labour force shares in each sector. Using data on aggregate unemployment and employment by sector we are then able to estimate sector-specific unemployment rates. Owing to the lack of time coverage in the sector level employment data that is available, we further assume that these sector-specific unemployment rates are common across countries in our baseline estimation.[2] We show that this new measure of sector-specific labour market frictions is positively correlated with existing proxies of labour market frictions such as labour union coverage, and the US Census sector level unemployment rate.[3]

In a second step, we compute country-specific correlations between measures of comparative advantage and sector-specific unemployment rates. The country with the highest correlation in our sample is Russia, which therefore has a comparative advantage in sectors with more inefficient labour markets. The country with the lowest negative correlation is Israel, which therefore has a comparative advantage in sectors with more efficient labour markets.

Our third and final step involves testing whether unemployment is lower in countries where the correlation between comparative advantage and sector level labour market efficiency is high. The empirical results confirm this theoretical prediction. Sensitivity analysis addressing measurement error and endogeneity of our measure of correlation to aggregate unemployment provide evidence that our results are robust.

Our paper builds on a growing literature on the impact of trade on unemployment; Helpman et al. (2013) provide a review. Brecher (1974) is an early example. He develops a 2x2 Hecskscher-Ohlin model of a small open economy with a minimum wage to show that the impact of trade on welfare and unemployment depends on relative factor endowments: labour-abundant countries experience a fall in unemployment as they open up to trade, whereas capital-abundant countries see unemployment increase. Davis (1998), building on Brecher's setup and allowing for terms-of-trade effects in a world with two identical economies except for their labour market rigidities, shows that openness reduces welfare and increases unemployment in the economy with more rigid labour markets. Davidson et al. (1999) find that the impact of trade on unemployment depends on relative capital-labour endowments across different countries as in Brecher (1974). More importantly, they also recognize that sectoral labour market frictions can be a source of comparative advantage. Helpman and Itskhoki (2010) build a Diamond-Mortensen-Pisarrides (henceforth DMP) model of labour market frictions in a two-sector 'new trade' model; a competitive sector produces a homogeneous good and a monopolistically competitive sector produces a differentiated good. They show that a country with relatively low frictions in the differentiated-good sector will be a net exporter of that good. Intuitively, lower frictions imply lower labour costs and, coupled with the 'Home-Market' effect a-la Krugman (1980), create a comparative advantage in the differentiated sector. The impact of trade on unemployment is ambiguous, with unemployment rising or falling in both or one country being possible depending on the extent of

[1] Specifically, we encapsulate Helpman and Itskhoki's (2010) static version of labour market matching frictions into Dornbusch et al.'s (1977) two-country Ricardian trade model. That model leads to the counterfactual prediction that gross and net trade flows coincide (countries do not produce goods that they import), which rules out intra-industry trade. We account for this feature of trade data in the empirical section. Working with Costinot et al.'s (2012) stochastic version of the Ricardian trade model would address this shortcoming of the model; see Carrère et al. (2020) for an extension along these lines. Here we stick to the simpler model by Dornbusch et al. (1977) for the sake of parsimony.

[2] Note that, unlike in Cuñat and Melitz (2012), this identifying assumption implies that sector-specific labour market frictions cannot be a source of comparative advantage. The model is general insofar as we do not impose this assumption in the theory, and we show that the qualitative theoretical predictions are identical. In the robustness checks subsection we provide evidence suggesting that our results are not sensitive to this assumption.

[3] These sectoral unemployment rates are defined as the share of unemployed workers that were previously employed in a given sector over the sum of employed and unemployed workers previously employed in a given sector.

labour frictions in the differentiated sector relative to the homogenous-good sector; we generalize this result and apply it to a comparative advantage framework. Proposition 6 in Helpman and Itskhoki (2010) establishes this result in the context of symmetric countries and in the absence of income effects. We relax both assumptions and show that the qualitative result holds more generally.[4] Our empirical results are consistent with this theoretical result. Finally, in a related paper, Carrère et al. (2020) build a multi-sector, multi-country quantitative model of trade and frictional unemployment featuring input-output linkages, risk-averse workers, and unemployment benefits. The goal of that related paper is to quantify the welfare and unemployment effects across countries of hypothetical scenarios that the current White House Administration seems sometimes close to bringing to life. The current paper provides empirical evidence for a key mechanism at work in both papers.

When theory provides contradicting answers, the natural next step is to look for patterns in the data. However, the rapidly growing empirical literature has not found an unambiguous unemployment response to trade either. Several important papers suggest that import growth has led to an increase in unemployment. Harrison and Revenga (1998) for the Czech Republic, Poland, Romania and Slovakia, Menezes-Filho and Muendler (2011) and Mesquita and Najberg (2000) for Brazil, Edwards and Edwards (1996) for Chile, Rama, (1994) for Uruguay: all provide evidence in this direction. There are also several important papers suggesting that trade has no impact on unemployment. The long run estimates in Trefler (2004) provide such evidence for Canada. Bentivogli and Pagano (1999) show that trade has little or no impact in France, Germany, Italy and the United Kingdom. Finally, there is also evidence suggesting that trade opening has led to reductions in unemployment. Kee and Hoon (2005) and Nathanson (2011) show that is the case in Singapore and Israel, respectively. Felbermayr et al. (2011) and Heid and Larch (2016) show that an increase in trade openness reduced unemployment in a sample of twenty OECD countries, while Dutt et al. (2009) establish this result for a large sample of developing and developed countries.

Our theoretical framework and empirical results help explain the conflicting results of these studies. Ranking countries in terms of our measure of correlation between comparative advantage and labour market frictions, Brazil, Chile, the Czech Republic, Poland, Romania, Slovakia, and Uruguay are in the top of the distribution with positive correlations over 1995–2009 which are statistically different from zero. Canada, France, Germany Italy and the United Kingdom are in the middle of the distribution and their correlation across time (1995–2009) is not statistically different from zero. Finally, both Singapore and Israel are at the bottom of the distribution with negative and statistically different from zero correlations between comparative advantage and sector-specific unemployment. Thus, our paper provides a theory-based framework to resolve the apparent ambiguity in the empirical literature.

2. Comparative advantage and labour market frictions

We merge a two-country Ricardian trade model with a model of equilibrium unemployment based on search-and-matching frictions to illustrate how the correlation between comparative advantage and sector level labour-market efficiency impacts the aggregate level of unemployment.

2.1. Preferences, technology and trade

Our trade model builds on Dornbusch et al. (1977). The world economy consists of two countries, Home and Foreign, one primary factor of production, workers, a homogenous final good sector, Y, and a measure one of homogenous intermediates that are indexed by $z \in [0, 1]$; $X(z)$ denotes output of tradable intermediate z. Preferences are linear in Y, namely, $U(Y) = Y$. Sector Y is perfectly competitive and produces under constant returns to scale assembling intermediates with a symmetric Cobb-Douglas production function. Specifically,

$$\ln Y = \int_0^1 \ln X(z) \mathrm{d}z. \tag{1}$$

Each intermediate sector z is produced with a labour-input requirement given by $1/\hat{a}(z)$ which varies across sectors and countries and provides a source of Ricardian comparative advantage in the model (thus $\hat{a}(z)$ is a country-sector-specific level of total factor productivity).

The market for each z is perfectly competitive and firms are homogenous in all sectors, which yield zero profits in equilibrium.

[4] Helpman et al. (2010) introduce heterogenous workers with match-specific ability and costly worker screening for hiring firms. In such a setup trade tends to increase unemployment because it reduces the hiring rate, as trade reallocates resources towards more productive firms that have stronger incentives to screen. Another important strand of this recent literature looks at the impact of trade on unemployment caused by 'efficient' or 'fair-wages', as in Davis and Harrigan (2011) or Egger and Kreickemeier (2009). Artuç et al. (2010) introduce frictions to the mobility of workers across sectors and study the outcome of this on the transitory unemployment rate. There is no transition in our static framework: we study the long run equilibrium effects of trade on unemployment. See Itskhoki and Helpman (2014), Dix-Carneiro (2014), or Caliendo et al. (2019) for models with transition effects.

International trade in Y is prohibitive, but trade in X is costless outside the autarky equilibrium.[5] Let $P(z)$ and $P^0(z)$ denote the Home and Foreign domestic prices of z, respectively (we solve for them below). Let also

$$\pi(z) \equiv \frac{P^0(z)}{P(z)} \quad \text{with} \quad \pi'(z) < 0. \tag{2}$$

The assumption $\pi'(z) < 0$ is without loss of generality: it is an arbitrary but convenient ranking of sectors. $\pi(z)$ encompasses all sources of comparative advantage in our model. Then Home's producers of Y purchase $X(z)$ locally if and only if $\pi(z) > 1$, and Foreign producers purchase intermediate z locally if and only if $\pi(z) < 1$.

At equilibrium both countries fully specialize as follows. Home exports goods in the interval $[0, \underline{z}]$, and Foreign exports goods in the interval $(\underline{z}, 1]$, where $\underline{z}$ is implicitly defined as $\pi(\underline{z}) = 1$.

We choose the final good produced in Foreign, Y^0, as the numéraire and we denote the Home price of Y by p. With equal expenditure shares across all industries in Eq. (1) and with complete specialization, Home's expenditure on imports is equal to $(1-\underline{z})pY$ and the value of Foreign's imports is equal to $\underline{z}Y^0$, where pY and Y^0 are the aggregate incomes of Home and Foreign, respectively. Thus, trade is balanced if and only if

$$\frac{pY}{Y^0} = \frac{\underline{z}}{1-\underline{z}} \tag{3}$$

holds.

Cost minimization in Home's sector Y subject to Eq. (1) and perfect competition yield (in logs)

$$\ln p = \int_0^{\underline{z}} \ln P(z)\mathrm{d}z + \int_{\underline{z}}^1 \ln P^0(z)\mathrm{d}z. \tag{4}$$

Likewise, cost minimization in Foreign's sector Y^0 and our choice of numéraire yield (in logs)

$$0 = \int_0^{\underline{z}} \ln P(z)\mathrm{d}z + \int_{\underline{z}}^1 \ln P^0(z)\mathrm{d}z. \tag{5}$$

Since all intermediates are traded in the free-trade equilibrium,

$$p = p^0 \equiv 1 \tag{6}$$

follows from these expressions; (5) thus applies to both Home and Foreign and (4) is redundant.

Wages are the missing link between incomes, Y and Y^0, and prices, $P(z)$ and $P^0(z)$. We depart from Dornbusch et al. (1977) and assume that wages are set in imperfectly functioning labour markets, following Helpman and Itskhoki (2010).

2.2. Labour market

There are L and L^0 workers in the Home and Foreign economies, respectively. Each worker supplies one unit of labour inelastically. We model strictly positive but finite inter-sectoral reallocation costs in our static environment as follows.[6] Workers are initially homogeneous, but they need to acquire sector-specific skills before being able to supply their labour and search for a job. Let $L(z)$ denote the mass of workers that choose to acquire the skills specific to, and search for a job in, sector z. This choice is sunk as in Anderson (2009) or Helpman and Itskhoki (2010). We refer to the exhaustive use of labour as the *full participation* condition, which we write as

$$L = \int_0^1 L(z)\mathrm{d}z \quad \text{and} \quad L^0 = \int_0^1 L^0(z)\mathrm{d}z \tag{7}$$

for Home and Foreign, respectively. In this subsection, we henceforth express all conditions for Home only; isomorphic expressions hold for Foreign.

We solve for the labour market equilibrium in two steps. We first take the allocation $L(z)$ of workers across sectors as given and solve for the partial equilibrium in all sectors in isolation. We then solve for $L(z)$ imposing the *full participation* condition (7).

Step 1: functioning of sectoral labour markets. There are search-and-matching frictions in the labour market, which generate matching rents over which the firm and the employee bargain. We follow Helpman and Itskhoki (2010) in modeling these DMP frictions in a static environment.

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[5] Introducing Samuelson iceberg trade costs for trade in X does not affect the results, as we show in a previous version of this paper (Carrère, Fugazza, Olarreaga, and Robert-Nicoud, 2014).

[6] There is growing evidence that sectoral reallocation can be substantial. Artuç and McLaren (2015) and Artuç et al. (2010) estimate sector switching costs for United States' workers which are several orders of magnitude higher than the annual wage. Artuç et al. (2015) estimate sector mobility costs across countries. They vary between 1.3 times the annual wage in Estonia to 5.1 times the annual wage in Jordan, suggesting that moving across sectors is very costly for workers in most countries. Empirical results from the literature on the consequences of the China trade shock on the local labour markets in the US and elsewhere are also consistent with substantial spatial and sectoral relocation costs (Autor et al., 2016a).

Let $V(z)$ denote the number of vacancies that Home firms choose to open in sector z and let $H(z)$ denote the number of employed workers in sector z. The number of firm-worker matches $H(z)$ is increasing in $L(z)$ and $V(z)$ and in the exogenous sector-specific total factor productivity of the matching technology, which is governed by $\mu(z)$ in Home and by $\mu^0(z)$ in Foreign. Specifically, we assume the following Cobb-Douglas matching function:

$$H(z) = [\mu(z)V(z)]^{\alpha} L(z)^{1-\alpha},$$

where $0 < \alpha < 1$.[7] Using this expression, the labour market tightness, which we define as the probability that a worker finds a job, is equal to

$$\lambda(z) \equiv \frac{H(z)}{L(z)} = \left[\mu(z)\frac{V(z)}{L(z)}\right]^{\alpha}. \tag{8}$$

In equilibrium, $\lambda(z)$ is also the sectoral employment rate.

Consider the representative worker and firm of sector z. Upon forming a match, they engage in cooperative wage bargaining. At this stage, all choices and costs are sunk and the firm and the worker's outside options are zero. Assuming equal bargaining weights for simplicity, the revenue $r(z)$ that the match generates is split evenly between the two; the sectoral wage is thus equal to $w(z) = r(z)/2$.[8] Free entry and exit prevails in all sectors. Firms open vacancies until the benefits from hiring one worker, $r(z) - w(z) = r(z)/2$, is equal to its cost, which we denote as $b(z)$. It follows that $w(z)$ is equal to $b(z)$ in equilibrium.

The cost of hiring one worker, $b(z)$, is equal to the expected number of vacancies that need to be open in order to hire one worker, $V(z)/H(z) = \lambda(z)^{\frac{1-\alpha}{\alpha}}/\mu(z)$, times the unit vacancy cost, which is sector-specific and equal to $\nu(z)$ units of the domestically produced final good in Home (and to $\nu^0(z)$ units of the Foreign final good in that country).[9] Therefore, the wage and the cost of hiring one worker in sector z are equal to

$$w(z) = b(z) \equiv pv(z)\lambda(z)^{\frac{1-\alpha}{\alpha}}, \tag{9}$$

where $v(z) \equiv \nu(z)/\mu(z)$ is the unit vacancy cost adjusted for the total factor productivity of the matching function in z (by the same token we define $v^0(z) \equiv \nu^0(z)/\mu^0(z)$ for the collection of Foreign parameters).[10] As a result, the unit labour cost is equal to

$$\widetilde{w}(z) \equiv b(z) + w(z) = 2pv(z)\lambda(z)^{\frac{1-\alpha}{\alpha}}. \tag{10}$$

We can use the expression above to obtain an explicit expression for the unit cost pricing conditions in each sector:

$$P(z) = \frac{1}{\hat{a}(z)}\widetilde{w}(z), \qquad P^0(z) = \frac{1}{\hat{a}^0(z)}\widetilde{w}^0(z). \tag{11}$$

Step 2: integrating labour markets. Consider now the sectoral decisions of workers. They are risk neutral. Expected returns must then be the same in all active sectors. This ex-ante indifference condition for workers implies

$$\lambda(z)w(z) \le w, \quad L(z) \ge 0, \quad [w - \lambda(z)w(z)]L(z) = 0, \tag{12}$$

some $w > 0$ to be determined in general equilibrium. Sectors that are active in equilibrium all yield the same expected return w to workers. Sectors that fall short of granting the expected return w attract no one (and hence $w(z)$ is a shadow price for these sectors).

Eqs (9) and (12) together yield an equilibrium expression for the level of unemployment pertaining to Home's sector z:

$$u(z) \equiv 1 - \lambda(z) = 1 - \left[\frac{w}{p}\frac{1}{v(z)}\right]^{\alpha}. \tag{13}$$

[7] This assumes that labor market frictions are sector-specific. There are several recent papers that support this assumption. Barnichon and Figura (2015) show that considering a non-unified labor market helps reconcile theory with observed behavior of job finding rates across industries. Carrère et al. (2020) show that similar results are obtained if one assumes the better empirically documented assumption that labor markets are occupation-specific. The management literature also suggests that even though labor market institutions are often universally defined and applied at the national level their incidence could vary across sectors due to differences in terms of industrial relations and technology (Wright and Lansbury, 2020), for instance. Based on indicators calculated for EU country members, Bechter et al. (2012) found that industrial relations vary across sectors as deeply as they do across countries implying that analysis of industrial relations should be undertaken at the sector rather than at the aggregate level.

[8] We can assume instead sector-specific bargaining weights, where $\psi(z) \in (0, 1)$ is the labour bargaining share. In this case $w(z) = \psi(z)r(z)$. We develop the theoretical consequences of this generalization in footnote 10 below.

[9] In the case of sector-specific bargaining weights, we obtain $v(z) \equiv \nu(z)/\mu(z)\psi(z)/[1 - \psi(z)]$ and $\widetilde{w}(z) = pv(z)\lambda(z)^{\frac{1-\alpha}{\alpha}}/[1 - \psi(z)]$. A higher labour share $\psi(z)$ in the bargaining process has the same impact on sectoral wages and hiring costs as a higher vacancy cost or a lower matching total factor productivity. That is because a higher ψ implies a lower rent share for entrepreneurs, which discourages job creation. It is worth bearing that result in mind in Section 3, where we show that our measure of sector-specific market frictions is positively correlated with the union membership and coverage in the United States.

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Note that $u(z)$ is decreasing in the economy-wide average wage and increasing in the sector-specific labour market frictions; thus (13) is akin to a labour supply curve in the $(\lambda, w/p)$-space. The wage and unemployment rates are negatively correlated in equilibrium because a higher demand for labour in sector z lowers unemployment and raises wages in that sector.

We finally solve for sectoral employment, $L(z)$. The zero profit condition in z implies that the value of production in z, which is equal to the revenue generated by each hired worker times the employment level, covers labour costs; in mathematical symbols, $R(z) \equiv r(z)H(z) = \tilde{w}(z)H(z) = 2w(z)H(z)$, where the last equality follows from (9) and (10). Using (8) in turn, we may write this expression as $R(z) = 2w(z)\lambda(z)L(z)$. Finally, using the indifference condition (12) yields $R(z) = 2wL(z)$.

Turning to the demand for intermediate good z, the symmetric Cobb-Douglas production function in (1) implies $R(z) + R^0(z) = pY + Y^0$, for all z.[11] Together with the supply-side expression above, this result yields

$$\frac{pY + Y^0}{2} = wL(z) + w^0 L^0(z) \tag{14}$$

for all z. That is, the worldwide wage bill of each sector is identical by the symmetry of (1). Another convenient implication of the symmetric Cobb-Douglas production function in (1) is that the number of workers seeking employment in a given sector depends only on the export status of the sector in each country.

Let Λ and Λ^0 denote the common level of job seekers in Home and Foreign's exporting sectors, respectively; that is to say, $L(z) = \Lambda$ and $L^0(z) = 0$ for all $z \in [0, \underline{z}]$, and $L(z) = 0$ and $L^0(z) = \Lambda^0$ for all $z \in (\underline{z}, 1]$. Manipulating Eqs (3), (7), and (14) yields expressions for the equilibrium labour force in each sector as a function of the trade patterns cutoffs.[12] The equilibrium labour forces of exporting sectors in Home and Foreign are equal to

$$\Lambda = \frac{1}{\underline{z}} L \quad \text{and} \quad \Lambda^0 = \frac{1}{1 - \underline{z}} L^0. \tag{15}$$

2.3. Equilibrium unemployment

We close the model in the appendix where we show that the equilibrium exists and is unique. Here we focus on equilibrium unemployment and on the impact of trade on unemployment.

The unemployment rate in the Home economy, u, is a weighted average of the unemployment rates prevailing in each active sector, $u(z)$, where the weights are given by the participation rates:

$$u = \frac{1}{\underline{z}} \int_0^{\underline{z}} u(z) \mathrm{d}z \tag{16}$$

and

$$u^0 = \frac{1}{1 - \underline{z}} \int_{\underline{z}}^1 u^0(z) \mathrm{d}z, \tag{17}$$

where $u(z)$ is given by (13) and $u^0(z) \equiv 1 - \lambda^0(z) = 1 - \left[w^0/v^0(z)\right]^\alpha$. Let us use subscripts 'a' to denote autarky values. The following, intuitive result immediately follows:

Lemma 1. *Assume Home is equipped with better performing labour market institutions than Foreign in the sense $v(z) < v^0(z)$ for all z. Then its equilibrium unemployment rate is lower than in Foreign, ceteris paribus. In particular, the autarky unemployment rate in Home,*

$$u_a \equiv \int_0^1 u(z) \mathrm{d}z,$$

is lower than that in Foreign,

$$u_a^0 \equiv \int_0^1 u^0(z) \mathrm{d}z,$$

given the equilibrium vector of autarky prices $\{p_a, w_a, w_a^0\}$. Formally:

$$\forall z \in [0, 1] : v(z) < v^0(z) \qquad \Rightarrow \qquad \left(u_a - u_a^0\right)\Big|_{\{p_a, w_a, w_a^0\}} < 0.$$

Proof. It follows from (13) and from the definitions of u_a and u_a^0 that we can write:

$$\frac{1 - u_a}{1 - u_a^0} \left(\frac{w_a/p_a}{w_0}\right)^{-\alpha} = \frac{\int_0^1 v(z)^{-\alpha} \mathrm{d}z}{\int_0^1 \left(v^0(z)\right)^{-\alpha} \mathrm{d}z} = \int_0^1 \left(\frac{v(z)}{v^0(z)}\right)^{-\alpha} \frac{\left(v^0(z)\right)^{-\alpha}}{\int_0^1 \left(v^0(z')\right)^{-\alpha} \mathrm{d}z'} \mathrm{d}z > 1$$

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[11] Note that the revenue of each sector equals the average revenue given the symmetric Cobb-Douglas production function in (1). Recall also that we use a unit measure of sectors.

[12] Thus Heid and Larch's (2016) Armington model has as many sectors as countries whereas our model has an arbitrary number of sectors (its mass is normalized to unity) but only two countries for simplicity; Carrère et al. (2020) show that we can generalize the expression in (18) to any arbitrary number of sectors and countries (their model also accounts for trade costs, input-output linkages,unemployment benefits, and risk aversion).

The rightmost expression is a weighted average of sector-by-sector adjusted relative unit vacancy costs. Each term is larger than unity by assumption, which implies the inequality in this expression and establishes the result. □

In order to illustrate the effects of trade on equilibrium unemployment, let us compare the trade equilibrium with the autarky equilibrium. Let $\omega \equiv w/p$ denote the real wage and let $\lambda_a = 1 - u_a$ and $\lambda = 1 - u$ denote the autarky and trade equilibrium employment rates, respectively. We can then use these definitions as well as (13), (15), and (16) to obtain the following expression (it turns out that it is more convenient to write this result in terms of the employment rate λ):

$$\frac{\lambda}{\lambda_a} \equiv \frac{1-u}{1-u_a} = \left(\frac{\omega}{\omega_a}\right)^{\alpha}\left[1 + \frac{1}{1-u}\mathrm{Cov}\left(\frac{L(z)-L_a(z)}{L}, u(z)\right)\right]^{-1}, \tag{18}$$

where $\mathrm{Cov}\left(\frac{L(z)-L_a(z)}{L}, u(z)\right) \equiv \int_0^1 \left[\frac{L(z)-L_a(z)}{L}\right][u(z)-u]\mathrm{d}z$ is the covariance between *revealed comparative advantage* and sector-specific unemployment rates.[13]

The first term in the right hand side of (18) is an overall efficiency effect.[14] Moving from autarky, trade raises the (real) wage $\omega \equiv w/p$ by Samuelson (1962) and Kemp's (1962) Gains From Trade theorems. This makes opening vacancies more profitable, which in turn decreases unemployment in equilibrium. This effect was highlighted by Heid and Larch (2016) in two multi-country trade models (Armington and Eaton-Kortum) and by Carrère et al. (2020) in a multi-sector, multi-country Ricardian trade model.[15]

The second term of the right hand side of (18) captures the labour reallocation effect on which we focus here. The covariance term captures the *unemployment content of trade*: for all $z \in [0, \underline{z}]$ (i.e. for all export sectors), $\frac{L(z)-L_a(z)}{L} = \frac{\Lambda}{L} - 1$ is positive by (15) and represents a shift of resources into the export sectors relative to the autarky equilibrium (or, equivalently, relative to the world average); conversely, $\forall z \in (\underline{z}, 1] : \frac{L(z)-L_a(z)}{L} = -1$ is negative and represents a shift of resources out of import competing sectors; these shifts form our theory-based measure of *revealed comparative advantage*. In order to understand the logic that the expression in (18) uncovers from a different angle, let us define the *unemployment-content of exports* and the (shadow) *unemployment-content of imports* as

$$u_X \equiv \left(\frac{1}{\underline{z}} - 1\right)\int_0^{\underline{z}} u(z)\mathrm{d}z \quad \text{and} \quad u_M \equiv \int_{\underline{z}}^1 u(z)\mathrm{d}z,$$

respectively, so that

$$\mathrm{Cov}\left(\frac{L(z)}{L} - 1, u(z)\right) = u_X - u_M,$$

by (15).[16] If the unemployment-content of exports u_X, is lower than the unemployment rate in the importing sectors u_M, then the move from autarky to free trade reduces unemployment as workers are reallocated towards sectors with smaller labour frictions. Conversely, if the unemployment-content of imports is lower than u_X then unemployment may increase with trade. Summarizing:

Proposition 2. *Consider the open economy depicted in this section. If the sectors in which Home has a comparative advantage have lower labour-market frictions (and hence unemployment rates) than the sectors that produce Home imports, then Home's unemployment rate is lower at the trade equilibrium than in autarky, namely:*

$$u_X < u_M \Rightarrow u < u_a.$$

Proof. The trade equilibrium real wage is larger than the autarky real wage by Kemp (1962) and Samuelson's (1962) Gains From Trade theorems, i.e. $\omega/\omega_a > 1$. Second, if $u_X < u_M$ then $\mathrm{Cov}(\cdot) < 0$ by (19). Together, $\omega/\omega_a > 1$ and $\mathrm{Cov}(\cdot) < 0$ imply $u < u_a$ by inspection of (18), as was to be shown. □

We can then extend the logic of Proposition 2 to cross-country comparisons, which we shall bring to the data.

Corollary 3. *Controlling for country-specific autarky real wages and unemployment rates, Home has a higher unemployment rate than Foreign if and only if Home's comparative advantage is in sectors with higher labour market frictions than Foreign.*

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[13] Thus Heid and Larch's (2016) Armington model has as many sectors as countries whereas our model has an arbitrary number of sectors (its mass is normalized to unity) but only two countries for simplicity; Carrère et al. (2020) show that we can generalize the expression in (18) to any arbitrary number of sectors and countries (their model also accounts for trade costs, input-output linkages,unemployment benefits, and risk aversion).

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[16] To fix ideas, consider the following example. Assume $u(z) = \frac{1+\varepsilon(z)}{2} - \kappa z$, where ε is a random variable that is i.i.d. with mean zero and $\kappa \in \mathbb{R}$ is a parameter that governs the correlation between Home's comparative advantage and sector-specific frictions. Substituting into (19) yields $\mathrm{Cov}(\cdot) = \kappa(1 - \underline{z})/2$. Clearly, this covariance is positive if and only if Home has a comparative advantage in friction-intensive sectors and negative otherwise.

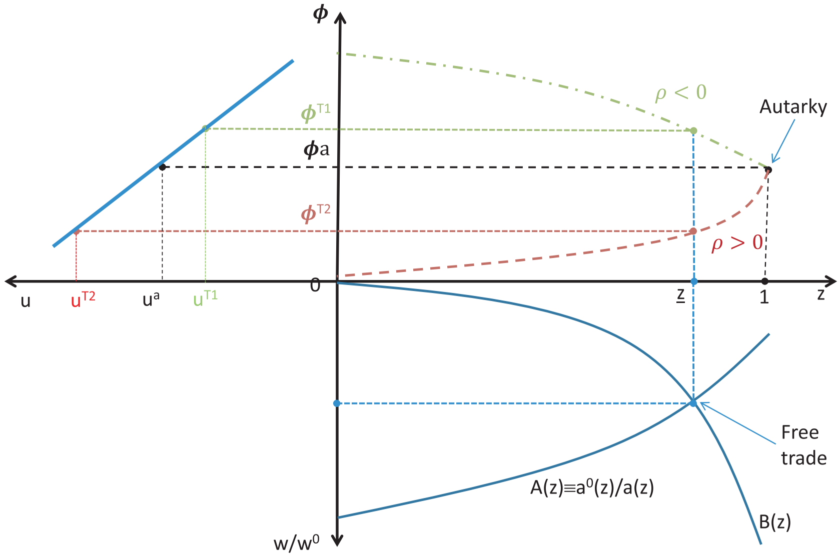

Fig. 1. DFS meets DMP. Note: The lower panel describes the equilibrium in the DFS model and the upper panel the level of aggregate unemployment as a function of the sectors in which the country is producing. ϕ is the average level of labour-market efficiency and ρ the correlation between comparative advantage and sector level labour-market inefficiency.

Two comments are in order. First, this corollary is almost tautological in our two-country model because Home's imports are Foreign's exports and vice-versa but the logic goes through unaltered in a proper multi-country, multi-sector model (Carrère et al., 2020). Second, when we take this corollary to the data in our empirical work, we control for the first term in the right-hand side of (18) using country and year fixed effects, as well as country-time varying GDP per capita.

Fig. 1 illustrates these results. The top left-panel provides the relationship between aggregate unemployment and the average level of labour market efficiency across sectors in which Home has a comparative advantage, defined as $\phi(z) \equiv z^{-1}\int_0^z \nu(t)^{-\alpha}(t)dt$. The more efficient are sector labour markets on average and the lower is the aggregate level of unemployment. The bottom panel is the classic illustration of a trade equilibrium in the Dornbusch et al. (1977) Ricardian model with a continuum of goods. The upward sloping B-curve provides the relationship between relative wages and the range of goods produced domestically. In this static framework the ratio of home to foreign (average) wages need to increase with the number of goods produced domestically for trade to be balanced. The downward sloping A curve provides the relative wages for which it is profitable to produce goods at home and abroad given the respective labour productivities for good z. The intersection of B and A determines $\underline{z}$.

The top right panel of Fig. 1 illustrates the relationship between the average level of labour-market efficiency and the range of goods produced in the economy. Two cases are depicted. First, the green, downward-sloping curve illustrates the case of a negative correlation between labour-market inefficiency and the comparative advantage of the home country. Goods in which the home country has a comparative advantage tend to have labour markets that are less inefficient. Thus as the country moves from autarky to free-trade, unemployment declines by Corollary 3 and Eq (18). This case is depicted in the top left panel where there is a negative correlation between the aggregate level of unemployment and the average level of labour-market efficiency. Second, the red, upward sloping curve illustrates the case of a positive correlation between comparative advantage and sector level labour market inefficiency. A move to free-trade leads to an increase in the average labour-market inefficiency and therefore in unemployment as shown in the top left panel.

3. Empirical strategy

The model works with a continuum of sectors $z \in [0, 1]$; we reset notation to fit the data and let $z \in \{1, \ldots, 23\}$, where 23 is the number of sectors in our data.

We put forward the following empirical model in order to test the qualitative predictions in the previous section:

$$\ln(u_{ct}) = \delta_c + \delta_t + \delta_1\rho_{ct} + \delta_2\ln(w/p)_{ct} + \epsilon_{ct}, \tag{19}$$

where u_{ct} is aggregate unemployment in country c in year t, ρ_{ct} is the correlation between the country's comparative advantage and its sector level labour market frictions, $(w/p)_{ct}$ is proxied with GDP per capita, and also controls for country-specific business cycles, ϵ_{ct} is an i.i.d error term. δ_c and δ_t are country and time-specific fixed effects, respectively. The former controls for any time-invariant and country-specific determinant of unemployment, such as the autarky level of unemployment or differences in institutional setups at the country level. The latter control for year-specific aggregate shocks that may affect unemployment in all countries, such as global technological shocks or the average level of (common) sector level labour market efficiencies.

From Corollary 3 we expect $\delta_1 > 0$ to hold (having a comparative advantage in sectors with more inefficient labour markets is associated with a higher aggregate unemployment rate, ceteris paribus) and from (18) we expect $\delta_2 < 0$ to hold (a larger income per capita is associated with a lower level of unemployment).

A measure of the correlation between comparative advantage and labour market frictions for each country and year is required in order to implement the empirical model. In order to compute this correlation, we need measures of both comparative advantage and labour market frictions at the sector level.

3.1. Measuring comparative advantage

As a measure of comparative advantage we use Costinot et al. (2012) methodology based on a fixed-effect gravity model. For every year t we estimate

$$\ln x_{cpz} = \alpha_{cp} + \alpha_{cz} + \alpha_{pz} + \epsilon_{cpz}, \tag{20}$$

where subscript c stands for the exporting country, p for (importing) partners and z for sectors, and therefore x_{cpz} are exports of good z from country c to partner p. Only fixed effects are introduced. We are interested in the α_{cz} fixed-effects which, after a monotonic transformation, provide a measure of the export capability of country c in tradable sector z relative to a benchmark country. The comparative advantage of country c in sector z at time t is then given by

$$r_{czt} = e^{\alpha_{czt}/\sigma}, \tag{21}$$

where σ is the elasticity of exports with respect to productivity. We use Costinot et al.'s (2012) estimate of $\sigma = 6.53$ to compute r_{czt}. As a robustness test we also use Hanson et al.'s (2015) normalization. They argue that, because of the presence of the importer-industry fixed effect in (20), export capability is only identified up to an industry normalization. Industry export capability of a given exporter is computed as $e^{\alpha_{czt}/\sigma} / \sum_{c'} e^{\alpha_{c'tz}/\sigma}$. This normalization differences out both worldwide industry supply conditions and worldwide industry demand conditions.

3.2. Measuring sector level labour market frictions

The second component of ρ_{ct} is the vector of the unemployment rates at the sector level. We face two constraints given the available data. First, to the best of our knowledge there exist no data on sector-specific labour market frictions or unemployment covering a wide range of countries and time periods.[17] We thus need to estimate unemployment rates at the sector level. Second, the time period we use is relatively short and there is insufficient time variation to identify unemployment rates at the sector level using a country within estimator.

In order to estimate the unemployment rates at the sector level, our identifying assumption is that u_z is common across all countries and constant over time. We relax the assumption that u_z is the same across *all* countries in the robustness Subsection 4.2.

The unemployment rate of any country is a weighted average of the unemployment rates prevailing in the sectors active in this country. Let L_{ct} and L_{czt} denote the aggregate and sector-z labour forces of country c in year t, respectively; under our identifying assumption, we may then write the accounting identity linking aggregate unemployment u_{ct} in c in year t and u_z as

$$u_{ct} = \sum_{z=1}^{23} \omega_{czt} u_z, \quad \text{where} \quad \omega_{czt} \equiv \frac{L_{czt}}{L_{ct}} \tag{22}$$

is the share of sector z in the labour force of country c at time t, with $\sum_{z=1}^{23} \omega_{czt} = 1$.

We observe the left-hand-side of (22) but we observe neither u_z nor the vector of workforce at the level of sectors, L_{czt} (which includes job seekers as well as current employees). However, we do observe employment in each sector H_{czt}; in turn, we exploit the fact that H_{czt}, L_{czt}, and u_z are related by the following identity:

$$L_{czt} = H_{czt} + u_z L_{czt} = \frac{H_{czt}}{1 - u_z}. \tag{23}$$

By the same token, we may write $L_{ct} = \sum_{z=1}^{23} H_{czt}/(1 - u_{ct}) = H_{ct}/(1 - u_{ct})$. Substituting this expression and (23) into (22) yields

$$\frac{u_{ct}}{1 - u_{ct}} = \sum_{z=1}^{23} \frac{u_z}{1 - u_z} \frac{H_{czt}}{H_{ct}},$$

[17] Carrère et al. (2020) use such data for one country, the United States.

Table 1
Sector level labour market frictions[a].

	u_z	s.e. of u_z	Share of sector z
Medical, precision and optical instruments	6.34%	0.032	0.68%
Radio,television and communication equipment	8.73%	0.029	0.62%
Machinery and equipment n.e.c.	11.80%	0.030	2.61%
Textiles	11.88%	0.032	1.86%
Rubber and plastics products	12.15%	0.040	1.12%
Non-metallic mineral products	12.56%	0.038	1.81%
Printing and publishing	12.86%	0.036	1.72%
Furniture; manufacturing n.e.c.	13.64%	0.042	1.35%
Services	14.96%	0.045	54.89%
Agriculture	15.07%	0.045	14.17%
Food, beverages and Tobacco	15.19%	0.047	6.21%
Fabricated metal products	15.41%	0.047	2.92%
Wearing apparel, fur	16.05%	0.050	2.07%
Other transport equipment	16.10%	0.052	0.77%
Chemicals and chemical products	16.83%	0.052	1.80%
Wood products (excl. furniture)	16.97%	0.056	1.27%
Office, accounting and computing machinery	17.19%	0.060	0.17%
Coke,refined petroleum products,nuclear fuel	17.42%	0.070	0.18%
Motor vehicles, trailers, semi-trailers	17.6%	0.061	0.72%
Paper and paper products	18.79%	0.064	0.90%
Basic metals	20.31%	0.069	0.90%
Leather, leather products and footwear	21.70%	0.078	0.50%
Electrical machinery and apparatus	25.31%	0.082	0.76%

[a] Sectors are defined according to the International Standard Industrial Classification (ISIC Revision 3). Note that u_z are obtained using a nonlinear combination of parameter estimates. Thus, calculations of the associated standard errors are based on the delta method, which is a good approximation appropriate in large samples. Sector shares correspond to averages over 95 countries and 1995–2009. The regression to obtain the β estimates which are then used to obtain the sector-specific unemployment rates (u_z) is performed on a sample of 843 observations, with 95 countries over the 1995–2009 period. The R^2 of that regression is 0.173.

where $H_{ct} \equiv \sum_{z=1}^{23} H_{czt}$ is aggregate employment. Adding an i.i.d. error term to this expression to allow for measurement error in u_{ct} (which may include country and year fixed components), and defining employment shares as $\varpi_{czt} \equiv H_{czt}/H_{ct}$, we obtain:

$$\frac{u_{ct}}{1-u_{ct}} = \sum_{z=1}^{23} \beta_z \varpi_{czt} + \epsilon_{ct}, \tag{24}$$

where $\beta_z \equiv u_z/(1-u_z)$ can be estimated by ordinary least squares and the value of u_z can be recovered by $u_z = \beta_z/(1+\beta_z)$.

We estimate u_z using data for 1995–2009 under our identifying assumption $u_{czt} = u_z$. We relax the assumption that u_z is common across all countries in the sample to allow u_z to first vary by region and then by country in Subsection 4.2, which allows for labour market frictions to be a source of comparative advantage as in Cuñat and Melitz (2012). We also address potential endogeneity concerns associated with the estimation of (19) and the construction of (24) in Subsection 3.4 below.

Table 1 provides the estimated u_z and their standard errors for 21 manufacturing sectors, as well as for two broad sectors: agriculture and services. These values can be interpreted as sector-specific unemployment rates (in %) due to labour market frictions.[18] The mean and a median of this distribution are around 15% with a standard deviation of 5, a maximum of 25 and a minimum of 6%.

Recall that footnote 10 develops an extension of our model that delivers a positive equilibrium relationship between the bargaining weight of workers and sector-specific frictions. We interpret a higher union membership rate as a proxy for a higher worker bargaining weight in the wage bargaining process. We can then test the external validity of our sector-specific labour market frictions by correlating our estimates with an index of labour union incidence in the United States constructed using data from the Union Membership and Coverage Database. The available estimates are compiled from the Current Population Survey.[19]

Fig. 2 plots union membership (expressed as a share of total employment) in sector z against our measure u_z. The simple correlation is 0.59. The figure also reports the underlying linear correlation and the 95% confidence interval; the estimated

[18] For inference reasons, we actually include a constant when estimating Eq (24), and calculate the sectoral unemployment rate as follows: $u_z = (\beta_z + \text{constant})/(1+\beta_z+\text{constant})$, and $u_z = \text{constant}/(1+\text{constant})$ for the excluded sector.

[19] Data available at www.unionstats.com. We compute the percent of employed workers who are covered by a collective bargaining agreement from the series Union Membership, Coverage, Density and Employment by Industry, 2005 that we first convert from the North American Industry Classification System (NAICS) to the International Standard Industrial Classification (ISIC Revision 3).

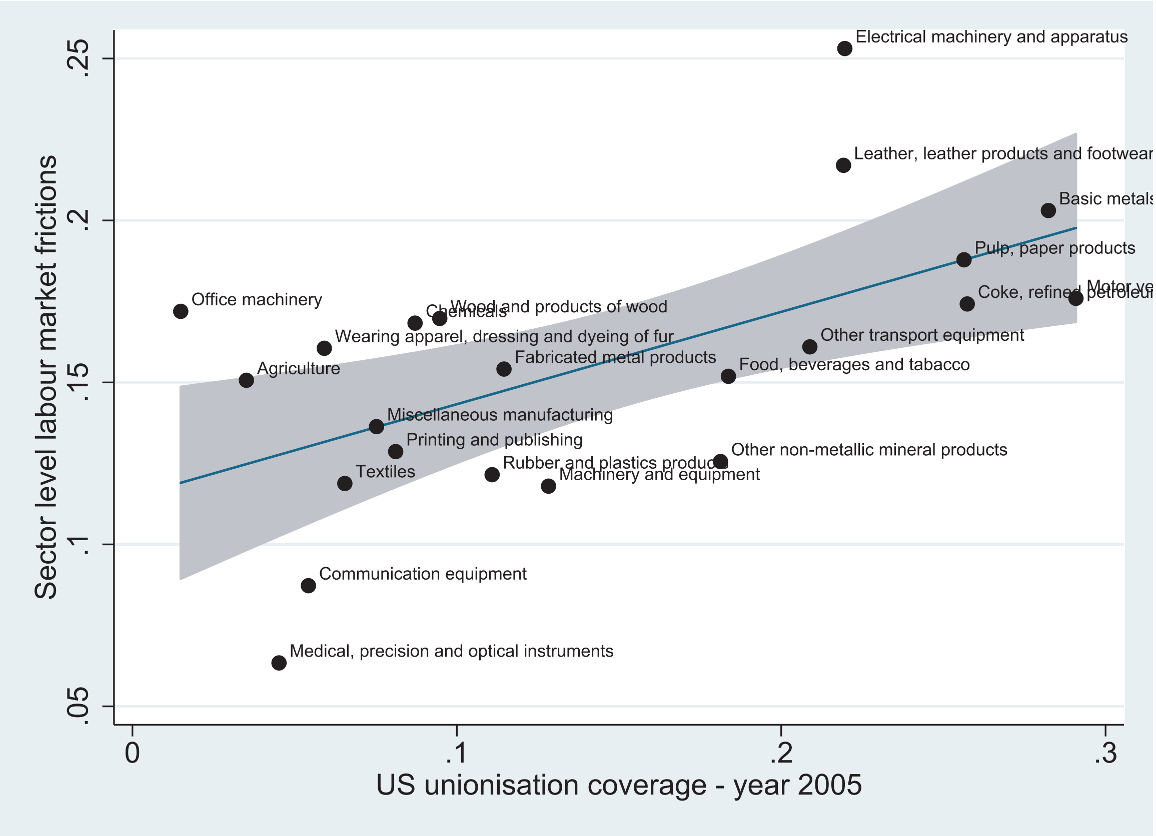

Fig. 2. Correlation between u_z and indices of labour union incidence. Note: Computed using the estimated u_z and the Union Membership and Coverage Database (www.unionstats.com).

correlation is positive (slope = 0.29) and statistically different from zero (standard error = 0.09), with a R^2 of 0.35. Similar results are obtained using data by Robinson (1995) for forty Canadian industries.

As an additional external test for our measure of sector level unemployment we compute its correlation with existing measures of sector level unemployment available for the United States and constructed using US Census data and downloaded from IPUMS for the year 2000. Fig. 3 plots the correlation between the two estimates. The simple correlation is 0.35. The figure also reports the underlying linear correlation and the 95% confidence interval; the estimated correlation is positive (slope = 0.67) and statistically different from zero (standard error = 0.30), with a R^2 of 0.13.

3.3. Correlation between labour market frictions and revealed comparative advantage

Equipped with our measures of comparative advantage r_{czt} and sector level labour market frictions u_z, we can construct the correlation between labour market frictions and comparative advantage, ρ_{ct}. Table 2 displays the median ρ during the period 1995–2009 for each of the 107 countries in our sample. We rank countries from the lowest to the highest ρ.[20] The country with the highest ρ is Russia, suggesting that more open trade is associated with higher unemployment in this country. At the other end of the spectrum, the country with the lowest ρ is Israel, which makes it the country where trade is the most likely to result in a fall in unemployment. Note that Brazil, Chile, the Czech Republic, Poland, Romania, Slovakia, and Uruguay, which are countries for which existing studies suggest that trade contributed to increases in unemployment, are among the countries with the highest ρ. Similarly, Singapore and Israel, which are countries for which existing studies

[20] Note that 94 out of the 107 countries in the sample have a positive median. This asymmetry is explained by the fact that we are reporting the median ρ across time within a country. If we were to report individual year estimates the share of positive ρs declines to 70%. If we further compute ρ using the Spearman rank correlation instead of the simple correlation, then the share of positive ρs further declines to 57%. Also note that theoretically one would expect a 50% split only if our sample had two countries.

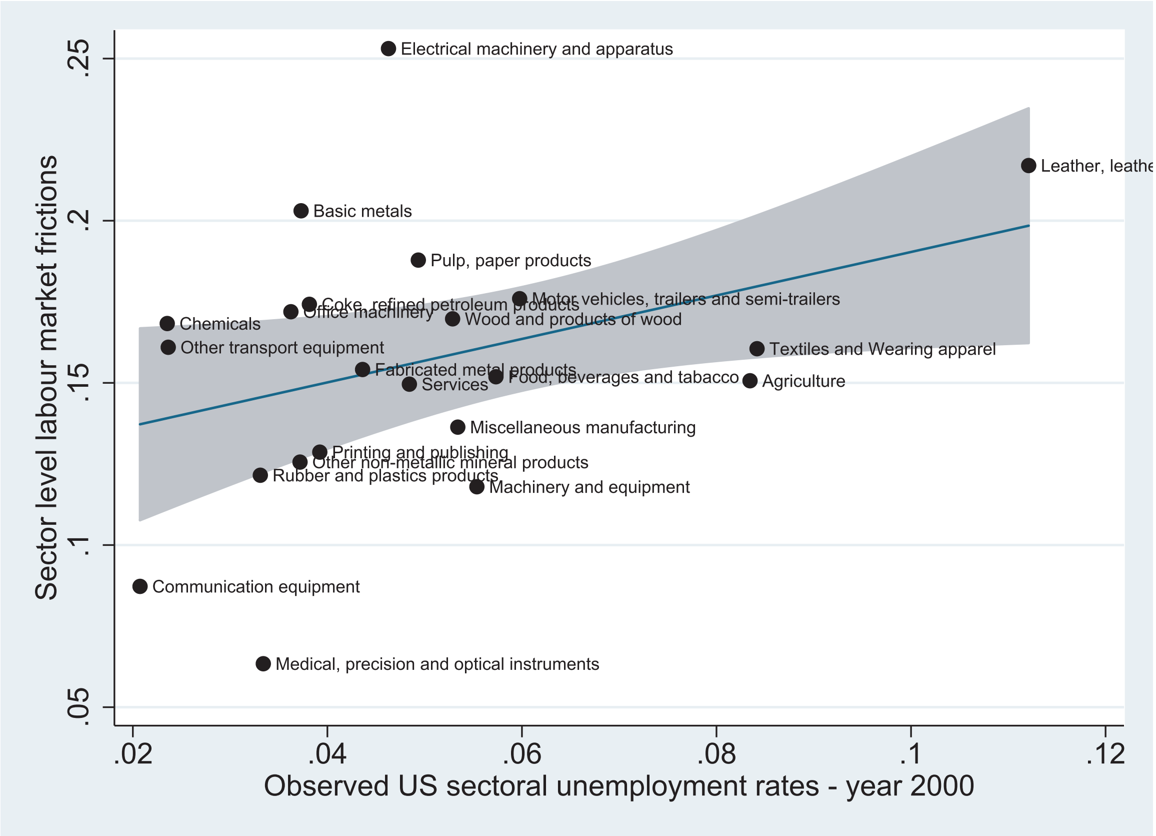

Fig. 3. Correlation between u_z and US Census sector level unemployment. Note: Computed using the estimated u_z and the US census sector level unemployment data (www.ipums.org).

suggest that trade contributed to a decline in unemployment, are among the countries with the lowest ρ. This *prima facie* evidence is in line with the theoretical predictions of our model.[21]

3.4. Identification issues

There are three potential issues associated with the estimation of (19). We address them in turn.

The first source of concern is associated with the fact that aggregate unemployment rates are used to construct our measures of sector market frictions at the sector level; these are in turn used to construct our key right-hand side variable, ρ_{ct}, on which we regress u_{ct}. Thus, there seems to be a cause of endogeneity. Before proceeding to propose a correction to this source of bias, note that the problem is strongly mitigated by the fact that we do not regress u_{ct} on u_z in (19) – which would lead to a simultaneity bias by construction – but on ρ_{ct}, which is the correlation between country c's comparative advantage and u_z.

We aim to rule out any remaining potential concern by undertaking four different robustness tests. First, instead of using our measure of u_z to compute ρ_{ct}, we use the sector level unemployment rates in the United States provided by the US Census and used in Fig. 3. This circumvents any circularity concern. Second, we divide our sample into two subperiods and estimate u_z with data for the early period (1995–1999) and only estimate (19) with data for the later period (2000–2009). Third, in the spirit of Angrist et al.'s (1999) 'Jackknife' IV estimator, we compute the vector of u_z's for each country separately, using data from all countries but country c itself; we label this c-specific estimate of u_z by $u_z^{(\backslash c)}$. We then construct ρ_{ct} using $u_z^{(\backslash c)}$ instead of u_z. Finally, we undertake a Placebo test in which we assign unemployment rates randomly to each country and then estimate u_z. We next compute ρ_{ct} and, finally, re-estimate (19) using the randomly assigned unemployment rates as dependent variable. The coefficient of ρ_{ct} is expected to be statistically indistinguishable from zero under the null hypothesis that the simultaneity bias is negligible.

[21] Note however that the value of ρ is not a sufficient statistic to predict the impact of trade on unemployment as trade liberalization may have a direct impact on unemployment that does not go through the reallocation of resources. As the first term on the right hand side of Eq (18) makes clear, terms of trade effects, which may lead to increases or decreases in real wages, affect labour demand and aggregate unemployment via ω.

Table 2
Correlation between labour market frictions and comparative advantage (median ρ for 1995–2009).

Country name	Country code	Median ρ	s.e. of ρ
Russia	RUS	0.32	0.05
Romania	ROM	0.32	0.07
Algeria	DZA	0.30	0.06
Ukraine	UKR	0.29	0.05
Macedonia	MKD	0.29	0.06
Croatia	HRV	0.28	0.06
Trinidad and Tobago	TTO	0.27	0.05
Chile	CHL	0.27	0.04
Albania	ALB	0.27	0.06
Grenada	GRD	0.27	0.06
Cameroon	CMR	0.27	0.06
Argentina	ARG	0.25	0.05
Venezuela	VEN	0.24	0.05
Ghana	GHA	0.24	0.05
Brazil	BRA	0.24	0.05
Tunisia	TUN	0.24	0.06
Georgia	GEO	0.23	0.06
Zambia	ZMB	0.22	0.05
Côte d'Ivoire	CIV	0.22	0.04
Slovakia	SVK	0.22	0.06
Poland	POL	0.22	0.06
Jamaica	JAM	0.22	0.05
Latvia	LVA	0.22	0.05
Paraguay	PRY	0.22	0.04
St. Kitts and Nevis	KNA	0.22	0.07
Morocco	MAR	0.21	0.05
South Africa	ZAF	0.21	0.06
Bulgaria	BGR	0.21	0.06
Belize	BLZ	0.20	0.05
Tanzania	TZA	0.20	0.05
Slovenia	SLV	0.19	0.05
Azerbaijan	AZE	0.19	0.05
Colombia	COL	0.19	0.05
Moldova	MDA	0.19	0.05
Bolivia	BOL	0.19	0.05
Rwanda	RWA	0.19	0.06
Estonia	EST	0.19	0.06
Surinam	SUR	0.18	0.04
Maldives	MDV	0.18	0.05
Kenya	KEN	0.18	0.05
Saudi Arabia	SAU	0.18	0.05
Uganda	UGA	0.18	0.05
Peru	PER	0.17	0.04
Mongolia	MNG	0.17	0.06
Guatemala	GTM	0.17	0.05
Senegal	SEN	0.16	0.06
Honduras	HND	0.16	0.04
Lebanon	LBN	0.16	0.05
Indonesia	IDN	0.16	0.05
Portugal	PRT	0.15	0.05
Nicaragua	NIC	0.15	0.04
St. Lucia	LCA	0.15	0.06
Egypt	EGY	0.14	0.05
Ethiopia	ETH	0.14	0.05
Macao	MAC	0.14	0.06
Uruguay	URY	0.13	0.04
Greece	GRC	0.13	0.05
Hungary	HUN	0.13	0.06
Turkey	TUR	0.13	0.05
Cyprus	CYP	0.13	0.06
Madagascar	MDG	0.13	0.05
India	IND	0.13	0.06
Czech Republic	CZE	0.12	0.06
Niger	NER	0.11	0.06
Spain	ESP	0.11	0.05
Ecuador	ECU	0.11	0.05
Jordan	JOR	0.10	0.05
Burkina Faso	BFA	0.10	0.06
Dominica	DMA	0.10	0.05
Malawi	MWI	0.09	0.04
Lithuania	LTU	0.09	0.05
Panama	PAN	0.09	0.06
Mali	MLI	0.09	0.05

(continued on next page)

Table 2 (*continued*)

Country name	Country code	Median ρ	s.e. of ρ
Bangladesh	BGD	0.09	0.04
Costa Rica	CRI	0.08	0.06
Belgium	BEL	0.08	0.05
Barbados	BRB	0.08	0.05
Slovenia	SVN	0.07	0.06
Luxembourg	LUX	0.06	0.05
France	FRA	0.06	0.06
Seychelles	SYC	0.06	0.06
Netherland	NLD	0.05	0.06
Austria	AUT	0.05	0.05
Norway	NOR	0.05	0.06
Mexico	MEX	0.04	0.06
Australia	AUS	0.04	0.06
Italy	ITA	0.04	0.05
Iceland	ISL	0.03	0.06
Finland	FIN	0.03	0.05
China	CHN	0.02	0.05
United Kingdon	GBR	0.02	0.06
Canada	CAN	0.02	0.06
New Zealand	NZL	0.02	0.05
Germany	DEU	0.01	0.06
Thailand	THA	0.01	0.05
Mauritius	MUS	0.01	0.05
Malta	MLT	0.00	0.06
Sweden	SWE	-0.02	0.06
Philippines	PHL	-0.05	0.06
Korea	KOR	-0.06	0.05
United States	USA	-0.08	0.06
Singapore	SGP	-0.09	0.06
Ireland	IRL	-0.09	0.05
Malaysia	MYS	-0.10	0.05
Switzerland	CHE	-0.10	0.05
Japan	JPN	-0.11	0.05
Denmark	DNK	-0.11	0.05
Hong Kong	HKG	-0.15	0.05
Israel	ISR	-0.26	0.05

The second issue to be dealt with is measurement error in ρ_{ct} that arises because we estimate u_z. We do two things in order to attenuate the role of outliers: (i) we replace the standard correlation by the Spearman rank correlation between r_{czt} and u_z, and (ii) we create five categories for ρ_{ct}, one for each quintile, and we regress u_{ct} on these dummies instead of on ρ_{ct}.

The third potential issue we address is the identifying assumption that sector level labour market frictions are common across all countries. Theoretically, we already allow labour market frictions to vary across both sectors and countries and the central qualitative predictions of the model do not hinge on this assumption. However, the empirical implementation of such an extension is impracticable. Indeed, it would require estimates of sector level market frictions by country, which requires substantial time variation. We have maximum fifteen years of data per country and sector, and therefore we lack the statistical power to estimate labour market frictions at this level of disaggregation.

Nevertheless, we relax the assumption that sector-specific labour market frictions are common across all countries by first allowing them to vary across groups of countries at similar level of development. More formally, we estimate Eq (24) in two different samples, allowing for labour market frictions at the sector level to be different between advanced and emerging economies. Second, we rely on the non-linearities on the left-hand-side of (24) to compute labour market frictions at the sector level that vary across countries and time. In order to do so, let us define the odds of unemployment in country c sector z and time t as an additive function of country, sector and time components:

$$\beta_{czt} \equiv \frac{u_{czt}}{1 - u_{czt}} = \beta_c + \beta_z + \beta_t, \tag{25}$$

where β_c captures cross-country labour market institutional differences, and β_t controls for worldwide business cycles; β_z captures the previous sector specific effect given by the labour shares in each sector, $\varpi_{czt} \equiv H_{czt}/H_{ct}$, as in (24). We further assume that country specific effects are a linear function of the country's labour market rigidity index (LAMRIG) provided by Campos and Nugent (2012), and replace the country fixed effects by the average value of Campos and Nugent's (2012) index, which is an update of Botero et al. (2004)'s (2004) index. Adding an i.i.d. error term for measurement error, we can rewrite

Table 3
Trade and unemployment (benchmark estimations)[a].

	Baseline (1)	Hanson et al. (2)	Rank (3)	Quintiles (4)	US Census. (5)	Tariff (6)
ln GDP per capita	-0.69***	-0.70***	-0.69***	-0.68***	-0.86***	-0.66***
	(0.16)	(0.17)	(0.17)	(0.17)	(0.21)	(0.16)
Correlation r_{czt} and u_z	0.41**	0.35**	0.26***		0.32***	0.41**
	(0.18)	(0.17)	(0.09)		(0.12)	(0.17)
2nd quintile				0.07**		
				(0.03)		
3rd quintile				0.04		
				(0.04)		
4th quintile				0.09*		
				(0.05)		
5th quintile				0.14**		
				(0.06)		
Avg. Tariff						-0.08
						(0.05)
Observations	1189	1189	1189	1189	802	1099
R^2	0.21	0.21	0.21	0.21	0.32	0.24

[a] All regressions are estimated by OLS at the country-year level and include country and year fixed effects. r_{czt} denotes 'revealed comparative advantage.' In column (4), the levels of the correlations are replaced by four dummies; the default category is the first quantile. Robust standard errors in parentheses are clustered at the country level. $\star\star\star$ $p < 1\%$, $\star\star$ $p < 5\%$, and $\star$ $p < 10\%$.

(24) as

$$\frac{u_{ct}}{1-u_{ct}} = \gamma \times \text{LAMRIG}_c + \sum_{z=1}^{23} \beta_z \varpi_{czt} + \beta_t + \epsilon_{ct}. \tag{26}$$

The β's and γ can be estimated using ordinary least squares. Note that we expect γ to be positive as countries with overall more rigid labour markets are likely to have higher levels of aggregate unemployment.

We can then compute sector, country and time specific labour market frictions, u_{czt}, using (25):

$$u_{czt} \equiv \frac{\beta_{czt}}{1+\beta_{czt}}, \tag{27}$$

which we can then correlate with the measure of revealed comparative advantage to construct ρ_{ct}.

4. Empirical results

We start by discussing the main results associated with the estimation of (19) and then turn to various robustness tests.

4.1. Baseline estimations

Table 3 displays the results of the estimation of (19). Column (1) reports the baseline estimates, which are in line with both theoretical predictions: a higher correlation between sector level labour market frictions and comparative advantage is associated with higher levels of unemployment; and a higher level of per capita GDP (w/p in the model) is associated with a lower level of unemployment. The quantitative effects are also meaningful: a one-standard deviation increase in ρ (+0.22) is associated with a 9% increase in u; and a 10% increase in per-capita GDP is associated with a 7% reduction in u (this elasticity is stable across all specifications).

Column (2) uses the normalized measure of comparative advantage introduced by Hanson et al. (2015) instead of Costinot et al.'s (2012) measure. The empirical results are again in line with our theoretical predictions, a one-standard deviation increase in ρ being associated with a 7.7% increase in u.[22]

Columns (3) and (4) aim to reduce the influence of possible outliers and to address measurement error in the correlation between comparative advantage and sector level labour market frictions. In Column (3), ρ is redefined as the Spearman rank correlation between u_z and r_{czt}. Note that this procedure also relaxes the identifying assumption that sector specific unemployment rates need to be identical across countries and replaces it by the less restrictive assumption that the rank of sector specific unemployment rates is identical across countries. Qualitative results are unchanged and quantitative results are similar. We transform the correlation measure into five quintile dummies in Column (4) with the aim of attenuating the

[22] We also ran our reference specification using the Balassa revealed comparative advantage (RCA) index since 2000. Obtained estimates are in line with benchmark ones. The coefficient on ρ is positive (+0.43) and statistically significant at the 10% level. The coefficient on real wages is negative (-0.89) and as precisely estimated as in our reference specification.

Table 4
Trade and unemployment (robustness estimations)[a].

	Baseline (1)	2-periods (2)	Placebo (3)	\c (4)	2-regions (5)
ln GDP per capita	-0.69***	-0.72***	0.09	-0.69***	-0.66***
	(0.16)	(0.20)	(0.16)	(0.16)	(0.16)
Correlation r_{czt} and u_z	0.41**	0.39**	0.01	0.40***	0.27**
	(0.18)	(0.16)	(0.42)	(0.17)	(0.11)
Observations	1189	739	1189	1189	1126
R^2[b]	0.21	0.32	0.02	0.21	0.21

[a] All regressions are estimated by OLS at the country-year level and include country and year fixed effects. r_{czt} denotes 'revealed comparative advantage.' Robust standard errors in parentheses are clustered at the country level. $\star\star\star$ $p < 1\%$, $\star\star$ $p < 5\%$, and $\star$ $p < 10\%$.
[b] Column (3) is estimated using bootstrap and therefore the R^2 reported is the average over 100 repetitions.

role of potential outliers further; the default category is the first correlation quintile. We expect positive and non-decreasing coefficients as one moves up the distribution of ρ – unemployment is higher in countries with a strong correlation between comparative advantage and sector level labour market frictions. The results are once more in line with our theoretical predictions.

The correlation ρ in the regression of Column (5) is constructed using the unemployment rates by sector in the United States since 2000 instead of our measure of u_z. Our results are robust to the use of this alternative measure, which alleviates potential concerns associated with the construction of u_z.

Finally, Column (6) introduces a measure of trade policy restrictiveness to the baseline regression as a time-varying control in order to mitigate potential omitted variable bias. While the coefficient of the average tariff is not statistically significant, the coefficient of per capita GDP the coefficient of ρ are unchanged; both remain precisely estimated.[23]

4.2. Robustness checks

We perform different robustness checks. Table 4 reports the results of the first four of them.

Column (1) reproduces the baseline estimation of Table 3, Column (1), in order to ease comparison with the regression results of this subsection. The next three columns address concerns regarding the fact that measures of ρ_{ct} may be endogenous by construction (see discussion in Subsection 3.4).

In the specification of Column (2), the u_z's are estimated running (24) on data for the time period 1995–1999 while we run the aggregate unemployment regression (19) on data for the time period 2000–2009. This methodology mitigates the time dimension of the potential simultaneity bias associated with the construction of ρ. Reassuringly, the results of Columns (1) and (2) are statistically indistinguishable from one another at the usual significance levels.

Column (3) performs a placebo test where aggregate unemployment rates are sampled randomly from the actual distribution to different countries; we then implement our algorithm as before – first estimating sector level labour market frictions using (24); then computing their correlation with comparative advantage, and finally estimating the impact of the correlation on the randomly assigned unemployment as per (19). We perform 100 iterations and we report the average coefficients and standard deviations. As expected under the null hypothesis that the correlation between u_{ct} and ρ_{ct} is not mechanical, the estimate of δ_1 is statistically indistinguishable from zero.[24] Note that the estimate of the coefficient of per capita GDP, δ_2, is also statistically insignificant, which was also to be expected from this placebo specification.

A final exercise helps us rule out the possibility that our results are the spurious outcome of a simultaneity bias. In the specification the results of which we report in Column (4), for each country c, we construct ρ_{ct} using estimates of u_z obtained from running (24) on all countries but c; thus, the error term in (19) is orthogonal to ρ and other regressors by construction. In this way, we obtain a different estimate of u_z for each c, which we label $u_z^{(\backslash c)}$, and we construct ρ_{ct} replacing u_z by $u_z^{(\backslash c)}$; such a procedure is similar in spirit to Angrist et al.'s (1999) 'Jackknife' instrumental variable estimator. Results are qualitatively identical and quantitatively very close to those of the baseline regression reported in Column (1).

Column (5) deals with a different issue. We have assumed throughout that sector-specific labour market frictions are common across all countries, regardless of their level of development. Here, we relax this (arguably strong) assumption by dividing the world into high- and low-income countries as defined by the World Bank and then estimate u_z for each of these two samples separately. We calculate ρ_{ct} and estimate the impact of ρ_{ct} on u_{ct} for each country as before. The results show

[23] Note that the absence of a significant relationship between the average tariff and the unemployment rate is consistent with an extension of our theory that allows for positive trade costs (which shows that the average tariff has an ambiguous effect on aggregate unemployment) and is in line with extant empirical work (which tends to find ambiguous effects). See Carrère et al. (2014).

[24] Only 9 out of the 100 δ_1 coefficients we estimated in the placebo regressions were positive and statistically significant; 10 were negative and statistically significant, and the remaining 81 coefficients δ_1 coefficients were statistically insignificant.

Table 5
Trade and unemployment (using country and time-varying u_{czt})[a].

	Baseline (1)	Hanson et al. (2)	Rank (3)	Quintiles (4)	US Census (5)	Tariff (6)
ln GDP per capita	-0.73***	-0.75***	-0.74***	-0.72***	-0.86***	-0.71***
	(0.17)	(0.17)	(0.17)	(0.17)	(0.21)	(0.17)
Correlation r_{czt} and u_{czt}	0.56**	0.50***	0.26***		0.32***	0.51**
	(0.23)	(0.19)	(0.10)		(0.12)	(0.24)
2nd quintile				0.07**		
				(0.04)		
3rd quintile				0.12***		
				(0.05)		
4th quintile				0.16***		
				(0.05)		
5th quintile				0.21***		
				(0.06)		
Avg. Tariff						-0.10**
						(0.05)
Observations	1109	1109	1109	1109	802	1019
R^2	0.23	0.23	0.23	0.23	0.32	0.27

[a] All regressions are estimated by OLS at the country-year level and include country and year fixed effects. r_{czt} denotes 'revealed comparative advantage.' In column (4), the levels of the correlations are replaced by four dummies; the default category is the first quintile. Robust standard errors in parentheses are clustered at the country level. $\star\star\star$ $p < 1\%$, $\star\star$ $p < 5\%$, and $\star$ $p < 10\%$.

that the coefficient of per capita GDP are stable and that coefficient of interest, δ_1, is halved but remains statistically positive and quantitatively meaningful. Note that by estimating different u_z in high and low-income countries we are allowing the labour market frictions to be a source of comparative advantage. Again, as argued before, Corollary 3 does not depend on whether labour market frictions are a source of comparative advantage.

Finally in Table 5 we report the results of all specifications in our baseline, but using an estimate of sector labour market frictions that also varies across countries and time. It is constructed using Eqs (25)-(27). Note that running (26), the estimated coefficient γ of the labour market rigidity measures is positive as expected, and statistically significant at the 5% level. This outcome suggests that in countries with more rigid labour markets we observe higher odds of unemployment. All columns in Table 5 confirm (and most reinforce) the benchmark results in Table 3. A higher correlation between sector level labour market frictions and comparative advantage leads to higher levels of unemployment.

5. Summary and conclusion

We have embedded a model of the labour market with sector-specific search-and-matching frictions into a Ricardian model with a continuum of goods to show that trade leads to higher unemployment in countries with comparative advantage in sectors with low labour market efficiency, and to lower unemployment in countries with comparative advantage in sectors with high labour market efficiency. We test this prediction in a panel dataset of 107 countries covering the period 1995–2009, and find that the data support our theoretical predictions.

Our model and empirical findings help explain the apparent lack of consensus in the empirical literature regarding the impact of trade on unemployment. Harrison and Revenga (1998) find that trade increased unemployment in the Czech Republic, Poland, Romania and Slovakia. Menezes-Filho and Muendler (2011) and Mesquita and Najberg (2000) provide evidence of a similar impact in Brazil, Edwards and Edwards (1996) in Chile, and Rama (1994) in Uruguay. These are all countries for which our empirical model predicts a positive and statistically significant impact of trade on unemployment, because our estimates of the correlation between labour market frictions and comparative advantage in these countries are large and positive. Bentivogli and Pagano (1999) show that trade has little or no impact in France, Germany, Italy and the United Kingdom. Trefler (1994) finds a similar result for Canada. This set of findings is again consistent with our empirical results, since the average correlation between comparative advantage and sector level labour market frictions is in the statistical insignificant range for these countries. Finally, Kee and Hoon (2005) and Nathanson (2011) show that trade reduces unemployment in Singapore and Israel, respectively. These findings are once again consistent with our empirical results because of the large and negative correlation between labour market frictions and comparative advantage in these countries. Our results for OECD countries display substantial heterogeneity but, in most cases, our results are in line with those of Felbermayr et al. (2011) for a sample of twenty OECD countries

A central finding of our paper is that labour market frictions at the sector level and comparative advantage interact in shaping the aggregate unemployment rate of countries. In our two-country setting, 'comparative advantage' is synonymous to trade patterns. In a multi-country environment, trade patterns are jointly determined by comparative advantage, the whole matrix of bilateral trade frictions, as well as general equilibrium effects. In a related paper, Carrère et al. (2020) extend the current work to a quantitative model of trade and frictional unemployment. Other applications of this finding are possible. Applying it to trade in value added would be another natural venue. We leave it for further research.

Data Appendix

We use trade and unemployment data for 107 countries for the period 1995–2009. Trade data comes originally from United Nations' Comtrade, but we use the clean version provided by CEPII's BACI (Gaulier and Zignago, 2010). Unemployment and employment data are from the ILO (KILM 6th edition). Average tariffs are from UNCTAD's Trains which is also available through WITS. Collected duties are from the World Bank's World Development Indicators.

The appendix table provides descriptive statistics for the variables used in the estimation of (19).

Appendix Table: Descriptive statistics 1995–2009

Variable	Obs	Mean	Std. Dev.	Min	Max
$\ln(u_{ct})$	1189	2.00	0.60	-0.51	3.62
$\ln(w_{ct}/p_{ct})$	1189	9.26	1.00	5.91	11.47
ρ_{ct}	1189	0.08	0.22	-0.64	0.50
Average tariff	1099	1.96	0.81	0.00	3.74

Theory Appendix: Closing the model

An equilibrium is a tuple $\{\underline{z}, p, w, w^0, u, u^0\}$ such that Eqs (6), (16), and (17) in the text and Eqs (32), (33), and (34) below hold. To prove existence and uniqueness, first note that this system of equations is recursive: we can first solve for the equilibrium tuple $\{\underline{z}, p, w, w^0\}$ using Eqs (6), (32), (33), and (34). This equilibrium exists and is unique; see Dornbusch et al. (1977). Once this tuple is known, the unique solutions to u and u^0 follow from Eqs (16) and (17).

Closing the model requires a link between intermediate good markets and labour markets. Such a link is provided by the marginal cost pricing conditions in each sector, (11).

Let

$$a(z) \equiv 2\hat{a}(z)\nu(z)^{\frac{-1}{1+\alpha}} \quad \text{and} \quad a^0(z) \equiv 2\hat{a}^0(z)\nu^0(z)^{\frac{-1}{1+\alpha}} \tag{28}$$

collect parameters that govern overall total factor productivity in sector z and lump together all potential sources of *Ricardian comparative advantage* in the model.

Using Eqs (10), (11), and (28) yields expressions for $P(z)$ and $P^0(z)$ that depend on country-specific expected wages, z-specific parameters, and the Home price of Y alone; in logs:

$$\ln P(z) = -\ln a(z) + (1-\alpha)\ln w + \alpha \ln p \tag{29}$$

and

$$\ln P^0(z) = -\ln a^0(z) + (1-\alpha)\ln w^0. \tag{30}$$

Using Eqs (29) and (30) enables us to rewrite our metric for comparative advantage in Eq (2) as follows:

$$\pi(z) \equiv \frac{P^0(z)}{P(z)} = p^{-\alpha}\left(\frac{w^0}{w}\right)^{1-\alpha}\frac{a(z)}{a^0(z)}. \tag{31}$$

Three features of (31) are noteworthy. First, relative production costs depend on relative wages and on the relative price of Y in a way that is symmetric across sectors (i.e. p and the wage ratio do not depend on z). Second, production and labour matching productivity enter (28) and (31) in a symmetric way. They cannot be identified separately from price and trade data. Finally, the total factor productivity ratio governs comparative advantage in the usual way: Home is the low-cost producer for goods z such that $\pi(z) > 1$, that is, for goods with a relatively high ratio $a(z)/a^0(z)$. Our ranking of sectors in (2) involves ordering sectors so that the ratio $a(z)/a^0(z)$ is decreasing in z. Home has a comparative advantage in the low-z sectors. Using (31), we may characterize the marginal sector $\underline{z}$ as $\pi(\underline{z}) = 1$. Using $p = 1$, (6) and (31) together yield

$$\frac{a(\underline{z})}{a^0(\underline{z})} = \left(\frac{w}{w^0}\right)^{1-\alpha}. \tag{32}$$

We are now in position to close the model by using (29) and (30) to substitute for $P(z)$ and $P^0(z)$ in the Y-sector marginal cost pricing Eqs (4) or (5). Using $p = 1$ from (6) yields

$$A(\underline{z}) = (1-\alpha)\left[\underline{z}\ln w + (1-\underline{z})\ln w^0\right], \tag{33}$$

where

$$A(z) \equiv \int_0^z \ln a(t)\mathrm{d}t + \int_z^1 \ln a^0(t)\mathrm{d}t$$

is a measure of log effective total factor productivity in the production of $X(z)$: importing intermediate goods implies importing Foreign's technology.

Finally, zero profits in all final and intermediate good sectors and (10) together imply that the value of production is equal to twice the wage bill: $pY = 2wL$ and $Y^0 = 2w^0L^0$. Using these, we may rewrite the trade balance Eq (3) as

$$\frac{wL}{w^0L^0} = \frac{\underline{z}}{1-\underline{z}}. \tag{34}$$

Eqs (16), (17), (32), (33), and (34) characterize the general equilibrium tuple $\{\underline{z}, w, w^0, u, u^0\}$. This equilibrium exists and is unique.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.euroecorev.2020.103496 .

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