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Trade in Unemployment

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We embed a model of the labor market with sector-specific search-and-matching frictions into a Ricardian model with a continuum of goods to show that trade liberalization causes higher unemployment in countries with comparative advantage in sectors with strong labor market frictions and leads to lower unemployment in countries with comparative advantage in sectors with weak labor market frictions. We test this prediction in a panel dataset of 97 countries during the period 1995-2009 and find that the data supports the theoretical prediction. Our results also help reconcile the apparently contradicting evidence in the empirical literature on the impact of trade on unemployment.

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1 Introduction

Does international trade create or destroy jobs? We develop a model that introduces search-and-matching labor market frictions in a trade model with a continuum of sectors to address this question. Comparative advantage and trade costs drive the patterns of trade, whereas labor market frictions generate equilibrium unemployment. In our model, labor market frictions are sector-specific and the aggregate unemployment rate of a country can be thought of as the weighted average of sector-specific unemployment rates. As a result, patterns of trade and sector-specific labor market frictions interact in shaping aggregate unemployment. If a country has a comparative advantage in sectors that have strong labor market frictions, then trade liberalization reallocates resources towards these sectors, and therefore increases aggregate unemployment. Conversely, if comparative advantage and sector-specific labor market frictions are negatively correlated, unemployment falls after trade liberalization. We find strong empirical support for this theoretical prediction in a panel of 97 countries that account for more than 95 percent of world trade over the period 1995-2009.

Integrating labor market frictions in trade models is important for at least four 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), on which we build. It is therefore important to understand when to expect the adverse effects to dominate and our empirical work provides an empirical test of the sector reallocation effect in their seminal paper. Third, welfare and unemployment are negatively correlated in our setting, but not perfectly: so freer trade may destroy more jobs than it creates *and* yet increase welfare. Fourth, 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 after trade liberalization. Among trade sceptics is Senator Obama, who during his first presidential campaign claimed that "one million jobs have been lost because of NAFTA". Among trade enthusiasts is President Obama, who in 2012 suggested: "The US-Korea trade agreement will support 70 thousand American jobs." Who is right? Our model and empirical evidence suggest that the answer depends on the correlation between patterns of trade and labor market frictions.

Bringing our theoretical predictions to the data requires three steps. First, we need a measure of comparative advantage, which is straightforward, and a measure of sectoral labor market frictions, which is more challenging. We measure the former using Balassa-type Revealed Comparative Advantage (RCA) indices. We construct the latter building on an idea developed by Hausmann, Hwang and Rodrik (2007) to measure product sophistication at the sector level. Concretely, we define the unemployment rate of a sector as the trade-weighted average of the unemployment rate in each country. The idea is that countries with production bundle tilted towards sectors with strong labor-market frictions tend to have high unemployment rates. We show that this new measure of sector-specific labor market frictions is positively correlated with existing proxies such as labor union coverage and membership.

In a second step, we compute country-specific correlations between measures of comparative advantage and labor market frictions. The country with the highest correlation in our sample is Italy, which therefore has a comparative advantage in sectors with strong labor market frictions. The country with the lowest negative correlation is Iceland, which therefore has a comparative advantage in sectors with weak labor market frictions.

Our third and final step involves testing whether trade liberalization increases unemployment in countries where the correlation between RCA and sector level labor market frictions is high. The empirical results confirm this theoretical prediction.

Our paper builds on a growing literature on the impact of trade on unemployment. 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 liberalization on welfare and unemployment depends on relative factor endowments: labor-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 labor market rigidities, shows that openness reduces welfare and increases unemployment in the economy with more rigid labor markets. Davidson, Martin and Matusz (1999) find that the impact of trade liberalization on unemployment depends on relative capital-labor endowments across different countries as in Brecher (1974). More importantly, they also recognize that sectoral labor market frictions can be a source of comparative advantage. Helpman and Itskhoki (2010) build a Diamond-Mortensen-Pisarrides (henceforth DMP) model of labor market frictions in an open economy and 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 labor costs and therefore a comparative advantage in the differentiated sector. The impact of trade on unemployment is ambiguous, with unemployment raising or falling in both or one country being possible depending on the extent of labor frictions in the differentiated sector relative to the homogenous-good sector.[1] Our empirical results are consistent with this theoretical result.

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 liberalization either. Several important papers suggest that trade liberalization or import growth have led to an increase in unemployment. Revenga (1997) provides evidence in this direction for Mexico, Menezes-Filho and Muendler (2011) and Mesquita and Najberg (2000) for Brazil, and Autor, Dorn and Hanson (2013),

[1]Helpman, Itshkhoki and Redding (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 Helpman and Itskhoki (2013) for a model with transition effects.

Ebeinstein et al. (2009) and Pierce and Schott (2013) for the United States.[2] There are also several important papers suggesting that trade has no impact on unemployment. Hasan et al. (2012) and Currie and Harrison (1997) provide such evidence for India and Morocco, respectively. Finally, there is also evidence suggesting that trade opening has led to reductions in unemployment. Dutt et al. (2010) do so in a cross-section of countries, Kpodar (2007) for Algeria, Nicita (2008) for Madagascar, and Balat, Brambilla and Porto (2007) for Zambia.

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 labor market frictions, Brazil, Mexico, and the United States are in the top 25 percent of the distribution. Algeria, Madagascar and Zambia are in the bottom 25 percent, and India and Morocco are in the statistically insignificant range in the middle of the distribution. Thus, our paper provides a theory-based framework to resolve the apparent ambiguity in the empirical literature.

2 Comparative advantage and labor market frictions

We merge a trade model based on comparative advantage with a model of equilibrium unemployment based on search-and-matching frictions. We start by developing a reduced-form model in order to fix ideas in subsection 2.1. The hurried reader uninterested in the details of the theory may then jump straight to section 3.

2.1 The model in a nutshell

Consider an open economy that produces, consumes and exports goods from n_X distinct sectors, imports and consumes goods from n_M sectors, and produces purely for domestic consumption in the remaining $n_D \equiv 1 - n_X - n_M$ sectors (there is an exogenous unit measure of sectors). Let Λ and ℓ be the (average) number of workers seeking a job in each exporting

[2] Autor, Dorn and Hanson (2013) and Pierce and Schott (2013) focuses on the rapid increase of United States manufacturing imports from China.

sector and in each purely domestic sector, respectively. L is the inelastically supplied total number of workers in the economy. The 'full-participation' of all workers requires

$$L = n_X \Lambda + n_D \ell. \tag{1}$$

The unemployment rate at the country level is the weighted sum of unemployment rates at the sector level, namely,

$$u = \bar{u}_X \frac{n_X \Lambda}{L} + \bar{u}_D \frac{n_D \ell}{L}, \tag{2}$$

where $\bar{u}_X$ and $\bar{u}_D$ are the average unemployment rates in the exporting and purely domestic sectors, respectively. In the model we develop below, unemployment arises as the result of DMP-like labor market frictions.

The patterns of trade are driven by comparative advantage.[3] When trade barriers fall, the number of exporting and importing sectors increases ($\mathrm{d}n_X > 0$ and $\mathrm{d}n_M > 0$) and the number of purely domestic sectors falls ($\mathrm{d}n_D < 0$). This implies a reallocation of workers across sectors. The number of people seeking a job in each exporting sector rises because they now serve a larger fraction of world demand, i.e. $\mathrm{d}\Lambda > 0$, while the effect on the number of job seekers in purely domestic sectors is ambiguous. Differentiating the full-participation condition (1) yields

$$0 = (\Lambda \mathrm{d}n_X + \ell \mathrm{d}n_D) + (n_X \mathrm{d}\Lambda + n_D \mathrm{d}\ell), \tag{3}$$

that is, the sum of the extensive margins and intensive margins of adjustment are equal to zero because the supply of L is fixed.

In order to evaluate the effect of trade opening on the overall unemployment rate in the economy, totally differentiate (2) using (3) to substitute for $\ell \mathrm{d}n_D + n_D \mathrm{d}\ell$. This yields

$$L\mathrm{d}u = (\bar{u}_X - \bar{u}_D) n_X \mathrm{d}\Lambda + (\bar{u}_X - \bar{u}_D) \Lambda \mathrm{d}n_X + \left[n_X \Lambda \mathrm{d}\bar{u}_X + n_D \ell \mathrm{d}\bar{u}_D \right]. \tag{4}$$

[3] The source of comparative advantage is Ricardian in our model below but this assumption is not important.

In words, the total effect on the unemployment level is the outcome of the reallocation of workers from import-competing to newly and existing export sectors, and an "efficiency term" in square brackets. The number of job seekers in each exporting sector rises by $\mathrm{d}\Lambda$ and each of these job seekers faces a probability of being unemployed of $\bar{u}_X$ instead of $\bar{u}_D$. The difference between the two gives the net contribution of the *intensive margin* adjustment to unemployment. The number of exporting sectors increases by $\mathrm{d}n_X$ and each of these sectors is composed by Λ job seekers. Thus $\Lambda \mathrm{d}n_X$ of job seekers who exit the marginal import-competing sectors, where the probability of unemployment rate is $\bar{u}_D$, find a job in the export sectors, where the probability of unemployment is $\bar{u}_X$. The difference between the two is the net contribution of the *extensive margin* to the unemployment adjustment. Finally, we provide a precise interpretation of the "efficiency term" in subsection 2.5 below.[4]

Put simply, and abstracting from the efficiency term, a country will see its unemployment rate go up following a trade liberalization episode if it has a comparative advantage in 'unemployment-intensive' sectors (which is the case if $\bar{u}_X > \bar{u}_D$); conversely, unemployment falls if trade shifts resources towards sectors with relatively low labor-market frictions (which is the case if $\bar{u}_X < \bar{u}_D$).

In the rest of this section, we develop microeconomic foundations for equation (4), and in section 3 we develop the empirical strategy to test its prediction.

2.2 Preferences, technology and trade

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-

[4]Note that this effect also includes a mechanical change in $\bar{u}_D$ and $\bar{u}_X$ that results from the changes at the extensive margin in particular.

Douglas production function. Specifically,

$$\ln Y = \int_0^1 \ln X(z) \mathrm{d}z. \tag{5}$$

Each intermediate sector z is produced with a labor-output requirement given by $1/\hat{a}(z)$ which varies across sectors and countries and provides the 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.

International trade in Y is prohibitive and trade in X is feasible but costly. Conventionally, we assume that trade between Home and Foreign involves a Samuelson iceberg trade cost parameterized by $\tau \geq 1$.[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

$$\pi(z) \equiv \frac{P^0(z)}{P(z)} \quad \text{with} \quad \pi'(z) < 0. \tag{6}$$

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 $\pi(z) > 1/\tau$, and Foreign producers purchase intermediate z locally if and only if $\pi(z) < \tau$.

At equilibrium both countries fully specialize as follows. Home exports goods in the interval $[0, z_h]$, where z_h is implicitly defined as $\pi(z_h) = \tau$, and Foreign exports goods in the interval $[z_f, 1]$, where z_f is implicitly defined as $\pi(z_f) = 1/\tau$. We may rewrite these cutoffs implicitly as

$$\pi(z_h) = \frac{1}{\pi(z_f)} = \tau. \tag{7}$$

Goods in the interval (z_h, z_f) are non-traded.

[5] Namely, τ units of the good must be shipped for one unit to reach a foreign destination.

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 equation (5) and with complete specialization, Home's expenditure on imports is equal to $(1-z_f)pY$ and the value of Foreign's imports is equal to $z_h Y^0$, where pY and Y^0 are the aggregate incomes of Home and Foreign, respectively. Thus, trade is balanced if and only if

$$\frac{pY}{Y^0} = \frac{z_h}{1-z_f}. \tag{8}$$

Cost minimization in Home's sector Y subject to equation (5) and perfect competition yield (in logs)

$$\ln p = \int_0^{z_f} \ln P(z)\,\mathrm{d}z + \int_{z_f}^1 \left[\ln \tau + \ln P^0(z)\right] \mathrm{d}z. \tag{9}$$

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

$$0 = \int_0^{z_h} \left[\ln \tau + \ln P(z)\right] \mathrm{d}z + \int_{z_h}^1 \ln P^0(z)\,\mathrm{d}z. \tag{10}$$

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

2.3 Labor market

Workers are initially homogeneous, but they need to acquire sector-specific skills before being able to supply their labor 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 in our static model as in Anderson (2009) and Helpman and Itskhoki (2010). We refer to the exhaustive use of labor as the *full participation* condition, which we write as

$$L = \int_0^1 L(z)\mathrm{d}z \quad \text{and} \quad L^0 = \int_0^1 L^0(z)\mathrm{d}z \tag{11}$$

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 labor 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 (11).

Step 1: functioning of sectoral labor markets. There are search-and-matching frictions in the labor 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.

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.[6] 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 parameterized by $\mu(z)$. Specifically, we assume the following Cobb-Douglas matching function:

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

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

$$\lambda(z) \equiv \frac{H(z)}{L(z)} = \left[\mu(z)\frac{V(z)}{L(z)}\right]^{\alpha}. \tag{12}$$

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

[6] There is free entry and opening a firm does not require resources.

sectoral wage is thus equal to $w(z) = r(z)/2$.[7] 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. Therefore, the wage and the cost of hiring one worker in sector z are equal to

$$w(z) = b(z) \equiv pv(z)\lambda(z)^{\frac{1-\alpha}{\alpha}}, \tag{13}$$

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.[8] As a result, the unit labor cost is equal to

$$\widetilde{w}(z) \equiv b(z) + w(z) = 2pv(z)\lambda(z)^{\frac{1-\alpha}{\alpha}}. \tag{14}$$

Step 2: integrating labor markets. Consider now the sectoral decisions of workers. They are risk neutral. Expected returns must then be the same in all sectors. This no-arbitrage condition for workers implies

$$\lambda(z)w(z) = w, \tag{15}$$

some $w > 0$ to be determined in general equilibrium.

Equations (13) and (15) together yield an equilibrium expression for the level of unem-

[7] We can assume instead sector-specific bargaining weights, where $\phi(z) \in (0, 1)$ is the labor bargaining share. In this case $w(z) = \phi(z)r(z)$. In a series of footnotes below we develop the theoretical consequences of this generalization.

[8] In the case of sector-specific bargaining weights, we obtain $v(z) \equiv \nu(z)/\mu(z)\phi(z)/\left[1 - \phi(z)\right]$ and $\widetilde{w}(z) = pv(z)\lambda(z)^{\frac{1-\alpha}{\alpha}}/\left[1 - \phi(z)\right]$. A higher labor share $\phi(z)$ 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. This is because a higher ϕ implies a lower rent share for entrepreneurs, which discourages job creation. This is worth bearing 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.

ployment pertaining to Home's sector z:

$$u(z) \equiv 1 - \lambda(z) = 1 - \left[\frac{w}{p}\frac{1}{v(z)}\right]^{\alpha}. \tag{16}$$

where $u(z)$ is decreasing in the economy-wide average (real) wage and increasing in the sector-specific labor market frictions. The real wage and unemployment rates are negatively correlated in equilibrium because anything that makes opening positions easier (typically, lower labor market frictions) lowers unemployment and increases demand for labor, which raises wages.

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 labor 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 (13) and (14). Using (16) in turn, we may write this expression as $R(z) = 2w(z)\lambda(z)L(z)$. Finally, using the no-arbitrage condition (15) yields $R(z) = 2wL(z)$.

Turning to the demand for intermediate good z, the symmetric Cobb-Douglas production function in (5) implies $R(z) + R^0(z) = pY + Y^0$, all z.[9] Together with the supply-side expression above, this yields

$$\frac{pY + Y^0}{2} = wL(z) + w^0 L^0(z) \tag{17}$$

for all z. That is, the worldwide wage bill of each sector is the same.

Because of the symmetric Cobb-Douglas production function in (5) the number of workers seeking employment in a given sector depends only on the export status of the sector in each country. Let Λ denote the common level of job seekers in Home's exporting sectors and let ℓ denote the common level of job seekers in Home purely domestic sectors; that is to say, $L(z) = \Lambda$ and $L^0(z) = 0$ for all $z \in [0, z_h)$; $L(z) = \ell$ and $L^0(z) = \ell^0$ for all $z \in [z_h, z_f]$;

[9]Note that the revenue of each sector equals the average revenue given the symmetric Cobb-Douglas production function in (5), and we have a measure 1 of sectors.

and $L(z) = 0$ and $L^0(z) = \Lambda^0$ for all $z \in (z_f, 1]$. Using (8), (11), and (17), straightforward calculations yield the following expressions for employment in the exporting sectors as a function of the trade patterns cutoffs,[10]

$$\Lambda = \left(1 + \frac{1 - z_f}{z_h}\right) L \quad \text{and} \quad \Lambda^0 = \left(1 + \frac{z_h}{1 - z_f}\right) L^0, \tag{18}$$

and for the non-traded sectors $z \in [z_h, z_f]$:

$$\ell = L \quad \text{and} \quad \ell^0 = L^0. \tag{19}$$

2.4 General equilibrium

We close the model in the appendix where we show that the equilibrium exists and is unique. Here we focus on equilibrium 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 Λ/L (in the exporting sectors) and ℓ/L (in the non-traded sectors):

$$u \;=\; \frac{1}{L}\left[\Lambda \int_0^{z_h} u(z)\mathrm{d}z + \ell \int_{z_h}^{z_f} u(z)\mathrm{d}z\right] \tag{20}$$

[10] This footnote is a guide to calculations that lead to (18) and (19). Using the definitions for Λ and ℓ, (17) yields

$$\begin{aligned} \frac{pY + Y^0}{2} &= w\Lambda \\ &= w^0\Lambda^0 \\ &= w\ell + w^0\ell^0. \end{aligned}$$

These definitions also lead us to rewrite the full participation conditions in (11) as

$$L = z_h\Lambda + (z_f - z_h)\ell \quad \text{and} \quad L^0 = (z_f - z_h)\ell^0 + (1 - z_f)\Lambda^0.$$

Using (8) and the three expressions in this footnote yields the expressions in the text.

and

$$u^0 = \frac{1}{L^0}\left[\Lambda^0 \int_{z_f}^{1} u^0(z)\mathrm{d}z + \ell^0 \int_{z_h}^{z_f} u^0(z)\mathrm{d}z\right], \tag{21}$$

where $u(z)$ is given by (16), $u^0(z) = 1 - [w^0/v^0(z)]^{\alpha}$, Λ and Λ^0 are given by (18), and ℓ and ℓ^0 are from (19).

2.5 Comparative statics

In order to illustrate the effects of trade *liberalization* on equilibrium unemployment formally, totally differentiate equation (20) using expressions (16), (18), and (19) with respect to *minus* τ; this yields

$$\begin{aligned} -\frac{\mathrm{d}u}{\mathrm{d}\tau} &= \alpha(1-u)\frac{\mathrm{d}}{\mathrm{d}\tau}\ln\frac{w}{p} \\ &+ \frac{1}{L}z_h\left[\frac{1}{z_h}\int_0^{z_h} u(z)\mathrm{d}z - u(z_f)\right]\frac{\mathrm{d}}{\mathrm{d}\tau}\ln\Lambda \\ &+ (1-z_f)\left[u(z_h) - u(z_f)\right]\frac{\mathrm{d}}{\mathrm{d}\tau}\ln z_h, \end{aligned} \tag{22}$$

where we have totally differentiated (18) to eliminate $\mathrm{d}z_f$.[11] This expression is the equivalent to the reduced form expression in (4) and it is the key result that we bring to the data.

The first line in the right hand side of (22) is an overall efficiency effect: more trade raises the (real) wage w/p unless the terms of trade deteriorate. This makes opening vacancies more profitable, which in turn decreases unemployment in equilibrium. This effect is novel relative to Helpman and Itskhoki's (2010) framework.[12]

The last two lines of the right hand side above capture the intensive and extensive margins of the labor reallocation effect, respectively. Qualitatively, these composition effects are also present in Helpman and Itskhoki's (2010) framework. Employment in each exporting sector

[11] Total differentiation of (18) yields $-L\mathrm{d}z_f = (\Lambda - L)\mathrm{d}z_h + z_h\mathrm{d}\Lambda$ because the supply of L is inelastic by assumption.

[12] There are two sectors in their model, including a freely traded perfectly competitive and constant returns to scale sector, which pins down expected wages.

usually increases at the intensive margin following trade liberalization ($\mathrm{dln}\Lambda > 0$ if $\mathrm{d}\tau < 0$). At the extensive margin, the number of exporting sector also increases ($\mathrm{d}z_h > 0$ if $\mathrm{d}\tau < 0$). The intensive margin effect increases equilibrium unemployment if

$$\bar{u}_X \equiv \frac{1}{z_h} \int_0^{z_h} u(z)\mathrm{d}z > u(z_f), \tag{23}$$

i.e., the unemployment rate in the average exporting sector is larger than the unemployment rate in the purely domestic sector at the margin of imports. Similarly the extensive margin effect increases unemployment if the unemployment rate in the marginal export sector, $u(z_H)$, is larger than the unemployment rate in the marginal domestic sector, $u(z_F)$. Note that the intensive and extensive margin effects are stronger, the more open is the Home economy (i.e. the larger is z_h and/or $1 - z_f$).

2.6 From theory to estimation

To empirically measure the last two lines in (22) seems a complicated task *a priori*. Fortunately, and as discussed above, the correlation across sectors between comparative advantage and sector level unemployment should capture quite well the intensive and extensive margins of the labor reallocation effect as reflected in the last two lines of (22). Indeed, these two terms suggest that a positive correlation between comparative advantage and sector level unemployment is likely to lead to an increase in unemployment as trade barriers decline. And it is quite straightforward to empirically calculate a correlation with information on comparative advantage and sector level unemployment.

The question of how to measure sector level unemployment will be addressed in subsection 3.1, so let us assume for the moment that we have a measure of $u(z)$. As for comparative advantage, we need a measure that takes into account trade-induced potential adjustments on both the export and import sides. We define it as:

$$r(z) \equiv \mathrm{RCA}^x(z) - \mathrm{RCA}^m(z) \tag{24}$$

where

$$\begin{aligned}\text{RCA}^x(z) &\equiv \frac{x(z)}{x(z)+x^0(z)}\left[\int_0^1 \frac{x(t)}{x(t)+x^0(t)}\text{d}t\right]^{-1} \\ &= \frac{1}{z_h} \end{aligned} \tag{25}$$

for positive exports $x(z)$, and $\text{RCA}^x(z) = 0$ otherwise, and

$$\begin{aligned}\text{RCA}^m(z) &\equiv \frac{m(z)}{m(z)+m^0(z)}\left[\int_0^1 \frac{m(t)}{m(t)+m^0(t)}\text{d}t\right]^{-1} \\ &= \frac{1}{1-z_f} \end{aligned} \tag{26}$$

for positive imports $m(z)$, and $\text{RCA}^m(z) = 0$ otherwise. The expressions in (25) and (26) correspond to Proudman and Redding's (2000) adaptation of Balassa's revealed comparative advantage index that allows for their comparison across time and countries. We need to perform such comparisons in our empirical specification (more on this in Section 3). The second equality in (25) and (26) follows from $m(z) = (\Lambda^0 - L^0)w^0$, $x(z) = (\Lambda - L)w$, and the use of (18). Note that $\bar{r} = 0$.

We can then compute the correlation between comparative advantage and sector unemployment as

$$\begin{aligned}\rho &\equiv \frac{\int_0^1 [r(z)-\bar{r}][u(z)-\bar{u}]\text{d}z}{\sqrt{\int_0^1 [r(z)-\bar{r}]^2\text{d}z \int_0^1 [u(z)-\bar{u}]^2\text{d}z}} \\ &= \sqrt{\frac{z_h(1-z_f)}{1-z_f+z_h}}\left[\frac{1}{z_h}\int_0^{z_h} u(z)\text{d}z - \frac{1}{1-z_f}\int_{z_f}^1 u(z)\text{d}z\right]\frac{1}{\sigma_u} \\ &= \text{Openness}\left[\bar{u}^X - \bar{u}^M\right]\frac{1}{\sigma_u}. \end{aligned} \tag{27}$$

The first line holds by definition. The second equality follows from $\bar{u} = u$ and from the definitions of $r(z)$ in (24) and of σ_u as the standard deviation of unemployment. The third equality follows by noting, first, that the term in the square root of the second line is increasing in the ranges of exported goods, z_h, and imported goods, $1 - z_f$, and as such is a measure of Home's trade openness; and, second, from the definitions of $\bar{u}_X$ in (23) and of $\bar{u}_M \equiv (1 - z_f)^{-1} \int_{z_f}^{1} u(z)\mathrm{d}z$, the (shadow) unemployment rate of the average importing sector.

Note the similarity with lines two and three of the right hand side of (22): these terms, too, are the product of a measure of trade openness and a difference between unemployment rates in exporting vs. importing sectors, as well as a margin of adjustment to time-varying trade reforms (intensive and extensive, respectively). Therefore, ρ, which is easy to measure empirically, is a close proxy to the net effect of the intensive and extensive margins of adjustment in (22).

3 Empirical strategy

To test the theoretical prediction of equations (22) and (4) we put forward the following empirical model:

$$\begin{aligned} \ln(u_{ct}) &= \beta_c + \beta_t + \beta_1 \rho_{ct} + \beta_2 \tau_{ct} + \beta_3 (\tau_{ct} \times \rho_{ct}) \\ &+ \beta_4 \ln(H_{ct}) + \beta_5 \ln(w_{ct}) + \epsilon_{ct}, \end{aligned} \tag{28}$$

where u_{ct} is aggregate unemployment in country c in year t, ρ_{ct} is the correlation between revealed comparative advantage and a measure of sector level labor market frictions, τ_{ct} is a measure of the trade restrictiveness (we use simple average tariffs or the share of collected duties in total imports), H_{ct} is total employment, w_{ct} is real wages which is proxied with GDP per capita to also control for business cycles, and ϵ_{ct} is an i.i.d error term. β_c and β_t are country and time-specific fixed effects, respectively. The former controls for any time-invariant determinant of unemployment, such as differences in institutional setups at the country level, and the latter control for year-specific aggregate shocks that may affect unemployment in all countries, such as global technological shocks. These fixed effects imply that the identification relies on the within country variation. This is consistent with our theoretical prediction in (22) that the impact of a country's trade liberalization on its level of unemployment depends on the correlation between comparative advantage and sector level labor market frictions.

Our model predicts a negative coefficient on the interaction between import barriers and the correlation between labor market frictions and comparative advantage ($\beta_3 < 0$). The marginal impact of a reduction in trade barriers on unemployment is given by $\partial \ln(u)/\partial\tau = \beta_2 + \beta_3 \times \rho_{ct}$, which is country- and year-specific and can be positive or negative depending on the values of β_2, β_3 and ρ_{ct}.

From (22) we also expect to get $\beta_1 > 0$ (having a comparative advantage in friction-intensive sectors is associated with a higher equilibrium unemployment rate, ceteris paribus) and $\beta_5 < 0$ (a larger income per capita is associated with a higher level of employment). The model does not provide clear predictions for β_2 or β_4, the coefficients of τ and H.[13]

3.1 Measures of comparative advantage and labor market frictions

To implement the empirical model we need a measure of the correlation between comparative advantage and labor market frictions for each country and year. As a measure of comparative advantage we use a discrete version of r in equations (24), (25), and (26):

$$r_{cst} = \frac{x_{cst}/\sum_{c'} x_{c'st}}{\frac{1}{S}\sum_{s'}\left(x_{cs't}/\sum_{c'} x_{c's't}\right)} - \frac{m_{cst}/\sum_{c'} m_{c'st}}{\frac{1}{S}\sum_{s'}\left(m_{cs't}/\sum_{c'} m_{c's't}\right)},$$

where x_{cst} and m_{cst} are respectively exports and imports of country c in sector s at time t, and S is the total number of sectors. As noted by Proudman and Redding (2000), this modification of the denominator in Balassa's original formula for comparative advantage makes possible the comparison of revealed comparative advantage across sectors within a country, which is needed when measuring the correlation between labor market frictions and

[13] We need τ in (28) because it is part of the interaction of interest. We introduce H to control for time varying country-specific unobservables that correlate with employment size. This is not featured in our model, and we will therefore also discuss estimates of (28) without using H as a control.

a country's comparative advantage. Depending on the distribution of trade flows, Balassa's measure has different means in different countries or sectors. Symmetry with respect to the neutrality threshold is desirable in an empirical assessment. Thus, we opted for a monotonic transformation of RCA^x and RCA^m given by $x/(1+x)$ to ensure that their variations are comparable and can be added up. This transformation was not needed in our theoretical analysis because RCA^x and RCA^m could only take two values depending on whether z was traded or not. Vollrath (1991) proposes a log transformation of Balassa's comparative advantage index, but he works at a higher level of aggregation than us. In our dataset a log transformation is not feasible because of the large number of zero imports and exports at the six-digit of the HS.

Measures of sector level labor market frictions are not readily available. To proxy for them in a way that is consistent with our theoretical model, we follow an idea developed by Hausmann, Hwang and Rodrik (2007) to measure product sophistication at the sector level. The idea is simple. Countries that specialize in sectors characterized by strong labor market frictions feature a higher unemployment rate. Thus, we can proxy the degree of labor market frictions in each sector by the product of the presence of individual countries in this sector times the observed unemployment rates of these countries. In other words, we proxy the labor market frictions in sector s (i.e., the discrete version of z) by the weighted average of countrywide unemployment rates, where the weights are given by a measure of the comparative advantage of each country in sector s:[14]

$$u_s = \sum_c \text{PR}^x_{cs} u_c, \tag{29}$$

where u_c is aggregate unemployment in country c and

$$\text{PR}^x_{cs} = \frac{x_{cs}/\sum_{s'} x_{cs'}}{\frac{1}{C}\sum_{c'}\left(x_{c's}/\sum_{s'} x_{c's'}\right)}$$

[14]Ideally one would like to use production rather than export data, but production data is only available for a much smaller number of countries and a much smaller number of sectors.

is a Proudman and Redding (2000) indicator of comparative advantage (observe that the denominators of (25) and the expression above differ).

We construct u_s using data at the beginning of the sample (1995-1997) to mitigate potential endogeneity concerns when estimating (28), so that u_s does not vary over time. The implicit assumption is that sector level labor market frictions do not rapidly change across time. It does not vary by country either as we use the variation in aggregate unemployment across countries to construct u_s. The identifying assumption here is that sector level labor market frictions are the same across countries.[15] In the robustness section we use the rank of u_s rather than its value.

The weights, PR_{cs}, in (29) are constructed using export data at the six-digit of the Harmonized System (HS), allowing us to construct u_s for 4975 sectors. In the robustness section we also provide results using data at the four- and two-digit levels of the HS (1240 and 96 sectors, respectively). The advantage of using highly disaggregated data is that most labor reallocation associated with trade liberalization tend to occur within large, broadly-defined sectors. Using more aggregated data would not allow to capture the impact that this reallocation of labor within broadly-defined sectors has on aggregate unemployment. The disadvantage of using highly disaggregated data is that we are making the implicit assumption that labor market frictions are specific to narrowly-defined sectors. A variance decomposition of u_s calculated at the six-digit level of the HS reveals that most of the variance occurs across six-digit HS goods and within four-digit HS sector, which vindicates our decision to use the more disaggregated data.[16]

Figure 1 displays the distribution of u_s when calculated at the six-digit level of the HS. These values can be interpreted as sector level unemployment rates (in %) due to labor market frictions. The mean and a median of this distribution are around 8.5 with a standard deviation of 2.5, a maximum of 25.1 and a minimum of 1.9. Table 1 provides the top and bottom fifteen HS 2-digit sectors when ranked in terms of the median u_s (calculated at the

[15] Note that we do not need to assume that they are the same, but only that they are highly correlated, as what we are after is not u_s per se, but rather its correlation with a measure of comparative advantage.

[16] Less than half of the total variance of u_s is explained by four-digit HS dummies, and only 14 percent of the total variance in u_s is explained by two-digit HS dummies.

six-digit level of the HS). Sectors such as iron and steel (HS 72), which are well known for their strong labor unions around the world, are ranked among the sectors with the highest labor market frictions. There are also several primary sectors in this list, which is consistent with McMillan and Rodrik's (2011) observation that the growth of primary sectors fails to generate a significant amount of new jobs. On the other hand, sectors such as clock and watch (HS 91) come at the bottom of the ranking. In Switzerland, this sector is notoriously struggling to fill its vacancies in a structural manner. This sector is not known to be strongly unionized. Indeed, a google search on "labor union" and "steel workers" or "iron workers" yields more than 350 thousand hits, whereas a search on "labor union" and "clock workers" or "watch workers" yields a bit more than 1 thousand hits.[17]

To perform a more systematic external test of the validity of our estimates of sector level labor market frictions, we correlate u_s with an index of labor union incidence constructed using data from the Union Membership and Coverage Database.[18] The available estimates are compiled from the Current Population Survey in the United States. We use estimates for the period 1990-2010. Figure 2 reports the unconditional correlation between union membership (expressed as a share of total employment) and our measure u_s (top panel), and between union coverage (as a share of total employment) and u_s (bottom panel). Each panel also plots the underlying linear correlation and the 95 percent confidence interval. It is clear from both panels that there is a positive correlation between our measure of labor market unemployment and measures of union membership and coverage at the sector level in the United States.[19]

[17] It is a bit more difficult to find anecdotic evidence regarding search frictions in the labor markets. We did however the same google searches but substituting "labor union" with "search frictions" and we found 170 hits for iron and steel, and 0 hits for clocks and watches.

[18] Available at www.unionstats.com.

[19] Similar results are obtained using data by Robinson (1995) for forty Canadian industries. This is consistent with our theoretical modeling of labor market frictions: as discussed in footnote 8 in section 2.3 an increase in labor's bargaining weight has a similar impact on unemployment as an increase in hiring costs.

3.2 Correlation between labor market frictions and revealed comparative advantage

With a measure of comparative advantage r_{cst} and sector level labor market frictions u_s at hand, it is trivial to calculate their correlation:

$$\rho_{ct} \equiv \frac{\sum_s (r_{sct} - \bar{r}_{ct})(u_s - \bar{u})}{\sqrt{\sum_s (r_{sct} - \bar{r}_{ct})^2 \sum_s (u_s - \bar{u})^2}} \tag{30}$$

Table 2 displays the median ρ during the period 1995-2009 for each country in our sample. We rank countries from the lowest to the highest ρ. The country with the highest ρ is Italy, suggesting that trade liberalization is likely to bring an increase in Italian unemployment. The country with the lowest ρ is Iceland, which makes it the country where trade liberalization is the most likely to result in a fall in unemployment. Note that the United States, Mexico and Brazil, which are countries for which existing studies suggest that trade liberalization contributed to increases in unemployment, are among the countries with the highest ρ as predicted by our model. Similarly, Algeria, Madagascar and Zambia, which are countries for which existing studies suggest that trade liberalization 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. [20]

3.3 Identification issues

There are several issues associated with the estimation of (28). First, trade restrictiveness may be endogenous. Indeed, there is a quite significant literature reviewed in Costinot (2009) that suggests that trade protection increases with unemployment. This creates a problem of reverse causality. Unfortunately, we could not think of any instrumental variable

[20] Note however that the value of ρ is not a sufficient statistic to predict the impact of trade liberalization on unemployment as trade liberalization may have a direct impact on unemployment that does not go through the reallocation of resources. Indeed trade liberalization may lead to increases or decreases in real wages which will in turn affect labor demand and aggregate unemployment. Indeed, depending on the sign of β_2 and its relative size with $\beta_3 < 0$ in (28) trade liberalization can always result in an increase or decrease in unemployment.

that would plausibly satisfy the exclusion restriction. We address this issue in the following way. First, we rely on a difference-in-difference (diff-in-diff) estimator using data for large trade liberalization episodes collected by Wacziarg and Welch (2008). Second, we test for parallel trends in unemployment for countries in the treatment and control groups before trade liberalization in order to rule out reverse causality. Trade liberalization episodes do not occur in the same year for all countries. We thus construct five different dummies that take a value of 1 in each of the treated countries one to five years before trade liberalization. If these dummies are not statistically different from zero, then we can safely conclude that there are no systematic changes in unemployment prior to trade liberalization, dampening worries of reverse causality. We also interact the treatment dummy with ρ to check whether the impact of trade liberalization on unemployment depends on ρ. The theoretical prediction implies that the coefficient on the interaction is positive, as trade liberalization leads to higher unemployment in countries with a relatively high correlation between labor market frictions and comparative advantage.

A second issue is the potential endogeneity of trade flows. We follow Feyrer (2009) and use a gravity setup where traditional geography determinants such as contiguity, common language, colonial relationship, common colonizer are complemented with time varying geography variables such as air and sea distance between countries (whose effects are allowed to vary by year). The predicted bilateral trade flows estimated at the six-digit of the HS are then aggregated across partners to obtain aggregate exports and imports, $\widehat{x_{cst}}$ and $\widehat{m_{cst}}$. These are then used to compute our indices of comparative advantage, $\widehat{r_{cst}}$, sector level labor market frictions, $\widehat{u_s}$, and their correlation across sectors, $\widehat{\rho_{ct}}$, which is used as an instrument for ρ_{ct}.

A third issue is the degree of aggregation at which we measure the correlation between sector level labor market frictions and comparative advantage. There are advantages and disadvantages associated with disaggregation. We argue above in favor of using as much disaggregation as possible as most of the variation in our measure of sector level labor market frictions occurs within HS four-digit sectors. However, we also report estimates where r_{cst},

u_s and ρ_{ct} are constructed using export and import data at the two and four-digit of the HS.

A final concern may be that the values of u_s, r_{cst} and therefore ρ_{ct} are measured with error. Fortunately, our framework suggest that the qualitative results are driven by the ranking of sectors according to u_s and r_{cst} rather than their value. We therefore test the robustness of results using the ranks of u_s and r_{cst} instead of their value.

4 Empirical Results

We start by discussing the main results associated with the estimation of (28) and then turn to various robustness tests.

4.1 Baseline Results

Table 3 reports the results of the estimation of (28). The first column uses simple average tariffs as our measure of trade restrictiveness and the second column uses collected duties as a share of imports. The predictions of the theoretical model are largely confirmed. First, the coefficient (β_1) on the correlation between comparative advantage and labor market frictions (ρ) is positive and statistically significant. Second, the coefficient (β_3) on the interaction between ρ and trade restrictiveness (τ) is negative and statistically significant. Thus, the impact of tariffs on unemployment is negative (and therefore trade liberalization increases unemployment) if the correlation between labor market frictions and comparative advantage is large.[21]

Figure 3 Figure 4 illustrate the marginal effect of average tariffs and collected duties on unemployment, respectively; the 90 percent confidence intervals are also reported. Both figures confirm that trade frictions have a negative impact on unemployment for sufficiently large values of ρ, whereas trade frictions have a positive impact on unemployment for sufficiently small values of ρ. The turning point occurs for values of ρ around -0.094 for average

[21]We run the same specification using the level of u on the left-hand-side and without controlling for employment levels. The results are identical in terms of sign and statistical significance as the ones reported in Table 3. Only the size of the coefficients obviously changes when we do not take logs in the left-hand-side.

tariffs, and around -0.050 for collected duties. In the case of average tariffs, Figthe impact of tariffs on unemployment is statistically above zero for values of ρ below -0.24, and it is statistically below zero for values of ρ above 0.02 (see Figure 3 for a visual confirmation). Similarly, in the case of collected duties (Figure 4), the impact of tariffs on unemployment is statistically above zero for values of ρ below -0.14, and it is statistically below zero for values of ρ above 0.04. For values within those thresholds the impacts are not statistically different from zero. As reported in Table 2, only eleven countries have a median value of ρ below -0.24; that is trade liberalization leads to a reduction in unemployment in these countries.[22] Twenty countries have a median value of ρ above 0.04. Trade liberalization results in an increase in unemployment in these countries.[23]

Table 3 also reports the coefficients of our control variables. GDP per capita, which controls for the real wage, but also institutional quality and business cycles, is negatively correlated with unemployment. Employment size is negatively correlated with unemployment perhaps suggesting that as labor markets get larger it is easier to find a job. The direct impact of tariffs on unemployment is not statistically different from zero.

4.2 Robustness checks

We perform five robustness checks. The first robustness check aims to correct for the potential reverse causality between trade protection and unemployment by using a difference-in-difference estimator. We also check for possible differences in the evolution of unemployment rates of countries in the treatment and control groups, before treatment occurs. To do so, we replace our proxies for τ (average tariffs or collected duties), by a dummy variable constructed by Wacziarg and Welch (2008) that indicates large episodes of trade liberalization before 2001. Because most trade liberalization episodes occur in the very early 1990s or 1980s, we extend the unemployment data to also include the 1980s so that we can test for

[22] These are Algeria, Belize, Bolivia, Ethiopia, Iceland, Kazahkhstan, Mali, Panama, Qatar, Uganda and Zambia.

[23] These countries are Austria, Belgium, Brazil, Colombia, Czech Republic, Denmark, Finland France, Germany, Hungary, Italy, Korea, Malaysia, Poland, Slovak Republic, Slovenia, Switzerland, Thailand, Turkey, and United States.

differences in trends before treatment. Our treatment group is made of the 28 countries in our sample that open to trade after 1985. Another 11 countries never open to trade in this sample that spans from 1980 to 2001, and these constitute our control group. Thus, the sample in this exercise includes the 39 countries that were not open to trade in the early 1980s according to Wacziarg and Welch (2008), and it spans from 1980 to 2001, when the data for trade liberalization episodes stops.[24]

We estimate the heterogeneity of the impact of these trade liberalization episodes on unemployment for different levels of ρ using a diff-in-diff setup for these 39 countries. Table 4 reports the results. The direct impact of trade liberalization on unemployment is statistically insignificant. The coefficient on the interaction between trade liberalization and ρ is positive and statistically different from zero, confirming the results of Table 3. Trade liberalization leads to higher levels of unemployment in countries that have a relatively large ρ.

A necessary condition for the diff-in-diff estimates to correct for the potential reverse causality between unemployment and trade liberalization is that unemployment was not trending upwards before these countries engage in trade liberalization. A test of parallel trends before liberalization can ensure that this was not the case. Since trade liberalization episodes occur at different times for different countries, we construct five dummies that take the value of 1 in each treated country five to one year before a trade liberalization event. As can be seen from column 2 in Table 4 these five dummies are statistically insignificant. Thus, unemployment was not trending differently in countries that engaged in trade reforms.

The second robustness check addresses the potential endogeneity of ρ, as the the trade flows behind the construction of ρ may be endogenous. We follow Feyrer (2009) to predict trade flows that are determined by time-varying geography variables and recalculate $\hat{r}$, $\hat{u_s}$ and $\hat{\rho}$ using these predicted trade flows. We use this new measure of $\hat{\rho}$ as an instrument for ρ and for the interaction of ρ with τ. The results are reported in Table 5 and they largely confirm

[24] The Harmonized System became a standard customs classification used by many countries only in the early 1990s. So for this exercise we construct measures of revealed comparative advantage from 1980 to 2001 using the disaggregation available in its predecessor: the SITC revision 2 classification. If instead we use the median of ρ for each country in our original sample (1995-2009), results are qualitatively the same as the ones reported in Table 4.

the results of Table 3.[25] Countries with large ρs experience an increase in unemployment as trade costs are reduced. The magnitude of the estimated β_3 (the coefficient of the interaction between ρ and τ) in Tables 3 and 5 are comparable. Trade costs have a statistically significant postive impact on unemployment, while the direct impact of ρ on unemployment is no longer statistically different from zero. The marginal impact of protection on unemployment as a function of ρ is plotted in Figures 5 and 6. The marginal impact is zero for values of ρ around -0.1. The impact is statistically larger than zero for values of ρ below -0.2 and statistically smaller than zero for $\rho \approx 0$ or larger.

The IV estimates have smaller standard errors, which implies that there is a larger number of countries for which the impact of trade reform on unemployment is statistically different from zero. Relative to the cutoffs of the OLS estimation in Table 3, we have an additional eight countries for which trade liberalization leads to a statistically significant reduction in unemployment.[26] Similarly, we have an additional ten countries where trade liberalization leads to a statistically significant increase in unemployment.[27]

The third robustness test consists of computing ρ using trade data at higher levels of aggregation, i.e., at the four and two-digit of the HS. Figure 7 displays the distribution of ρs calculated using trade data at different levels of aggregation. Interestingly, the distribution of ρs estimated using trade data at the two-digit of the HS (96 sectors) has a larger standard deviation than the distribution of ρs estimated using trade data at the four-digit of the HS (1240 sectors), and the latter has a larger standard deviation than the distribution of ρs estimated using trade data at the six-digit of the HS (4975). This is partly explained by the fact that we have more zeroes in the disaggregated data, which mechanically drives ρ towards zero. Tables 6 and 7 provide estimates using trade data at the four and two-digit of the HS, respectively. Qualitatively, the estimates confirm the results of Table 3. In particular, the coefficient of the interaction between trade protection measures and ρ is negative and statistically different from zero.

[25]The first stages show a strong and significant correlation between ρ and $\hat{\rho}$ with an estimated coefficient of 0.8 for average tariffs and 0.6 for collected duties. Botha are statistically significant at the 1 percent level.

[26]These are countries with a ρ ranked between Zambia and Kuwait in Table 2.

[27]These are countries with a ρ ranked between South Africa and Denmark in Table 2.

The final robustness test uses the rank correlation between comparative advantage and labor market frictions to control for measurement error in the estimation of u_s, r and therefore ρ. The results are reported in Table 8 and they largely confirm the results of Table 3.

5 Concluding Remarks

We embedded a model of the labor market with sector-specific search-and-matching frictions into a Ricardian model with a continuum of goods to show that trade liberalization causes higher unemployment in countries with comparative advantage in sectors with strong labor market frictions, and leads to lower unemployment in countries with comparative advantage in sectors with weak labor market frictions. We test this prediction in a panel dataset of 97 countries during the period 1995-2009, and find that the data supports the theoretical prediction.

Our model and empirical findings help explain the apparent lack of consensus in the empirical literature regarding the impact of trade liberalization on unemployment. Autor, Dorn and Hanson (2013), Ebeinstein et al. (2009) and Pierce and Schott (2013) find that trade increased unemployment in the United States. Revenga (1997) find a similar result for Mexico, and Menezes-Filho and Muendler (2011) and Mesquita and Najberg (2000) do so for Brazil. These are all countries for which our empirical model predicts a positive and statistically significant impact of trade liberalization on unemployment, because our estimates of the correlation between labor market frictions and comparative advantage in these countries are large and positive. Currie and Harrison (1997) and Hasan et al. (2012) find no impact of trade liberalization on unemployment in Morocco and India, respectively. This is again consistent with our empirical results, since the correlation between comparative advantage and sector level labor market frictions is in the statistical insignificant range for these countries. Finally, Kpodar (2007), Nicita (2008) and Balat, Brambilla and Porto (2007) find that trade liberalization led to a reduction in unemployment in Algeria, Madagascar and Zambia, respectively. This is once again consistent with our empirical results because of the large and negative correlation between labor market frictions and comparative advantage in these countries.

The framework in this paper can also help explain why both President and Senator Obama can be right while making seemingly contradictory assertions. President Obama argued that free trade with Korea would create American jobs, and senator Obama argued that Nafta destroyed American jobs. If the United States bilateral comparative advantage with Korea is negatively correlated with its sector level labor market frictions, and its comparative advantage with Mexico is positively correlated with its sector level labor market frictions, then it is possible that Obama was right both times. However, to confidently answer this question requires a trade framework that allows for different bilateral trade relationships among countries. This is explored in Grujovic and Robert-Nicoud (2014).

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Data Appendix

We use trade and unemployment data for 97 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. Gravity variables are from the CEPII.

The appendix table provides descriptive statistics for the variables used in the estimation of (28).

Appendix Table: Descriptive statistics 1995-2009

Variable	Obs	Mean	Std. Dev.	Min	Max
$\ln(u_{ct})$	878	1.98	0.64	-0.69	3.62
$\ln(H_{ct})$	878	8.57	1.62	3.84	12.87
$\ln(w_{ct})$	878	8.66	1.40	5.29	11.46
ρ_{ct}	878	-0.04	0.13	-0.37	0.34
τ_{ct}					
Average tariff	878	8.09	7.03	0.00	50.10
Collected duties	747	3.18	3.92	0.06	26.48

Appendix: Closing the model

An equilibrium is a tuple $\{z_h, z_f, p, w, w^0, u, u^0\}$ such that equations (7), (20), and (21) in the text and equations (36) - (38) below hold. To prove existence and uniqueness, first note that this system of equations is recursive: we can first solve for the equilibrium tuple $\{z_h, z_f, p, w, w^0\}$ using equations (7) and (36) to (38). This equilibrium exists and is unique; see Dornbusch, Fischer and Samuelson (1977). Once this tuple is known, the unique solutions to u and u^0 follow from equations (20) and (21).

Closing the model requires a link between intermediate good markets and labor markets. Such a link is provided by the unit cost pricing conditions in each sector:

$$P(z) = \frac{1}{\hat{a}(z)} \widetilde{w}(z). \tag{31}$$

Let

$$a(z) \equiv 2\hat{a}(z) v(z)^{\frac{-1}{1+\alpha}} \quad \text{and} \quad a^0(z) \equiv 2\hat{a}^0(z) v^0(z)^{\frac{-1}{1+\alpha}} \tag{32}$$

collect parameters that govern overall total factor productivity in sector z and lump together the potential sources of *Ricardian comparative advantage* in the model. In order to be consistent with our identification strategy below, we assume $v^0(z) = v(z)$.[28]

Using equations (14), (31), and (32) 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:

$$\ln P(z) = -\ln a(z) + (1-\alpha)\ln w + \alpha \ln p \tag{33}$$

and

$$\ln P^0(z) = -\ln a^0(z) + (1-\alpha)\ln w^0. \tag{34}$$

Using equations (33) and (34) enables us to rewrite our metric for comparative advantage

[28] It is straightforward to generalize the model to allow the v's to become an additional source of Ricardian comparative advantage. All the qualitative results of the model continue to hold in that extended model.

in equation (6) as follows:

$$\pi(z) \equiv \frac{P^0(z)}{P(z)} = p^{-\alpha} \left(\frac{w^0}{w}\right)^{1-\alpha} \frac{a(z)}{a^0(z)}. \tag{35}$$

Two features of this expression 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, the total factor produtivity 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 (6) 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.

We are now in position to close the model by using (33) and (34) to substitute for $P(z)$ and $P^0(z)$ in the Y-sector marginal cost pricing equations (9) and (10):

$$\begin{aligned} \ln p &= -A(z_f) + (1-\alpha)\left[z_f \ln w + (1-z_f)\ln w^0\right] \\ &+ \alpha z_h \ln p + (1-z_f)\ln \tau, \end{aligned} \tag{36}$$

and

$$0 = -A(z_h) + (1-\alpha)\left[z_h \ln w + (1-z_h)\ln w^0\right] + \alpha z_h \ln p + z_h \ln \tau, \tag{37}$$

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 (14) 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 equation (8) as

$$\frac{wL}{w^0 L^0} = \frac{z_h}{1 - z_f}. \tag{38}$$

Equations (7) and (35) to (21) characterize the general equilibrium. This equilibrium exists and is unique.

Table 1
Labor market frictions: top and bottom fifteen HS 2-digit sectors

HS-2	Top fifteen sectors Description	Median ν[a]
31	Fertilisers	10.77
43	Furskins and artificial fur; manufactures thereof	9.45
08	Edible fruit and nuts; peel of citrus fruit or melons	9.42
27	Mineral fuels, oils & product of their distillation; etc	9.39
72	Iron and steel	9.13
86	Railw/tramw locom, rolling-stock & parts thereof; etc	9.10
62	Art of apparel & clothing access, not knitted/crocheted	9.08
20	Prep of vegetable, fruit, nuts or other parts of plants	9.04
22	Beverages, spirits and vinegar	8.95
64	Footwear, gaiters and the like; parts of such articles	8.94
07	Edible vegetables and certain roots and tubers	8.84
18	Cocoa and cocoa preparations	8.81
78	Lead and articles thereof	8.79
45	Cork and articles of cork	8.69
36	Explosives; pyrotechnic prod; matches; pyrop alloy; etc	8.59

HS-2	Bottom fifteen sectors Description	Median ν
91	Clocks and watches and parts thereof	5.34
67	Prepr feathers & down; arti flower; articles human hair	6.09
80	Tin and articles thereof	6.23
50	Silk	6.42
95	Toys, games & sports requisites; parts & access thereof	6.51
92	Musical instruments; parts and access of such articles	6.61
37	Photographic or cinematographic goods	6.76
05	Products of animal origin, nes or included	6.79
03	Fish& crustacean, mollusc & other aquatic invertebrate	6.80
66	Umbrellas, walking-sticks, seat-sticks, whips, etc	6.85
46	Manufactures of straw, esparto/other plaiting mat; etc	6.95
90	Optical, photo, cine, meas, checking, precision, etc	6.97
52	Cotton	7.01
96	Miscellaneous manufactured articles.	7.02
97	Works of art, collectors' pieces and antiques	7.12

[a]We take the median ν across six-digit HS goods and within two-digit HS sectors.

Table 2
Correlation between labor market frictions
and comparative advantage (median ρ for 1995-2009)

Country name	Country code	Median ρ
Iceland	ISL	-0.33
Panama	PAN	-0.30
Bolivia	BOL	-0.30
Kazakhstan	KAZ	-0.29
Ethiopia	ETH	-0.27
Belize	BLZ	-0.27
Algeria	DZA	-0.27
Mali	MLI	-0.26
Uganda	UGA	-0.25
Qatar	QAT	-0.25
Zambia	ZMB	-0.24
Maldives	MDV	-0.23
Mongolia	MNG	-0.23
Yemen, Rep.	YEM	-0.23
Madagascar	MDG	-0.23
Nicaragua	NIC	-0.22
Benin	BEN	-0.22
Paraguay	PRY	-0.21
Bahamas, The	BHS	-0.21
Kuwait	KWT	-0.19
Zimbabwe	ZWE	-0.18
Chile	CHL	-0.18
Jamaica	JAM	-0.18
Seychelles	SYC	-0.18
Georgia	GEO	-0.17
Bhutan	BTN	-0.16
Peru	PER	-0.16
Fiji	FJI	-0.15
Honduras	HND	-0.14
Iran, Islamic Rep.	IRN	-0.14
Sierra Leone	SLE	-0.14
Norway	NOR	-0.14
Trinidad and Tobago	TTO	-0.14
Kyrgyz Republic	KGZ	-0.14
Uruguay	URY	-0.13
Russian Federation	RUS	-0.13
Dominican Republic	DOM	-0.12
Cyprus	CYP	-0.12

Country name	Country code	Median ρ
Kenya	KEN	-0.12
Moldova	MDA	-0.12
Malta	MLT	-0.11
Ireland	IRL	-0.09
Guatemala	GTM	-0.08
Estonia	EST	-0.08
Syrian Arab Republic	SYR	-0.08
Australia	AUS	-0.08
New Zealand	NZL	-0.07
Macedonia, FYR	MKD	-0.06
Venezuela, RB	VEN	-0.06
Jordan	JOR	-0.06
Ukraine	UKR	-0.05
El Salvador	SLV	-0.05
Bahrain	BHR	-0.05
Hong Kong SAR, China	HKG	-0.04
Latvia	LVA	-0.04
Croatia	HRV	-0.04
Morocco	MAR	-0.04
Sri Lanka	LKA	-0.04
Macao SAR, China	MAC	-0.04
Nepal	NPL	-0.03
Pakistan	PAK	-0.03
Lithuania	LTU	-0.02
Israel	ISR	-0.02
Singapore	SGP	-0.02
Lebanon	LBN	-0.02
Argentina	ARG	-0.02
South Africa	ZAF	-0.02
Indonesia	IDN	0.00
Egypt, Arab Rep.	EGY	0.00
India	IND	0.00
Philippines	PHL	0.01
Tunisia	TUN	0.01
Mexico	MEX	0.01
Greece	GRC	0.02
China	CHN	0.02
Bangladesh	BGD	0.03
Bulgaria	BGR	0.03
Denmark	DNK	0.04
Slovak Republic	SVK	0.04

Country name	Country code	Median ρ
Germany	DEU	0.05
Finland	FIN	0.05
Austria	AUT	0.05
Hungary	HUN	0.06
United States	USA	0.06
Czech Republic	CZE	0.06
Brazil	BRA	0.07
Slovenia	SVN	0.07
Switzerland	CHE	0.08
Malaysia	MYS	0.09
Thailand	THA	0.09
Colombia	COL	0.10
France	FRA	0.10
Poland	POL	0.10
Belgium	BEL	0.11
Turkey	TUR	0.14
Korea, Rep.	KOR	0.20
Italy	ITA	0.31

Table 3
The impact of trade liberalization on unemployment depends on ρ (benchmark estimates)[a]

$\ln(u)$	Average Tariff	Collected duties
Employment size	-0.257***	-0.255***
$\ln(H)$	(0.11)	(0.12)
GDP per capita	-0.270***	-0.369***
$\ln(w)$	(0.10)	(0.09)
Trade restrictiveness	-0.010	-0.014
τ	(0.01)	(0.01)
Correlation btw r and ν	2.530***	3.416***
ρ	(0.84)	(0.85)
Interaction	-0.104**	-0.285***
$\tau \times \rho$	(0.05)	(0.09)
Observations	878	747
# clusters	97	94
Period	1995-2009	1995-2009
Marginal impact of zero for ρ equal to[b]	-0.094	-0.050

[a]OLS estimates. All regression have country and year fixed effects. 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]This is the value of ρ for which the marginal impact of trade restrictiveness on unemployment is equal to zero and therefore changes sign. For countries with a value of ρ below these values the estimated marginal impact of trade protection on unemployment is positive, whereas for countries with a value of ρ above these values the impact of trade protection on unemployment is negative.

Table 4
Diff-in-diff impact of trade liberalization episodes on unemployment[a]

ln (u)	Diff-in-Diff	Pre-trend?
Wacziarg and Welch trade liberalization dummy	0.098	0.241
(WW)	(0.141)	(0.233)
Correlation between r and ν	-0.557	-0.530
(ρ)	(0.661)	(0.691)
Interaction	1.652**	1.639**
$WW \times \rho$	(0.777)	(0.728)
WW_{t-1}		0.188
		(0.181)
WW_{t-2}		0.139
		(0.156)
WW_{t-3}		0.124
		(0.147)
WW_{t-4}		0.109
		(0.119)
WW_{t-5}		0.155
		(0.111)
Observations	512	512
# clusters	39	39
Period	1980-2001	1980-2001

[a]OLS estimates. All regression have country and year fixed effects. Robust standard errors in parentheses are clustered at the country level. $\star\star\star$ $p < 1\%$, $\star\star$ $p < 5\%$, and $\star$ $p < 10\%$.

Table 5
The impact of trade liberalization on unemployment depends on ρ
(IV estimates)[a]

$\ln(u)$	Average Tariff	Collected duties
Employment size	-0.229***	-0.272***
$\ln(H)$	(0.06)	(0.07)
GDP per capita	-0.310***	-0.431***
$\ln(w)$	(0.05)	(0.06)
Trade restrictiveness	-0.015***	-0.016*
τ	(0.00)	(0.01)
Correlation btw r and ν	0.844	-0.470
ρ	(0.63)	(0.98)
Interaction	-0.123***	-0.161**
$\tau \times \rho$	(0.04)	(0.06)
Observations	878	747
# clusters	97	94
Period	1995-2009	1995-2009
Marginal impact of zero for ρ equal to[b]	-0.118	-0.098

[a]IV estimates. Both ρ and $\tau \times \rho$ are instrumented using predicted trade flows from time-varying geography determinants of bilateral trade flows in a gravity setup. All regression have country and year fixed effects. 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]This is the value of ρ for which the marginal impact of trade restrictiveness on unemployment is equal to zero and therefore changes sign. For countries with a value of ρ below these values the estimated marginal impact of trade protection on unemployment is positive, whereas for countries with a value of ρ above these values the impact of trade protection on unemployment is negative.

Table 6
The impact of trade liberalization on unemployment depends on ρ
(using 4-digit HS trade data)[a]

$\ln(u)$	Average Tariff	Collected duties
Employment size	-0.270***	-0.262**
$\ln(H)$	(0.11)	(0.12)
GDP per capita	-0.269***	-0.380***
$\ln(w)$	(0.10)	(0.09)
Trade restrictiveness	-0.008*	-0.010
τ	(0.00)	(0.01)
Correlation btw r and ν	2.162***	2.547***
ρ	(0.65)	(0.68)
Interaction	-0.083*	-0.230**
$\tau \times \rho$	(0.05)	(0.06)
Observations	878	747
# clusters	97	94
Period	1995-2009	1995-2009
Marginal impact of zero for ρ equal to[b]	-0.099	-0.045

[a]OLS estimates. All regression have country and year fixed effects. 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]This is the value of ρ for which the marginal impact of trade restrictiveness on unemployment is equal to zero and therefore changes sign. For countries with a value of ρ below these values the estimated marginal impact of trade protection on unemployment is positive, whereas for countries with a value of ρ above these values the impact of trade protection on unemployment is negative.

Table 7
The impact of trade liberalization on unemployment depends on ρ
(using 2-digit HS trade data)[a]

$\ln(u)$	Average Tariff	Collected duties
Employment size	-0.242**	-0.286*
$\ln(H)$	(0.10)	(0.12)
GDP per capita	-0.296***	-0.411***
$\ln(w)$	(0.10)	(0.09)
Trade restrictiveness	-0.011*	-0.007
τ	(0.01)	(0.01)
Correlation btw r and ν	1.115***	0.880**
ρ	(0.38)	(0.42)
Interaction	-0.054*	-0.091**
$\tau \times \rho$	(0.03)	(0.04)
Observations	878	747
# clusters	97	94
Period	1995-2009	1995-2009
Marginal impact of zero for ρ equal to[b]	-0.195	-0.074

[a]OLS estimates. All regression have country and year fixed effects. 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]This is the value of ρ for which the marginal impact of trade restrictiveness on unemployment is equal to zero and therefore changes sign. For countries with a value of ρ below these values the estimated marginal impact of trade protection on unemployment is positive, whereas for countries with a value of ρ above these values the impact of trade protection on unemployment is negative.

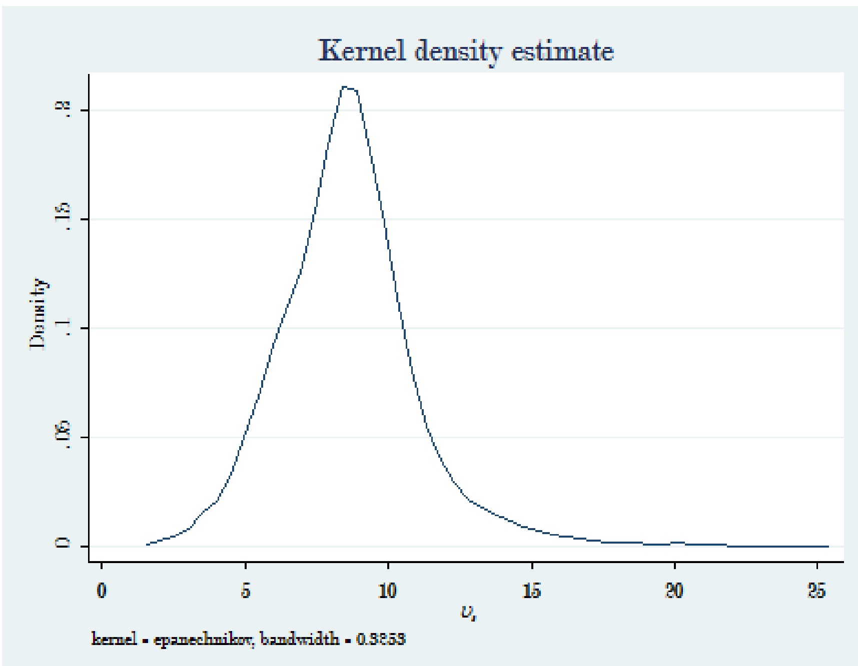
Table 8
Using ranks of ν and r rather than their value[a]

$\ln(u)$	Average Tariff	Collected duties
Employment size	-0.252**	-0.248**
$\ln(H)$	(0.10)	(0.12)
GDP per capita	-0.268**	-0.390***
$\ln(w)$	(0.10)	(0.09)
Trade restrictiveness	-0.014*	-0.024
τ	(0.01)	(0.02)
Correlation btw r and ν	2.115***	2.597***
ρ	(0.74)	(0.82)
Interaction	-0.080*	-0.234***
$\tau \times \rho$	(0.04)	(0.08)
Observations	878	747
# clusters	97	94
Period	1995-2009	1995-2009
Marginal impact of zero for ρ equal to[b]	-0.177	-0.100

[a]OLS estimates. All regression have country and year fixed effects. 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]This is the value of ρ for which the marginal impact of trade restrictiveness on unemployment is equal to zero and therefore changes sign. For countries with a value of ρ below these values the estimated marginal impact of trade protection on unemployment is positive, whereas for countries with a value of ρ above these values the impact of trade protection on unemployment is negative.

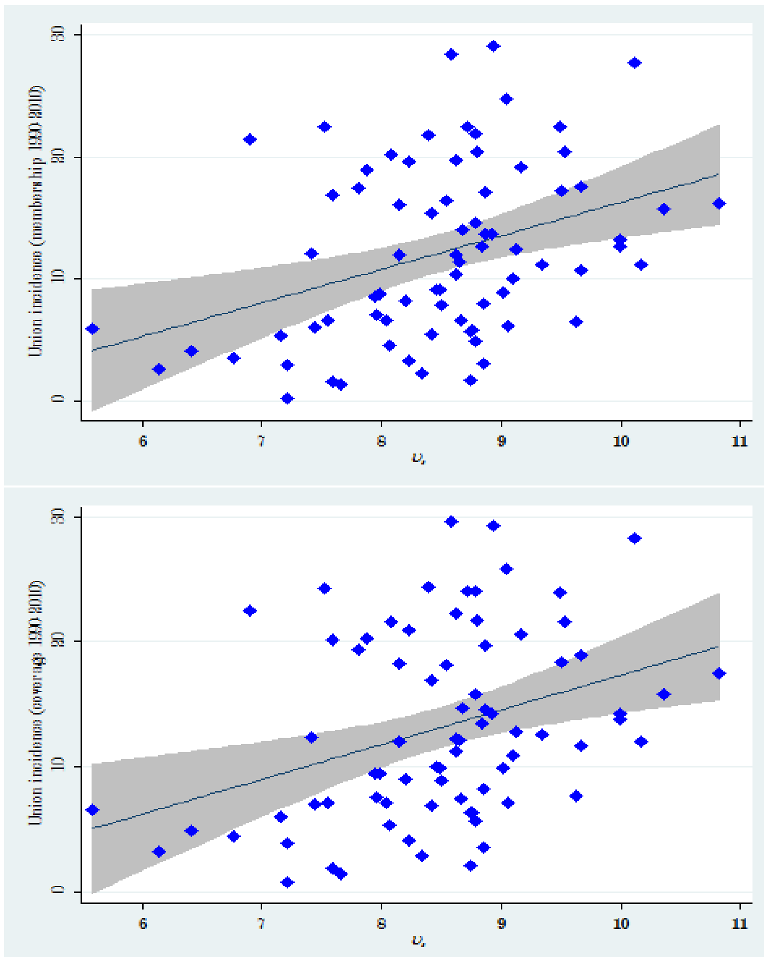
Figure 1
Distribution of sector level labor market frictions ν_s



Note: Authors' computation using export data at the six-digit of the HS from CEPII's BACI and aggregate unemployment data from the ILO.

Figure 2

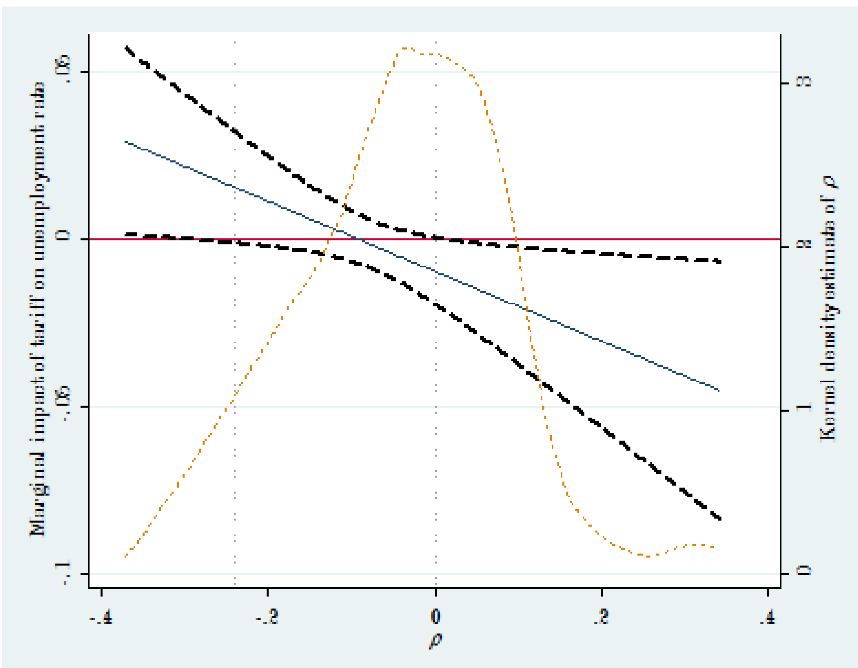
Correlation between ν_s and indices of labor union incidence



Note: Computed using the estimated ν_s and the Union Membership and Coverage Database (www.unionstats.com). The top panel provides the correlation with union membership and the bottom panel the correlation with union coverage measured between 1990-2010.

Figure 3

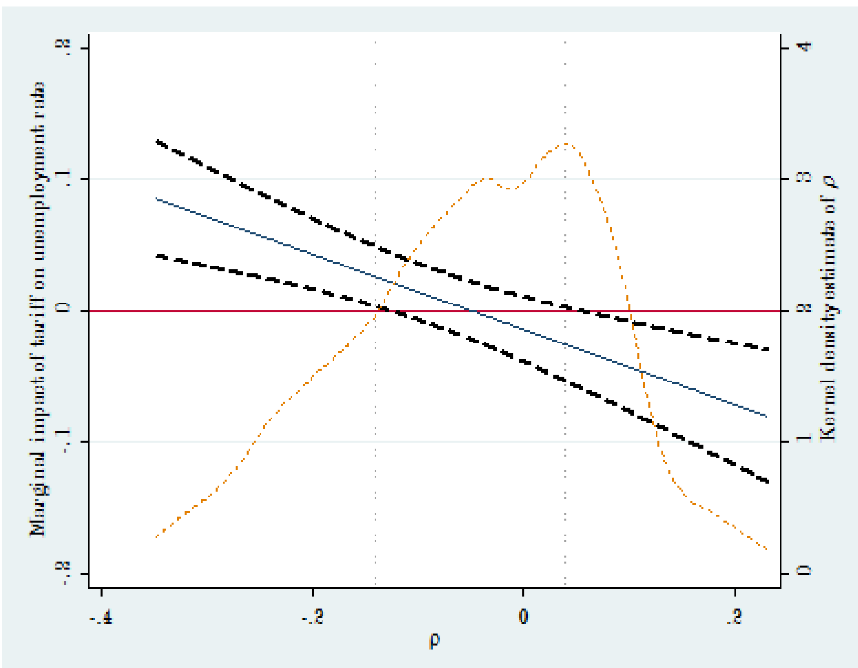
Marginal impact of average tariffs on unemployment as a function of ρ



Note: The thick dashed lines provide the 90 percent confidence intervals. The thin dashed line is a kernel density estimate of ρ.

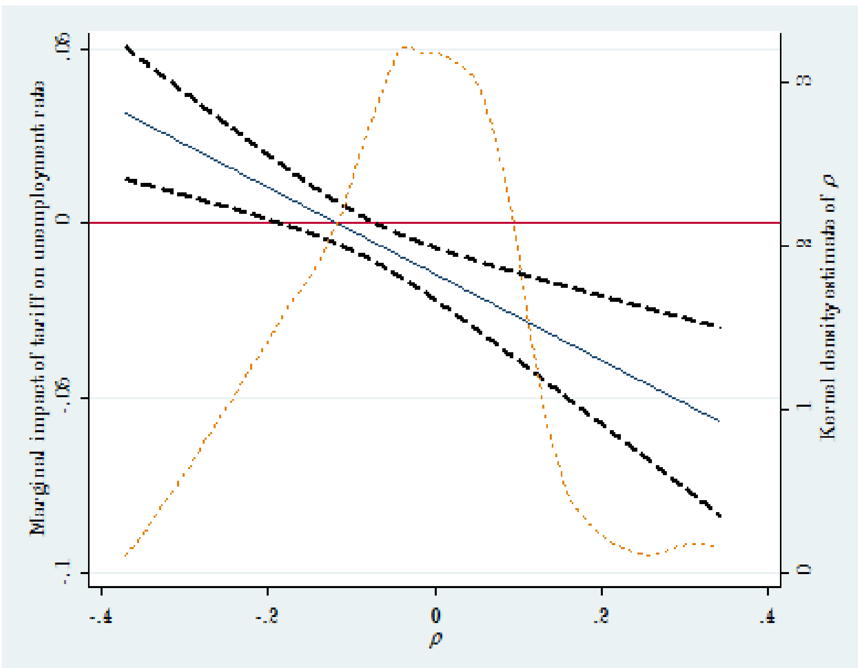
Figure 4

Marginal impact of collected duties on unemployment as a function of ρ



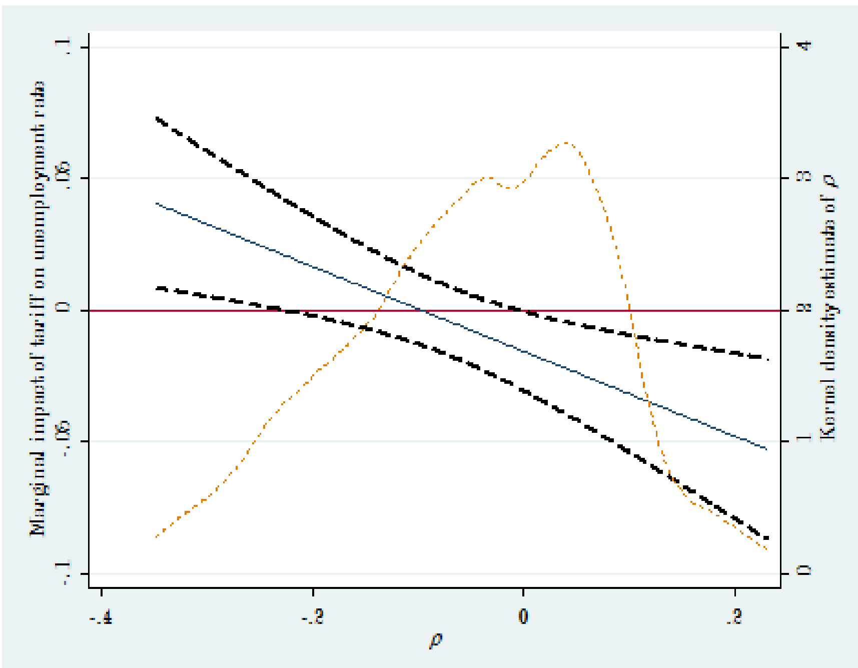
Note: The thick dashed lines provide the 90 percent confidence intervals. The thin dashed line is a kernel density estimate of ρ.

Figure 5
Marginal impact of average tariffs on unemployment as a function of ρ
(IV estimates)



Note: The thick dashed lines provide the 90 percent confidence intervals. The thin dashed line is a kernel density estimate of ρ.

Figure 6
Marginal impact of collected duties on unemployment as a function of ρ
(IV estimates)



Note: The thick dashed lines provide the 90 percent confidence intervals. The thin dashed line is a kernel density estimate of ρ.

Figure 7
Distributions of ρ estimated at different levels of production aggregation