Trading Unemployment*

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December 2013

Abstract

We embed a static Diamond-Mortensen-Pissarides model of labor market frictions à la Helpman and Istkhoki into a Dornbush-Fischer-Samuelson Ricardian trade model. The impact of trade on unemployment depends on the correlation between comparative advantage and sector level labor market frictions. If the correlation is large and positive then trade liberalization leads to an increase in unemployment, whereas if the correlation is large and negative then unemployment falls as the economy opens up to trade. This prediction is empirically confirmed in a panel of 97 countries during the period 1995-2009.

JEL classification: F10, F13, F16.
Keywords: Trade, Search unemployment.

*We are grateful to Nicolas Berman, Beata Javorcik, Mustapha Sadni, and seminar participants at the University of Antwerp, University of Valencia, the Geneva Trade and Development Workshop at the WTO, and UNECA's trade workshop in Rabat for their very constructive comments.

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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 frictions 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 can be thought of as the weighted average of sector-specific unemployment rates.[1] As a result, the 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 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 –if not all– international economics textbooks have no chapter on the impact of trade on unemployment. We aim at filling this gap in the wake of Helpman and Itskhoki (2010). Second, the 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. Third, in our setting, welfare and unemployment are negatively correlated, but not perfectly: freer trade may destroy more jobs than it creates *and* yet increase welfare. Fourth, this is an important political issue, and policymakers are convinced that there is a link between trade and unemployment, but they

[1] The weights are given by employment shares.

disagree on the direction on which unemployment moves after trade liberalization. Among trade sceptics there is Senator Obama, who during his first presidential campaign claimed that "one million jobs have been lost because of NAFTA". Among trade enthusiasts there is President Obama, who in 2012 suggested: "The US-Korea trade agreement will support 70 thousand American jobs." So, who is right? Our model and empirical evidence suggests that potentially both can be right.

Our empirical strategy comprises three steps. First, to bring our theoretical prediction to the data requires a measure of comparative advantage, which is straightforward, and measures of sectoral labor market frictions, which is more challenging. We measure the former using Balassa-type Revealed Comparative Advantage (RCA) indices. To construct the latter we build on an idea developed by Hausmann, Hwang and Rodrik (2007) to measure product sophistication at the sector level. More concretely, we define the unemployment rate of a sector as the RCA-weighted average of the unemployment rate in each country. The idea is that countries with high rates of unemployment tend to have their production bundle tilted towards sectors with strong labor-market frictions. 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.

Ours is not the first paper to study the impact of trade reforms on unemployment. Brecher (1974) is an early example. He develops a 2x2 Hecsksсher-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 are the first to recognize that sectoral labor market frictions can be a source of comparative advantage. Helpman and Itskhoki (2010) build a Diamond-Mortensen-Pisarrides 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 and homogenous-good sectors.[2]

Thus, while this growing theoretical literature recognizes an impact of trade on unemployment, there does not seem to be a consensus regarding the sign of the impact. As put by Hoekman and Winters (2005): "These are complex models with complex and ambiguous results, but at least they admit the possibility that trade reform could have long-run consequences for employment."

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 unanimous answer either. Several important papers suggest that trade liberalization or import growth

[2]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).

have led to an increase in unemployment. Revenga (1997) provides evidence for Mexico, Menezes-Filho and Mundler (2011) and Mesquita and Najberg (2000) for Brazil, and Autor, Dorn and Hanson (2013), Ebeinstein et al. (2009) and Pierce and Schott (2013) for the United States.[3] There are also several important papers suggesting that trade has no impact on unemployment. Hasan et al. (2012) provide evidence for India, and Currie and Harrison, (1997) for Morocco. Finally, there is also evidence suggesting that trade 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 can help explain the conflicting results of these studies. If we rank countries in terms of the correlation between comparative advantage and labor market frictions, Brazil, Mexico, and the United States are in the top third of the distribution. On the other hand, Ethiopia, Madagascar and Zambia are in the bottom 33 percent, whereas India and Morocco are in the statistically insignificant range in the middle of the distribution. This suggests that our paper provides a 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 comparative advantage with a model of equilibrium unemployment based on search-and-matching frictions. We start by developping a reduced-form model in the first subsection below in order to fix ideas. The hurried reader uninterested in the details of the theory may then skip the rest of this section and go directly to Section 3.

2.1 The model in a nutshell

Consider an open economy that produces and exports goods from n_X distinct sectors, imports and consumes goods from n_M sectors, and produces purely for domestic consumption in the

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

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 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 $\bar{u}_M$ 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.[4] 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 the 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

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

[4] The source of comparative advantage is Ricardian in our model below but this assumption is immaterial.

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, the "efficiency term" for which we provide a precise interpretation in subsection 2.5 below.

Put simply, a country will see its unemployment rate go up following a trade liberalization episode if it has a comparative advantage in 'unemployment-intensive' sectors; conversely, unemployment falls if trade shifts resources towards sectors with relatively low labor-market frictions.

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-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 TFP).

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 as

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

The production of goods in the interval (z_h, z_f) is purely for domestic consumption and are therefore non-traded goods.

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

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

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 Dornbush, Fisher, and Samuleson (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 Diamond-Mortensen-Pissarides 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 TFP of the matching technology, which is parameterized by $m(z)$. Specifically, we assume the following Cobb-Douglas matching function:

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

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

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

In equilibrium, $\lambda(z)$ is also the sectoral employment rate. The expected number of vacancies a firm needs to open in order to fill exactly one is equal to $V(z)/H(z) = \lambda(z)^{\frac{1-\alpha}{\alpha}}/m(z)$.

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 $w(z) = r(z)/2$.[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

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

[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.

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, $\lambda(z)^{\frac{1-\alpha}{\alpha}}/m(z)$, 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 $v(z) \equiv \nu(z)/m(z)$ is the unit vacancy cost adjusted for the TFP 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 probability of finding a job $\lambda(z)$,

$$\lambda(z)^{\frac{1}{\alpha}} = \frac{w}{p}\frac{1}{v(z)}, \tag{16}$$

[8]In the case of sector-specific bargaining weights, we obtain $v(z) \equiv \nu(z)/m(z)\phi(z)/\left[1-\phi(z)\right]$ and $\widetilde{w}(z) = pv(z)\lambda(z)^{\frac{1-\alpha}{\alpha}}/\left[1-\phi(z)\right]$. A higher labor share in the bargaining process has the same impact on sectoral wages and hiring costs as a higher vacancy cost or a lower matching TFP. 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.

as well as for the hiring cost expressed in physical units of the domestically produced final good $b(z)/p$,

$$\frac{b(z)}{p} = \left(\frac{w}{p}\right)^{1-\alpha} v(z)^{\alpha}. \tag{17}$$

Three aspects of (16) and (17) are noteworthy. First, sector-specific labor market frictions $v(z)$ affect the employment rate and the hiring cost in opposite and intuitive directions. Second, the (real) hiring cost is increasing in (real) wages as per (17), which is also quite intuitive. Finally, the real wage w/p is positively related with the employment rate as per (16) because well-functioning labor markets are associated with high employment rates and high levels of real consumption (more on this below after equations (23) and (24)).

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

$$\frac{pY + Y^0}{2} = wL(z) + w^0 L^0(z) \tag{18}$$

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 (18), tedious but straightforward calculations yield the following expressions for employment in the exporting sectors as a function of the trade patterns cutoffs:

$$\Lambda = \Lambda(z_h, z_f) \equiv \left(1 + \frac{1 - z_f}{z_h}\right) L \quad \text{and} \quad \Lambda^0 = \Lambda^0(z_h, z_f) \equiv \left(1 + \frac{z_h}{1 - z_f}\right) L^0. \tag{19}$$

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

$$\ell = L \quad \text{and} \quad \ell^0 = L^0. \tag{20}$$

The following footnote provides a guide to calculations.[10]

2.4 General equilibrium

We close the model in the appendix where we show that there exists a unique equilibrium. 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, $u(z) \equiv 1 - \lambda(z)$, where the weights are given by the participation rates, $L(z)/L$. Equations (19) and (20) provide the employment levels for the exporting and non-traded sectors, respectively. These considerations and (16) lead to

[10] Using the definitions for Λ and ℓ, (18) yields

$$\begin{aligned} \frac{pY + Y^0}{2} &= w\Lambda \\ &= w^0\Lambda^0 \\ &= w\ell + w^0\ell^0. \end{aligned} \tag{21}$$

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

$$L = z_h\Lambda + (z_f - z_h)\ell \quad \text{and} \quad L^0 = (z_f - z_h)\ell^0 + (1 - z_f)\Lambda^0. \tag{22}$$

Using (8), (21), and (22) yields the expressions in the text.

the following expressions for the unemployment rates:

$$
\begin{aligned}
u &= u\left(\frac{w}{p}, z_h, z_f\right) \\
&\equiv 1-\left(\frac{w}{p}\right)^{\alpha}\frac{1}{L}\left[\Lambda(z_h, z_f)\int_0^{z_h}\frac{1}{v(z)^{\alpha}}\mathrm{d}z+\ell\int_{z_h}^{z_f}\frac{1}{v(z)^{\alpha}}\mathrm{d}z\right]
\end{aligned}
\tag{23}
$$

and

$$
\begin{aligned}
u^0 &= u^0\left(w^0, z_h, z_f\right) \\
&\equiv 1-\left(w^0\right)^{\alpha}\frac{1}{L^0}\left[\ell^0\int_{z_h}^{z_f}\frac{1}{v^0(z)^{\alpha}}\mathrm{d}z+\Lambda^0(z_h, z_f)\int_{z_f}^{1}\frac{1}{v^0(z)^{\alpha}}\mathrm{d}z.\right]
\end{aligned}
\tag{24}
$$

Two aspects of equations (23) and (24) are noteworthy. First, both provide an equilibrium negative relationship between the unemployment rate and the real average wage of each country (between u and w/p in Home and between u^0 and w^0 in Foreign). Quite intuitively, anything that lowers unemployment tends to raise welfare. Second, the pattern of production influences the unemployment rate over and above its effect on real wages. This is a composition effect that arises because labor market frictions are sector-specific and the unemployment rate of an economy as a whole reflects the sectoral unemployment rates of the sectors in which it specializes.

2.5 Comparative statics

Inspection of expressions (23) and (24) reveals that trade has two kinds of impact on equilibrium unemployment. First, freer trade allows for a more efficient allocation of resources. This boasts job creation and raises welfare in at least one of the two countries; this effect is captured by w/p in equation (23) and by w^0 in equation (24). Second, by reallocating resources across sectors, trade changes the industry mix of each economy and, since labor frictions are sector specific, this changes the level of aggregate unemployment.

To see these formally, let us take the total derivative of equation (23) using expressions

(19) and (20):

$$
\begin{aligned}
-\mathrm{d}u &= \alpha\,(1-u)\left(\frac{w}{p}\right)^{-1}\mathrm{d}\left(\frac{w}{p}\right) \\
&+ \left(\frac{w}{p}\right)^{\alpha}\frac{1}{v(z_f)^{\alpha}}\mathrm{d}z_f \\
&+ \left(\frac{w}{p}\right)^{\alpha}\left(\frac{\Lambda}{L}-1\right)\frac{1}{v(z_h)^{\alpha}}\mathrm{d}z_h \\
&+ \left(\frac{w}{p}\right)^{\alpha}\frac{1}{L}\left[\int_0^{z_h}\frac{1}{v(z)^{\alpha}}\mathrm{d}z\right]\mathrm{d}\Lambda. \qquad (25)
\end{aligned}
$$

This expression summarizes the channels by which trade reforms may affect unemployment and it is the equivalent to the reduced form expression in (4). The first line in the right hand side is an overall efficiency effect and it encompasses a terms of trade effect: more trade raises the (real) wage w/p (unless it results in a worsening of the the terms of trade). This makes opening vacancies more profitable, which in turn decreases unemployment in equilibrium. The second, third, and fourth lines are composition effects. The second and third lines capture workers seeking jobs out of sectors facing new competition from Foreign exports (in the case $\mathrm{d}z_f < 0$) and into Home sectors that are new to exports (in the case $\mathrm{d}z_h > 0$).[11] The fourth line is an intensive margin: it captures changes in the unemployment rate that arise as the result of extra workers seeking jobs in the exporting sectors.

Since labor supply is inelastic by assumption, it follows from (19) that

$$-L\mathrm{d}z_f = (\Lambda - L)\mathrm{d}z_h + z_h\mathrm{d}\Lambda,$$

that is, people who face import competition and loose their job as a result (the left hand side above) seek jobs in sectors that start exporting (the first term in the right hand side above) as well as in the already exporting sectors (the second term in the right hand side). Plugging

[11] Note that the sign of $\mathrm{d}z_h$ is the opposite of the sign of $\mathrm{d}z_f$ by (7).

this expression into (25) yields the equivalent of equation (4) in our Ricardian model:

$$\begin{aligned} -\mathrm{d}u &= \alpha\left(\frac{w}{p}\right)^{-1}\mathrm{d}\left(\frac{w}{p}\right) \\ &+ \left(\frac{w}{p}\right)^{\alpha}\left(\frac{\Lambda}{L}-1\right)\left[\frac{1}{v(z_h)^{\alpha}}-\frac{1}{v(z_f)^{\alpha}}\right]\mathrm{d}z_h \\ &+ \left(\frac{w}{p}\right)^{\alpha}\frac{1}{L}\left\{\int_0^{z_h}\left[\frac{1}{v(z)^{\alpha}}-\frac{1}{v(z_f)^{\alpha}}\right]\mathrm{d}z\right\}\mathrm{d}\Lambda. \end{aligned} \tag{26}$$

The first line of (26) is as in (25): it captures the overall efficiency effect. In order to convey the main intuition for the second and third lines, consider the effect of an expansion of trade on both the extensive margin (in which case $\mathrm{d}z_h > 0$) and the intensive margin (in which case $\mathrm{d}\Lambda > 0$). Then an increase in trade openness is associated with a fall in unemployment if trade frictions in the marginal import competing sectors are larger than those of the marginal exporting sector (i.e. if the term in the square bracket of the second line is positive) and if trade frictions in the marginal import competing sector are larger than those of the average inframarginal exporting sector (i.e. if the term in the square bracket of third line is positive). This is the main theoretical prediction of the model that we take to the data.

An interesting corollary of this model is that after trade liberalization workers do not necessarily move towards the sectors with the strongest comparative advantage, but rather towards sectors that were previously non-traded and that become exportable after the trade liberalization. So the reallocation of resources goes from sectors just below the initial z_f to sectors above the initial z_h.[12]

[12] This is consistent with the empirical evidence regarding the reallocation of workers after Brazil's trade liberalization provided by Menezes-Filho and Muendler (2011). If we reasonably assume that z sectors that are closely ranked in terms of $a(z)/a^0(z)$ tend to be within the same industry, our model also also matches the evidence in Wacziarg and Wallack (2004) who suggests that the larger reallocation of workers after trade liberalization occurs within industries rather than across industries.

3 Empirical strategy

To test the theoretical prediction of equations (26) and (4) we put forward the following empirical model:

$$\begin{aligned} \ln(u_{ct}) &= \beta_c + \beta_t + \beta_1 \rho_{ct} + \beta_2 \tau_{ct} + \beta_3 (\tau_{ct} \times \rho_{ct}) \\ &+ \beta_4 \ln(H_{ct}) + \beta_5 \ln(w_{ct}) + \mu_{ct}, \end{aligned} \tag{27}$$

where u_{ct} is aggregate unemployment in country c at time 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 μ_{ct} is an i.i.d error term. β_c and β_t are country time-specific fixed effects. The former controls for any time-invariant determinant of unemployment, such as differences in institutional setups at the aggregate level, and the latter for year-specific aggregate shocks that may affect unemployment in all countries, such as global technological shocks. The other βs are the estimated coefficients for the right-hand-side variables discussed above. 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 value of β_2, β_3 and ρ_{ct}.

From (26), 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). On the other hand the model does not provide clear predictions for β_2 or β_4, which are the coefficients of τ and H respectively.[13]

[13] We need τ 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 discuss estimates without using H as a control.

3.1 Measures of 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. 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 (2005) to measure product sophistication at the sector level. The idea is very simple. Countries with high rates of unemployment tend to be specialized in sectors with strong labor market frictions. Thus, we can proxy the degree of labor market frictions in each sector by exploring the extent of unemployment as a function of the sector specialization. In other words, labor market frictions in sector s (i.e., the discrete version of z) is captured by the weighted average of unemployment rates, where the weights are given by a measure of the comparative advantage of each country in sector s. We use Proudman and Redding's (2000) comparative advantage indicator. This is well suited for our purpose for two reasons. First, it allows for comparisons across countries within a sector, which is important for our measure of labor market friction at the sector level to make sense. Second, it allows for comparisons across sectors, which is important if we want to compare our measure of labor market friction across sectors.[14]

$$RCA_{cs}^{x} = \frac{x_{cs}/\sum_s x_{cs}}{\frac{1}{C}\sum_c (x_{cs}/\sum_s x_{cs})}$$

where x_{cs} are country c exports of sector s.[15] Note that by construction the means across sectors of RCA_{cs} is equal to 1 in all sectors, and therefore the sum of RCA_{cs}^{x} is equal to C.

The measure of sector level labor market frictions is then given by the following sector-specific weighted average of countrywide unemployment rates:

$$v_s = \sum_c \theta_{cs} u_c, \quad \text{where} \;\; \theta_{cs} = \frac{1}{C} RCA_{cs}^{x}, \tag{28}$$

[14] Indeed, as discussed in Proudman and Redding (2000), Balassa's original measure makes comparisons across sectors and countries impossible. Depending on the distribution of trade flows, Balassa's measure has different means in different countries or sectors.

[15] Ideally one would have 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.

where C is the total number of countries, u_c is a measure of aggregate unemployment.

We construct v_s using data at the beginning of the sample (1995-1997) to mitigate potential endogeneity concerns when estimating (27), so that v_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 v_s. The assumption here is that sector level labor market frictions are highly correlated across countries (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 v_s per se, but rather its correlation with a measure of comparative advantage). In the robustness section we use measures of v_s that vary between developed and developing countries, and also the rank of v_s rather than its value.

The weights, θ_{cs}, in (28) are constructed using export data at the six-digit of the Harmonized System (HS), allowing us to construct v_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. If one were to use more aggregated data, we would fail to capture the impact that this within broad sector reallocation of labor 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 narrowly defined sectors. A variance decomposition of v_s calculated at the six-digit level of the HS suggests that most of the variance occurs across six-digit HS goods and within four-digit HS sector.[16]

Figure 1 displays the distribution of v_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 v_s (calculated at the

[16]Less than half of the total variance of v_s is explained by four-digit HS dummies, and only 14 percent of the total variance in v_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 its 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 (2011) view that the growth of primary sectors tends not 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. 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 our estimates of sector level labor market frictions, we correlate v_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 shows the unconditional correlation between union membership expressed as a share of total employment and our measure v_s (top panel), and between union coverage as share of total employment and v_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 frictions and measures of union membership and coverage at the sector level in the United States.[19]

3.2 Measure of revealed comparative advantage

For our purposes, it is important to use a measure of comparative advantage that takes into account trade-induced potential adjustments on both the export and import sides. We

[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. As discussed in footnote 8 an increase in the bargaining weight of labor unions will have a similar impact on unemployment than an increase in hiring costs.

introduce the following measure of revealed comparative advantage:

$$r_{cst} = \frac{\widetilde{RCA}^{x}_{cst}}{1+\widetilde{RCA}^{x}_{cst}} - \frac{\widetilde{RCA}^{m}_{cst}}{1+\widetilde{RCA}^{m}_{cst}} \tag{29}$$

where

$$\widetilde{RCA}^{x}_{cst} = \frac{x_{cst}/\sum_c x_{cst}}{\frac{1}{S}\sum_s \left(x_{cst}/\sum_c x_{cst}\right)} \quad \text{and} \quad \widetilde{RCA}^{m}_{cst} = \frac{m_{cst}/\sum_c m_{cst}}{\frac{1}{S}\sum_s \left(m_{cst}/\sum_c m_{cst}\right)}$$

where m_{cst} are sector s imports of country c at time t, and S is the total number of sectors. Note that $\widetilde{RCA}$ is different from RCA. RCA makes possible the comparison of revealed comparative advantage indices across countries within a sector, given that the denominator is the average share across countries for each sector. This was the type of comparison we needed when building the measure of labor market frictions at the sector level. $\widetilde{RCA}$ makes possible the comparison of revealed comparative advantage across sectors within a country, which is what we need when trying to measure the correlation between labor market frictions and comparative advantage within a country (and year). Finally, in sectors with a comparative advantage, r_{cst} takes a value between 0 and 1, and in sectors without a comparative advantage r_{cst} is between -1 and 0.[20]

The correlation between our measures of labor market frictions, v_s and comparative advantage r_{cst} is given by:

$$\rho_{ct} = \frac{\sum_s \left(r_{sct} - \bar{r}_{ct}\right)\left(v_s - \bar{v}\right)}{\left(\sum_s \left(r_{sct} - \bar{r}_{ct}\right)^2 \sum_s \left(v_s - \bar{v}\right)^2\right)^{\frac{1}{2}}} \tag{30}$$

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 highes ρ. The country with the highest ρ is Italy, suggesting that trade liberalization is likely to bring an increase in unemployment

[20]To obtain a symmetric measure of comparative advantage Vollrath (1991) proposes 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.

in Italy. The country with the lowest ρ is Iceland, which makes it the country where trade liberalization is the more 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 is *prima facie* evidence in line with the theoretical predictions of our model. [21]

There are several problems associated with the estimation of (27). 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 that would plausible satisfy the exclusion restriction. We therefore on a difference-in-difference (diff-in-diff) estimator using data for large trade liberalization episodes collected by Wacziarg and Welch (2008). To check for potential reverse causality we test for parallel trends in unemployment for countries in the treatment and control groups before trade liberalization. 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 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

[21] 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 (27) trade liberalization can always result in an increase or decrease in unemployment.

high correlation between labor market frictions and comparative advantage.

A second problem is the potential endogeneity of trade flows. We follow Freyer (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 effect 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, $\widehat{v_s}$, and their correlation across sectors, $\widehat{\rho_{ct}}$, which is used as an instrument for ρ_{ct}. Figure 3 shows the distribution of ρ_{ct} and $\widehat{\rho_{ct}}$.

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 argued earlier 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 will also provide estimates where r_{cst}, v_s and ρ_{ct} are constructed using export and import data at the two and four-digit of the HS.

A fourth concern is that we assume that labor market frictions are common across all countries. This may be overly restricting, and we will test the robustness of our results by estimating different labor market frictions for developed and developing countries.

A final concern may be that the value of v, r and therefore ρ are measured with error. Fortunately, our framework suggest that the qualitative results are driven by the ranking of sectors according to v and r rather than their value. We therefore test the robustness of results using the ranks of v, r instead of their value.

4 Empirical Results

We start discussing the main results associated with the estimation of (27) and then turn to the different robustness tests.

4.1 Baseline Results

The results of the estimation of (27) are reported in Table 3. The first column uses simple average tariffs as a 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, there is a statistically positive coefficient β_1 on the correlation between comparative advantage and labor market frictions (ρ). Second, β_3 which is the coefficient on the interaction between ρ and trade restrictiveness, τ, is negative and statistically significant. Thus, the impact of tariffs on unemployment is more likely to be negative (and therefore trade liberalization more likely to increase unemployment) the larger is the correlation between labor market frictions and comparative advantage.[22]

The marginal effect of average tariffs is illustrated in Figure 4, and the marginal effect of collected duties is illustrated in Figure 5 alongside the 90 percent confidence intervals. Both figures confirm that for sufficiently large values of ρ trade frictions have a negative impact on unemployment, whereas for sufficiently small values of ρ trade frictions have a positive impact on unemployment. The turning point occurs for values of ρ around -0.094 for average tariffs, and for values of ρ around -0.050 for collected duties. In the case of average tariffs, Figure 4 shows that the 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. Similarly, in the case of collected duties (Figure 5), 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

[22] 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.

from zero. As reported in Table 2 here are only eleven countries in the sample with a median value of ρ below -0.24 where trade liberalization leads to a reduction in unemployment.[23] There are twenty countries in the sample with a median value of ρ above 0.04 where trade liberalization results in an increase in unemployment.[24]

The other estimates reported in Table 3 also have the expected sign. 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 diff-in-diff framework. We also check for possible differences in the evolution of unemployment rates of countries in the treatment and control groups, before the 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 apply a meaningful diff-in-diff framework and test for differences in trends before treatment. We find 28 countries in our sample that open to trade after 1985 and are therefore part of our treatment group. Another 11 countries never open to trade in this sample that spans from 1980 to 2001, and are part of 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

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

[24] 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.

stops.[25]

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. The results are reported in Table 4. 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, the 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.

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 Freyer (2009) to predict trade flows that are determined by time-varying geography variables and recalculate $\hat{r}$, $\hat{v}$ 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 the results of Table 3. Countries with large ρs will experience an increase in unemployment as protection is reduced. The magnitude of the estimated β_3 (the coefficient of the interaction between ρ and τ) in Tables 3 and 5 are comparable. Interestingly, trade protection now has a statistically significant direct impact on unemployment, but the direct impact of ρ on unemployment is no longer statistically different from zero. The marginal

[25] The Harmonized System only started being used by a large number of countries in the 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.

impact of protection on unemployment as a function of ρ is plotted in Figures 6 and 7. 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 $\rho > 0$.

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 8 shows 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.

The fourth robustness test relaxes the assumption that labor market frictions are common across all countries and estimates them separately for OECD and non-OECD countries. The correlation between the two types of v_s is positive and significant, but the value is only 0.21, which suggests that the assumption of common sectoral labor market frictions is worth relaxing. Table 8 reports the results. The results are very similar to those reported in Table 3, except that the interaction coefficient between ρ and τ becomes statistically insignificant

[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.

when using average tariffs as a measure for τ (even though it is still negative and not statistically different from the one reported in Table 3).

The final robustness test uses the rank correlation between comparative advantage and labor market frictions to control for measurement error in the estimation of v, r and therefore ρ. The results are reported in Table 9 and they largely confirm the results of Table 3.

5 Concluding Remarks

We embedded a model of the labor market with sector-specific search frictions into a Ricardian model with a continuum of goods to show that the impact of trade liberalization on unemployment is ambiguous. 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 tested this prediction in a panel dataset of 97 countries during the period 1995-2009, and found 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) found that trade increased unemployment in the United States. Revenga (1997) found a similar result for Mexico, and Menezes-Filho and Muendler (2007) 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 of the estimated high correlation between labor market frictions and comparative advantage in these countries. Currie and Harrison (1997) and Hasan et al. (2012) found 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, Kpdoar (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 will 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 (2013).

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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 (27).

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) and (36) - (24) BELOW hold. To prove existence and uniqueness, first note that the system of equations (7) and (36) to (24) 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 Dornbush, Fisher and Samuelson (1977). Once this tuple is known, the unique solutions to u and u^0 follow from equations (23) and (24).

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 TFP 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 $v^0(z) = \gamma v(z)$, some $\gamma > 0$. The parameter γ captures country-wide differences in institutional features of the labor market.[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 TFP 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 TFP 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 (24) characterize the general equilibrium. This equilibrium exists and is unique.

Table 1

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

	Top fifteen sectors	
HS-2	Description	Median v[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

	Bottom fifteen sectors	
HS-2	Description	Median v
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 v 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 v	2.530***	3.416***
ρ	(0.84)	(0.85)
$\tau \times \rho$	-0.104**	-0.285***
	(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]These are OLS estimates. All regression have country and year fixed effects. Numbers in parenthesis are robust standard errors, which are clustered at the country level. $\star\star\star$ stands for statistical significance at the 1 percent level, $\star\star$ for statistical significance at the 5 percent level, and $\star$ for statistical significance at the 10 percent level.

[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 Correlation btw r and v	-0.557	-0.530
(ρ)	(0.661)	(0.691)
$WW \times \rho$	1.652**	1.639**
	(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]These are OLS estimates. All regression have country and year fixed effects. Numbers in parenthesis are robust standard errors, which are clustered at the country level. $\star\star\star$ stands for statistical significance at the 1 percent level, $\star\star$ for statistical significance at the 5 percent level, and $\star$ for statistical significance at the 10 percent level.

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 v	0.844	-0.470
ρ	(0.63)	(0.98)
$\tau \times \rho$	-0.123***	-0.161**
	(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]These are IV estimates. Both ρ and $\tau \times \rho$ are instrumented using 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. Numbers in parenthesis are robust standard errors, which are clustered at the country level. $\star\star\star$ stands for statistical significance at the 1 percent level, $\star\star$ for statistical significance at the 5 percent level, and $\star$ for statistical significance at the 10 percent level.

[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 v	2.162***	2.547***
ρ	(0.65)	(0.68)
$\tau \times \rho$	-0.083*	-0.230**
	(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]These are OLS estimates. All regression have country and year fixed effects. Numbers in parenthesis are robust standard errors, which are clustered at the country level. $\star\star\star$ stands for statistical significance at the 1 percent level, $\star\star$ for statistical significance at the 5 percent level, and $\star$ for statistical significance at the 10 percent level.

[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 v	1.115***	0.880**
ρ	(0.38)	(0.42)
$\tau \times \rho$	-0.054*	-0.091**
	(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]These are OLS estimates. All regression have country and year fixed effects. Numbers in parenthesis are robust standard errors, which are clustered at the country level. $\star\star\star$ stands for statistical significance at the 1 percent level, $\star\star$ for statistical significance at the 5 percent level, and $\star$ for statistical significance at the 10 percent level.

[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
Estimating v_s for developed and developing countries[a]

$\ln(u)$	Average Tariff	Collected duties
Employment size	-0.258**	-0.258**
$\ln(H)$	(0.11)	(0.12)
GDP per capita	-0.266**	-0.365***
$\ln(w)$	(0.10)	(0.09)
Trade restrictiveness	-0.006	-0.009
τ	(0.01)	(0.01)
Correlation btw r and v	2.587***	3.478**
ρ	(0.87)	(0.89)
$\tau \times \rho$	-0.084	-0.283***
	(0.06)	(0.09)
Observations	878	747
# clusters	97	94
Period	1995-2009	1995-2009
Marginal impact of zero for ρ equal to[b]	-0.076	-0.032

[a]These are OLS estimates. All regression have country and year fixed effects. Numbers in parenthesis are robust standard errors, which are clustered at the country level. $\star\star\star$ stands for statistical significance at the 1 percent level, $\star\star$ for statistical significance at the 5 percent level, and $\star$ for statistical significance at the 10 percent level.

[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 9
Using ranks of v and r rather than their value[a]

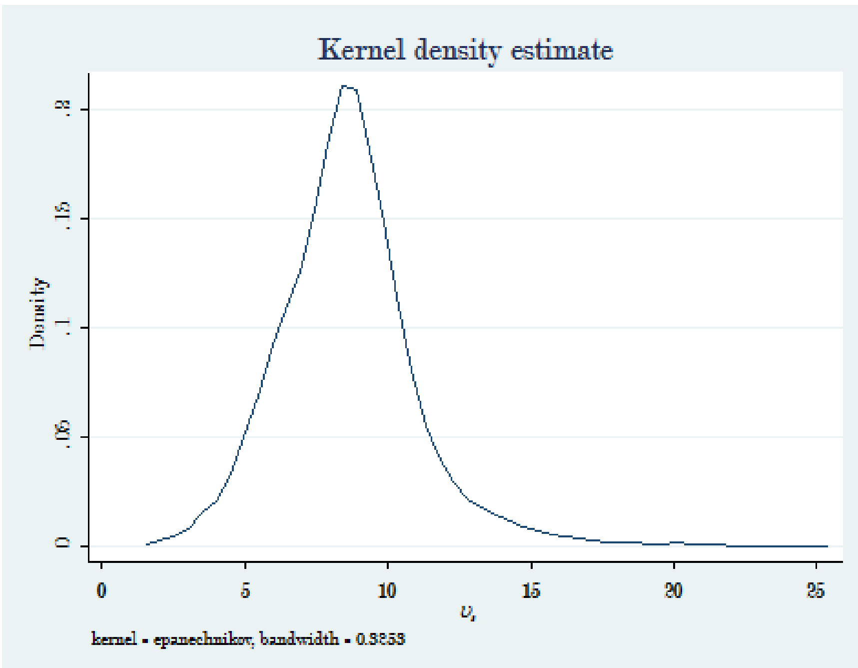
$\ln(u)$	Average Tariff	Collected duties
Employment size	-0.252**	-0.248**
$\ln(H)$	(0.10)	(0.12)
GDP per capita	-0.268**	-0.390***
$\ln(w)$	(0.10)	(0.09)
Trade restrictiveness	-0.014*	-0.024
τ	(0.01)	(0.02)
Correlation btw r and v	2.115***	2.597***
ρ	(0.74)	(0.82)
$\tau \times \rho$	-0.080*	-0.234***
	(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] These are OLS estimates. All regression have country and year fixed effects. Numbers in parenthesis are robust standard errors, which are clustered at the country level. $\star\star\star$ stands for statistical significance at the 1 percent level, $\star\star$ for statistical significance at the 5 percent level, and $\star$ for statistical significance at the 10 percent level.

[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.

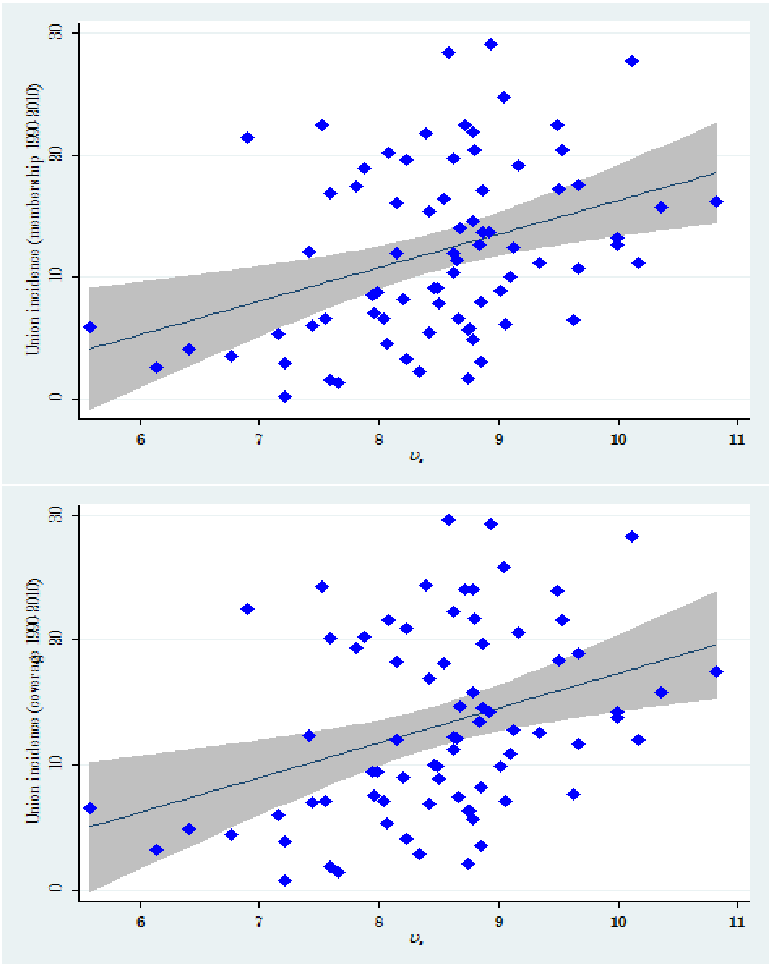
Figure 1

Distribution of sector level labor market frictions v_s



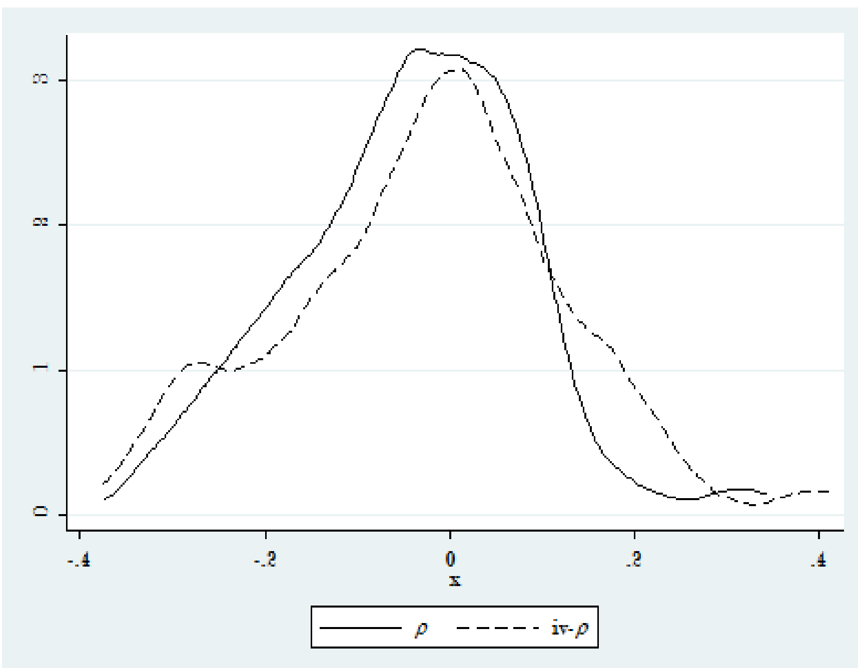
Note: Authors' computation using export data at the six-digit of the HS from CEPII's BACI and aggregate unemployment data from the ILO.

Figure 2
Correlation between v_s and indices of labor union incidence



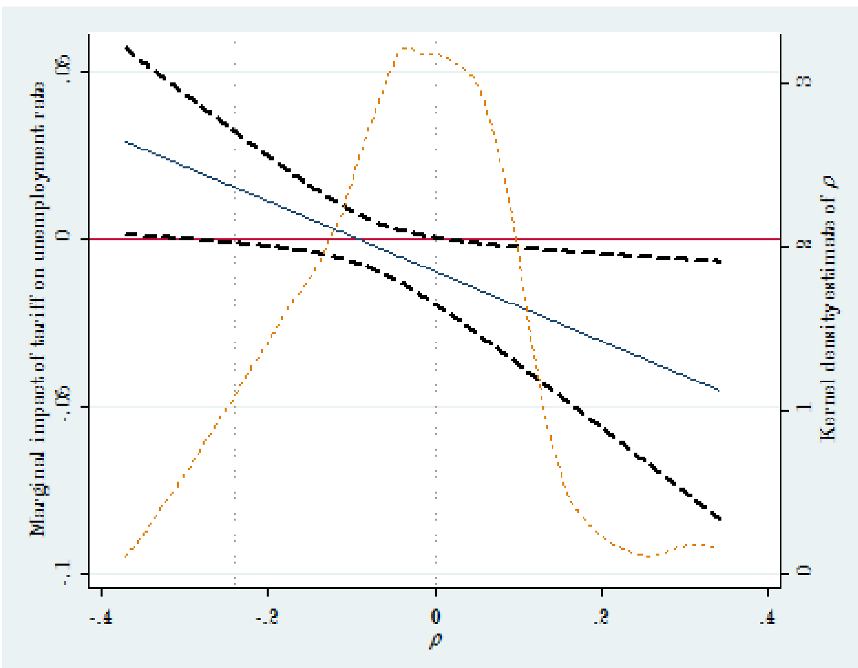
Note: Computed using the estimated v_s and the Union Membership and Coverage Database (www.unionstats.com). The top panel provides the correlation with union membership and the bottom panel the correlation with union coverage measured between 1990-2010.

Figure 3
Distribution of ρ and $\widehat{\rho}$ (iv-ρ)



Note: $\widehat{\rho}$ is constructed using the predicted trade flows from gravity setup, which are then used to construct $\widehat{r}$ and $\widehat{v}$ and their correlation $\widehat{\rho}$.

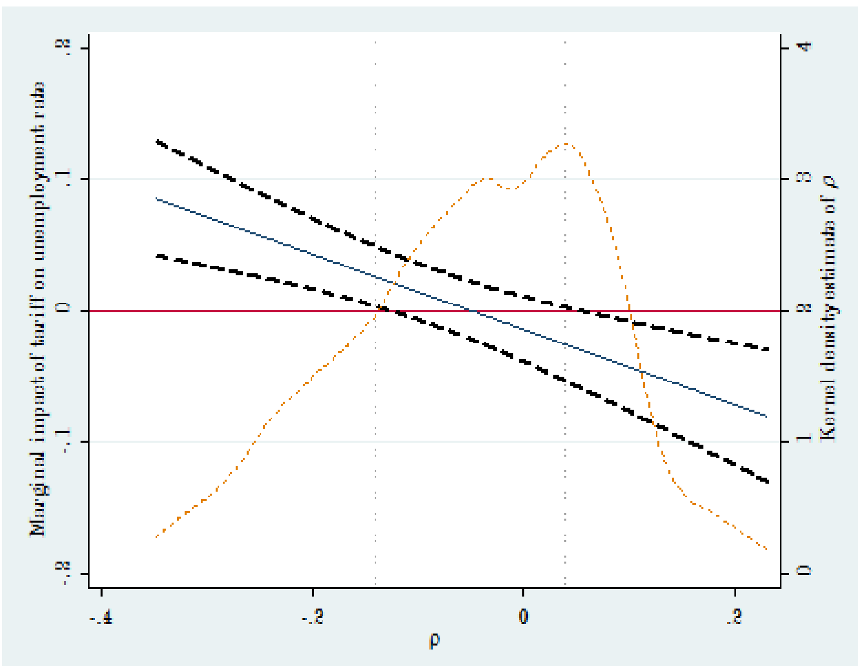
Figure 4
Marginal impact of average tariffs on unemployment as a function of ρ



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

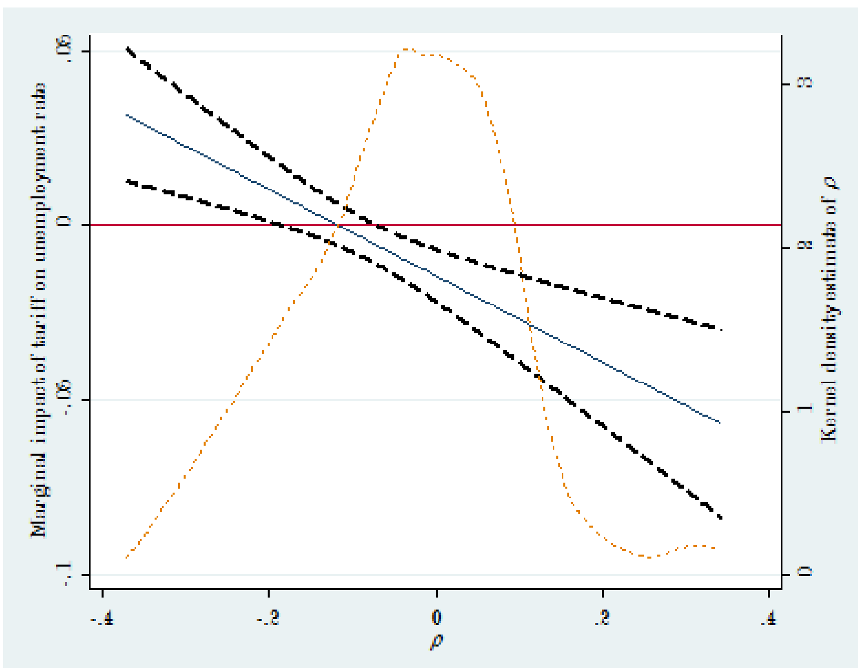
Figure 5

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



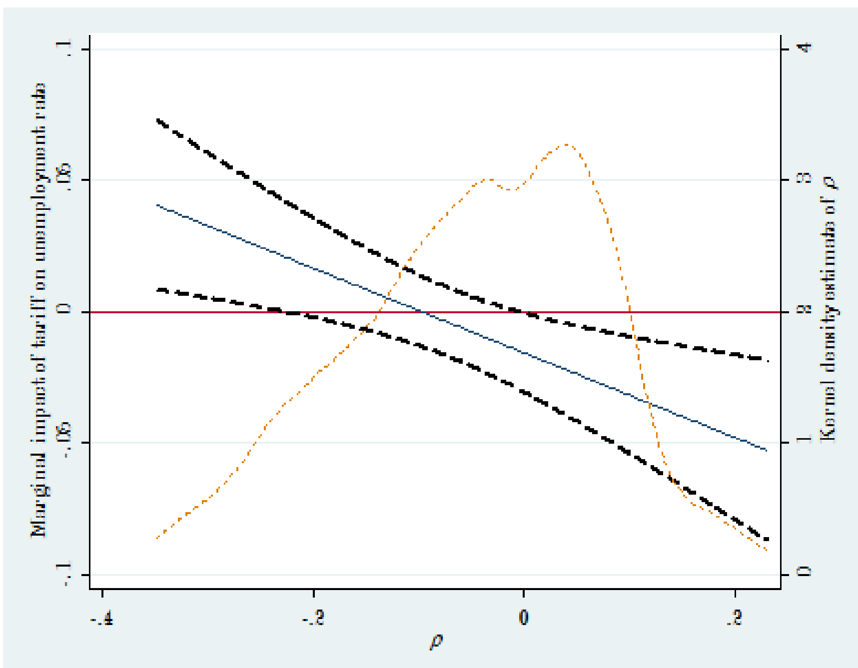
Note: The thick dashed lines provide the 90 percent confidence intervals. The thin dashed line is a kernel density estimate of ρ.

Figure 6
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 7
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 8
Distributions of ρ estimated at different levels of production aggregation