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Trade Policy and Factor Prices: An Empirical Strategy

Daniel Ortega and Francisco Rodríguez*

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Abstract

This paper presents a new empirical strategy for estimating the effects of trade policy on domestic factor prices when policy endogeneity is suspected. Absent income effects on factor supplies or domestic prices, the coefficient on the terms of trade can provide an unbiased estimator of the effect of trade barriers on the factor distribution of income for a small economy. In the more general case where income effects are allowed for, we provide a means to quantify and control for the possible bias. We implement our strategy on a cross-national data set of trade policies and income shares of capital and labor. We find little evidence of the existence of Stolper-Samuelson effects, both for the sample as a whole as well as within cones of diversification. Consistent with a model of wage bargaining, we find that the effect of openness on capital shares is greater for countries with higher unionization rates.

JEL Classification: F13, F16.

Keywords: Factor prices, trade policy, Stolper-Samuelson theorem, wage bargaining.

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1 Introduction

The possible existence of distributive effects of policies leading to greater economic integration is one of the topics of major interest today in academic and policy circles. In the past few years, a massive array of empirical and theoretical tools has been used to attempt to understand the effects of openness to international trade on the returns to different factors of production in both developing and developed countries. At the same time, a contentious policy debate has formed around the benefits and costs of greater liberalization in developing and developed economies, with the potential distributive impact of greater openness commonly appealed to by both sides.[1]

The issue of whether protection harms or helps different factors of production has been around for quite a while. It was precisely the discussion between Frank Taussig (1927), who believed that labor's greater mobility helped insulate it from potential losses from international trade, and Bertil Ohlin (1933), who held the view that labor's scarcity implied that it would benefit from protection, that inspired the seminal work of Stolper and Samuelson (1941)[2]. These debates were not purely academic, either. As Irwin (2000) has noted, the major political justification for the US high import tariffs during the late nineteenth and early twentieth century was the view that it protected high American wages against the low wages of its European competitors.

The estimation of the effects of trade policy on the domestic distribution of income poses the formidable empirical problem of disentangling the causal effects that openness can have on factor prices from the impact that these prices have on the politico-economic equilibrium that generates policies. Indeed, a considerable part of the literature concerned with the

[1] An interesting example of how differing views on the same issue can be used to support contrasting policy stances comes from the ongoing debate on the formation of the Free Trade Area of the Americas (FTAA). Global Exchange, an international NGO that is actively involved in the anti-globalization movement, lists the fact that "the agreement will increase poverty and inequality "among its "Top Ten Reasons to oppose the FTAA" (Global Exchange, 2003) In contrast, when discussing the prospects for the FTAA before a meeting of the Americas Business Forum in Miami, Secretary of Commerce Donald Evans stated the administration's position as follows: "President Bush believes that free trade offers hope, opportunity, and expanded freedom to people in the grip of poverty" (Department of State, 2003)

[2] See Samuelson, 1994.

relationship between trade policies and income distribution postulates that domestic income distribution affects policy determination (see Magee (1980), Rogowski (1987) and Beaulieu (2002) for some examples). The common approach of using instrumental variables to resolve this problem has several pitfalls, among which are the lack of an abundant supply of sources of exogenous variation, the possible independent effect that instruments may have on the variable of interest, and the small-sample bias of instrumental variables estimators[3].

This paper presents an alternative empirical strategy for estimating the effects of trade policies on domestic income distribution. Our strategy relies on the result that in a broad class of models of international trade, the elasticity of the return of a factor of production with respect to tariffs should be equal to its elasticity with respect to the prices of importables. Therefore, the coefficient on import prices in a regression with factor prices as a dependent variable enables us to estimate the effect of trade policies on domestic income distribution. If the economy in question is sufficiently small so as to rule out its impact on international prices, then we can obtain a consistent estimate of the coefficient of interest (the coefficient on the policy variable) by using the estimate on the exogenous variable (the price variable).

Figure 1 illustrates the basis of our strategy. In it we show the effect that changes in prices and tariffs have on the derivation of labor demand. Labor demand is derived in a competitive market by tracing out the desired use of labor by competitive firms at different wage rates. An increase in prices from P_1 to P_2 leads to a shift outwards of the value of the marginal product of labor and thus an increase in the desired level of employment at a given wage rate w^0 from $L_1^D(w^0)$ to $L_2^D(w^0)$. But this is exactly the same effect that will be generated by an increase of the tariff rate from t_1 to t_2, where $\frac{t_2}{t_1} = \frac{P_2}{P_1}$[4]. As the labor demand schedule that is generated by t_2 (given P_1) is the same as that which is generated by P_2 (given t_1) then so will be the equilibrium factor prices. Figure 1 suggests that if we are doubtful of our capacity to estimate the effect of t on domestic factor prices because of possible simultaneity problems, we think of estimating the effect of P.

Figure 1 also makes evident two potential pitfalls of this strategy. One comes from the possible endogeneity of P itself. If P is endogenous, then the effect of P on factor prices will

[3] See Rigobón and Rodrik (2004) for a discussion of these problems as well as a new approach based on identification through heteroskedasticity.

[4] For convenience, we define t as one plus the ad-valorem tariff rate on importables.

be no easier to estimate than that of t, leaving little value added to our approach. We will adress this problem by restricting the estimation to small countries, for which the assumption of exogenous terms of trade is quite appealing. A second pitfall comes form the possibility that P may cause subsequent shifts in t. If t moves in tandem with P, then it will be econometrically difficult to disentangle their effects. However, as long as we believe that exogeneity of P is a tenable assumption, it will be easy to verify whether this correlation exists in practice, and whether the necessary conditions for our estimation approach are validated.

Additional complications can arise if factor supplies are income-elastic or if some goods are non-traded. The reason is that tariffs and international prices do have non-symmetric effects on aggregate income, so that any type of income effects wil introduce a wedge between the price elasticity and the tariff elasticity of factor returns. However, as we show below, it is possible to quantify this bias and to ascertain the magnitude of the difference between the two coefficients, preserving the validity of our estimation strategy.

We illustrate our approach through empirical tests of competing theories of the relationship between trade and factor prices using data on factor shares of capital and labor in 109 economies for the period between 1960 and 1999 from the United Nations' *System of National Accounts*. Using data on multilateral trade flows, we are able to distinguish between countries that control a significant share of the market for their exports or imports and those that do not. For the latter group, our identification assumption enables us to use the coefficient on a country's terms of trade to estimate the effect of trade restrictions on domestic income distribution.

Our results do not support the predictions of neoclassical trade theory. We find that the coefficient on international prices in poor economies is statistically undistinguishable from that in rich economies, so that the data do not indicate the existence of a distinction between the effect of trade that varies with a country's capital abundance, as implied by the Stolper-Samuelson theorem. These results hold both in the complete data set as well as in Gollin's (2002) income shares corrected for self-employment, which are available for 25 of the economies in our sample. On the other hand, our data offers suggestive evidence in favor of the existence of an interaction between economic integration and the wage bargaining process: we find that countries are more likely to see capital shares increase with openness when their labor force is highly unionized, a result that is consistent with the predictions of a wage-bargaining model of relative factor returns.

The rest of the paper proceeds as follows. Section 2 presents our key theoretical results, establishing the conditions under which the elasticities of factor returns with respect to the terms of trade are identical to those with respect to the terms of trade, and quantifying the potential bias when those conditions do not hold. Section 3 develops our empirical strategy and presents our empirical results. Section 5 concludes.

2 Trade and factor prices: theoretical links

The relationship between trade and factor prices in trade-theoretic models forms an extensive body of literature that is aptly surveyed, among others, by Dixit and Norman (1980), Jones and Neary(1984), Ethier (1984) and Feenstra (2004). We appeal to some well-known results of this literature to establish the conditions under which our identification assumption - that the price and tariff elasticities of factor returns are equal - holds. As we will show, these two elasticities will be equal whenever all goods are traded and factor supplies do not depend on income levels. When we allow for non-traded goods and income-responsive factor supplies, the equality will break down; however, we will derive conditions which will help us to quantify and control for the difference between these two coefficients.

Let there be M factors of production and I goods. Let $\mathbf{w} = \{w_1...w_M\}'$ denote the vector of factor returns for each of the M factors of production. Likewise, let the use of each of the M factors by industry i be captured by the vector $\mathbf{B}_i = \{B_{1i}...B_{Mi}\}'$. Production is given by the vector of production functions $\mathbf{q} = \{F_1(\mathbf{B}_1)...F_I(\mathbf{B}_I)\}'$, and price levels in the vector $\mathbf{p} = \{p_1...p_I\}'$. Factor supplies are given by $\mathbf{B}^s = \{B_1^s, ...B_M^s\}'$. Firms are price-takers and profit-maximizers, and perfect competition implies free entry and zero profits. The unit cost function for industry i will be $c_i(w) = \min_{B_i \geq 0} \mathbf{w}'\mathbf{B}_i$ subject to $F_i(B_i) = 1$. Let $\mathbf{c} = \{c_1(\mathbf{w})...c_I(\mathbf{w})\}'$. $\mathbf{p}^* = \{p_1^*...p_I^*\}'$ is the vector of international prices and $\mathbf{T} = diag\{\mathbf{t}\}$ is an $I \times I$ diagonal matrix with one plus the ad-valorem tariff rate for good i, t_i on the i-th term of the diagonal. Thus the $I \times 1$ vector $\mathbf{Tp}^*$ will give us the tariff-inclusive price of imported goods. If good i is exported in equilibrium, then $t_i > 0$ should be taken to indicate an export subsidy. Equilibrium will be given by the $\mathbf{w}$ and $\mathbf{q}$ vectors that satisfy the I zero-profit conditions and the M factor market equilibrium conditions:

$$\mathbf{p} = \mathbf{c}(\mathbf{w}) \tag{1}$$

$$\mathbf{A}(\mathbf{w})\mathbf{q} = \mathbf{B}^s, \tag{2}$$

where A is the $M \times I$ matrix with component $a_{ij}(\mathbf{w}) = \frac{\partial c_j}{\partial w_i}$ in the i-th row and j-th column. (1) and (2) provide a system of $M + I$ equations in the $M + I$ variables $\mathbf{w}$ and $\mathbf{q}$.[5]

2.1 No income effects

We start out by considering the case in which all goods are tradable and factor supplies are given. In this case $\mathbf{B}^s = \{\overline{B}_1, ...\overline{B}_M\}'$, a vector of fixed factor supplies, and $\mathbf{p} = \mathbf{T}\mathbf{p}$.

Let us first look at the case of "even" technologies, where $I = M$ so that there are as many goods as factors. Equation (1) now defines a system of I equations in $M = I$ variables. The implicit function theorem implies that, if $c_1(\mathbf{w})...c_I(\mathbf{w})$ are C^k-functions in R^I and $det|\mathbf{A}'| \neq 0$ at a solution $\{\mathbf{p}^0, \mathbf{w}^0\}$ then (1) defines $\mathbf{w}$ as a C^k-function of $\mathbf{p}$ and:

$$\frac{\partial \mathbf{w}}{\partial \mathbf{p}} = \left(A'\right)^{-1}.$$

Let ε_{xy} denote the elasticity of x with respect to y. Then the chain rule implies that $\varepsilon_{w_j y} = \varepsilon_{w_j p_i}\varepsilon_{p_i y}$ for $y = \{p_i^*, t_i\}$. As $p_i = t_i p_i^*$, then $\varepsilon_{p_i p_i^*} = \varepsilon_{p_i t_i} = 1$, allowing us to establish our result[6]:

$$\varepsilon_{w_j p_i^*} = \varepsilon_{w_j t_i}, \tag{3}$$

that is, the elasticity of wages with respect to trade restrictions will be the same as its elasticity with respect to international prices. In the case of two factors of production (call

[5] Economies of scale can be accommodated by writing the unit cost function as $\mathbf{c}(\mathbf{w}, \mathbf{q})$. The reasoning presented for the $I \neq M$ case would hold, although the sense of an equation such as (1) might be thrown into question. Section 2.3 presents a special case in which (1) need not hold.

[6] Note that we have simply assumed $\det|\mathbf{A}'| \neq 0$ instead of the more restrictive Nikaido (1972) conditions. The reason is that for our result to hold we do not require uniqueness of w; even if there is more than one wage vector consistent with a given price vector, equation (3) will be true for small changes in the price level at a particular equilibrium.

them k and l), we can derive the expression:

$$\frac{dw_k}{w_k} - \frac{dw_l}{w_l} = \frac{1}{\alpha_1 - \alpha_2} \frac{d(p_1^* t_1)}{p_1^* t_1}, \tag{4}$$

which restates the familiar Stolper-Samuelson result.[7] Note that (4) implies an exact linear functional form for estimation in the Cobb-Douglas case. To see this, define capital's share of national income as:

$$\alpha = \frac{w_k B_k}{w_l B_l + r_k B_k}. \tag{5}$$

Integrate out (4) and substitute in (5) to get:

$$h(\alpha) = \ln \frac{\alpha}{1-\alpha} \equiv c_0 + \frac{1}{\alpha_1 - \alpha_2} \ln p_1^* t + \ln(\frac{B_k}{B_l}). \tag{6}$$

Since in the Cobb-Douglas case $\frac{1}{\alpha_1 - \alpha_2}$ is fixed,(6) can be estimated by linear methods, takng into account that the sign of the coefficient changes according to whether the country imports or exports good 1.

As is well known, technologies in which the number of goods differs from the number of factors have non-trivial implications for many results in international trade. Nevertheless, equation (3) will continue to characterize the relationship between wages, trade restrictions and international prices when $N \neq I$ at any equilibrium in which $\varepsilon_{w_j t_i}$ and $\varepsilon_{w_j p_i^*}$ are well-defined. The reason is simple: when the technology is odd, (1) and (2) still provide a system of $M + I$ equations that can be solved for $\mathbf{w}$ and $\mathbf{q}$. As p_i^* and t_i only enter multiplicatively in this system, then if there is a solution to $\mathbf{w}$, it can be expressed as $w = w(\mathbf{B}^s, \mathbf{p})$. As $\varepsilon_{p_i p_i^*} = \varepsilon_{p_i t_i} = 1$, if it is possible to calculate $\varepsilon_{w_j p_i}$, then the chain rule can be applied to establish that $\varepsilon_{w_j p_i^*} = \varepsilon_{w_j t_i}$.

This reasoning applies equally to the case of complete specialization. When the economy is outside of the FPE set, some goods will not be produced. The zero-profit conditions for those goods now need not hold[8], and $\mathbf{w}$ and $\mathbf{q}$ must now solve a system of $M + I - I_0$ equations, where I_0 is the set of goods that is not produced in equilibrium. There will now be $M + I - I_0$ unknowns: $I - I_0$ production levels and M prices. If there is a solution for $\mathbf{w}$, it can again be expressed as $\mathbf{w}(\mathbf{B}^s, \mathbf{p})$, with $\varepsilon_{w_j t_i} = \varepsilon_{w_j p_i^*}$.

[7] Since both sectors face the same factor prices, $\alpha_1 > \alpha_2$ if and only if the more familiar factor intensity condition $\frac{K_1}{L_1} > \frac{K_2}{L_2}$ holds.

[8] They are replaced by inequalities of the form $p_i \leq c_i(w)$.

It may well be the case, however, that it is not possible to find a solution to the system defined by (1) and (2). This will generally be the case when $I > M$, as then (1) provides a system of I equations in M variables, which have no solution except for very special price vectors. Obviously, our result cannot be derived in such a case, not because $\varepsilon_{w_j t_i}$ and $\varepsilon_{w_j p_i^*}$ are different, but because they do not exist. However, some authors have argued that in this case of inexistence of equilibrium, international prices will adjust to levels consistent with positive production of all goods (see Dixit and Norman, 1980). In such a case, $I - M$ zero profit conditions become redundant and the remaining M conditions can be solved as before. Even though production levels will be indeterminate, factor prices will not, and the equality between $\varepsilon_{w_j t_i}$ and $\varepsilon_{w_j p_i^*}$ will be maintained.

We summarize our results in the following Proposition

Proposition 1 *Let all goods be traded and factor supplies be given. Then if there is a solution for w in the system of equations given by (1) and (2) and at that equilibrium $\varepsilon_{w_j p_i}$ exists, then $\varepsilon_{w_j p_i^*} = \varepsilon_{w_j t_i}$.*

2.2 Income effects

The equivalence between $\varepsilon_{w_j t_i}$ and $\varepsilon_{w_j p_i^*}$ can be broken if income levels are allowed to affect domestic wages. The reason is that international prices and tariff rates affect income differently: an increase in the terms of trade can shift a country's consumption possibilities set outwards, but an increase in tariffs cannot. In other words, the one equation in which international prices and tariffs do not enter multiplicatively is that pertaining to the determination of aggregate GDP:

$$Y = \mathbf{w}'\mathbf{B}\imath + \imath'\mathbf{\Pi}\mathbf{M}$$

where $\mathbf{B}$ is an $N \times I$ matrix whose columns are the factor use vectors $\mathbf{B}_i$, $\imath$ is an $I \times 1$ vector of ones, $\mathbf{\Pi}$ is a diagonal matrix with $p_i(t_i - 1)$ in each of the i diagonal terms, and $\mathbf{M} = \mathbf{D}(Y, \mathbf{p}) - \mathbf{q}$ a vector of import levels, where $\mathbf{D}(Y, \mathbf{p})$ denotes aggregate economy demand for good i.

Let us first think about the income effects that operate through factor supplies. Let $\mathbf{B}^s = \mathbf{B}^s(\mathbf{w}, \mathbf{p}, Y)$. Note first that whenever (1) can be solved for $\mathbf{w}$ then $\mathbf{B}^s$ has no effect whatsoever on factor prices, and whether it depends on Y or not is irrelevant. Therefore, if $I = M$ and the conditions necessary for the implicit function theorem to be applied hold, then $\varepsilon_{w_j t_i} = \varepsilon_{w_j p_i^*}$.

This will also be true when $I > M$ if it is the case that international prices are such that there is positive production of all goods in the home country, as then the number of linearly independent zero-profit conditions reduces to M. It cannot, however, be applied when $I < M$. In such a case, equilibrium $\mathbf{w}$, $\mathbf{q}$ and Y must solve:

$$\mathbf{T}\mathbf{p}^* = \mathbf{c}(\mathbf{w}) \tag{7}$$

$$\mathbf{A}(\mathbf{w})\mathbf{q} = \mathbf{B}^s(\mathbf{w}, \mathbf{T}\mathbf{p}^*, \mathbf{Y}) \tag{8}$$

$$Y = \mathbf{w}'\mathbf{B}\imath + \imath'\mathbf{\Pi}\mathbf{M}. \tag{9}$$

Note that if there exists a solution to this system, there also must be a solution to the subsystem formed by the first $I + M$ equations for $\mathbf{w}$ and $\mathbf{q}$ as a function of $\mathbf{T}\mathbf{p}^*$ and Y. Therefore, it must be the case that

$$\varepsilon_{w_j p_i^*} - \varepsilon_{w_j t_i} = \varepsilon_{w_j Y}\left(\varepsilon_{Y p_i^*} - \varepsilon_{Y t_i}\right). \tag{10}$$

Letting $FI(\mathbf{T}\mathbf{p}^*, Y) = \mathbf{w}(\mathbf{T}\mathbf{p}^*, Y)'\mathbf{B}\imath$ denote domestic factor income gives us an implicit solution for the equilibrium Y as a function of p_i^* and t_i (provided of course that the conditions of the implicit function theorem are satisfied):

$$Y = FI(\mathbf{T}\mathbf{p}^*, Y) + \sum_i p_i^*(t_i - 1)M_i(\mathbf{T}\mathbf{p}^*, Y). \tag{11}$$

Taking derivatives with respect to p_i^* and t_i, subtracting, reorganizing and substituting in (10) gives us:

$$\varepsilon_{w_j p_i^*} = \varepsilon_{w_j t_i} - \varepsilon_{w_j Y}\frac{1}{1 - FI_Y - \sum_j P_j^*(t_j - 1)M_Y^j} m_i. \tag{12}$$

where $m_i = P_i^* M_i / Y$ is the ratio of industry i imports to GDP at world prices. (12) will be extremely important in our estimation strategy, as it allows us to quantify the potential bias that can arise from using $\varepsilon_{w_k p_i^*}$ as an estimator of $\varepsilon_{w_k t_i} - \varepsilon_{w_l t_i}$.

We turn now to the case of income effects that operate through the demand for non-tradables. When some goods are not traded internationally, their prices become endogenous, and must be determined by clearing of the domestic market. (7) now becomes:

$$\begin{aligned} p_i &= c_i(\mathbf{w}) \text{ for } i \in NT \\ p_i^* t_i &= c_i(\mathbf{w}) \text{ for } i \in T, \end{aligned} \tag{13}$$

with (8) and (9) as above, but with a new set of NT additional market clearing conditions:

$$D_i(\mathbf{p}, Y) = Q_i \text{ for } i \in NT. \tag{14}$$

(8),(9), (13) and (14) now form a system of $M+I+NT+1$ equations that can be solved for the M factor returns, I production levels, NT domestic prices and income Y. As before, the first $M+I+NT$ equations can be solved for $\mathbf{w} = \mathbf{w}(\mathbf{Tp}^*, Y), \mathbf{q} = \mathbf{q}(\mathbf{Tp}^*, Y)$ and $\mathbf{p} = \mathbf{p}(\mathbf{Tp}^*, Y)$. The above reasoning can now be applied to derive (12). The results are summarized in

Proposition 2 *Assume that some goods are non-traded, with their domestic demand given by* $\mathbf{D}(Y, \mathbf{p})$*, and that factor supplies depend on income according to the factor supply function* $\mathbf{B}^s(\mathbf{w}, \mathbf{Tp}^*, \mathbf{Y})$*. Then if there is a solution for* w *in the system of equations given by (8),(9), (13) and (14) and at that equilibrium* $\varepsilon_{w_j p_i}$ *and* $\varepsilon_{w_j Y}$ *exist, then* $\varepsilon_{w_j p_i^*} = \varepsilon_{w_j t_i} - \varepsilon_{w_j Y} \frac{1}{1 - FI_Y - \sum_j P_j^*(t_j - 1) M_Y^j} m_i$.

2.3 Wage bargaining

Although the model presented above is quite general, it may not encompass some cases that can be highly relevant for the study of the relationship between factor prices and international trade. Recent contributions to the literature have emphasized the importance of the process of intra-firm bargaining for relative price determination (see, for example, Rodrik (1997), Panagariya (1999), Mezetti and Dinopoulos (1991), Reddy and Dube (2000) and Skillman (2000)). The latter three papers, for example, derive the effect of trade on the solution to a bargaining problem when an import-competing industry receives rents. However, the solution to a Nash bargaining problem over factor returns and output levels will generally not satisfy the assumption of cost minimization, as firm objectives will put a positive weight on factor returns, and thus cannot be embodied in the models presented in sections 2.1 and 2.2.

A general characterization of wage determination under non-cost minimization objectives is outside the scope of this paper. In this discussion, we concentrate on wage-setting processes that can be described as the result of:

$$\underset{\mathbf{B}_i,\mathbf{w}_i}{Max}\ G(\pi_i, \mathbf{w}_i, \mathbf{B}_i) \tag{15}$$

subject to

$$\mathbf{B}_i \geq 0 \tag{16}$$

$$\mathbf{w}_i \geq \overline{w} \tag{17}$$

$$p_i(Q_i, Y) \leq p_i^* t_i \tag{18}$$

where $\mathbf{w}_i = \{w_{i1}, ...w_{iM}\}$ is an industry-specific wage vector and $\overline{w}$ is a vector of reservation wages. This schematic description subsumes a number of bargaining solution such as the Generalized Nash Bargaining Solution, the Kalai-Smorodinski Solution and the Utilitarian Solution, as long as firm and union preferences can be described as functions of $\pi_i, \mathbf{w}_i$ and $\mathbf{B}_i$. The basic assumption is that the wage-setting process is now internal to the industry and that different industries can have different wage levels. We model the firm as having market power, as it makes little sense to think about bargaining over the distribution of rents when there is perfect competition. Neither the zero-profit condition nor the labor-market clearing conditions are relevant any longer: it is assumed that profits are greater than zero and that the wage levels set through bargaining are high enough so as to generate equilibrium unemployment. In this case, industry wage and employment levels are simply those that solve (15) subject to (16)-(18). Let us first look at the solutions where (18) is binding. In these cases the solution for factor returns takes the form $\mathbf{w}_i = \mathbf{w}_i(\overline{w}, p_i^* t_i)$, so that:

$$\varepsilon_{w_{ij}t_i} = \varepsilon_{w_{ij}p_i^*}.$$

Note that factor returns for industry i in this case depend only on international prices and tariffs for industry i, and thus $\varepsilon_{w_{ij}t_k} = \varepsilon_{w_{ij}p_k^*} = 0$ when $k \neq i$. If, on the other hand, (18) is not binding in equilibrium, then $p_i^* t_i$ does not enter into the arguments for determination of wages or factor use of any industry, so that

$$\varepsilon_{w_{ij}t_i} = \varepsilon_{w_{ij}p_i^*} = 0.$$

However, there may still be income effects arising from the impact that tariffs on other industries can have on income levels Y and thus on demand for industry i's good, so that:

$$\varepsilon_{w_{ij}p_k^*} = \varepsilon_{w_{ij}t_k} - \varepsilon_{w_{ij}Y} \frac{1}{1 - FI_Y - \sum_l P_l^*(t_l - 1)M_Y^l} m_k \text{ for } k \neq i. \tag{19}$$

The results related to the general wage bargaining problem are summarized in

Proposition 3 *Let wage-setting in industry i be defined by the solution to (15)-(18). At any solution to this problem:*

(i) if $\varepsilon_{w_{ij}p_k}$ exists and(18) is binding then $\varepsilon_{w_{ij}t_k} = \varepsilon_{w_{ij}p_k^*}$ for all i, j. Furthermore,$\varepsilon_{w_{ij}t_k} = \varepsilon_{w_{ij}p_k^*} = 0$ when $k \neq i$.

(ii) If $\varepsilon_{w_{ij}p_k}$ and $\varepsilon_{w_{ij}Y}$ exist and (18) is not binding, then $\varepsilon_{w_{ij}t_k} = \varepsilon_{w_{ij}p_k^*} = 0$ when $k = i$. Furthermore, $\varepsilon_{w_{ij}p_k^*} = \varepsilon_{w_{ij}t_k} - \varepsilon_{w_{ij}Y} \frac{1}{1-FI_Y-\sum_l P_l^*(t_l-1)M_Y^l} m_k$ when $k \neq i$.

2.3.1 A simple example

The above model of wage bargaining is too general to allow us to draw testable empirical implications. In order to get an idea of the basic mechanisms at work in the wage bargaining framework, we specialize to a simple two factor model ($j = \{l, k\}$) in which the production technology is Leontieff and income effects on factor supply are absent. Firm profits are:

$$\pi_i = (p_i(q_i) - w_{li} - \overline{w_r})B_{li},$$

where $\overline{w}_r$ is the market interest rate. We assume that $p_i^* t_i - \overline{w}_r > \overline{w}_l$, so that there effectively exist rents over which to bargain. Bargaining takes place between the firm and a domestic union which seeks to maximize:

$$U_i = (w_{li} - \overline{w}_l)^\delta B_{li}.$$

The equilibrium will be given by the solution of the Generalized Nash Bargaining problem:

$$\underset{l_i, w_i}{Max} a \ln\left[\left(p_i(B_{li}) - w_{li} - \overline{w}_r\right) B_{li}\right] + (1-a)\ln\left[(w_{li} - \overline{w}_l)^\delta B_{li}\right]$$

subject to

$$p(B_{li}) \leq p_i^* t_i, w_{li} \geq \overline{w}_l.$$

The first-order conditions will be:

$$\frac{1}{B_{l_i}} + \frac{a}{p(B_{li}) - w_{li} - \overline{w}_r} p'(B_{li}) + \lambda_{l_i} = 0 \qquad (20)$$

$$-\frac{a}{p(B_{li}) - w_{li} - \overline{w}_r} + \frac{(1-a)\delta}{w_{li} - \overline{w}_l} + \lambda_{w_{li}} = 0 \qquad (21)$$

$$\lambda_{l_i}\left(B_{li} - p^{-1}(p_i^* t_i)\right) = 0 \qquad (22)$$

$$\lambda_{w_{li}}\left(w_{li} - \overline{w}_l\right) = 0 \qquad (23)$$

First we look at the case where $\lambda_{l_i} = 0$. As long as $p'(B_{li}) < 0$, $p(B_{li}) > \overline{w}_r + \overline{w}_l$ is ensured, so that there exists a $w_{li} > \overline{w}_l$ such that $\lambda_{w_{li}} = 0$. The solution will be given by

$$|\varepsilon_{pi}| = \frac{a}{\theta}$$

$$w_{li} = (1-\gamma)\left(p(B_{li}) - \overline{w}_r\right) + \gamma \overline{w}_l.$$

where $\theta = \frac{p - w_{li} - \overline{w}_r}{p} \leq 1$ denotes the markup and $\gamma = \frac{a}{a+(1-a)\delta}$.$\gamma$ is increasing in a and decreasing in δ, so it forms a combined measure of the bargaining power of capital and the relevance of employment for the union. Note that neither p_i^* nor t_i enter into this system of equations, so that changes in trade restrictions (or in the terms of trade) will have no effect on internal equilibrium ($\varepsilon_{w_{ji} t_i} = \varepsilon_{w_{ji} p_i^*} = 0$).

Now look at the solutions in which $\lambda_{l_i} > 0$, so that $p(B_{li}) = p_i^* t_i$. In that case $p_i^* t_i - \overline{w}_r > \overline{w}_l$ ensures that there is a $w_{li} > \overline{w}_l$ that solves (21) with $\lambda_{w_{li}}$, with the solutions now given by:

$$B_{li} = p^{-1}(p_i^* t_i)$$

$$w_{li} = (1-\gamma)\left(p_i^* t_i - \overline{w}_r\right) + \gamma \overline{w}_l.$$

Given that $w_{ki} = p_i^* t_i - w_{li}$, a few steps of algebra help establish that:

$$\varepsilon_{w_{ki} t_i} - \varepsilon_{w_{li} t_i} = \varepsilon_{w_{ri} p_i^*} - \varepsilon_{w_{li} p_i^*} = \frac{p_i^* t_i}{w_{li} w_{ki}}\left(\gamma \overline{w}_l - (1-\gamma)\overline{w}_k\right). \qquad (24)$$

This term will be positive when $\gamma > \gamma^0 = \frac{\overline{w}_k}{\overline{w}_l + \overline{w}_k}$, and negative otherwise. In other words, if the bargaining power of capital is high or the disagreement between the union and the capitalists's objectives is low, then protection will increase the return to capital relative to labor; otherwise it will enhance the relative return to labor. Equation (24) thus suggests a pair of intersting testable implications that will be evaluated in our empirical section.

3 Estimation

In this section we will provide an illustration of our empirical method using data on the shares of labor and capital income in aggregate factor income taken from United Nations (2000), which compiles national accounts statistics elaborated according to its *System of National Accounts* for 117 countries. Data on import duties, export taxes and trade/GDP ratios come from World Bank (2002). The terms of trade variable is constructed as the quotient of the GDP deflators for export and import prices from the national accounts data. Depending on the specification, our baseline regressions cover between 88 and 103 countries. The data are divided into five-year averages for the 1960-1999 period, in order to diminish the possible contamination from business cycle effects. We use import and export volume data for every country at the 2-digit level from the COMTRADE database (United Nations, 2004) to construct an index of international market power by country. This index is simply the weighted average of the country's export (import) share in world exports (imports) by product, where the weights are the product's share in the country's exports (imports). We define a country as large of it has a value greater than 0.1 in either the export-based or the import-based index. The resulting list of large countries includes 7 economies: USA, Japan, Germany, Saudi Arabia, Colombia, UK and Canada.[9]

Section 2 has described the links between international prices, trade restrictions and domestic factor prices that arise in the general case of many commodities and goods. The data that we will use in our paper refer to the shares in national income accounts of two factors of production, which, following convention, we call capital (k) and labor (l). The first necessary step in order to set up our estimation strategy is to transform our results into testable implications regarding the shares of these two factors in aggregate income.

[9] An eight economy (South Africa) also appears as large in this index because it accounts for 60% of world exports and 29% of world imports of commodity class S2-93 "Special transactions, commodity not classified according to class." This is an artifact of the large level of unclassified trade occurring in the South African Customs Union and is not indicative of any significant level of market power. We tried other specifications (with and without South Africa and using other thresholds for market power), with none of them yielding significant differences from the specification reported.

We start from the national accounting identity:

$$\alpha \equiv \frac{w_k B_k}{w_k B_k + w_l B_l}. \tag{25}$$

Taking natural logs and reorganizing gives:

$$g(\alpha) = \ln \frac{\alpha}{1-\alpha} = \ln \left(\frac{w_k}{w_l} \right) + \ln \left(\frac{B_k}{B_l} \right) \tag{26}$$

Proposition 1 implies that if all goods are traded and the income elasticity of factor supplies is zero:

$$\frac{dg(\alpha)}{d \ln t_i} = \varepsilon_{w_k t_i} - \varepsilon_{w_l t_i} + \frac{d \ln \left(\frac{B_k}{B_l} \right)}{d \ln t_i} = \left(\varepsilon_{w_k p_i^*} - \varepsilon_{w_l p_i^*} \right) + \frac{d \ln \left(\frac{B_k}{B_l} \right)}{d \ln t_i} \tag{27}$$

Propositions 2 and 3 imply that in the presence of income effects we will have the more general result:

$$\frac{dg(\alpha)}{d \ln t_i} = \varepsilon_{w_k t_i} - \varepsilon_{w_l t_i} + \frac{d \ln \left(\frac{B_k}{B_l} \right)}{d \ln t_i} = \left(\varepsilon_{w_k p_i^*} - \varepsilon_{w_l p_i^*} \right) + \frac{d \ln \left(\frac{B_k}{B_l} \right)}{d \ln t_i} + b_{kli} \tag{28}$$

where $b_{kli} = \frac{1}{1 - FI_Y - \sum_j P_j^*(t_j - 1) M_Y^j} \left(\varepsilon_{w_k Y} - \varepsilon_{w_l Y} \right) m_i$ denotes the difference between $\varepsilon_{w_k t_i} - \varepsilon_{w_l t_i}$ and $\varepsilon_{w_k p_i^*} - \varepsilon_{w_l p_i^*}$.

Equations (27) and (28) lead us to the following estimation specification:

$$g(\alpha_{rt}) = \beta_0 + \beta_1 \ln p_{rt} + \beta_2 \ln \tau_{rt} + \beta_3 \ln k_{rt} + \beta_4 \ln b_{rt} + \theta_r + \lambda_t + \varepsilon_{rt}, \tag{29}$$

where $r = 1, 2, ..., R$ denotes countries and $t = 1, 2, ..., T$ time periods. θ_r and λ_t are country and period fixed effects, p_{rt} is a terms of trade measure (the ratio of export to import prices), τ_{rt} is the ratio of import to export duties, $k_{rt} = B_{krt}/B_{lrt}$ is the relative endowment of capital, b_{rt} is a time-varying country-specific control designed to capture the potential bias arising from income and $\varepsilon_{rt} \sim iid(0, \sigma_\varepsilon^2)$. We prefer this specification over the alternative of constructing measures of factor prices using factor shares and factor endowment data, as measurement error in $\ln B_k/B_l$ would bias any effect of trade restrictions on factor prices towards zero. For a similar measurement problem in the context of an earnings equation see Bound et. al. (1994).

Several points are worth noting with respect to this specification. The first one is that our preferred functional form for estimation uses the logarithmic transformation $g(\alpha) = \ln\left(\frac{\alpha}{1-\alpha}\right)$ as the dependent variable. This functional form is derived above from the accounting identity (25) and has the implication that the coefficients of $\ln p_{it}$ and $\ln \tau_{it}$ will be equal to the elasticities that Proposition 1-3 refer to, regardless of the functional forms taken by the unit cost and factor supply functions. A more common approach in the literature is to derive the equation to be estimated form the translog specification for the GDP function (see Kohli, 1990, 1991). This specification can cause severe consistency problems if the translog functional form is incorrect. The reason is that by definition factor shares are bounded between 0 and 1, and when estimating an equation like (29), standard assumptions about the disturbance ε_{rt} (such as normality) require an unbounded support, something that is in contradiction with the dependent variable being restricted to the unit interval. The logit transform of the dependent variable (as suggested by Davidson and MacKinnon, 1993) allows it to take on values anywhere on the real line. Although this fact is well understood in the context of linear probability models with unbounded explanatory variables, it is often disregarded in other applied settings (for an exception, see Emmons and Schmid, 2000). The choice of specification, however, is not crucial to our results, and we provide below estimates for the more common tranlog GDP function functional form.

A second point that we wish to call attention to is that our terms of trade indicator is by definition country-specific, as it is built using prices of exports and imports taken from national income accounts. Therefore these indexes are not comparable across countries, making the cross-sectional variation among them meaningless. This is the reason for which we do not present random effect estimates in our results[10].

In the third place, the results of Propositions 1-3 form the backbone of our identification strategy. In particular, we assume that $\varepsilon_{w_k p_i^*} - \varepsilon_{w_l p_i^*}$ provides a reasonable estimate of $\varepsilon_{w_k t_i} - \varepsilon_{w_l t_i}$, as long as the potential bias arising from income effects is appropriately controlled for. The theoretical results support the argument that this is a reasonable assumption for a broad subset of theories of international trade that subsumes the theories that we want to evaluate, such as Stolper-Samuelson and wage bargaining. In this sense, our approach of

[10] Hausmann specification tests without the price variable also favor the fixed effects specification.

identification through theory is similar to that of authors like Levitt and Porter (2001), who impose reasonable restrictions on observed behavior of individual agents in order to derive identification assumptions, and contrasts with the use of instrumental variables with exogenous instruments common in cross-country empirical studies and perhaps best exemplified by contributions such as those of Frankel and Romer (2000) and Acemoglu, Johnson and Robinson (2001).

Notice that we do not impose the restriction that $\beta_1 = -\beta_2$ in our model, which is what our identification assumption may be taken to imply. The reason is that if τ_{rt} is endogenous, β_2 will be difficult to estimate empirically and imposing such a restriction will bias our estimate of β_1. Instead, we know that as long as we restrict ourselves to the case of small countries, shocks to p_{rt} will be exogenous to the process determining income shares within an economy, so $E[p_{rt}\varepsilon_{rt}] = 0$, guaranteeing identification of β_1 even if $E[\tau_{rt}\varepsilon_{rt}] \neq 0$, provided appropriate controls for $\ln(B_k/B_l)$ and b_{rt} are included[11].

The endogeneity of τ_{rt} may still cause difficulties for our approach if it is also correlated with the exogenous terms of trade measure. In that case, the endogeneity τ_{rt} contaminates the coefficient estimate of $\ln p_{rt}$ in (29) despite the fact that $E[p_{rt}\varepsilon_{rt}] = 0$. As an illustration, suppose there exists a relationship between the trade policy variable and the terms of trade of the form $\ln \tau_{rt} = \alpha_0 + \alpha_1 \ln p_{rt} + \alpha_2 \kappa_{rt} + \delta_r + \nu_{rt}$, where the error term in equation (29) is related to κ_{rt} by $\varepsilon_{rt} = \gamma\kappa_{rt} + u_{rt}$ with $u_{rt} \sim iid(0, \sigma^2)$. These expressions describe the endogeneity of trade restriccions through the ommited variable κ_{rt}. After the appropriate substitutions, equation (29) becomes:

$$\begin{aligned} g(\alpha_{rt}) &= \left[\beta_0 - \frac{\gamma\alpha_0}{\alpha_2}\right] + \left[\beta_1 - \frac{\gamma\alpha_1}{\alpha_2}\right] \ln p_{rt} + \left[\beta_2 + \frac{\gamma}{\alpha_2}\right] \ln \tau_{rt} + \beta_3 \ln k_{rt} \\ &\quad + \beta_4 \ln b_{rt} + \left[\theta_r - \frac{\gamma}{\alpha_2}\delta_r\right] + \lambda_t - \frac{\gamma}{\alpha_2}\nu_{rt} + u_{rt}. \end{aligned} \tag{30}$$

Estimating (30) would yield a biased and inconsistent estimate of β_1 if $\alpha_1 \neq 0$. This implies that for the estimation procedure to identify the effect of the policy variable on income shares,

[11] For obvious reasons, we restrict ourselves to addressing and solving the problems for estimation that could be caused by endogeneity of the trade policy variable. We therefore assume that all the other controls in equation (29) are uncorrelated with the error term.

it is important that the exogenous variable be uncorrelated with the endogenous variable of interest.

Fortunately, whether this is the fact or not can be verified by running a regression of $\ln \tau_{rt}$ on $\ln p_{rt}$, κ_{rt} and a set of country fixed effects. Since we can safely assume exogeneity of $\ln p_{rt}$, such a regression allows us to accurately estimate α_1 as long as the relevant κ_{rt} are controlled for. This regression would be analogous to the first-stage regressions common in implementations of instrumental variables techniques. But unlike conventional first-stage regressions, the necessary condition for the validity of our approach would be established by failing to find a significant coefficient for $\ln p_{rt}$. It is only in this way that we can be certain that the coefficient estimate on $\ln p_{rt}$ in (30) will not be contaminated by the potential endogeneity of (30) (i.e., that $\alpha_1 = 0$)

Such a set of regressions is reported in Table 1. We report equations for the whole sample and for sample splits distinguishing poor and rich countries, as well as with and without a full set of controls. Both the criteria for splitting the sample and the list of controls parallel those used in the estimates of (30) reported below. The results confirm a lack of association between the terms of trade indicator and the trade policy variable: the coefficient on $\ln p_{rt}$ is never significant, and the lowest p-value it attains is 0.303.

It is worth noting that one advantage of our approach over the IV approach is that it allows us to get away from the small-sample bias of instrumental variables estimators. As is well-know, instrumental variables estimators are consistent, but they are also biased (see Davidson and Mackinnon, 1993). Cross country datasets are naturally of limited size, so inference based on IV estimates is weak at best. Our approach, in contrast, provides an estimate that is both consistent and unbiased under the aforementioned models. This makes inference about the effects of a policy variable such as trade policy much more reliable.

A fourth point refers to the appropriate way to control for b_{rt}, the bias arising from the possible existence of income effects. It will be noted that equations like (12) show a highly non-linear term in all parameters of the system, presenting a formidable estimation problem given its generality. There are, however, two simple ways in which we can control for this bias. One possibility comes from noting that equation (10) allows us to rewrite the bias as:

$$-\left(\varepsilon_{w_k Y} - \varepsilon_{w_l Y}\right)\left(\varepsilon_{Y p_i} - \varepsilon_{Y t_i}\right), \tag{31}$$

which shows that the bias is caused by the indirect effect that tariffs and external prices have on relative factor returns through Y. These effects are due to fact that the only place in the system of equations determining $\mathbf{w}$ where p_i^* and t_i do not enter multiplicatively is in the equation for Y, (9). (31) therefore suggests controlling for Y when we estimate a regression of $g(\alpha)$ on p_i^*. An alternative comes from taking a first-order Taylor approximation of (12) around $m_i = 0$, which reduces us:

$$b_{kli} \cong \frac{1}{1 - FI_Y^0} \left(\varepsilon_{w_k Y}^0 - \varepsilon_{w_l Y}^0 \right) m_i, \tag{32}$$

an expression which is proportional to m_i. (32) implies that an appropriate way to control for the bias is to introduce an interaction term between $\ln p_{it}$ and m_i in the regresion. Given that when $m_i < 0$, t_i corresponds to an export subsidy, the appropriate empirical counterpart of m_i is the share of exports plus imports in GDP.

One last point that we wish to emphasize is that the nature of our data naturally limits its ability to deal with the effects of trade policy on the distribution of income when there are more than two factors of production. The results that follow should be read as a comparative evaluation of the explanatory power of two-factor models of international trade. Despite this limitation, there is nothing in our empirical strategy that impedes its application to multi-factor contexts, and we view our exercise as illustrative of the possibilities inherent in our approach rather than as a definitive evaluation of existing theories.

3.1 Results

Table 2 displays the results of our first attempt to test for the existence of Stolper-Samuelson effects in the data. Recall that the coefficient of interest is the one on the terms of trade variable, which should be positive for capital abundant economies and negative for labor-abundant economies. In this table, we use per capita GDP as our indicator of capital-abundance; we explore other measures below. According to (31), controlling for per capita GDP also allows us to take care of income effects. We estimate the coefficient through two specifications: in the first one (columns 1 and 2) we split the sample into labor-abundant and capital-abundant countries,[12] while in the second one (column 3) we introduce an interaction

[12] A country is labor (capital) abundant if its per capita GDP is below (above) world per capita GDP.

term between the capital abundance indicator and the terms of trade variable. Columns 4-6 repeat these regressions but with an additional direct control for the bias term b_{kl}, which is an interaction term between the trade share and the terms of trade variable, as suggested by (28). These first results should be disappointing for Stolper-Samuelson advocates. The coefficient on the terms of trade variable is insignificant and has the wrong sign for labor-abundant countries regardless of whether the direct control for b_{kl} is introduced or not. For capital-abundant countries, there is a positive and significant coefficient, as expected by theory, in column 2, but it disappears and becomes negative though not significant as soon as the bias control term is introduced, with that term being strongly significant. As to the interaction term between terms of trade and capital abundance, it is insignificant and the sign becomes negative when the bias control is introduced.

Table 3 confirms the results of Table 2 using the conventional translog-GDP function approach, which has the capital share (instead of the logit transform) as the dependent variable. The results are very similar in terms of sign and statistical significance of the coefficients on the terms of trade, with the only substantial difference being that the sign of the terms of trade variable in the regression for capital-abundant countries with the bias control now becomes significantly negative, in contradiction to the expected positive coefficient.

In a recent paper, Gollin (2002) has argued that standard national accounting significantly misrepresents income shares by classifying income from self-employment as capital income. Therefore some countries may falsely appear to have high capital shares due to the existence of a large informal sector. Gollin produces a set of adjustments to income shares for a reduced subset of economies for which data on the income from unincorporated enterprises is available. In order to make sure that our results are not due to the bias arising from this misclassification of self-employment, we repeat our tests of Tables 2 and 3 on the Gollin data.[13] None of the six coefficients reported in this table are significantly different from zero. Some comfort may be taken from the fact that all but one of the coefficients have the sign indicated by theory; on the other hand the coefficients are very far from conventional

[13] We use Gollin's first adjustment, which imputes all income from unincorporated enterprises as labor income. Results are similar if one uses his second adjustment (impute same labor share as the rest of the economy); his third adjustment (which imputes a wage for proprietors and self-employed individuals), however, yields insufficient observations for our estimation.

significance levels (the average p-value for the six coefficients of interest is 0.67).

One possible explanation for these results is that some countries may be completely specialized in a subset of goods, invalidating the assumption of factor price equalization that is the backbone of the Stolper-Samuelson model. Fortunately, factor price equalization is not a necessary condition for our identification assumptions to be valid, allowing us to apply to modified versions of the Stolper-Samuelson theorem that apply in a setting of multiple cones of diversification. As shown by Davis (1996) and Xu (2000), among others, what is relevant in a world of multiple cones of diversification is a country's level of capital abundance relative to its cone of diversification. Table 5 makes a first attempt to address this issue: in it we split the sample further into two groups, corresponding respectively to above and below world per-capita GDP. This would correspond with the existence of two symmetrically distributed cones of diversification. Within each cone, we run the same six regressions as in Tables 2-4. For the capital-abundant cone, four of the six coefficients have the wrong sign, one of them being significant, while for the labor-abundant cone, none of the coefficients are significant and two have the wrong sign.

A potential problem with this test is that it assumes the existence of two cones of diversification, while theory offers no guide as to the number of cones of diversification nor to the dividing points between them. One way to address this issue is by trying to find whether there is evidence of a cone of diversification of any size at each extreme of the distribution of capital abundance. Figures 2 and 3 show our attempt to do so. Figure 2 graphs the coefficient and t-statistics on the interaction between the log of the terms of trade and the log of per capita GDP taken from a regression identical to that reported in columns 6 and 12 of Table 5, but run for all possible definitions of the cone of diversification corresponding to the highest range of capital-abundance. This means running 168 regressions, ranging from the most restrictive definition of the capital-abundant cone (the one with the minimum number of observations for which the regression can be run) to the most inclusive one (the whole sample). Figure 3 does the same thing, but ranging from the most to least restrictive definition for the labor-abundant cone. Recall that this interaction term should be positive if the Stolper-Samuelson theorem holds. Figure 2 shows a striking fact: the coefficient on the interaction is never significant and positive for **any** possible definition of the highest capital-abundant cone of diversification. In the range in which the interaction is significant (a range corresponding to 16-18 economies) the coefficient is actually negative, indicating that the effect of trade on returns to capital decreases as capital intensity increases within the cone. Figure 3 shows a similar fact for the lowest range of capital-abundance: with the not very relevant exception of the first regression (which has one degree of freedom), no other regression in this figure displays a significant coefficient, be it of the correct or incorrect sign. Additional tests (not reported) replicate these results when we split each cone between its capital-abundant and labor-abundant countries: for no definition of the most and least capital-abundant cones of diversification is there a regression in which both coefficients are significant and of the right sign.

In Table 6 we address some logical questions that might arise about our specification. In the first place, we have used per capita GDP above as a control for capital abundance. This is an admittedly rough measure of capital abundance. The first three columns of Table 6 repeat our regressions using the Summers-Heston (1992) estimates of the capital stock with the bias control term. Note that as these are unavailable in the latest version of the Penn World Tables and are only compiled for a reduced number of countries, we lose a significant number of observations when using this indicator: the number of countries in the labor-abundant group fall from 42 to 20 and those in the capital-abundant group from 46 to 21. None of the three coefficients are significant and two have the wrong sign. The rest of the columns experiment with additional specifications: columns 4-6 use Barro and Lee's (2004) measure of terms of trade instead of our national accounts based data; columns 7-9 use the share of imports and exports in GDP as our policy indicator, while columns 10-12 return to our baseline specification but add a set of alternative controls: for the level of human capital (measured by the average years of secondary and higher schooling, the level of political liberties and the right to bargain collectively. None of these additional specifications particularly seem to favor Stolper-Samuelson: only two out of the nine specifications in columns 4-12 have the right sign, and none of them are significant.

Given the disappointing performance of the Stolper-Samuelson hypothesis on our data, we turn in Table 7 to identifying whether there is evidence of an effect of trade on domestic factor prices that operates through the wage bargaining channel. As we showed in Section 2.3, the effect of trade restrictions on factor shares should vary according to the relative bargaining power of capital and labor. Therefore, we should expect to see trade increasing capital shares in countries where labor organization is strong, whereas the opposite would happen where it is weak. We use unionization rates from Rama and Artecona (2000) as our measure of the degree of labor organization. Thus we introduce into the specification an interaction between unionization levels and the log of the terms of trade variable. Since we are interested in testing the wage bargaining model on its own (as opposed to a combination of it and the Stolper-Samuelson model), the specification in Table 7 assumes that the coefficient on terms of trade is the same for poor and rich countries[14]. We present six possible specifications in this regression, corresponding to the three dependent variables in Tables 2-4, with and without alternative controls. All of the estimates are positive, with three of them significant at 5%. Even the non-significant coefficients are reasonably close to statistical significance (p-values of .11, .29 and .14). The estimated effects are economically very significant: the coefficient on the interaction term in equation 2, for example, implies that a country with a unionization rate of 25.7% (the average of the sample) that raised tariffs from their free trade level to an average level of 50% would see an increase of 5.9 percent of GDP in labor's share relative to a country with no unions.

These results suggest that there may be something to the wage bargaining story. Certainly, if viewed as a horse race between Stolper-Samuelson and wage bargaining theories, wage bargaining has managed to leave Stolper-Samuelson behind, though partly thanks to Stolper-Samuelson not running very fast (or, actually, that it seemed to be running in the wrong direction). A fuller analysis of the empirical implications of the wage bargaining hypothesis is beyond the scope of our paper. It is possible of course that unionization be proxying for other variables that affect the trade-income distribution link. There may also be problems of selection bias in the reporting of unionization data[15]. However, the fact that a simple wage-bargaining theory does much better than neoclassical trade theory in this initial horse race suggests that much of the effort directed at understanding the causes of

[14] Tests allowing for different coefficients accoding to levels of income and capital intensity generate similar results. Details are available upon request.

[15] A simple selection model using real per capita GDP as the selection variable for non-missing values yields similar results.

factor price movements may have been misplaced.

4 Concluding Remarks

This paper has proposed a simple strategy for identifying the effect of trade restrictions on relative factor prices. In contrast to the common approach in the cross-national empirical literature, which addresses problems of identification by instrumenting on sources of exogenous variation in policy variables, we derive our identification assumptions directly from theory. As we have shown, a broad class of trade theories implies that the elasticity of factor returns with respect to a tariff on good i should be identical to that with respect to an increase in the price of good i. Even when these elasticities are not the same, theory suggests a way in which we can quantify and control for the bias that could arise when we estimate the former using the latter. The plausibility of the assumption of exogeneity of terms of trade changes when the sample is restricted to small economies and the empirically verifiable fact that trade policy and terms of trade are not correlated give us an opportunity to estimate the effect of a policy variable using information on an exogenous variable, while at the same time avoiding the small-sample bias of instrumental variables.

We have implemented our strategy on a cross-national panel of data on factor shares and trade policy for more than one hundred economies. Our results are not supportive of the Stolper-Samuelson theorem. As we have shown, Stolper-Samuelson effects are very hard to find in the data, regardless of whether we look for them at the world level or at the level of specific cones of diversification. In contrast, we do find evidence in the data that confirms the predictions of wage-bargaining models whereby economic integration weakens the bargaining power of unions.

Our results are naturally limited by the nature of our data, which reports income distribution for only two factors of production. One explanation for the disappointing results could be that they are due to the incapacity of two-factor models for understanding the reaction of factor prices to international trade. Indeed, our results can be seen as confirming the extensive empirical literature that has systematically failed to confirm the empirical predictions of the Heckscher-Ohlin-Vanek model. The methodology presented in this paper, however, is applicable to multi-factor, multi-good contexts, suggesting a natural direction for future research.

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Table 1. "First Stage" Regressions

	1	2	3	4	5	6
	Whole Sample	Poor	Rich	Whole Sample	Poor	Rich
Ln(Terms of Trade)	**-0.006**	**0.001**	**0.022**	**0.022**	**0.036**	**0.080**
	(0.019)	**(0.028)**	**(0.021)**	**(0.055)**	**(0.102)**	**(0.120)**
Ln(Terms of Trade)*(High Union Dummy)				0.003*	0.001	-0.001
				(0.002)	(0.003)	(0.003)
High Union Dummy				0.000*	0.002	-0.000
				(0.001)	(0.001)	(0.000)
Ln(Per capita GDP)				-0.024	-0.040	0.006
				(0.030)	(0.063)	(0.036)
Ln(Terms of Trade)*(Trade Share)				-0.001*	-0.001	-0.000
				(0.001)	(0.002)	(0.001)
Political Rights				-0.013***	-0.022*	-0.008*
				(0.005)	(0.012)	(0.005)
Secondary Schooling				-0.000	0.100	-0.008
				(0.012)	(0.098)	(0.008)
Higher Level Schooling				-0.001	-0.12	0.037
				(0.083)	(0.223)	(0.070)
Bargaining Rights				0.073	0.293	0.037
				(0.068)	(0.206)	(0.051)
N. Observations	482	265	201	199	92	107
Countries	124	77	56	69	38	36
F-Test	F(123, 352)	F(76, 182)	F(55, 139)	F(68, 117)	F(37, 41)	F(35, 58)
	13.3	7.29	17.68	6.15	4.27	7.36
H0: (All coefficients are zero)	Reject	Reject	Reject	Reject	Reject	Reject

Note: Large Countries (excluded from the sample) are USA, Japan, Germany, Saudi Arabia, Colombia, UK and Canada

Standard errors are in parentheses.*,** and *** indicate the coefficient is significant at the 10%, 5%, and 1% levels, respectively

Table 2. Baseline Specification

	1	2	3	4	5	6
	Poor	Rich	Whole Sample	Poor	Rich	Whole Sample
Ln(Terms of Trade)	**0.182**	**0.300****	-0.148	**0.607**	**-0.483**	0.147
	(0.160)	**(0.143)**	(0.886)	**0.368**	**(0.324)**	(0.910)
Import Duties / Export Duties	-0.995*	0.801	-2.928	-0.789	0.932	-1.146
	(0.522)	(0.667)	(2.682)	(0.531)	(0.649)	(2.757)
Ln(Per capita GDP)	-0.445**	0.076	-0.302***	-0.378*	0.000	-0.276**
	(0.195)	(0.157)	(0.114)	(0.196)	(0.155)	(0.114)
Ln(Per capita GDP)*(ImpDut/ExpDut)			0.339			0.136
			(0.332)			(0.340)
Ln(Per capita GDP)*(Terms of Trade)			**0.046**			**-0.010**
			(0.106)			**(0.107)**
Ln(Terms of Trade)*(Trade Share)				-0.006	0.013***	0.003
				(0.006)	(0.005)	(0.004)
N. Observations	107	153	260	104	153	257
Countries	42	46	78	42	46	78
F-Test	F(8,57)	F(8,99)	F(10,172)	F(9,53)	F(9,98)	F(11,168)
	2.14	1.22	1.99	1.61	1.95	1.71
H0: (All coefficients are zero)	Reject		Reject		Reject	Reject

Note: Large Countries (excluded from the sample) are USA, Japan, Germany, Saudi Arabia, Colombia, UK and Canada

Standard errors are in parentheses.*,** and *** indicate the coefficient is significant at the 10%, 5%, and 1% levels, respectively

Table 3. Translog specification

	1	2	3	4	5	6
	Poor	Rich	Whole Sample	Poor	Rich	Whole Sample
Ln(Terms of Trade)	**0.046**	**0.072****	-0.029	**0.135**	**-0.124***	0.008
	(0.036)	**(0.031)**	(0.195)	**(0.084)**	**0.069**	(0.202)
Import Duties / Export Duties	-0.198*	0.166	-0.577	-0.165	0.199	-0.253
	(0.117)	(0.144)	(0.592)	(0.122)	(0.138)	(0.612)
Ln(Per capita GDP)	-0.092**	0.010	-0.068***	-0.081*	-0.008	-0.064**
	(0.044)	(0.034)	(0.025)	(0.045)	(0.033)	(0.025)
Ln(Per capita GDP)*(ImpDut/ExpDut)			0.067			0.030
			(0.073)			(0.075)
Ln(Per capita GDP)*(Terms of Trade)			**0.010**			**0.000**
			(0.023)			**(0.024)**
Ln(Terms of Trade)*(Trade Share)				-0.001	0.003***	0.001
				(0.001)	(0.001)	(0.001)
N. Observations	107	153	260	104	153	257
Countries	42	46	78	42	46	78
F-Test	F(8,57)	F(8,99)	F(10,172)	F(9,53)	F(9,98)	F(11,168)
	2.00	1.22	1.98	1.56	2.28	1.77
H0: (All coefficients are zero)	Reject		Reject		Reject	Reject

Note: Large Countries (excluded from the sample) are USA, Japan, Germany, Saudi Arabia, Colombia, UK and Canada

Standard errors are in parentheses.*,** and *** indicate the coefficient is significant at the 10%, 5%,

Table 4. Gollin's Adjustment

	1	2	3	4	5	6
	Poor	Rich	Whole Sample	Poor	Rich	Whole Sample
Ln(Terms of Trade)	**0.066**	**0.601**	-0.155	**-0.174**	**1.991**	-0.650
	(0.206)	**(0.538)**	(3.895)	**(1.116)**	**(1.841)**	(3.955)
Import Duties / Export Duties	-3.137	-3.569	-23.616	-2.989	-4.646	-12.606
	(2.563)	(3.831)	(25.225)	(3.599)	(4.095)	(28.448)
Ln(Per capita GDP)	2.403**	0.440	0.414	2.319	0.332	0.565
	(0.292)	(0.492)	(0.430)	(0.550)	(0.514)	(0.467)
Ln(Per capita GDP)*(ImpDut/ExpDut)			2.409			1.277
			(2.843)			(3.150)
Ln(Per capita GDP)*(Terms of Trade)			**0.087**			**0.037**
			(0.438)			**(0.444)**
Ln(Terms of Trade)*(Trade Share)				0.004	-0.021	0.014
				(0.019)	(0.026)	(0.017)
N. Observations	17	44	61	17	44	61
Countries	8	13	20	8	13	20
F-Test	F(7,2)	F(7,24)	F(9,32)	F(8,1)	F(8,23)	F(10,31)
	30.05	3.45	5.40	13.81	3.05	4.89
H0: (All coefficients are zero)	Reject	Reject	Reject		Reject	Reject

Note: Large Countries (excluded from the sample) are USA, Japan, Germany, Saudi Arabia, Colombia, UK and Canada

Standard errors are in parentheses.*,** and *** indicate the coefficient is significant at the 10%, 5%,

Table 5. Two Cones of Diversification	1	2	3	4	5	6	7	8	9	10	11	12
	Capital Abundant Cone						Labor Abundant Cone					
	Poor	Rich	Whole Sample	Poor	Rich	Whole Sample	Poor	Rich	Whole Sample	Poor	Rich	Whole Sample
Ln(Terms of Trade)	**0.460***	**-0.067**	2.997	**-0.805**	**0.068**	2.136	**0.082**	**0.192**	-0.090	**1.811**	**0.455**	0.484
	(0.228)	**(0.217)**	(4.835)	**(0.493)**	**(0.517)**	(4.696)	**(0.322)**	**(0.240)**	(1.881)	**(1.217)**	**(0.529)**	(1.958)
Import Duties / Export Duties	-0.830	0.608	**18.610**	-0.183	0.582	19.251	-2.240*	-0.806	**-0.696**	-2.487	-0.711	0.503
	(1.166)	(0.800)	**(13.183)**	(1.091)	(0.812)	(12.777)	(1.108)	(0.686)	**(4.789)**	(1.361)	(0.719)	(5.332)
Ln(Per capita GDP)	-0.283	0.004	0.141	-0.373	0.033	0.068	-2.009	-0.344	-0.439**	-1.218	-0.331	-0.354
	(0.249)	(0.248)	(0.170)	(0.230)	(0.269)	(0.167)	(1.248)	(0.216)	(0.214)	(1.516)	(0.221)	(0.221)
Ln(Per Capita GDP)*(ImpDut/ExpDut)			-1.936			-1.991			-0.037			-0.171
			(1.424)			(1.380)			(0.637)			(0.707)
Ln(Per Capita GDP)*(Terms of Trade)			-0.296			**-0.288**			0.036			**0.012**
			(0.524)			**(0.508)**			(0.252)			**(0.275)**
Ln(Terms of Trade)*(Trade Share)				0.021***	-0.002	0.013***				-0.031	-0.004	-0.006
				(0.007)	(0.007)	(0.005)				(0.021)	(0.006)	(0.006)
N. Observations	75	78	153	75	78	153	35	72	107	33	71	104
Countries	31	18	46	31	18	46	16	26	42	16	26	42
F-Test	F(8,36)	F(8,52)	F(10,97)	F(9,35)	F(9,51)	F(11,96)	F(7,12)	F(8,38)	F(10,55)	F(8,9)	F(9,36)	F(11,51)
	1.12	3.71	1.21	2.09	3.24	1.83	1.5	1.04	1.66	1.08	0.88	1.28
H0: (All coefficients are zero)		Reject		Reject	Reject	Reject						

Note: Large Countries (excluded from the sample) are USA, Japan, Germany, Saudi Arabia, Colombia, UK and Canada
Standard errors are in parentheses.*,** and *** indicate the coefficient is significant at the 10%, 5%, and 1% levels, respectively

Table 6. Alternative specifications

	1	2	3	4	5	6
	Poor	Rich	Whole Sample	Poor	Rich	Whole Sample
Ln(Terms of Trade)	**-0.484**	**-0.053**	-0.007			
	(0.505)	**(0.501)**	(0.844)			
Import Duties / Export Duties	-0.413	1.373*	-6.961***	-1.367	0.465	-2.046
	(0.705)	(0.719)	(2.454)	(0.921)	(0.947)	(5.628)
Ln(Per capita GDP)	-0.994***	0.327	-0.505***	-0.459	0.030	-0.486*
	(0.292)	(0.299)	(0.192)	(0.405)	(0.442)	(0.288)
Ln(Capital per Worker)	0.348	-0.097	-0.061			
	(0.274)	(0.248)	(0.187)			
Ln(Terms of Trade)*(Trade Share)	0.014	0.004	0.010*			
	(0.009)	(0.010)	(0.282)			
Ln(Capital per Worker)*(Imp.Dut/Exp.Dut)			0.813***			
			(0.087)			
Ln(Capital per Worker)*(Terms of Trade)			**-0.051**			
			(0.006)			
Ln(Per capita GDP)*(Terms of Trade)						
Ln(Terms of Trade Barro-Lee)				**3.941**	**-1.247**	**6.882**
				(2.963)	**(2.037)**	**(7.793)**
Ln(Terms of Trade Barro-Lee)*(Trade Share)				-0.057	0.010	-0.008
				(0.044)	(0.020)	(0.017)
Ln(Per capita GDP)*(Terms of Trade Barro-Lee)						**-0.658**
						(0.936)
Ln(Per capita GDP)*(Imp.Dut/Exp.Dut)						0.177
						(0.671)
Trade Share						
Ln(Per capita GDP)*(Trade Share)						
Political Rights						
Secondary Schooling						
Higher Level Schooling						
Bargaining Rights						
N. Observations	64	86	150	53	57	110
Countries	20	21	38	33	30	59
F-Test	F(19, 35)	F(20, 56)	F(37, 101)	F(32, 14)	F(29, 21)	F(58, 43)
	18.05	16.64	29.25	10.21	12.36	14.22
H0: (All coefficients are zero)	Reject	Reject	Reject	Reject	Reject	Reject

Note: Large Countries (excluded from the sample) are USA, Japan, Germany, Saudi Arabia, Colombia, UK and Canada

Standard errors are in parentheses.*,** and *** indicate the coefficient is significant at the 10%, 5%, and 1% levels, respectively

Table 7. Unionization interactions

	1	2	3	4	5	6
	Logit Transform		Translog		Gollin	
Ln(Terms of Trade)	-0.510	-0.433	-0.105	-0.089	-0.333	-0.713
	(0.376)	(0.484)	(0.083)	(0.106)	(1.211)	(1.169)
Import Duties / Export Duties	0.643	0.911	0.115	0.213	-13.585	-7.618
	(0.913)	(0.944)	(0.201)	(0.206)	(9.934)	(9.085)
Ln(Per capita GDP)	-0.520***	-0.486***	-0.126***	-0.121***	0.814	0.875*
	(0.147)	(0.182)	(0.032)	(0.040)	(0.516)	(0.472)
Ln(Terms of Trade)*(Trade Share)	0.006	0.003	0.001	0.000	-0.003	0.003
	(0.006)	(0.007)	(0.001)	(0.002)	(0.018)	(0.017)
Political Rights		0.098***		0.021***		0.176**
		(0.033)		(0.007)		(0.071)
Secondary Schooling		-0.066		-0.013		0.090
		(0.050)		(0.011)		(0.088)
Higher Level Schooling		1.148***		0.258***		-0.896
		(0.417)		(0.091)		(0.875)
Bargaining Rights		0.207		0.043		-0.189
		(0.284)		(0.062)		(0.359)
(Imp.Dut/Exp.Dut)*Unionization Rate	-0.059*	-0.067*	-0.011*	-0.014*	0.188	0.224
	(0.032)	(0.035)	(0.007)	(0.008)	(0.200)	(0.182)
Ln(Terms of Trade)*Unionization Rate	**0.010**	**0.022****	**0.001**	**0.005****	**0.045****	**0.029**
	(0.007)	**(0.010)**	**(0.001)**	**(0.002)**	**(0.020)**	**(0.019)**
Unionization Rate	0.001	0.001	0.000	0.000	0.007	0.002
	(0.003)	(0.003)	(0.001)	(0.001)	(0.005)	(0.005)
N. Observations	147	123	147	123	52	52
Countries	49	42	49	42	18	18
F-Test	F(48, 86)	F(41, 66)	F(48, 86)	F(41, 66)	F(17, 23)	F(17, 19)
	22.4	20.15	23.41	21.78	7.02	6.9
H0: (All coefficients are zero)	Reject	Reject	Reject	Reject	Reject	Reject

Note: Large Countries (excluded from the sample) are USA, Japan, Germany, Saudi Arabia, Colombia, UK and Canada

Standard errors are in parentheses.*,** and *** indicate the coefficient is significant at the 10%, 5%, and 1% levels, respectively

Figure 1: Effect of Changes in Prices and Tariffs on Labor Demand Derivation

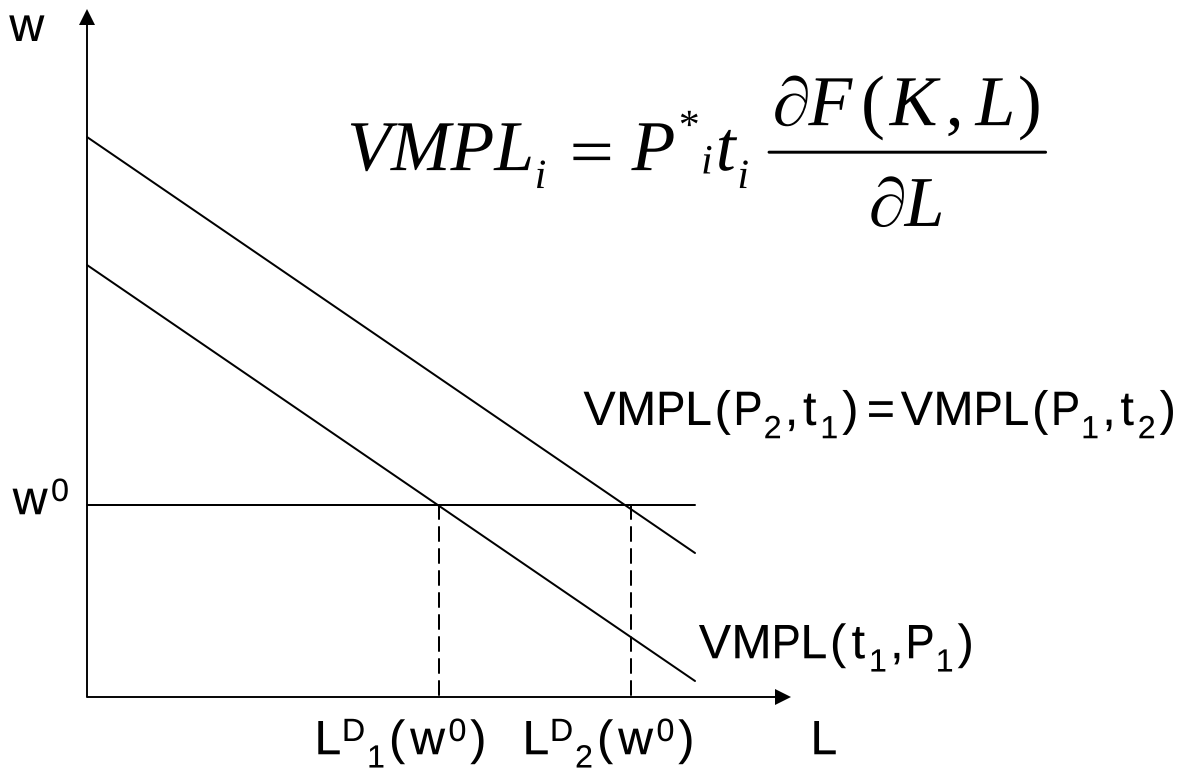

Figure 2: Interaction Term with GDP, Capital-Abundant Group

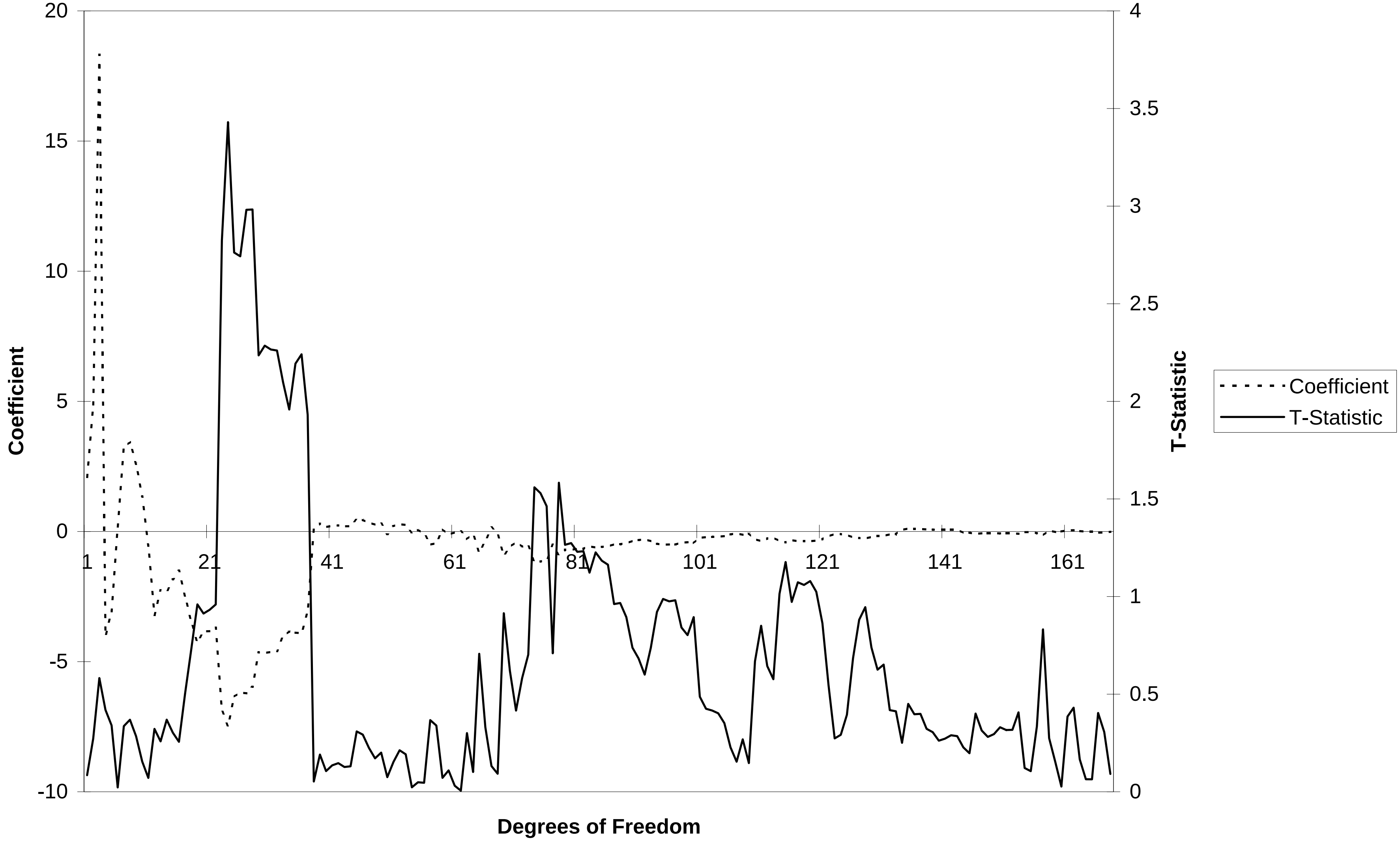

Figure 3: Interaction Term with GDP, Labor-Abundant Cone