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Tariffs, Technology and Global Integration*

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Abstract

In the last two decades tariffs around the globe have fallen significantly. However, less well known are their changes in the sectorial structure of protection rates. Between 1988 and 1998, relative tariffs have increased in capital-intensive sectors, and this shift is specially strong in low wage countries. These changes in tariff structures reflect the response of governments to increasing integration in product and capital markets in the presence of international technology differences. Integration in factor markets revives the concept of absolute advantage, and countries adjust their tariff structure in order to compensate for technology differences and cost pressures in order to keep a diversified production structure. As a corollary, wage differences increase both within and between countries.

Key Words: Globalization, International Technology Differences, Tariffs.
JEL: F1, F20

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Globalization is usually viewed as a process of increasing integration in world product markets. Indeed, a huge rise in international trade in goods and services has been observed in the last 40 years, and openness to world product markets in many countries around the globe is one of the more salient features of the world trading system.[1] The rise in world trade has been accompanied with important changes in factor markets, mainly the rise in wage dispersion across skill groups within developed and developing countries, and the shift toward more capital-intensive production processes (Desjonqueres et.al., (1999)). Traditional trade models have been used to analyze the impact of globalization on factor markets, and their success has been limited because they cannot explain the rise in capital(human and physical)-labor ratios together with a rise in the relative price of skilled labor.

Although new channels through which globalization affect factor markets have been developed, like outsourcing (see Feenstra and Hanson (1997)), the most common explanation for these outcomes continues to be technological change, more specifically, labor-saving technological change. According to Trefler and Zhu (2001), some form of factor-bias technological change is needed to make consistent a trade-based explanation with the change in skill-intensities across most sectors. However, as Neary has pointed out (2002a, b), in a multisector world technology change has to be factor-biased and sector-biased to account for the empirical regularities already mentioned, and the evidence on this is scarce. Therefore, he argues in favor of factor-markets' effects of global integration in imperfectly competitive models.

This paper presents an alternative look at the globalization and technology debate by looking at the evolution of tariffs since mid 1980s across developed and developing countries. Over the last two decades, tariffs have shifted toward protecting more capital-intensive sectors, and this bias is stronger in low-wage countries. The paper argues that the evolution of tariffs provides a novel way to determine the mechanisms through which global integration affects different countries. For that, two modifications of traditional trade models are required, one formal and the other conceptual. First, to understand the effect of globalization on factor markets we must focus on the determinants of international factor price differences. I work on the

[1] As percentage of GDP, exports plus imports have risen from around 23% in 1973 to about 28% in 1992. These number compare to a 21% ratio in 1913, the peak of global trade in the whole period before the 1970s. See Estevadeordal et.al., (2003).

basis on international technology differences. Second, we must recognize that global integration is not only about product market integration. It is also about factor market integration.[2]

These two variations are relevant for several reasons. Traditional trade models project factor price equalization as a result of product market integration if technologies are similar across countries and factor endowments are not too dissimilar. In this case, the zero profit conditions in viable sectors are the same, and so are factor prices. Thereby, product price equalization leads to factor price equalization. However, differences in factor prices are significant and persistent over time. The existence of technology differences may be crucial to understand this. In a model with internationally immobile factors of production, differences in technology are compensated with differences in factor prices. This is the relevant channel through which native industries keep a competitive position in world markets. This is indeed the mechanism that makes comparative advantage rather than absolute advantage the key concept in international specialization. After product price distortions have been removed, world factor prices are fully dominated by international technology differences.

However, the mechanism described above is seriously limited if globalization is also a process of increasing integration in factor markets. With international factor mobility, factor prices in countries with backward technologies cannot adjust to compensate for the technological differences, as they can obtain a greater return in high-technology countries. Therefore, the concept of absolute advantage is revived, as absolute technology differences imply factor price differences that are not sustainable over time. Countries can either see their factors migrate or they can introduce distortions in product and factor markets to sustain their native industry. These interventions may not be optimal from a welfare point of view, but I argue they adequately reflect the response of countries to global integration.

In particular, the paper emphasizes the role of interventions in product markets, namely tariffs, in sustaining domestic industries. I argue that the evolution of tariffs in the last fifteen years can be understood as the response of governments to increasing integration in product markets, measured as a fall in average tariffs, and to increasing integration in capital markets, measured as convergence in the return to capital

[2] See Jones (2000).

across countries. In both scenarios, capital-intensive sectors face greater cost pressures, and a shift in protection in their favor is required to sustain them. As a corollary, increases in wage inequality within countries follow. Moreover, international wage divergence rather than international wage convergence is the more likely outcome of globalization.

Finally, this mechanism do not account for the observed changes in the factor-intensities of production processes. In that sense, as Trefler and Zhu (2001) point out, some form of technological change is required. However, I argue that labor-saving technology changes are a partial explanation, for they can account for the changes in tariff structures and international wage differences under very special circumstances.

The paper is divided as follows. Next section presents the evidence on the structure and evolution of tariffs for a cross-section of developed and developing countries between 1988 and 1998. Section 2 presents a simple general equilibrium model to explain the tariff structure consistent with the production of all sectors in the economy under the assumption of international technology differences and some degree of integration in factor markets. I discuss the impact of product market integration, capital market integration, terms-of-trade changes and technology changes in the evolution of tariffs. Section 2 also presents empirical evidence on the evolution of international wage differences. Section 3 concludes.

1 The Evolution of Tariffs

Tariffs have fallen significantly in the last two decades. However, these changes in average tariffs have been accompanied with important changes in the structure of tariffs. This section provides evidence on the changes in relative sectorial tariffs for a cross-section of developed and developing countries between 1988 and 1998. For that, I use the Trade and Production Database from Nicita and Olarreaga (2001) that contains data on production, employment, labor payments and tariffs between 1976 and 1999 for 67 countries at the 3-digit ISIC manufacturing classification. However, the requirement of sectorial estimates of factor intensities, wages and tariffs for at least two years shrinks significantly the availability of data.[3].

[3]See the Appendix for details and dimensions of the Database.

At any point in time, tariffs across countries can vary in two dimensions. First, average tariffs may be different. Second, the sectorial distribution of tariffs across sectors may also differ across countries. More specifically, I focus on whether there exists a significant association between tariffs and factor-intensities, and on whether this relationship varies across countries with different income or wage levels. The introduction of a time dimension to the analysis increases the scope of changes in the tariff structure. Over time, average tariffs can change, the distribution of tariffs can change, and these changes may differ across countries with different wage levels. I therefore consider the following empirical specification

$$\tau_{it}^{c} = \alpha_{1c} + \alpha_{2c} T_t + \beta_1 \left(L/K\right)_{it}^{c} + \beta_2 \left(L/K\right)_{it}^{c} T_t + \gamma_1 \left(L/K\right)_{it}^{c} w_t^{c} + \gamma_2 \left(L/K\right)_{it}^{c} w_t^{c} T_t + \varepsilon_{it}$$

where τ_{it}^{c} represents the tariff rate in industry i of country c in year t. (L/K) represent the labor-capital ratio, T_t is a trend variable and w_t^{c} is the average wage level of country c in year t. Consider first the case when $\alpha_{2c} = \beta_2 = \gamma_2 = 0$. The coefficient β_1 measures whether the tariff structure differs across sectors with different capital-labor ratios, and the country-specific α_{1c} intercept reflects differences in average tariffs. The coefficient γ_1 allows for differences in the sectorial bias of tariffs across countries with different average wage levels. Consider now changes over time in tariffs. The coefficients α_{2c} and β_2 reflect changes in average tariffs and its sectorial distribution, and $\gamma_2 \neq 0$ reveals changes in the sectorial distribution of tariffs across countries with different wage levels.

[*Insert Table* 1]

Tables 1 and 2 report the results of alternative specifications using 3-digit ISIC manufacturing data for 29 countries between 1988 and 1998. All panel regressions use country-specific fixed-effects. In table 1, labor-intensity $(L/K)_{it}^{c}$ is measured as the labor share in value-added, θ_{Li}^{c}. The first two columns consider $\gamma_1 = \gamma_2 = 0$. Tariffs are greater in labor-intensive sectors. However, this bias have decreased over time. These results are not dominated by outliers, as the exclusion of data point with tariff level greater than 200% (8 observations) reveal. The last two columns allow for differences in the tariff structure across countries with different wage levels. Excluding data points with tariffs greater than 200%, it is clear that tariffs tend to be greater in labor-intensive sectors, specially in low-wage countries. Over time, protection to

labor-intensive sectors have decreased, and this shift is more important in low-wage countries.

[*Insert Table* 2]

These regressions are subject to two endogeneity problems. First, tariffs may affect wages. However, this might be relevant for sector-specific wages but not for average manufacturing wages. If no sector is big enough to affect significantly the labor market, w^c does not depend on τ_i^c. Second, labor-share in value-added may be affected by the level of the tariff in each sector, meaning that θ_{Li}^c is not a good proxy of the labor-capital ratio. Therefore, I consider $(\theta_L/\theta_K)_i^c$ as an alternative measure for $(L/K)_i^c$. The advantage of this variable is that $(\theta_L/\theta_K)_i^c = (L/K)_i^c \cdot (w/r)_i^c$. As long as relative factor prices are similar across sectors ($(w/r)_i^c \approx (w/r)^c$), θ_L/θ_K is a good proxy of factor intensity. Moreover, even if sectorial tariffs affect sector-specific factor prices, θ_L/θ_K does not depend on τ as long as the tariff rate does not alter relative factor prices. The regression results reported in table 2 show similar patterns as those obtained in table 1. Tariffs tend to be greater in labor-intensive sectors, specially in low-wage countries. However, over time tariffs have shifted toward capital-intensive sectors, specially in low-wage countries.[4]

2 Model

2.1 Endogenous Factor Prices

Consider an economy with two sectors of production and perfectly competitive product and factor markets. Sector x is assumed to be the capital-intensive industry. Technologies are assumed of fixed proportions and with constant-return-to-scale.[5] Production factors, labor (L) and capital (K), are internationally immobile, so their returns are endogenously determined. Product prices are set internationally, although tariffs may distort them. The zero profit condition for sector i is given by

$$p_i^w(1+\tau_i) = a_{Li}w + a_{Ki}r \tag{1}$$

[4] The results are not affected if we use relative average country wages (w^c/w^*) rather than average dollar country wages. Neither the results are affected if the United States is excluded from the specification. The rationale for this is discussed below.

[5] The Leontief assumption helps to simplify the algebra and it does not alter the results.

where p_i^w is the world price of product $i = x, y$; τ_i is the tariff level in industry i, a_{Fi} is the requirement of factor $F = L, K$ to produce one unit of good i (the inverse of average productivity), and w and r are the returns per unit of labor and capital respectively. The solution to the system of equations implicit in (1) is a vector of wage and rental rate consistent with production in both sectors. The well-known graphical solution to this problem is the Lerner-Pierce diagram depicted in figure 1, that shows the unit-value isoquants for both sectors. As long as relative factor endowments are not extreme, w_0 and r_0 are the only wage and rental rate levels consistent with production efficiency and zero profit conditions in both sectors.

[*Insert Figure* 1]

With internationally immobile production factors, their returns depend on technologies, world product prices and tariffs. The first two are exogenously determined, while tariffs are a policy choice of the government.

Consider also that there exist technological differences between the home country and a foreign country (represented by a star sign $*$). In sector i, the technological differences can be represented as $a_{Li} = (1+\delta_i^L)a_{Li}^*$ and $a_{Ki} = (1+\delta_i^K)a_{Ki}^*$, where δ_i^L and δ_i^K greater than zero imply that average labor and capital productivity are smaller in the home country. Assuming that technology differences as hicks-neutral; $\delta_i^L = \delta_i^K = \delta_i$, we can rewrite (1) as

$$p_i^w(1+\tau_i) = (1+\delta_i)\left(a_{Li}^* w + a_{Ki}^* r\right). \tag{2}$$

Combining (2) with the zero-profit conditions in the foreign country ($p_i^w(1+\tau_i^*) = a_{Li}^* w^* + a_{Ki}^* r^*$) we get an expression for the ratio of home to foreign wages as a function of home and foreign tariffs (τ_i and τ_i^*), technology differences δ_i and the level of foreign technologies (a_{Li}^* and a_{Ki}^*).

2.2 Exogenous Factor Prices

Imagine now that this country were integrated at the factor-market level with the rest of the world. International differences in the opportunity costs of factors push for wage and rental rate equalization. However, I consider that factor price equalization is not complete due to distortions or costs associated with moving

factors.

In particular, consider that the return to factor F in the home country can be written as $p_f = \lambda_F p_f^*$ where p_f is the return to factor F in the native economy as a proportion of the return in the rest of the world p_f^*. λ_F measures the degree of factor markets' integration. I assume that the international return to capital and labor are set in the foreign country, that is big enough to determine w^* and r^*. Therefore, $w = \lambda_L w^*$ and $r = \lambda_K r^*$.[6] With this notation we can rewrite the zero profit conditions for each sector i in the home country as

$$p_i^w(1+\tau_i) = (1+\delta_i)\left(a_{Li}^*\lambda_L w^* + a_{Ki}^*\lambda_K r^*\right) \tag{3}$$

where δ_i is the hicks-neutral technology gap in sector i. Given values for λ_L, λ_F and international world prices, nothing assures that both zero profit conditions hold with the initial tariff structure. Hence, I assume that tariffs adjust such that both zero-profit conditions hold. The tariff structure consistent with equation (3) is

$$\frac{(1+\tau_x)/(1+\tau_x^*)}{(1+\tau_y)/(1+\tau_y^*)} = \left(\frac{1+\delta_x}{1+\delta_y}\right)\cdot\left(\frac{\theta_{Lx}^* + \theta_{Kx}^*\lambda_K/\lambda_L}{\theta_{Ly}^* + \theta_{Ky}^*\lambda_K/\lambda_L}\right). \tag{4}$$

Consider for the sake of the argument that both τ_x^* and τ_y^* are equal to zero. The structure of protection depends on two forces. The first one is related to the distribution of international technology differences. Factor market integration rises factor prices in a country with backward technologies. And this increase in greater for the factor used intensively in the industry with greater technology difference. Therefore, greater protection is required in more backward sectors. Tariffs are the compensating mechanism to support industries with international real cost pressures.

The second determinant of the tariff structure is related to the effects of uneven factor markets' integration. The greater the integration in capital markets relative to labor markets (λ_K/λ_L), the greater the cost pressures on capital-intensive sectors. Therefore, more protection is required for these industries. Indeed, the derivative of the right-hand-side of (4) with respect to λ_K/λ_L is positive if and only if sector x is the capital-intensive sector, revealing that increases in capital-market integration relative to labor-market integration generate greater cost pressures in capital-intensive sectors, shifting the tariff structure in their

[6] $\lambda_L \in [w_0/w^*, 1]$ if $w_0 < w^*$ and $\lambda_L \in [1, w_0/w^*]$ if $w_0 > w^*$. Similar for λ_K.

benefit. On the other hand, if $\lambda_K = \lambda_L$, then $(1+\tau_x)/(1+\tau_y) = (1+\delta_x)/(1+\delta_y)$ and tariffs are completely determined by international technology differences. The final tariff structure will depend on the strength on both effects. For $\delta_x < \delta_y$, the bounds for $(1+\tau_x)/(1+\tau_y)$ are given by

$$\lim_{\lambda_K/\lambda_L \to 0} \frac{1+\tau_x}{1+\tau_y} = \left(\frac{1+\delta_x}{1+\delta_y}\right) \cdot \frac{\theta^*_{Lx}}{\theta^*_{Ly}} < 1$$

$$\lim_{\lambda_K/\lambda_L \to \infty} \frac{1+\tau_x}{1+\tau_y} = \left(\frac{1+\delta_x}{1+\delta_y}\right) \cdot \frac{\theta^*_{Kx}}{\theta^*_{Ky}} \lesseqgtr 1.$$

Figure 2 plots $(1+\tau_x)/(1+\tau_y)$ against λ_K/λ_L implicit in (4).[7] If cross-industry differences in δs are big enough, and dominate differences in factor intensities, protection remains greater in the labor-intensive sector even with greater integration in capital markets.

[*Insert Figure* 2]

Removing the assumption that foreign tariffs are zero introduces a third element in the determination of domestic tariffs. In this case, disadvantages of domestic firms compared to foreign ones exist the tariffs receives by foreign firms that alter the equilibrium levels of w^* and r^*. Therefore, greater foreign protection in the capital-intensive sector generates upward pressures on r^*. This requires greater domestic protection in sector x.

The implications of the model are twofold. First, the structure of tariffs with integrated factor-markets is affected by the distribution of technology differences, the degree of labor and capital markets' integration and the tariff structure in the foreign country. Second, for a given level of technology differences, increases in capital market integration relative to labor market integration generates a shift in protection toward capital-intensive sectors. This last prediction coincides with the evidence presented in section 1. If globalization in the last decades is seen as a process of greater integration in capital markets (rise in λ_K), a shift in protection in favor of capital-intensive sectors follows if countries set their tariffs in order to keep a fully-diversified production structure.[8]

[7] In figure 2 $D = (1+\delta_x)/(1+\delta_y)$.

[8] See Rodrik (1997) for a discussion of different degrees of international integration in capital (human and physical) markets

However, the scope of the model is seriously limited by three forces. First, the effect of changes in λ_K/λ_L in relative tariffs does not vary across countries with different (average) technology gaps. Second, equation (3) determines not only relative tariffs but also their absolute levels. Third, and more important, the level and evolution of wages is fully determined by the parameter λ_L. This is an extreme assumption, specially because integration in labor markets, specially in low-skilled labor, is rather small (or null) compared to integration in capital or high-skilled labor markets. Therefore, I introduce in the model the possibility of endogenously determined wages by assuming that international integration exists only in capital (physical or human) markets.

2.3 Endogenous Wages

Consider now that only capital market are integrated internationally, while labor is immobile across borders. As before, the return to capital domestically is given by $\lambda_K r^*$. The set of zero-profit conditions in each sector in the home country becomes

$$p_i^w(1+\tau_i) = (1+\delta_i)\left(a_{Li}^* w + a_{Ki}^* \lambda_K r^*\right). \tag{5}$$

With exogenously determined λ_K, there are infinite combinations of τ_x, τ_y and w that satisfy (5) for sectors x and y. Therefore, to uniquely determine the equilibrium tariffs and wage level, I consider that the level of average tariffs is a policy variable that is exogenously determined. The reader can think of this as a measure of unilateral product market integration. Hence,

$$\gamma_x(1+\tau_x) + \gamma_y(1+\tau_y) = \overline{\tau}. \tag{6}$$

The solution to these three equations (the two in (5) and (6)) is a vector of τ_x, τ_y and w consistent with production in both sectors as a function of $a_{Li}^*, a_{Ki}^*, \delta_i, \overline{\tau}$ and $\overline{r} = \lambda_K r^*$. After some algebra manipulation we get

$$\frac{1+\tau_x}{1+\tau_y} = \frac{1+\delta_x}{1+\delta_y} \cdot \frac{a_{Lx}^* \overline{\tau} p_y^w + (1+\delta_y)\gamma_y \overline{r} A}{a_{Ly}^* \overline{\tau} p_x^w - (1+\delta_x)\gamma_x \overline{r} A} \tag{7}$$

versus labor markets.

where $A = a^*_{Kx}a^*_{Ly} - a^*_{Lx}a^*_{Ky} > 0$ under the assumption that x is the capital-intensive sector. Equation (7) takes r^* as given for any country. Solving for r^*, that is endogenously determined in the foreign country, and plugging it into (7) yields

$$\frac{1+\tau_x}{1+\tau_y} = \frac{1+\delta_x}{1+\delta_y} \cdot \frac{a^*_{Lx}\overline{\tau} + (1+\delta_y)\gamma_y\lambda_K B}{a^*_{Ly}\overline{\tau}p - (1+\delta_x)\gamma_x\lambda_K B} \tag{8}$$

where $p = p^w_x/p^w_y$ and $B = a^*_{Ly}p(1+\tau^*_x) - a^*_{Lx}(1+\tau^*_y) > 0$. This is a fundamental expression in the paper. It states the determinants of the tariff structure as function of policy variables $(\overline{\tau}, \lambda_K)$, international technology differences (δ_i), relative product prices (p) and the determinants of the international cost of capital (r^*). We can now discuss the impact of changes in these exogenous variables on $1+\tau_x/1+\tau_y$. In particular, we focus on the impact of a fall in average tariffs $\overline{\tau}$, a change in the degree of capital markets' integration λ_K, changes in relative product prices p, and technological changes.

2.3.1 Product Market Integration

Consider first the effect of a fall in average tariffs. It is possible to show that $\partial(1+\tau_x/1+\tau_y)/\partial\overline{\tau} < 0$. A fall in average tariffs imply a rise in relative protection to the capital-intensive. The intuition is the following. If both tariffs were to fall in the same proportion[9], both zero-profit conditions cannot hold simultaneously because the cost of capital does not adjust. The required adjustment in wages in the labor-intensive sector y leaves sector x non-competitive. Therefore, a rise in its relative tariff is required to compensate for the greater relative cost of capital.

Not only the tariff structure changes with the fall in $\overline{\tau}$ but the shift in favor of the capital-intensive sector is greater in low-wage countries. Consider for simplicity that $\delta_x = \delta_y = \delta$.[10] Countries with high δ have low wages, ceteris paribus. In such case, $\partial^2(1+\tau_x/1+\tau_y)/\partial\overline{\tau}\partial(1+\delta) < 0$, revealing that the effect on

[9] Strictly speaking, a similar fall in tariffs means that $\widehat{(1+\tau_x)} = \widehat{(1+\tau_y)}$.

[10] It is possible that international wage differences are not only related to the level of technology differences but also to its sectorial distribution. In Claro (2003b), I find evidence that the dispersion of technology differences across sectors is very small compared to cross-country differences in technologies, suggesting that international wage differences are mainly affected by average levels of technology differences. See also Trefler (1993) for the role of technology differences explaining international wage differences.

the tariff structure is greater in low-wage countries. The reason is that the cost disadvantage of capital-intensive sectors relative to the labor-intensive sector is increasing in the level of technology gap, even in the case where technology differences are the same across sectors. This is because the relative cost of capital domestically is increasing on the average technology gap. In summary, the empirical results described in section 1 are compatible with a process of continuous fall in average tariffs across countries in the presence of international technology differences and some degree of capital markets' integration.

The fall in average tariffs have also important implications for factor prices. Solving for international wage differences and relative factor prices from (5) and (6) yields

$$\frac{w}{w^*} = \frac{p\overline{\tau}A - \left[(1+\delta_x)\gamma_x a^*_{Kx} + p(1+\delta_y)\gamma_y a^*_{Ky}\right]\lambda_K B}{\left[(1+\delta_x)\gamma_x a^*_{Lx} + p(1+\delta_y)\gamma_y a^*_{Ly}\right]\cdot\left[a^*_{Kx}(1+\tau^*_y) - a^*_{Ky}p(1+\tau^*_x)\right]} \tag{9}$$

and

$$\frac{w}{r} = \frac{p\overline{\tau}A - \left[(1+\delta_x)\gamma_x a^*_{Kx} + p(1+\delta_y)\gamma_y a^*_{Ky}\right]\lambda_K B}{\left[(1+\delta_x)\gamma_x a^*_{Lx} + p(1+\delta_y)\gamma_y a^*_{Ly}\right]B}. \tag{10}$$

The partial derivative of (9) with respect to $\overline{\tau}$ is positive, showing that a fall in average tariffs generate a rise in international wage differences. A fall in average tariffs generate downward pressures on native wages for two reasons. First, there is a fall in nominal wages accompanying the fall in nominal product prices. This is of course a trivial and uninteresting effect. However, the fall in average tariffs imply a shift in protection toward the capital-intensive sector, benefiting the factor used intensively in that industry. Moreover, $\partial^2(w/w^*)/\partial\overline{\tau}\partial(1+\delta) < 0$, revealing that a similar fall in average tariffs generate a greater fall in international relative wages in poor or low-wage countries. This is an important result because even if globalization is a process of worldwide fall in average tariffs, a rise in international wage differences should be observed.

This is exactly what figure 3 shows. It plots the ratio of average manufacturing wages per worker between 43 countries and the United States in 1980 and 1995. There is a positive and significant association between both series, and the slope of .695 (st.error: .055) is significantly lower than the depicted 45^o line, revealing that low-wage countries have fallen behind high-wage countries, on average. Only Taiwan, Hong Kong, Korea, Singapore and Cyprus have been able to catch-up. This result is consistent with the evidence

presented in Freeman and Oostendorp (2000) regarding the evolution of international wage differences. Using a comprehensive database from ILO, they show that cross-country differences in pay for comparable work have increased since mid 1980s.

[*Insert Figure* 3]

A more systematic exercise is performed by estimating the following panel regression between 1977 and 1998

$$(w^c/w^*)_{it} = \alpha_{0c} + \alpha_1 \cdot T_t + \alpha_2 \cdot (T_t \cdot (w^c/w^*)_{i1976}) + \varepsilon_{it}$$

where $(w^c/w^*)_{it}$ is the ratio of average wage rates between country c and the United States in industry i in year t, and T_t is a trend variable. The specification allows for cross-industry differences in international relative wages. The interactive term α_2 measures whether the trend variable varies across countries with different wage ratios in 1976. The results of the regression using country-specific fixed effects is the following[11]

$$\begin{aligned} (w^c/w^*)_{it} &= .00368 \cdot T_t + .000399 \cdot (T_t \cdot (w^c/w^*)_{i1976}) \\ & \qquad (26.96) \qquad\quad (73.71) \end{aligned}$$

The overall R^2 is .75. The positive and highly significant coefficient on the interactive term reveals that increases in international wage differences have occurred, consistent with figure 3.

Finally, the partial derivative of equation (10) with respect to $\overline{\tau}$ is positive. This implies that a fall in average wages generate a fall in the relative price of the internationally-immobile factor. Generalizing the model to consider that the internationally mobile factor is human or physical capital and the immobile factor is unskilled labor, this result can be interpreted as an increase in wage differences between skilled and unskilled workers within countries. The shift in tariffs in favor of the capital-intensive sector benefits the factor used intensively in that industry.

[11] Test z in parenthesis.

2.3.2 Capital Markets' Integration

Alternatively, we can think of globalization as a process of increasing integration in international capital markets. From the perspective of developing countries, this implies a rise in λ_K. It is possible to show that $\partial(1+\tau_x/1+\tau_y)/\partial\lambda_K > 0$, revealing that a rise in capital market integration generates a shift in protection in favor of the capital-intensive sector. The increase in the cost of capital rises marginal costs more in the capital-intensive industry, with the consequent increase in protection. Assuming again that technology differences are similar across sectors, $\partial^2(1+\tau_x/1+\tau_y)/\partial\lambda_K\partial(1+\delta) > 0$. For similar increases in the cost of capital, the shift in protection toward the capital-intensive industry is greater in low-wage countries.[12] This is consistent with the evidence presented in section 1.

Regarding the impact of changes in λ_K on international wage differences between and within countries, it is possible to show that $\partial(w/w^*)/\partial\lambda_K < 0$ and $\partial(w/r)/\partial\lambda_K < 0$. The first inequality reveals that an increase in capital markets' integration implies a rise in international wage differences. This is because the rise in the cost of capital generates a fall in domestic wages, consistent with the rise in protection in the capital-intensive sector x. Likewise, within-country wage differentials increase. These effects are not dependent on the level of technology differences of countries, as $\partial^2(w/w^*)/\partial\lambda_K\partial(1+\delta) = \partial^2(w/r)/\partial\lambda_K\partial(1+\delta) = 0$.

2.3.3 Changes in Relative Product Prices

Changes in relative product prices p have two effects on the tariff structure. On the one hand, a fall in the relative price of the labor-intensive good (increase in p) generates a rise in the degree of protection required for that industry. This is the direct effect associated with changes in p when the return to capital is exogenously determined. On the other hand, changes in product prices affect the equilibrium in the foreign country, where r^* is determined. At given foreign tariffs τ^*, a fall in the relative price of the labor-intensive good generates a rise in foreign return to capital r^*, affecting negatively the domestic capital-intensive industry.

[12] This result is valid because the wage fall required to compensate a rise in the cost of capital is greater in countries with worse technologies, as θ_K/θ_L is lower in poor countries. However, this is only valid as long as the elasticity of substitution between labor and capital, σ, is smaller than 1. This is the case in the paper as $\sigma = 0$.

The final effect on the tariff structure will depend on the strength of both effects. Indeed, it is possible to show that

$$\frac{\partial(1+\tau_x/1+\tau_y)}{\partial p} = K \cdot \left[(1+\tau_x^*)\gamma_x((1+\delta_x)\lambda_K - 1) + (1+\tau_y^*)\gamma_y((1+\delta_y)\lambda_K - 1)\right] \tag{11}$$

with $K > 0$. To simplify the analysis, consider again that $\delta_x = \delta_y = \delta$. Expression (11) becomes positive as long as $(1+\delta)\lambda_K > 1$. This is not an obvious condition, as $(1+\delta)$ is greater than one but λ_K is smaller than one for the typical developing country. If δs are effectively evenly distributed across sectors, its impact on domestic factor prices w and r is also evenly distributed. However, $r = \lambda_K r^*$. Therefore, observing relative factor price ratios $(w/r)/(w^*/r^*)$ can shed light on the size of $(1+\delta)\lambda_K$. For example, if $(w/r)/(w^*/r^*) > 1$ it suggests that $(1+\delta)\lambda_K < 1$.

An alternative reaction of the foreign country is to adjust its tariff structure in order to keep the international return to capital constant. In this case, as evident from equation (9), a rise in p generates a shift in protection in favor of the labor-intensive good. If globalization is seen as a period of reacommodating relative product prices[13], no clear pattern for the structure of protection across countries is suggested by the model. The results not only depend on the strength on the technology gap and the degree of capital market integration, but also on the response of the foreign country to the relative price change.

The impact on international wage differences is not clear either. If r^* absorbs all the rise in p, there is a fall in w^*. The rise in r^* also affects negatively the domestic wage rate, and nothing can be said regarding w/w^*. Likewise for the case where foreign tariffs are adjusted in order to keep the foreign return to capital constant.

2.3.4 Technological change

One of the main features of factor markets in the last decades is related to the increase in the capital (physical and human) intensity of production processes, both in developed and developing countries. This is not a trivial effect considering that the relative price of unskilled labor have fallen in the same period. Traditional

[13] Leamer (1998) has shown that the 1970s was a decade of a significant fall in the relative price of labor-intensive manufacturing goods. Thereafter no significant pattern of relative product price changes has been documented.

trade channels like Stolper-Samuelson and outsourcing (Feenstra and Hanson (1996)) or the ones discussed in this paper are able to account for the evolution of the evolution of relative factor prices and tariffs, but they cannot account for the changes in factor intensities. Technological changes can do so. Specifically, labor-saving technological change may explain the fall in relative wages of unskilled labor and the rise in the skill-intensity of production processes. However, is labor-saving technological change able to explain the changes in tariff structures and the rise in international wage differences? The next lines are aimed to answer this question.

To focus the discussion I study the effect of labor-saving technological change keeping constant the hicks-neutral technological differences across countries in each industry. In other words, I consider that technological changes are multilateral.[14] Regarding the effects of technological changes on the foreign country, I assume that tariffs do not adjust and that all the effect is absorbed by factor prices. This is to be consistent with the changes in relative factor prices associated with technology changes.

Consider first the case when technological changes are symmetric across countries and across industries. In terms of the model, $\widehat{a_{Li}} = \widehat{a^*_{Li}} = -\rho_L < 0$ and $\widehat{a_{Ki}} = \widehat{a^*_{Ki}} = -\rho_K < 0$ for $i = x, y$. It is possible to show that $\widehat{w^*} = \rho_L$ and $\widehat{r^*} = \rho_K$. Contrary to the effect in a one-sector economy, a fall in w^*/r^* results from capital-saving technological change ($\rho_K > \rho_L$) rather than labor-saving technological change. This is because in a two-sector model a labor-saving symmetric technological change favors the labor-intensive industry (see Neary (2002a)). Therefore, the labor-saving technological change required to generate an increase in the capital-labor ratio in the production processes is not consistent with the fall in the ratio of unskilled to skilled (or capital) factor prices. This leads Neary to reject a technology-based explanation for the rise in wage inequality in rich and poor countries.

However, if labor-saving technology change is also sector-biased, favoring the capital-intensive sector, the rise in wage differences within countries is compatible with the increase in skill intensities.[15] Indeed, the

[14] Berman and Machin (2000) present evidence that technology changes have occurred in developed and developing countries alike.

[15] See Haskel and Slaughter (2002) for evidence on this.

condition for w^*/r^* to fall is $\widehat{a^*_{Kx}}\theta^*_{Kx} + \widehat{a^*_{Lx}}\theta^*_{Lx} < \widehat{a^*_{Ky}}\theta^*_{Ky} + \widehat{a^*_{Ly}}\theta^*_{Ly}$, that is, multifactor productivity growth is greater in the capital-intensive sector. Notice that if technological change is symmetric across countries and sectors as stated in last pharagraph, this condition is not satisfied. Therefore, we focus on technological changes that satisfy two conditions: a) multifactor productivity growth is greater in the capital-intensive sector and b) technological change is labor-saving: $\widehat{a^*_{Li}} > \widehat{a^*_{Ki}}$ for $i = x, y$.

The derivative of relative tariffs in equation (8) to technological changes is given by

$$\frac{\widehat{(1+\tau_x)}}{(1+\tau_y)} = Z \cdot \left[\overline{\tau} - \lambda_K \sum_{i=x,y} (1+\delta_i)\gamma_i(1+\tau^*_i)\right] \cdot \left[\widehat{a^*_{Lx}} - \widehat{a^*_{Ly}}\right] \tag{12}$$

with $Z > 0$. Neither of the bracket terms in the right-hand-side can be signed. Consider the first term, and assume for simplicity of exposition that technological differences are similar across sectors. The term can be written as $\overline{\tau} - \lambda_K(1+\delta)\overline{\tau^*}$, where $\overline{\tau^*}$ is the average tariff factor computed using domestic weights. Even if average protection is similar across countries, the sign depends on whether $\lambda_K(1+\delta) \gtrless 1$. This condition is the same as the one relevant to determine the effect of relative product price changes, and the same discussion applies. The second term in brackets cannot be signed either. Given the restrictions imposed to the form of technological change, nothing can be said with respect to $\widehat{a^*_{Lx}} - \widehat{a^*_{Ly}}$. However, the most likely sign for $\widehat{a^*_{Lx}} - \widehat{a^*_{Ly}}$ is negative.[16] In this case, tariffs will shift toward greater protection in capital-intensive sectors if $\overline{\tau} - \lambda_K(1+\delta)\overline{\tau^*} < 0$, that implies $\lambda_K(1+\delta) > \overline{\tau}/\overline{\tau^*}$. Given that average tariffs are usually greater in low-wage countries, this is not a very likely condition.

Therefore, nothing conclusive can be said regarding the impact of technological changes on relative tariffs without an empirical estimation of $\overline{\tau} - \lambda_K(1+\delta)\overline{\tau^*}$ and $\widehat{a^*_{Lx}} - \widehat{a^*_{Ly}}$. Similar conditions hold to determine the effect of labor-saving technological changes on international wage differences. Hence, it is not very likely (although it is possible) that technological changes are behind this changes in tariffs and international wage differences.

[16] Greater multifactor productivity growth in the capital-intensive sector implies that $\theta^*_{Kx}\left(\widehat{a^*_{Kx}} - \widehat{a^*_{Lx}}\right) + \widehat{a^*_{Lx}} < \theta^*_{Ky}\left(\widehat{a^*_{Ky}} - \widehat{a^*_{Ly}}\right) + \widehat{a^*_{Ly}}$. Considering that $\theta^*_{Kx} > \theta^*_{Ky}$, $\widehat{a^*_{Lx}} - \widehat{a^*_{Ly}} < 0$ unless the bias of the technological change in the labor-intensive sector is much greater than the bias of the technological change in the capital-intensive sector $\left(\widehat{a^*_{Ky}} - \widehat{a^*_{Ly}} > \widehat{a^*_{Kx}} - \widehat{a^*_{Lx}}\right)$.

3 Conclusion

The diminished capacity of traditional trade models to explain the main facts of international labor markets have left economists in an uncomfortable position. Some economists have pushed in favor of imperfect competitive models with broader transmission mechanisms into factor markets. I follow an alternative route. In a perfectly competitive setting, the paper argues that integration in product and factor markets in the presence of international technology differences revives the concept of absolute advantage. In this setting, countries respond by adjusting their tariff structures in order to avoid important factor reallocation and to defend some industries. This reaction is not optimal from a welfare point of view, but I argue it reflects adequately the response of governments to global competition.

The paper shows that the evolution of tariff structures can help to understand the role of globalization in factor markets. The shift in protection toward capital-intensive sectors in the last 15 years, specially in low-wage countries, is consistent with increasing integration in product and capital markets. As a corollary, increases in international wage differences are expected, as well as increases in wage differences within countries. The effect on relative tariffs of multilateral labor-saving technology is ambiguous and depends on the intensity of the technology change, the size and dispersion of technology differences, and differences in average tariffs between each country and the United States. This is clearly an area were further work is needed.

Appendix

The data corresponds to the data base organized by Alessandro Nicita and Marcelo Olarreaga of World Bank.[17] It contains data on industrial production, tariffs and trade flows. Industrial statistics are obtained from UNIDO's Industrial Statistics Database that contains data at the 3-digit ISIC manufacturing codes on output, value added, wages and salaries, employment and gross fixed capital formation. Trade data are from United Nations Statistics Department's Comtrade database. Tariff's statistics are from UNCTAD's Trains database.

[*Insert Table Appendix*]

[17] Nicita, A and M. Olarreaga (2001).

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Table 1
Evolution of Tariff Structure - 3-digit ISIC
Factor Intensity measured labor share in value-added

Variable	(1) τ_{ic}	(2) τ_{ic}	(3) τ_{ic}	(4) τ_{ic}
θ_{Lic}	7945,01	2653,45	6689,45	2964,21
	1545,36	*917,15*	*1696,28*	*998,13*
θ Lic * time	-3,99	-1,33	-3,35	-1,48
	0,78	*0,46*	*0,85*	*0,50*
θ Lic * w_c			29,78	-170,37
			108,14	*63,64*
θ Lic * wc * time			-0,02	0,09
			0,05	*0,03*
R-Squared Overall	0,16	0,27	0,16	0,21
Number of Observations	3377	3369	3377	3369
Number of Countries	29	29	29	29
Data Restrictions	none	t<200	none	t<200

Standard Errors in Italics
t_{ic} : Tariff level (*100) in industry i in country c
θL_{ic} : Labor share in value-added
w_c : Average wage in country c

Table 2
Evolution of Tariff Structure - 3-digit ISIC
Factor Intensity measured as relative factor usage (L/K*w/r)

Variable	(1) τ_{ic}	(2) τ_{ic}	(3) τ_{ic}	(4) τ_{ic}
L/K_{ic}	746,27	568,92	960,80	917,33
	267,63	*157,84*	*344,56*	*202,67*
L/K ic * time	-0,37	-0,28	-0,48	-0,46
	0,13	*0,08*	*0,17*	*0,10*
$L/K_{ic} * w_c$			-50,93	-64,37
			29,52	*17,37*
L/K ic * wc * time			0,03	0,03
			0,01	*0,01*
R-Squared Overall	0,15	0,26	0,13	0,21
Number of Observations	3377	3369	3377	3369
Number of Countries	29	29	29	29
Data Restrictions	none	t<200	none	t<200

Standard Errors in Italics
t_{ic} : Tariff level (*100) in industry i in country c
L/K_{ic} : $\theta_{Lic} / (1 - \theta_{Lic})$
w_c : Average wage in country c

Table Appendix
Data Availability and Database Dimensions

3-digit data

#	Code	Country	τ	θ_L	w	Data Available
1	BOL	Bolivia	93-98	88-98	88-98	93-98
2	CAN	Canada	89,93,95-98	88-98	88-98	89,93,95-98
3	CHL	Chile	92-95,97-98	88-98	88-98	92-95,97-98
4	CMR	Cameroon	94-95	89-97	89-97	94-95
5	COL	Colombia	91-92,94-97	88-98	88-98	91-92,94-97
6	ECU	Ecuador	93-98	88-97	88-97	93-97
7	HKG	Hong Kong	88,98	88-98	88-98	88-97
8	HUN	Hungary	91,93,96-97	88-98	88-98	91,93,96-97
9	IDN	Indonesia	89-90,93,95-96	88-97	88-97	89-90,93,95-96
10	IND	India	90,92,97	88-98	88-98	90,92,97
11	JPN	Japan	88-98	88-98	88-98	88-98
12	KOR	South Korea	88-90,92,95-96	88-97	88-97	88-90,92,95-96
13	LKA	Sri Lanka	90,93-94,97	88-95	88-95	90,93-94
14	MAR	Morocco	93,97	88-97	88-97	93-97
15	MEX	Mexico	91,95,97-98	88-98	88-98	91,95,97-98
16	MYS	Malaysia	88,91,93,96-97	88-98	88-98	88,91,93,96-97
17	NOR	Norway	88,93,95-96,98	88-98	88-98	88,93,95-96,98
18	NZL	New Zealand	92-93,96-98	88-96	88-97	92-93,96
19	PHL	Philippines	88-90,92-95,98	88-97	88-97	88-90,92-95
20	POL	Poland	91-92,95-96	88-98	88-98	91-92,95-96
21	SGP	Singapore	89,95	88-97	88-97	89,95
22	THA	Thailand	89,91,93,95	88-91,93-94	88-91,93-94	89,91,93
23	TTO	Trinidad Tobago	91-92,96	88-95	88-95	91-92
24	TUR	Turkey	93,95,97	88-98	88-98	93,95,97
25	TWN	Taiwan	89,92,96	88-96	88-97	89,92,96
26	URY	Uruguay	92,95-98	88-97	88-97	92,95-97
27	USA	United States	89-93,95-98	88-98	88-98	89-93,95-87
28	VEN	Venezuela	92,95,97-98	88-96	88-96	92,95
29	ZAF	South Africa	88,90-91,93,96-97	88-98	88-98	88,90-91,93,96-97

Source: Nicita and Olarreaga (2001)

Figure 1
Lerner-Pierce Diagram

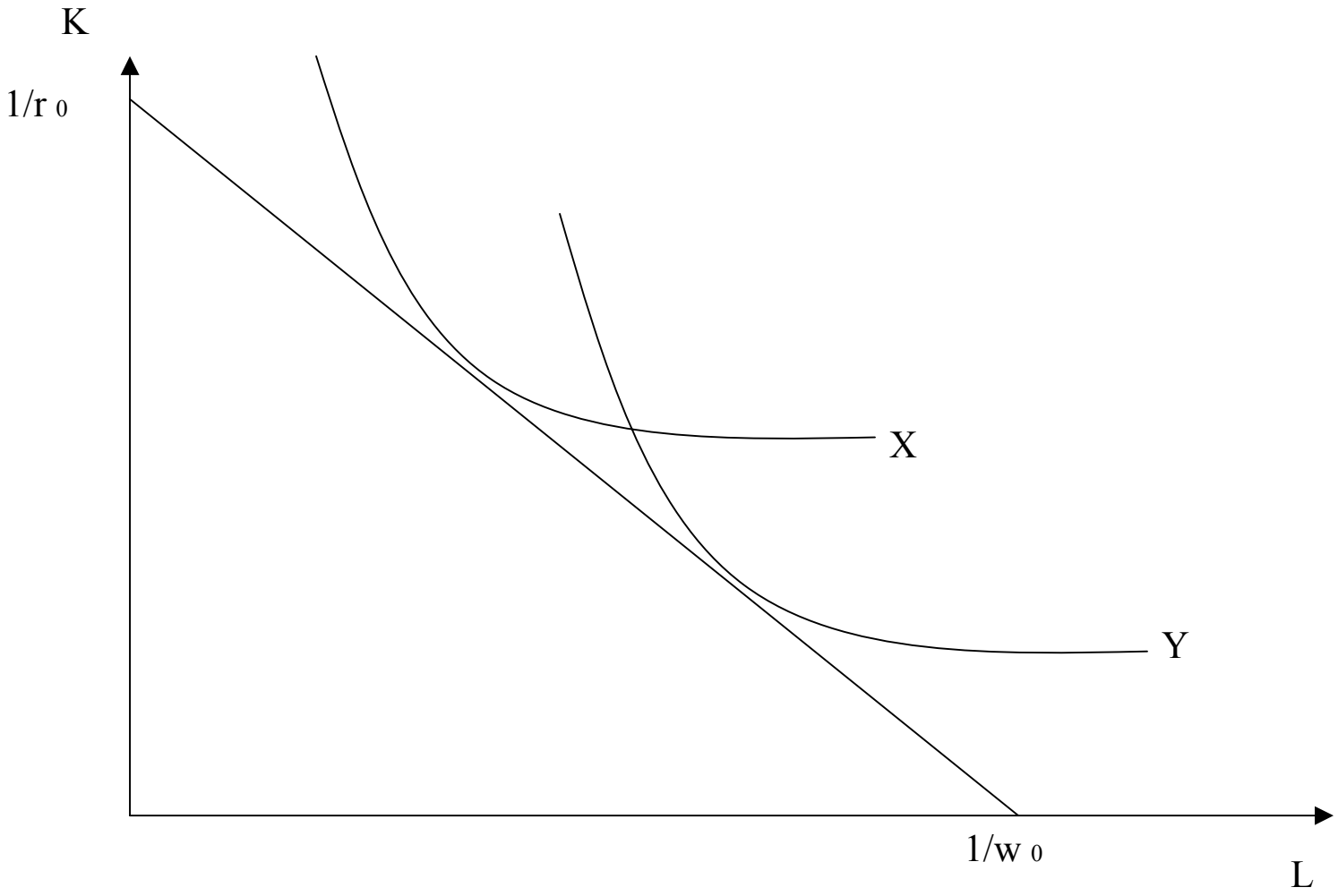

Figure 2
Bounds of Tariff Structure with Exogenous Factor Prices

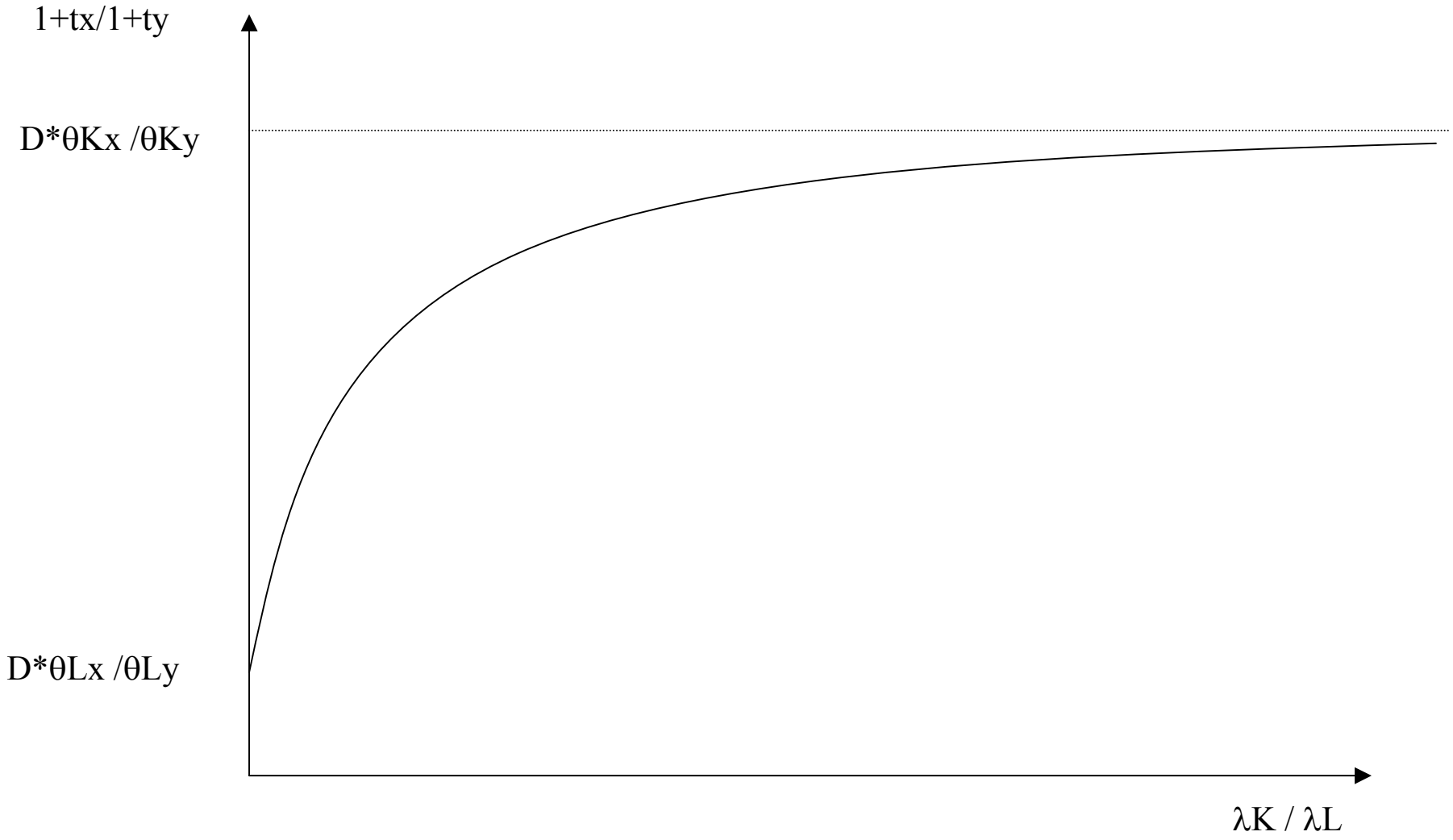

Figure 3
International Wage Ratios: 1980, 1995