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Abstract

This paper develops a two-country, general equilibrium model of oligopoly in which the degree of horizontal product differentiation is endogenously determined by firms' strategic investments in product innovation. Consumers seek variety and product innovation is more skill intensive than production. Stronger import competition increases innovation incentives, and thereby the relative demand for skill. An intraindustry trade expansion following trade liberalization can therefore increase wage inequality between skilled and unskilled workers. In addition, since product differentiation is resource consuming, freer trade entails a potential trade-off between production and variety. The import competition effect highlighted by the model, which plays a key role in determining the general equilibrium, is consistent with panel data on Chilean manufacturing plants.

JEL Classifications: F15, F16, L13, O31

Keywords: Trade liberalization, Product differentiation, Innovation, Wage inequality, General oligopolistic equilibrium

1 Introduction[1]

In the late 1970s a group of theorists working independently (Krugman, 1979; Lancaster, 1980; Norman, 1976) revolutionized the way economists think about international trade with a powerful insight: trade liberalization induces similar nations to specialize in different varieties of the same product, giving rise to intraindustry exchanges, as consumers love variety. The empirical dominance of this form of trade, formerly posing a major challenge to trade theory, therefore ceased to be a puzzle. Furthermore, a new and potentially important source of gains from trade was uncovered: intraindustry trade specialization allows economies of scale and expands the set of product varieties available to consumers, thereby increasing aggregate welfare.

The conceptual framework that made this breakthrough possible was the monopolistic competition model of Dixit and Stiglitz (1977), Lancaster (1979) and Spence (1976). By making it possible to study imperfect competition in a tractable general equilibrium framework, this model has naturally become the workhorse theory of international trade, alongside the perfect competition paradigm.[2] The elegance and simplicity of the monopolistic competition model comes at a cost, however. The set of differentiated varieties into which firms can specialize is exogenously given, and there is no cost to product differentiation. Consequently, in equilibrium each variety is produced by a single firm, which acts as a monopolist in the market for it. While the different varieties of a given product are linked by the elasticity of substitution, producers do not engage in any form of strategic interaction.

In this paper we develop a model of oligopoly in general equilibrium to argue that the process by which firms differentiate their product from their rivals' requires skilled labor and is affected by strategic interaction between producers. As a result, an intraindustry trade expansion following trade liberalization has potentially important implications for the relative rewards of skilled and unskilled workers and the intersectoral allocation of resources. In addition, since product differentiation is resource-consuming, trade liberalization between similar nations entails a potential trade-off between production and variety.

To formalize these arguments we build on the model by Neary (2009), who offers a theoretically consistent but tractable model of oligopoly in general equilibrium (GOLE).[3] There are two

[1]We would like to thank, without implicating, Matias Busso for sharing the plant data with us, and Daniel Bernhofen, Udo Kreickemeier, Kjell Erik Lommerud, Frode Meland and seminar participants at the New University of Lisbon for valuable comments. The views expressed in this paper are exclusively those of the authors and not those of the Inter-American Development Bank.

[2]Krugman (2009) offers a detailed account of the steps and state of mind that paved the way for the increasing returns revolution in trade and geography, and reviews some of the many fruitful directions in which the framework has been extended in the past three decades. From an empirical perspective, Broda and Weinstein (2006) offer an assessment of the "love of variety" gains from trade in the United States.

[3]See also Neary (2003) for a non-technical overview, and Neary (2007), Neary and Tharakan (2008) and Bastos and Kreckemeier (2009) for other applications.

countries each in which there is a continuum of imperfectly competitive industries. Firms have market power, allowing for strategic interaction, within their own industries. However, since each industry is small relative to the economy as a whole, each firm treats factor prices, goods prices in the other sectors and national income parametrically. As in the monopolistic competition model, consumers seek variety and firms produce horizontally differentiated products. As a distinctive feature of our setup, the degree of product differentiation is endogenously determined, as firms optimally decide how much to invest in product innovation, taking into account that this process requires skilled labor. We also deviate from the standard framework by assuming that some industries are open to trade while others are shielded from international competition. Aggregation across sectors allows for the endogenous determination of economy-wide variables, most importantly factor rewards and aggregate welfare.

The key partial equilibrium result of our model is that trade cost reductions in non-shielded industries increase firms' incentives to invest in product innovation in order to horizontally differentiate their products from those produced by their foreign rivals. This strategic effect is shown to be predominantly caused by increased import competition, leading *ceteris paribus* to an increase in the relative demand for skilled labor. However, since trade is intraindustry, trade liberalization also leads to higher export volumes. Assuming that product innovation requires skilled labor while production requires unskilled labor, the effect of trade liberalization on the relative demand for skilled and unskilled labor is consequently ambiguous.

In general equilibrium we show that globalization – measured either as a marginal trade cost reduction in non-shielded industries or a marginal reduction in the number of shielded industries – generally leads to higher wages for both skilled and unskilled workers. The effect on the skill premium is generally ambiguous but more likely to be positive the larger the share of industries that remain shielded from international competition, and the more elastic unskilled labor supply is relative to skilled labor supply. If skill upgrading is possible, we also identify a potential welfare trade-off between output and variety. If innovation incentives outweigh production incentives, globalization might paradoxically lead to less total output, but this will be compensated for by greater product variety. Even without innovation, we show that the welfare effects of globalization are not clear-cut in our model. When parts of the economy are shielded from international competition, globalization leads to a reallocation of resources from shielded to non-shielded industries with ambiguous welfare consequences.

We proceed by showing that the partial equilibrium *import competition effect* highlighted by our model, which plays an important role in determining the general equilibrium, is consistent with Chilean panel data on manufacturing plants for the period 1996-2006. Using movements in industry-specific import tariffs and real exchange rates to identify exogenous changes in the degree of international competition, we find that manufacturing plants respond to harsher market rivalry in

their own industry by increasing the share of skilled (non-manual) workers among the workforce related to the production process. Moreover, as discussed in more detail below, we show that the data appear to rule out the possibility that this effect is fully explained by a number of competing mechanisms, notably process innovation, exporting, foreign direct investment and outsourcing.

The theory we propose contributes to reconcile a number of salient, but as yet not fully connected stylized facts, which together remain puzzling in the light of the Heckscher-Ohlin and intraindustry trade theories. While a significant proportion of trade flows is intraindustry in nature, many trade liberalization episodes were followed by an increase in wage inequality between skilled and unskilled workers (Greenaway and Nelson, 2001; Bastos and Silva, 2008; Brulhart, 2009). Furthermore, this increase in inequality was not specific to skill-abundant nations (Goldberg and Pavcnik, 2007). Taken together, these facts leave both the traditional and the new trade theories in a difficult position. The former is able to explain an increase in wage inequality in richer nations, but would predict the converse to happen in developing nations. Although modified versions have been developed that can account for an increase in inequality in developing countries (Davis, 1996), the explanation relies on intersectoral reallocations of resources towards skill-intensive industries which find scant support in the data (Wacziarg and Wallack, 2004). The latter is able in turn to explain the prevalence of intraindustry specialization, but is silent with regard to the effects of freer trade on wage inequality.[4] Our theory predicts that wage inequality could increase precisely because of intraindustry specialization in horizontally differentiated products, being therefore able to accommodate the above facts.

This paper also builds on the theory of oligopoly in partial equilibrium. In seminal work, Brander (1981) and Brander and Krugman (1983) use a one-sector model to show that intraindustry trade in homogeneous products may arise due to strategic interaction between firms. Bernhofen (2001) extends this framework to allow for *exogenous* product differentiation, and shows that it also generates intraindustry trade in differentiated products even in the absence of increasing returns to scale, and irrespective of whether competition is Cournot or Bertrand.[5] As in the current paper, but in a closed economy setting, Lin and Saggi (2002) assume that product differentiation is costly and show that it is affected by strategic interaction between producers. By focusing on a single industry, however, this framework is not suited to examine general equilibrium interactions between goods markets and factor markets, a fact that is considered to be at the root of the relatively minor role thus far played by oligopoly theory in international trade (Neary, 2003, 2009, 2010).

[4] An integrated version of these two models, commonly referred to as the Chamberlin-Heckscher-Ohlin model, relaxes this assumption (Helpman, 1981; Helpman and Krugman, 1985). However, its implications for the effect on trade on relative factor rewards are similar to those of traditional trade theory and rely on intersectoral reallocations of resources due to comparative advantage.

[5] Several authors have also extended the reciprocal dumping framework by including unionized labor markets in order to study wage responses to trade liberalization in a partial equilibrium setting (see, e.g., Naylor, 1998, 1999; Straume, 2002, 2003; Lommerud, Meland and Sørgard, 2003; Bastos, Kreickemeier and Wright, 2009).

A number of recent papers link globalization to wage inequality in the context of heterogeneous-firms trade models of monopolistic competition. Yeaple (2005) models a situation in which initially identical firms end up being heterogeneous due to technology choices and worker heterogeneity.[6] Trade liberalization induces the most productive firms to enter the export market, raising demand for skilled labor and thereby the skill premium. Verhoogen (2008) develops a heterogeneous-firm model with vertical product differentiation in which an exchange rate devaluation induces export-market entry and product quality upgrading to appeal to richer Northern consumers. Production of higher-quality varieties requires higher-quality workers, implying that entry into export markets tends to increase wage dispersion within industries, a mechanism that is supported by Mexican plant-level data. In contrast to these papers, a distinctive feature of our model is to highlight the role of strategic interactions between producers in shaping firms' incentives to invest in product innovation, which implies that trade liberalization may affect relative demand for skill via both import competition and exporting. The empirical part of the paper suggests that increased import competition affects manufacturing plants' relative demand for skilled workers in a way that is consistent with our model.

An alternative explanation for the observed increase in returns to skill in developing nations is the rise in foreign investment and outsourcing activities by firms originally located in developed countries. In particular, Feenstra and Hanson (1996a,b) suggest that such an outcome could arise if the outsourced activities are low-skill in a rich country like the US, but high-skill in developing nations. In the empirical analysis of this paper, we show that the positive effect of tariff reductions on Chilean plants' relative demand for skill is not specific to foreign-owned firms. In addition, we provide evidence that an appreciation of an industry-specific real exchange rate index generates a qualitatively similar effect, which is difficult to reconcile with the outsourcing hypothesis.

Our paper is also related to a strand of literature suggesting that trade liberalization may increase wage inequality via greater incentives for skill-biased process innovation, including Acemoglu (2003), Dinopoulos and Segerstrom (1999), Ekholm and Midelfart Knarvik (2005) and Thoenig and Verdier (2000). In seeking to explain the aforementioned stylized facts, however, these models are vulnerable to the critique that in many countries trade liberalization was followed by an increase in wage inequality, but not by significant aggregate productivity growth (Gordon, 2000; Rodriguez and Rodrik, 2001). An exception is Neary (2002) who draws attention to the role of lower import barriers in determining firms' strategic investment in process innovation to deter foreign entry. In contrast to Neary (2002), however, the current paper stresses the role of trade-induced product innovation and shows that relative demand for skilled labor may increase even when actual intraindustry trade volumes expand. Moreover, it uncovers a potential trade-

[6] Bustos (2005) embeds a similar mechanism into a heterogeneous-firm trade model a la Melitz (2003) and derives similar implications.

off between production and variety, which might contribute to explain the coexistence of trade liberalization, increased wage inequality, and slow productivity growth.

Finally, the theory of this paper contributes to making sense of an emerging body of evidence suggesting that increased import competition fosters product innovation in both developed and developing countries (Bertschek, 1995; Bloom, Draca and Van Reenen, 2009; Fernandes and Paunov, 2009; Gorodnichenko, Svejnar and Terrel, 2010; Lu and Ng, 2009). In the context of this strand of work, a distinctive aspect of our empirical analysis is the focus on the effect of international competition on the relative demand for skilled workers within manufacturing plants, a mechanism that, as discussed above, plays an important role in our theoretical model.

The remainder of the paper is structured as follows. Section 2 presents the setup of the theoretical model. Section 3 shows how the partial equilibrium in the production game is determined. Section 4 solves for the general equilibrium with exogenous product differentiation. Section 5 introduces endogenous product differentiation in partial equilibrium, before Section 6 analyzes the general equilibrium. Section 7 presents the data employed and discusses the empirical strategy, then presents the empirical results. Finally, Section 8 offers some concluding remarks.

2 Theoretical Model

There are two identical countries – "domestic" and "foreign" – and in each country there is a continuum of imperfectly competitive industries defined on the unit interval. In line with the GOLE framework of Neary (2009), firms have market power, allowing for strategic interaction, within their own industry. However, since each industry represents an infinitesimal part of the economy, each firm treats all economy-wide variables as exogenously given.

In each industry, two horizontally differentiated products are produced by, respectively, a domestic and a foreign firm. However, some of these industries are shielded from international competition while others are not. More specifically, in all industries $z \in [0, \widehat{z}]$ both domestic and foreign firms engage in intraindustry trade, à la Brander (1981) and Brander and Krugman (1983), under the assumption of Cournot competition in segmented markets, where internationally traded goods are subject to a per-unit tariff t. In each of the remaining industries $z \in (\widehat{z}, 1]$ there is a domestic (foreign) monopolist that is shielded from international competition.

In each industry, firms play a two stage game. In the first stage, as in Lin and Saggi (2002), firms invest in product innovation which increases the degree of horizontal product differentiation. In the second stage, firms choose production quantities at home and abroad under the assumption of market segmentation. Realistically, product innovation is more skill intensive than production. We capture this in a simple way by assuming that product innovation requires only skilled labor,

while production requires only unskilled labor.[7] We will explore different assumptions about the supply of the two types of labor.

The utility of a representative consumer in the domestic country is given by

$$U\left[q_i\left(z\right), q_j\left(z\right)\right] = \int_0^1 u\left[q_i\left(z\right), q_j\left(z\right)\right] dz, \tag{1}$$

where, in each sector z, q_i is quantity consumed of the domestic product while q_j is quantity consumed of the foreign product. Notice that, due to our assumption of shielded and non-shielded sectors, $q_j = 0$ for $z \in (\widehat{z}, 1]$. We assume that the sub-utility function takes the following quadratic form:

$$u\left[q_i\left(z\right), q_j\left(z\right)\right] = q_i\left(z\right) + q_j\left(z\right) - \frac{1}{2}\left[q_i\left(z\right)^2 + q_j\left(z\right)^2 + 2b\left(z\right) q_i\left(z\right) q_j\left(z\right)\right], \tag{2}$$

where the implied degree of product differentiation, b^{-1}, will be endogenously determined by the amount of product innovation undertaken by the firms in each industry. It is thus potentially industry-specific. More specifically, $b\left(z\right)$ is given by $b\left(s_i, s_j\right)$, where s_i and s_j are the amounts of skilled labor employed by the domestic and foreign firm, respectively. We assume that $\frac{\partial b}{\partial s_k} < 0$ and $\frac{\partial^2 b}{\partial s_k^2} > 0$ for $k = i, j$. Since product innovation only affects parameter b, only firms in non-shielded sectors that face international competition have incentives to spend resources on innovation activities.[8]

We assume that each product can be produced using unskilled labor in a constant-returns-to-scale technology where one unit of output requires one unit of labor.[9] Both types of labor are perfectly mobile across industries within a country but internationally immobile. Denoting the skilled and unskilled wage in the domestic country by w_s and w_u, respectively, ex ante profits for a representative domestic firm in industry $z \in [0, \widehat{z}]$ are given by

$$\Pi_i\left(z\right) = \pi_i\left(z\right) - w_s s_i\left(z\right), \tag{3}$$

where

$$\pi_i\left(z\right) = p_i\left(z\right) q_i\left(z\right) + \left[p_i^*\left(z\right) - t\right] q_i^*\left(z\right) - w_u\left[q_i\left(z\right) + q_i^*\left(z\right)\right]. \tag{4}$$

[7] If we relax this assumption to let both types of activities require both types of labor, our results will be qualitatively the same as long as product innovation is more skill intensive than production.

[8] We model product innovation as a change in b, which is a parameter in the utility function, but we should not interpret this as changing consumers' preferences (as in the case of persuasive advertising). Rather, we can think of consumers having preferences over a range of possible varieties but where only two of them are actually available in the market. If product innovation means that a firm stops producing the current variety and switches to producing a different variety that is more differentiated from the product supplied by the competitor, this would be exactly equivalent to a reduction in b.

[9] Notice that by assuming constant returns to scale we are shutting down one of the two sources of gains from trade identified by Krugman (1979), namely economies of scale.

Here and throughout the analysis, variables with an asterisk refer to the foreign country.[10] By setting $s_i = 0$ and $q_i^* = 0$ in (3)-(4), we arrive at the profits for a representative firm in industry $z \in (\widehat{z}, 1]$.

From individual utility maximization, the indirect (domestic) demand function in industry z is given by

$$p_i(z) = \begin{cases} \frac{1}{\lambda}\left(1 - q_i(z) - b(z)\, q_j(z)\right) & if \quad z \in [0, \widehat{z}] \\ \frac{1}{\lambda}\left(1 - q_i(z)\right) & if \quad z \in (\widehat{z}, 1] \end{cases}, \tag{5}$$

where λ is the marginal utility of income in the domestic country. The corresponding direct demand function is

$$q_i(z) = \begin{cases} \frac{1}{1+b(z)} - \frac{\lambda}{1-b(z)^2}\left(p_i(z) - b(z)\, p_j(z)\right) & if \quad z \in [0, \widehat{z}] \\ 1 - \lambda p_i(z) & if \quad z \in (\widehat{z}, 1] \end{cases}. \tag{6}$$

Assuming that b is identical in all non-shielded industries (which will be the case in equilibrium), the marginal utility of income can be expressed as[11]

$$\lambda = \frac{\frac{1}{1+b}\mu_1^p + \widehat{\mu}_1^p - I}{\frac{1}{1-b^2}\mu_2^p + \widehat{\mu}_2^p - \frac{b}{1-b^2}\upsilon^p}, \tag{7}$$

where I is the income[12] of the representative domestic consumer[13] and

$$\begin{aligned} \mu_1^p &= \int_0^{\widehat{z}} \left(p_i + p_j\right) dz, \quad \widehat{\mu}_1^p = \int_{\widehat{z}}^1 p_i dz, \\ \mu_2^p &= \int_0^{\widehat{z}} \left(p_i^2 + p_j^2\right) dz, \quad \widehat{\mu}_2^p = \int_{\widehat{z}}^1 p_i^2 dz, \\ \upsilon^p &= 2\int_0^{\widehat{z}} \left(p_i p_j\right) dz. \end{aligned}$$

The indirect utility function of the representative domestic consumer, which is the relevant measure of domestic welfare, is given by[14]

$$V = \frac{1}{1+b}\left(\widehat{z} - \frac{\lambda^2\left(\mu_2^p - b\upsilon^p\right)}{2\left(1-b\right)}\right) + \frac{1}{2}\left(\left(1 - \widehat{z}\right) - \lambda^2 \widehat{\mu}_2^p\right). \tag{8}$$

[10] $q_i^*(z)$ is the quantity exported and sold to the foreign country by the domestic firm in industry z, while $p_i^*(z)$ is the price this firm can charge in the export market.

[11] Where appropriate, we use "$\widehat{\ }$" to denote variables that refer to the shielded sectors of the economy.

[12] In addition to wage income, we assume that profits and tariff revenues are costlessly redistributed to consumers.

[13] The fact that the subutility function (2) is a special case of the Gorman polar form allows for consistent aggregation over consumers with different incomes and enables us to use a representative consumer framework (see Neary, 2009).

[14] Again we assume that $b(z) = b$ for $z \in [0, \widehat{z}]$.

In this paper we are foremostly interested in studying the effects of globalization on wages and resource allocation between innovation and production in general equilibrium. In our modelling framework we have two adequate measures of globalization: (i) a reduction of trade costs (lower t) in non-shielded industries, and (ii) a reduction in the number of shielded industries in the economy (higher $\widehat{z}$). In the following, we will refer to t^{-1} as the degree of *product market integration*, while we refer to $\widehat{z}$ as the degree of *trade openness*.

3 Partial Equilibrium in the Production Subgame

We start by solving the model in partial equilibrium at the second stage of the game. Due to the segmented market hypothesis, we can analyze the two markets separately. Furthermore, since the two countries are identical in all respects, it must be the case that $\lambda^* = \lambda$, $w_u^* = w_u$ and $w_s^* = w_s$ in equilibrium.

For a given value of b, and in a *non-shielded* industry $z \in [0, \widehat{z}]$, the optimal quantities set by the domestic and foreign firms *in the domestic market* are indirectly given by

$$\frac{1}{\lambda}\left(1 - 2q_i - bq_j\right) - w_u = 0 \tag{9}$$

and

$$\frac{1}{\lambda}\left(1 - 2q_j - bq_i\right) - w_u - t = 0. \tag{10}$$

Simultaneously solving (9)-(10) and applying symmetry, equilibrium output in both markets are given by

$$q_i = q_j^* = \frac{\left(1 - \lambda w_u\right)\left(2 - b\right) + \lambda b t}{\left(2 - b\right)\left(2 + b\right)} \tag{11}$$

and

$$q_j = q_i^* = \frac{\left(1 - \lambda w_u\right)\left(2 - b\right) - 2\lambda t}{\left(2 - b\right)\left(2 + b\right)}. \tag{12}$$

In a *shielded* industry $z \in (\widehat{z}, 1]$, there is a domestic monopolist which sets the profit-maximizing quantity

$$\widehat{q_i} = \frac{1}{2}\left(1 - \lambda w_u\right). \tag{13}$$

As the real variables are homogeneous at degree zero in λ^{-1}, w_u and t, we can adopt the usual convention of choosing the marginal utility of income as numeraire and normalize by setting

$\lambda = 1$.[15] In each industry $z \in [0, \widehat{z}]$, equilibrium prices are then given by

$$p_i = p_j^* = \frac{(2-b)(1+w_u(1+b)) + bt}{(2-b)(2+b)} \tag{14}$$

and

$$p_j = p_i^* = \frac{(2-b)(1+w_u(1+b)) + t(2-b^2)}{(2-b)(2+b)}, \tag{15}$$

while profits are given by

$$\pi_i = \pi_j = \frac{((2-b)(1-w_u)+bt)^2}{(2-b)^2(2+b)^2} + \frac{((1-w_u)(2-b)-2t)^2}{(2-b)^2(2+b)^2}, \tag{16}$$

where the first (second) term is the profit earned from the home (export) market. It follows from (12) that there will be intraindustry trade in equilibrium if the tariff t is below a prohibitive level $\bar{t}$, given by

$$\bar{t} = \frac{(2-b)}{2}(1-w_u). \tag{17}$$

In each industry $z \in (\widehat{z}, 1]$, the market price and profits are given by

$$\widehat{p}_i = \frac{1}{2}(1+w_u) \tag{18}$$

and

$$\widehat{\pi}_i = \frac{1}{4}(1-w_u)^2. \tag{19}$$

4 General Oligopolistic Equilibrium with Exogenous Product differentiation

We consider first the case where the degree of product differentiation is exogenously given, implying that only unskilled labor is demanded. The labor market is assumed to be perfectly competitive with the supply of unskilled labor inelastically given by L_u. In general equilibrium, demand must equal supply in the labor market. The full employment condition is given by

$$L_u = \int_0^{\widehat{z}} (q_i + q_i^*)\, dz + \int_{\widehat{z}}^1 \widehat{q}_i dz, \tag{20}$$

[15] This implies that wages are expressed in real terms at the margin (Neary, 2007).

or, using (11), (12) and (13),

$$L_u = \widehat{z}\left(\frac{2\left(1-w_u\right)-t}{2+b}\right)+\left(1-\widehat{z}\right)\frac{1}{2}\left(1-w_u\right). \tag{21}$$

In general equilibrium, the unskilled wage is given by

$$w_u = 1-\frac{2\left(L_u\left(2+b\right)+t\widehat{z}\right)}{\Phi}, \tag{22}$$

where $\Phi := 2+b+\left(2-b\right)\widehat{z} > 0$. This implies that the condition for intraindustry trade in the non-shielded industries is $t < L_u\left(2-b\right)$. Since $\partial w_u/\partial t < 0$ and $\partial w_u/\partial\widehat{z} > 0$, the following result obtains:

Proposition 1. *In general oligopolistic equilibrium with exogenous product differentiation, the unskilled wage will increase as a result of globalization, measured either as product market integration (lower t) or increased trade openness (higher $\widehat{z}$).*

This result is not surprising and is well in line with previous literature. A trade cost reduction implies that each firm in non-shielded industries faces stronger import competition. In a symmetric model with two-way trade, this also implies that the competitiveness of each firm increases in the export markets. With linear demand, the export market effect always outweighs the import competition effect, leading to an overall increase in labor demand. Due to the economy-wide resource constraint (fixed labor supply), the unskilled wage will increase in general equilibrium. This leads in turn to a reallocation of resources from shielded to non-shielded industries. Notice also that the positive wage effect of increased product market integration is stronger the larger the share of industries that are opened to trade ($\widehat{z}$). The effect of opening up more industries to international competition is similar, since this is equivalent to reducing trade costs from above to below the prohibitive level in more industries.

Since total resources in the economy are fixed, the wage increase due to lower t or higher $\widehat{z}$ generally implies that globalization shifts rents from firms to workers. However, the effects on profits are different in shielded and non-shielded sectors, and it is not necessarily the case that all firms suffer from increased international competition. Clearly, all firms in shielded sectors are negatively affected by lower trade costs in non-shielded industries, due to the increased cost of labor. Regarding equilibrium profits in non-shielded sectors, the effects of globalization are given by

$$\frac{\partial\pi_i}{\partial t} = \frac{2\left[t\left(4+b^2+\widehat{z}\left(2-b\right)\left(2b+\left(2-b\right)\widehat{z}\right)\right)-2L_u\left(2-b\right)^2\left(1-\widehat{z}\right)\right]}{\left(2-b\right)^2\Phi^2} \gtrless 0, \tag{23}$$

and

$$\frac{\partial\pi_i}{\partial\widehat{z}} = -\frac{4\left(4L_u-t\left(1-\widehat{z}\right)\right)\left(L_u\left(2-b\right)-t\right)}{\Phi^3} < 0. \tag{24}$$

If more industries are opened up to trade, this reduces equilibrium profits for firms in the industries that were already non-shielded. This is simply due to higher wages. However, a trade cost reduction has an ambiguous effect on profits in the non-shielded industries. In particular, if both $\widehat{z}$ and t is sufficiently low, reduction of trade costs will increase profits. The reason is that the wage increase will be counteracted by an output expansion due to a shift in resources from shielded to non-shielded sectors. This is not possible if all industries are open to trade (i.e., $\widehat{z}=1$); in this case a trade cost reduction will effectually just be a transfer of rents from firms to workers.

Proposition 2. *(i) Increased trade openness (higher $\widehat{z}$) leads to lower profits in all sectors of the economy.*

(ii) Product market integration (lower t) leads to lower profits in shielded sectors while profits in non-shielded sectors will increase if t and $\widehat{z}$ are both sufficiently low.

In general equilibrium, prices in industries $z\in[0,\widehat{z}]$ are given by

$$p_i=1-\left(\frac{2L_u\left(1+b\right)\left(2-b\right)+t\left(\widehat{z}\left(2-b\right)-b\right)}{\Phi\left(2-b\right)}\right) \tag{25}$$

and

$$p_j=1-\left(\frac{2L_u\left(1+b\right)\left(2-b\right)-t\left(\left(2-b^2\right)-b\widehat{z}\left(2-b\right)\right)}{\Phi\left(2-b\right)}\right), \tag{26}$$

while prices in industries $z\in(\widehat{z},1]$ are given by

$$\widehat{p}_i=1-\frac{L_u\left(2+b\right)+t\widehat{z}}{\Phi}. \tag{27}$$

Inserting these equilibrium prices into (8), we can derive an expression for domestic welfare that is a function of parameters b, t, $\widehat{z}$ and L_u :

$$V=\frac{\left[\begin{array}{c}L_u\left(2-b\right)^2\left(2\Phi^2-L_u\left(\left(2+b\right)^2+\widehat{z}\left(4\left(1+b\right)-b^2\right)\right)\right)\\-t\widehat{z}\left(t\left(\left(4-3b^2\right)+\widehat{z}\left(2-3b\right)\left(2-b\right)\right)-2L_ub\left(2-b\right)^2\left(1-\widehat{z}\right)\right)\end{array}\right]}{2\left(2-b\right)^2\Phi^2}. \tag{28}$$

The welfare effect of product market integration is given by

$$\frac{\partial V}{\partial t}=\widehat{z}\frac{L_ub\left(2-b\right)^2\left(1-\widehat{z}\right)-t\left(\left(4-3b^2\right)+\widehat{z}\left(2-3b\right)\left(2-b\right)\right)}{2\left(2-b\right)^2\Phi^2}. \tag{29}$$

Interestingly, the sign of (29) is generally ambiguous and depends crucially on the degree of trade openness ($\widehat{z}$) and the degree of product differentiation (b^{-1}). If all industries are open to trade (i.e., $\widehat{z}=1$), (29) reduces to

$$\left.\frac{\partial V}{\partial t}\right|_{\widehat{z}=1}=-\frac{\left(1-b\right)t}{2\left(2-b\right)^2}<0, \tag{30}$$

implying that a trade cost reduction always increases welfare as long as products are differentiated ($b < 1$). Even if total output is unchanged in general equilibrium, the product mix changes (some home-market production is replaced by export production) and welfare increases due to a love-of-variety effect.

However, if some sectors are shielded from trade, product market integration will shift some production from shielded to non-shielded sectors. This will increase the price differential between non-shielded and shielded products, which – all else equal – reduces welfare. This means that the overall welfare effect of product market integration is positive only if the love-of-variety effect is sufficiently strong. In the special case of homogeneous products, where the love-of-variety gain from trade is eliminated, product market integration will always reduce welfare as long as some sectors are shielded from international trade:[16]

$$\left.\frac{\partial V}{\partial t}\right|_{b=1} = \frac{\widehat{z}\left(L_u - t\right)\left(1-\widehat{z}\right)}{2\left(3+\widehat{z}\right)^2} > 0. \tag{31}$$

A similar ambiguity is found when we consider the welfare effect of increasing the degree of trade openness. Considering, for simplicity, the special case of $t = 0$, the effect is given by

$$\left.\frac{\partial V}{\partial \widehat{z}}\right|_{t=0} = \frac{L_u^2}{2\Phi^3}\left[(2+b)\left(4\left(1-b\right)-b^2\right)+\widehat{z}\left(2-b\right)\left(4\left(1+b\right)-b^2\right)\right]. \tag{32}$$

The sign of this expression is positive if the degree of product differentiation is sufficiently high: $b < 2\left(\sqrt{2}-1\right)$. However, if products are sufficiently close substitutes, we see that increased trade openness will reduce welfare if the number of shielded sectors is sufficiently high to begin with. For the special case of homogeneous products ($b = 1$), a marginal increase in trade openness will reduce welfare if $\widehat{z} < 3/7$.

Proposition 3. *(i) Product market integration (lower t) will always increase welfare if domestic and foreign products are differentiated and all sectors are open to trade. If some sectors are shielded from trade, product market integration will reduce welfare if products are sufficiently close substitutes.*

(ii) When trade is costless, increased trade openness (higher $\widehat{z}$) will always increase welfare if $b < 2\left(\sqrt{2}-1\right)$. Otherwise, if $b > 2\left(\sqrt{2}-1\right)$, a marginal increase in trade openness will reduce welfare if the initial number of shielded sectors is sufficiently high.

[16] Notice that $t < L_u$ is required for intraindustry trade to take place in general equilibrium. This condition secures the positive sign of $\left.\frac{\partial V}{\partial t}\right|_{b=1}$.

5 Product Innovation

Let us now consider the more general case where firms can invest in product innovation at the first stage of the game. Innovation incentives are only present in non-shielded sectors, where ex ante profits are given by (3). As in Lin and Saggi (2002) we assume that, in each non-shielded industry, investments in product innovation by the domestic and foreign firms have the same marginal effects on the degree of horizontal product differentiation. More specifically, we assume that $b = b(s_i + s_j)$, with $b'(\cdot) < 0$ and $b''(\cdot) > 0$. This implies that innovation investment is a pure public good for the two firms; i.e., the investment of one firm benefits both firms equally. Naturally, this implies that each firm has an incentive to free-ride on the innovation investment undertaken by the competing firm.

Assuming that the innovation technology is the same in all industries, the first-order condition for optimal product innovation by the domestic firm in industry $z \in [0, \widehat{z}]$ is given by

$$\frac{\partial \Pi_i}{\partial s_i} = \frac{\partial \pi_i}{\partial b} b'(\cdot) - w_s = 0, \tag{33}$$

where

$$\frac{\partial \pi_i}{\partial b} = -\frac{2\left(2(2-b)^3(1-w_u)(1-w_u-t) - bt^2(12+b^2)\right)}{(2-b)^3(2+b)^3}. \tag{34}$$

A closer inspection of (34) reveals that $\frac{\partial \pi_i}{\partial b} < 0$ for all $b \in [0,1]$ if

$$t < \widetilde{t} := \left(\frac{\sqrt{(2-b)^3(2+b)^3} - (2-b)^3}{(12+b^2)\, b} \right) (1-w_u). \tag{35}$$

A comparison with (17) shows that $\widetilde{t}$ is very close to the prohibitive level of trade costs for all $b \in [0,1]$. Thus, we restrict attention to the case of $t < \widetilde{t}$, where firms have an incentive to horizontally differentiate their products for every initial level of product differentiation.[17]

From (33), the equilibrium level of product innovation (and, correspondingly, the demand for skilled labor) is given by $s_i^* = s_j^* = s^*(w_u, w_s, t)$. By total differentiation of (33) we can derive some key comparative statics results in partial equilibrium:

$$\frac{\partial s^*}{\partial t} = \frac{4\left((2-b)^3(1-w_u) + tb(12+b^2)\right) b'(\cdot)}{-\frac{\partial^2 \Pi_i}{\partial s_i^2}(2-b)^3(2+b)^3} < 0, \tag{36}$$

[17] The second-order condition,

$$\frac{\partial^2 \Pi_i}{\partial s_i^2} = \frac{\partial^2 \pi_i}{\partial b^2} b'(\cdot) + \frac{\partial \pi_i}{\partial b} b''(\cdot) < 0,$$

will be satisfied if $b(\cdot)$ is sufficiently convex in s_i.

$$\frac{\partial s^*}{\partial w_u} = \frac{4\left(2\left(1-w_u\right)-t\right)b'\left(\cdot\right)}{-\frac{\partial^2\Pi_i}{\partial s_i^2}\left(2+b\right)^3} < 0, \tag{37}$$

$$\frac{\partial s^*}{\partial w_s} = \left(\frac{\partial^2\Pi_i}{\partial s_i^2}\right)^{-1} < 0. \tag{38}$$

Proposition 4. *(i) Product market integration (lower t) will increase incentives for product innovation in non-shielded industries. (ii) Innovation incentives decrease in both the skilled and the unskilled wage level.*

The first part of the proposition is the key partial equilibrium result of our analysis. If the degree of international competition intensifies due to trade cost reductions, each firm has a stronger incentive to spend resources on differentiating its product from that of its foreign competitor. Notice that this result is primarily driven by increased import competition. Using (16), where profits are defined as a sum of profits from home market and export market sales, we can decompose the effect of lower trade costs on innovation incentives through these two different channels. If we denote the profit from home market and export market sales by π_i^h and π_i^e, respectively, we have that

$$\left|\frac{\partial^2\pi_i^h}{\partial t\partial b}\right| - \left|\frac{\partial^2\pi_i^e}{\partial t\partial b}\right| = \frac{4b\left(1-t-w_u\right)}{\left(2-b\right)^2\left(2+b\right)^2} > 0,$$

confirming that the import competition effect is the dominant force with respect to innovation incentives: lower trade costs increase import competition, which firms can partly escape by differentiating their products more.

Regarding the wage effects on innovation incentives, the negative effect of a higher skilled wage is obvious, since this directly increases the cost of product innovation. The effect of the unskilled wage on innovation incentives is more interesting, particularly with respect to general equilibrium effects, which will be discussed shortly. A higher unskilled wage means that production is more costly, which reduces profits for all degrees of product differentiation. This consequently reduces the gain of spending resources on innovation activities.

6 General Oligopolistic Equilibrium with Product Innovation

In general equilibrium, we are primarily interested in how globalization – interpreted as reductions in either trade costs or the number of shielded industries – affects the demand for skilled versus unskilled labor and thereby the skill premium ($\frac{w_s}{w_u}$). We will analyze this question under different assumptions about the supply of skilled and unskilled labor.

6.1 Fixed Labor Supply

Assume first that the supply of skilled and unskilled labor is fixed and given by L_s and L_u, respectively. Using the previously derived expressions for labor demand in partial equilibrium, the market for skilled labor is cleared when

$$\widehat{z}s^*\left(w_u, w_s, t\right) - L_s = 0, \tag{39}$$

while the market for unskilled labor is cleared when

$$\widehat{z}\left(\frac{2\left(1-w_u\right)-t}{2+b\left(s^*\left(w_u, w_s, t\right)\right)}\right) + \left(1-\widehat{z}\right)\frac{1}{2}\left(1-w_u\right) - L_u = 0. \tag{40}$$

Totally differentiating (39)-(40) and applying Cramer's Rule, the equilibrium wage effects with respect to product market integration are given by

$$\frac{\partial w_s}{\partial t} = \frac{\Phi\frac{\partial s^*}{\partial t} - 2\widehat{z}\frac{\partial s^*}{\partial w_u}}{-\Phi\frac{\partial s^*}{\partial w_s}} \lesseqgtr 0 \tag{41}$$

and

$$\frac{\partial w_u}{\partial t} = -\frac{2\widehat{z}}{\Phi} < 0. \tag{42}$$

The effect of product market integration on the unskilled wage is unambiguously positive and does not depend directly on innovation incentives. The intuition is equivalent to the one given for Proposition 1. The effect on the skilled wage, however, is a priori ambiguous. On the one hand, trade cost reductions increase innovation incentives, which drives up the skilled wage. On the other hand, demand for unskilled labor is also increased, which drives up w_u and dampens innovation incentives. The ambiguity can be resolved by using (36)-(38), yielding

$$\frac{\partial w_s}{\partial t} = \frac{4b'\left(\cdot\right)\left[\left(1-\widehat{z}\right)\left(\left(2-b\right)^3\left(1-w_u\right)+tb^3\right)+2t\left(6b+\widehat{z}\left(4-2b+b^2\right)\right)\right]}{\left(2+b\right)^2\left(2-b\right)^3\Phi} < 0, \tag{43}$$

which confirms that the direct effect always dominates the indirect one.

Thus, a marginal reduction in trade costs leads to higher wages for both types of workers. Obviously, the effect on the skill premium depends on the relative strength of the wage responses. A direct comparison of (42) and (43) shows quite clearly that the parameters $\widehat{z}$ and t both play a crucial role. While the unskilled wage response is independent of t, a higher initial level of trade costs will increase the response of the skilled wage, thus increasing the likelihood that product market integration increases the skill premium. A higher skill premium due to lower trade costs is also more likely if the number of shielded sectors in the economy is high. This is most clearly seen

by considering the limit $\widehat{z} \to 0$. In this case, a trade cost reduction will unambiguously increase the skilled wage while leaving the unskilled wage (almost) unchanged in general equilibrium. The reason is that the increase in the economy-wide demand for unskilled labor is smaller if the number of non-shielded industries (which are the ones affected by a trade cost reduction) is low. The dampening effect of an unskilled wage increase on innovation incentives is correspondingly low and the skill premium will increase.

We summarize as follows:

Proposition 5. *With fixed labor supply, product market integration (lower t) leads to higher wages for both skilled and unskilled labor in general equilibrium. The skill premium will increase if the number of shielded industries in the economy is sufficiently high. The scope for an increase in the skill premium is larger if trade costs are high to begin with.*

Turning now to the wage effects of increased trade openness, we set, for simplicity, trade costs to zero in non-shielded industries: $t = 0$. From (39)-(40), we have

$$\frac{\partial w_s}{\partial \widehat{z}} = \frac{s^* (2+b) \Phi + \widehat{z} \frac{\partial s^*}{\partial w_u} \Psi (1 - w_u)}{2 (2+b)^2 |J|} \gtrless 0 \tag{44}$$

and

$$\frac{\partial w_u}{\partial \widehat{z}} = -\frac{\widehat{z} \frac{\partial s^*}{\partial w_s} \Psi (1 - w_u)}{2 (2+b)^2 |J|} = \frac{\Psi (1 - w_u)}{\Phi (2+b)} > 0, \tag{45}$$

where $|J| = -\widehat{z} \frac{\partial s^*}{\partial w_s} \frac{2+b+(2-b)\widehat{z}}{2(2+b)} > 0$ and $\Psi := 4 s^* b' (\cdot) + 4 - b^2 > 0$.[18] Compared with the wage responses to trade cost reductions, we see here that the wage effects of increased trade openness are somewhat less clear-cut. The unskilled wage will increase, but the sign of the skilled wage response is ambiguous. More precisely, the skilled wage will increase if $\widehat{z}$ remains sufficiently low but may decrease otherwise. If one more industry is opened to trade, demand for both types of labor will increase in this sector. However, the resulting increase in the unskilled wage will dampen innovation incentives – and thus demand for skilled labor – in all industries that are *already open to trade*. If these industries constitute a sufficiently large part of the economy, the overall effect of opening up one more industry to trade could be that the wage level for skilled labor is reduced in general equilibrium. However, as long as $\widehat{z}$ remains sufficiently low, increased trade openness will always increase the skilled wage and, by comparing (44) and (45), we also see that the wage

[18] Applying the first-order condition for optimal product innovation, (33), $\Psi > 0$ if $w_s s^* < \frac{(2-b)(1-w_u)^2}{(2+b)^2}$. This condition must always hold in equilibrium, since $\frac{(2-b)(1-w_u)^2}{(2+b)^2}$ is larger than any possible profit gain from product innovation.

response will be stronger for skilled than for unskilled labor, implying a higher skill premium.[19] The intuition is similar to the equivalent result for trade cost reductions.

Proposition 6. *With fixed labor supply and zero trade costs in non-shielded industries, a marginal increase in trade openness will increase the unskilled wage while the skilled wage response is ambiguous in general equilibrium. Both the skilled wage and the skill premium will increase if the number of shielded industries remains sufficiently large.*

6.2 Elastic Labor Supply

Let us now relax the assumption of fixed labor supply and assume that the supply of skilled and unskilled labor is given by $L_s(w_s)$ and $L_u(w_u)$, respectively, where $\frac{\partial L_s}{\partial w_s} > 0$ and $\frac{\partial L_u}{\partial w_u} > 0$.[20] That the labor supply of skilled (unskilled) labor only depends on the skilled (unskilled) wage level implies that we here disregard the possibility of skill upgrading. We will return to that issue in the next subsection.

For simplicity, we will here set $\widehat{z} = 1$ and just focus on the effects of trade cost reductions. Using the two general equilibrium conditions, (39)-(40), with $L_s = L_s(w_s)$ and $L_u = L_u(w_u)$, the equilibrium wage effects of product market integration are given by

$$\frac{\partial w_s}{\partial t} = \frac{\frac{\partial s^*}{\partial t}\left(2 + (2+b)\frac{\partial L_u}{\partial w}\right) - \frac{\partial s^*}{\partial w_u}}{(2+b)^2 |J|} < 0 \tag{46}$$

and

$$\frac{\partial w_u}{\partial t} = \frac{(2+b)\left(\frac{\partial s^*}{\partial w_s} - \frac{\partial L_s}{\partial w_s}\right) - \frac{\partial L_s}{\partial w_s} b'(\cdot)\frac{\partial s^*}{\partial t}(2(1-w)-t)}{(2+b)^2 |J|} < 0. \tag{47}$$

As with fixed labor supply, both wage responses are unambiguous in sign. The negative sign of (46) is confirmed by noticing that, compared with (41), elastic supply of skilled labor just adds a negative term in the numerator. It is more interesting to see how the relationship between product market integration and the skill premium is affected by elastic labor supply. Since the numerator of (46) is decreasing in the magnitude of $\frac{\partial L_u}{\partial w}$ while the numerator of (47) is decreasing in the

[19] Since $\frac{\partial w_u}{\partial \widehat{z}} = \frac{\Psi(1-w_u)}{\Phi(2+b)}$ and $\frac{\partial w_s}{\partial \widehat{z}} \to \infty$ if $\widehat{z} \to 0$, it follows that

$$\frac{\partial\left(\frac{w_s}{w_u}\right)}{\partial \widehat{z}} = \frac{\frac{\partial w_s}{\partial \widehat{z}} w_u - \frac{\partial w_u}{\partial \widehat{z}} w_s}{(w_u)^2} > 0$$

if $\widehat{z}$ is sufficiently low.

[20] Since we are only interested here in the general equilibrium effects of globalization on the skill premium, we include elastic labor supply in a rather ad hoc fashion, by simply assuming that the total number of skilled and unskilled labor units supplied are increasing functions of the skilled and unskilled wage, respectively. In order to make welfare inferences we would have to endogenously derive labor supply from individual utility maximization.

magnitude of $\frac{\partial L_s}{\partial w_s}$, we have the following result:

Proposition 7. *Product market integration (lower t) is more likely to increase the skill premium if the supply of unskilled labor is elastic relative to the supply of skilled labor.*

The intuition behind this result is twofold and composed of a direct and an indirect effect. The direct effect is obvious: the more elastic the supply of unskilled labor, the lower the equilibrium wage increase due to lower trade costs. However, there is an indirect effect through innovation incentives. A lower wage increase for unskilled labor will increase incentives for product innovation and reinforce the skilled wage increase.

6.3 Costless Skill Upgrading

At least in the longer run, one would expect that even if total labor supply is fixed, the relative remuneration of skilled and unskilled labor will influence the relative supply of these two types of labor. If we allow for skill upgrading (or downgrading), resources can be shifted between the two activities: innovation and production. If the total amount of resources in the economy is fixed, this has interesting implications for the welfare effects of globalization. Since consumers enjoy both higher output and more product variety, there is a welfare trade-off between the two activities in the economy. If globalization leads to a shift in resource use from production to innovation, the love-of-variety effect of globalization will be reinforced, but this comes at the expense of lower total output. Vice versa, globalization might paradoxically lead to less product variety if resources are shifted from innovation to production, but this is then compensated for by an increase in total output.

We can illustrate this trade-off in a simple way by assuming that skill upgrading is costless. This effectually means that wages will be identical for skilled an unskilled workers in general equilibrium. Assuming that total labor supply is fixed and equal to L, a share δ will be allocated to innovation while the remaining share $(1-\delta)$ will be allocated to production. The share δ will then be endogenously determined in general equilibrium by the following two market- clearing conditions:

$$\widehat{z}s^{*}\left(w,t\right)-\delta L=0, \tag{48}$$

$$\widehat{z}\left(\frac{2\left(1-w\right)-t}{2+b\left(s^{*}\left(w,t\right)\right)}\right)+\left(1-\widehat{z}\right)\frac{1}{2}\left(1-w\right)-\left(1-\delta\right)L=0, \tag{49}$$

where w is the uniform wage level for both types of labor/activities. Totally differentiating (48)-(49) and applying Cramer's Rule, the effects of product market integration on wages and resource

allocation are given by

$$\frac{\partial w}{\partial t} = \frac{-\frac{\partial s^*}{\partial t}\left(\left(2\left(1-w\right)-t\right)b'\left(\cdot\right)-\left(2+b\right)\left(1+b\right)\right)}{-\frac{\partial s^*}{\partial w}\left[\left(2+b\right)^2-\left(2\left(1-w\right)-t\right)b'\left(\cdot\right)\right]+\left(2+b\right)\left(2+\frac{\left(1-\widehat{z}\right)}{2\widehat{z}}\left(2+b\right)\right)} > 0 \tag{50}$$

and

$$\frac{\partial \delta}{\partial t} = \frac{-2\widehat{z}\frac{\partial s^*}{\partial w}+\frac{\partial s^*}{\partial t}\Phi}{2\left(2+b\right)L\left(\frac{2}{2+b}+\frac{\left(1-\widehat{z}\right)}{2\widehat{z}}-\frac{\partial s^*}{\partial w}\left(1-\frac{\left(2(1-w)-t\right)}{\left(2+b\right)^2}b'\left(\cdot\right)\right)\right)} \gtrless 0. \tag{51}$$

Equivalently, the effects of a marginal increase in the degree of trade openness (where we set $t = 0$ for analytical simplicity) are given by

$$\frac{\partial w}{\partial \widehat{z}} = \frac{-s^*-\frac{1}{2}\left(1-w\right)\left(\frac{2-b}{2+b}\right)}{\widehat{z}\frac{\partial s^*}{\partial w}-\left(\widehat{z}\left(\frac{2(2+b)+(2(1-w))}{\left(2+b\right)^2}\right)b'\left(\cdot\right)\frac{\partial s^*}{\partial w}+\frac{1}{2}\left(1-\widehat{z}\right)\right)} < 0 \tag{52}$$

and

$$\frac{\partial \delta}{\partial \widehat{z}} = \frac{s^*\left(2+b\right)\Phi+\widehat{z}\frac{\partial s^*}{\partial w}\left(1-w\right)\left[4\left(1+s^*b'\left(\cdot\right)\right)-b^2\right]}{L\left[\left(2+b\right)\Phi-2\widehat{z}\frac{\partial s^*}{\partial w}\left(2+b\right)^2+4\widehat{z}b'\left(\cdot\right)\frac{\partial s^*}{\partial w}\left(1-w\right)\right]} \gtrless 0. \tag{53}$$

Generally, both measures of globalization provide qualitatively similar results. Since the denominators of (51) and (53) are both positive, the signs of $\frac{\partial \delta}{\partial t}$ and $\frac{\partial \delta}{\partial \widehat{z}}$ depend on the signs of the respective numerators. It is straightforward to see that $\frac{\partial \delta}{\partial t} < 0$ and $\frac{\partial \delta}{\partial \widehat{z}} > 0$ if $\widehat{z}$ is below a (strictly positive) threshold level:

Proposition 8. *With fixed total labor supply and costless skill upgrading, globalization (lower t or higher $\widehat{z}$) leads to higher wages while the effect of resource allocation between innovation and production is generally ambiguous. Labor resources will be shifted from production towards innovation if the number of shielded industries ($1-\widehat{z}$) remains sufficiently high.*

These results are not surprising in light of the previous analysis and the intuition follows our previous discussion. Since the partial equilibrium effect of globalization is an increase in demand for both types of labor/activities, wages will obviously increase in general equilibrium. Due to the total resource constraint of the economy, resources will be shifted one way or the other. In general equilibrium, a key parameter for determining the direction of resource reallocation is the share of shielded versus non-shielded industries. The larger share of the economy that is shielded from international competition, the more likely it is that (marginal) globalization will lead to lower total output and more product variety.

7 Empirical Analysis

An important mechanism of our theoretical model is that, under fairly general assumptions, fiercer import competition within-industries increases firms' incentives for product innovation, and thereby relative demand for skilled labor. This effect is partial equilibrium in the sense that it results from the strategic interaction between firms within industries, each of which is small relative to the economy as a whole. Once the full set of general equilibrium effects is accounted for, however, it has potentially important implications for the distribution of national income and aggregate welfare.

In this section, we show that this partial equilibrium *import competition effect* is consistent with rich Chilean panel data on manufacturing plants. We begin with a brief description of our data, deferring a more detailed exposition to the Appendix below. We then discuss the empirical strategy and present the econometric results.

7.1 Data

The main data set we use in the empirical analysis is Chile's Annual National Industrial Survey (ENIA) for the years 1996 to 2006. This data set is a census of manufacturing plants with more than 10 employees. Each plant has a unique and time-invariant identifier, which allows us to form a panel. The set of firm attributes includes total employment, total production, value added, export volume, proportion of foreign-owned capital, and industry code (4-dig ISIC). Importantly for our purposes, the information on employment is divided into occupational categories, notably: owners, directors, administrative and other staff not related to production, skilled (non-manual) workers related to the production process, and unskilled (manual) workers linked directly or indirectly to production activities.[21]

We have supplemented the plant-level panel with information on industry-specific import-weighted tariffs and real exchange rates (Revenga, 1992; Bertrand, 2004), both defined at the 4-dig level of the ISIC classification. These measures are constructed from bilateral import tariffs and real exchange rates between Chile and its trading partners, using as weights the share of imports from each trading partner in a base period (1996-1997). Data on scheduled import tariffs by industry-country come from the UNCTAD TRAINS data set, while information on imports (also by industry-country) come from the UN COMTRADE data set. Data on nominal bilateral exchange rates and CPIs come from the IMF International Financial Statistics. The final panel employed in the empirical analysis contain information on 9,656 plants in total (4,954 plants per year on average), yielding a total of 54,591 observations. The summary statistics are shown in Table 1 (figures and tables appear at the end of the paper).

[21] See the Appendix for a detailed definition of each of these occupations.

7.2 Empirical Strategy

To examine the partial equilibrium effect of increased international competition on plants' relative demand for skilled workers, we adopt the following econometric model:

$$\text{Share}_{ijt} = \mathbf{X}'_{ijt}\alpha + \beta\text{Tariff}_{jt} + \nu_i + \tau_t + \mu_{ijt} \tag{54}$$

where i, j, and t index plant, industry and year, respectively. The dependent variable is the share of skilled (non-manual) workers among the plant's workforce related to the production process, $\mathbf{X}_{ijt}$ is a vector of other plant attributes that are included in some specifications (and $\mathbf{X}'_{ijt}$ its transpose), and Tariff_{jt} denotes the industry-specific import tariff in industry j and period t. The ν_is are fixed-effects capturing any time-invariant differences across plants, while the τ_ts are year fixed-effects capturing any common macro-shocks affecting manufacturing plants each year.[22] It is worth noting that plants do not move between industries in our sample, implying that the plant fixed-effects also take care of industry fixed-effects. As is standard in the literature (e.g., Keller and Yeaple, 2009), inference relies on standard errors clustered by industry and year to account for the fact that plants in the same industry are subject to the same level of import tariffs in a given year.

During the period of analysis, weighted import tariffs in the Chilean manufacturing sector decreased from an average of 10.5 percent in 1996 to 2 percent in 2006. While tariffs fell across the whole manufacturing sector, the magnitude and pace of the decline varied considerably across industries; Figure 1 provides an illustration for a subset of 4-dig industries. These intersectoral differences in differences play a key role in our identification strategy, which relies on within-industry changes of these variables over time to identify the effect of interest. It is also worth emphasizing that the use of static weights to construct Tariff_{jt} obviates the concern that import weights might be endogenous to movements in tariffs.

Reductions of import tariffs over the period of analysis resulted from the implementation of the Uruguay Round from 1995 and increased participation in several preferential free trade agreements (WTO, 2003, 2009). A potential concern with relying solely on import tariffs to identify the effect of international competition is that they might not be strictly exogenous to plants, especially if employers (or their workers) have some ability to influence such agreements. To address this concern, we use industry-specific (import-weighted) real exchange rates as an alternative measure. Given that bilateral exchange rates are determined in international financial markers and their evolution over time is largely unpredictable (especially in the case of a small open economy like Chile),

[22] The microeconometric empirical strategy we adopt is not suited to estimate the general equilibrium wage effects of globalization emphasized by our theory. In the model, every firm faces the same wage rates (w_u and w_s), implying that wage changes due to trade liberalization would be captured by year dummies. We therefore focus on the partial equilibrium effect of import competition on plants' relative labor demand for skilled workers, which is a key driver of the general equilibrium wage effects emphasized by our model.

they can be used to capture an exogenous variation in the degree of international competition (Revenga, 1992; Bertrand, 2004). Figure 2 illustrates how these exchange rate indexes evolved over the sample period for a number manufacturing industries.

7.3 Main Results

Table 2 presents our central estimates of the impact of international competition on the share of skilled (non-manual) workers related to the production process within manufacturing plants. Column (1) reports the estimate of equation (54) without plant-level covariates. Consistent with the *import competition effect* highlighted by our theory, the estimated effect of import tariffs is negative and significant at the 1 percent level. The point estimate indicates that if import tariffs fall by 10 percentage points the share of skilled (non-manual) workers increases by about 9 percentage points, on average. Column (4) reports the results yielded by a similar specification, but using industry-specific exchange rates as the measure of international competition. Once again the results are consistent with the competition effect: the estimated coefficient indicates that if the industry-specific real exchange rate appreciates by 10 percent, the share of skilled (non-manual) workers increases by about 0.2 percentage points, on average. Columns (2)-(3) and (5)-(6) show that, for both these variables, the magnitude of the estimates remains almost unchanged when controls for plant size are included in the regressions. Finally, columns (7)-(9) show that the results remain very similar when tariffs and real exchange rates are included simultaneously in the estimated equation.[23]

7.4 Alternative Hypotheses

We proceed by examining the extent to which the results reported above might be explained by a number of competing mechanisms. First, we worry that the rise in the share of skilled (non-manual) workers linked to the production process might be fully explained by trade-induced skill-biased process innovation. To address this concern, we modify our baseline model to control for changes in labor productivity by simultaneously including employment and value added among the regressors. The results reported in column (1) of Table 3 show that the coefficients of interest remain virtually unaltered when controlling for changes in labor productivity, suggesting that process innovation is not the main driver of the results.

As we noted in the introduction, the models of Yeaple (2005) and Verhoogen (2008) suggest that, by triggering export market entry, improved access to foreign markets could impact on plants'

[23] As a robustness check, we have also clustered the standard errors at the plant level to account for serial correlation of the error term within plants. The coefficients of interest remain always statistically significant at the 1 percent level (results available upon request).

relative demand for skilled workers. To the extent that reductions of import tariffs in Chile were accompanied by a reciprocal decrease in export barriers imposed on Chilean plants, the above estimates could potentially be contaminated by the mechanisms highlighted in these models. We address this concern by modifying our baseline model in two different ways. First, we control for plant-level exports. Second, we re-estimate the basic model on the sub-sample of firms that do not export in each year. In both cases, the results remain qualitatively unchanged, suggesting that these competing mechanisms are not the key force behind our estimates (columns (2) and (3)).

We proceed by examining the extent to which our estimates might be driven by the FDI-outsourcing hypothesis of Feenstra and Hanson (1996a,b). As these authors emphasize, demand for skilled labor could increase in both developed and developing countries if the outsourced activities are relatively low-skill in the former countries, but high-skill in the latter. To the extent that lower tariffs facilitate such export-oriented outsourcing activities, our results might be partially capturing this mechanism. We investigate this possibility by altering our baseline model in two ways. In column (4), we include the share of foreign-owned capital among the regressors. The estimates reveal that increases in foreign ownership are indeed associated with higher demand for skilled workers. The coefficient on tariffs remains little changed, however, suggesting that the effect of tariffs is not solely driven by this mechanism. To investigate this aspect further, in column (5) we re-estimate the basic model using data on firms without any foreign-owned capital. Once again the estimates remain very similar, suggesting that the FDI hypothesis is not the main driver of our results. Further, it is worth emphasizing that the positive effect of a real exchange rate appreciation on plants' relative demand for skill is difficult to reconcile with both the exporting and the outsourcing hypotheses.

Finally, we would like to note that, while our plant data do not contain suitable measures of innovation efforts towards horizontal product differentiation, there is a large body of recent evidence suggesting that increased import competition fosters product innovation in both developed and developing countries (Bertschek, 1995; Bloom, Draca and Van Reenen, 2009; Fernandes and Paunov, 2009; Gorodnichenko, Svejnar and Terrel, 2010; Lu and Ng, 2009). Accepting that product innovation is more skill-intensive than manual production activities, the estimates we provide are therefore consistent with (and complementary to) this evidence.

7.5 Further Robustness Checks

A possible concern with the fixed-effects estimates presented above is that the dependent variable is bounded in the interval [0,100]. For this reason, the least squares estimates might lead to predictions of the dependent variable outside the extreme points. Furthermore, when there are many observations lying at the boundaries of the interval (or near them), linear regression might yield

biased estimates due to its inability to deal with the inherent nonlinearities around those regions. We address this concern by estimating Tobit random-effects models. Reassuringly, the results remain qualitatively unchanged: an inspection of Table 4 reveals that the marginal effects of both measures of international competition have the expected sign, are significant at the 1 percent level, and of a larger magnitude than those reported earlier.

Finally, we worry that there might be some lag in the translation of movements in tariffs and exchange rates into adjustments of the labor force within plants. To account for this possibility, we re-estimate our basic model using industry-specific import tariffs and real exchange rate indexes dated $t-1$ in the regressions. The results, shown in Table 5, are, once again, qualitatively similar.

8 Concluding Remarks

In this paper we develop a two-country, multi-sector model of oligopoly in general equilibrium in which the degree of horizontal product differentiation is endogenously determined by firms' strategic investments in product innovation. We use the model to re-examine classic questions of trade theory: the effect of freer trade on the distribution of national income, the intersectoral allocation of resources, and aggregate welfare.

The building blocks of our theory are simple. Firms are large in their own industries, but small relative to the economy as a whole. Hence they interact strategically against their foreign rivals in their own sector, but treat parametrically all economy-wide variables. Consumers love variety and product innovation is more skill intensive than production. Greater import competition increases firms' incentives to invest in differentiating their products from those produced by their foreign rivals. Freer trade between similar nations can therefore increase the relative demand for skilled labor, and thereby the skill premium. If skill upgrading is possible, there is a potential welfare trade-off between output and variety. Provided that innovation incentives outweigh production incentives, globalization might lead to less total output, but this will be compensated for by greater product variety.

The import competition effect emphasized by our partial equilibrium analysis, which plays an important role in determining the general equilibrium, is consistent with Chilean panel data on manufacturing plants for the years 1996 to 2006. Using movements of industry-specific import tariffs and exchange rates to identify exogenous variations in the degree of import competition, we find that harsher market rivalry induces manufacturing plants to increase the share of skilled (non-manual) workers among the workforce related to the production process. In addition, we provide evidence that this effect is not fully driven by a number of competing mechanisms, notably process innovation, exporting, foreign direct investment and outsourcing.

The mechanisms emphasized by our theory contribute to explain a number of important stylized

facts, which together are difficult to reconcile with the predictions of existing trade theories: the increasing prevalence of intraindustry trade, rising wage inequality between skilled and unskilled workers in both developed and developing countries, and slow aggregate productivity growth following trade liberalization.

By way of conclusion, we would like to discuss how different modelling choices for strategic product innovation should be expected to influence the impact of trade liberalization on relative demand for skilled workers. For simplicity, we model product innovation as a pure public good for the firms in each industry. In the arguably more realistic case that innovation investments yield greater returns to the investing firm, innovation incentives would be stronger and more responsive to freer trade. Accordingly, our model could be interpreted as providing a lower bound on the likelihood that trade liberalization between similar nations increases the relative demand for skilled labor, and thereby the skill premium.

Appendix

This appendix provides further details on the data sources and variables employed in the empirical analysis.

Annual National Industrial Survey (ENIA)

The Annual National Industrial Survey (ENIA) of Chile is conducted yearly by the National Statistics Institute. All manufacturing plants with more than 10 employees are surveyed in each year. A plant may exit the panel data set if its employment level falls below this threshold and re-enter in a subsequent year if employment grows above this level again. The information on employment is detailed by occupation. Table A.1 provides a detailed description of the occupational categories.

Imports, Tariffs and Real Exchange Rates

The plant-level data set was matched by 4-dig ISIC industry and year with information on industry-specific import tariffs and real exchange rate indexes. Industry-specific tariffs are defined as the weighted average of the scheduled bilateral import tariff. The weights are the share of each country in total industry imports in a base period (1996-1997). Data on scheduled import tariffs by industry-country come from the UNCTAD TRAINS data set. Information on imports (also by industry-country) come from the UN COMTRADE data set. Due to unavailability of tariff data for the years 1996 and 2003, a linear interpolation was made for these years using data for 1995-1997 and 2002-2004, respectively.

Following Bertrand (2004), the industry-specific real exchange rate index is defined as the weighted average of the log real exchange rates of the countries of origin, where the weights are the share of each country in total industry imports in a base period (1996-1997). Real exchange rates are nominal exchange rates (in foreign currency per Chilean peso) multiplied by the ratio between the Chilean CPI and the foreign country's CPI. Data on nominal bilateral exchange rates and CPIs come from the IMF International Financial Statistics.

References

Acemoglu, D. 2003. "Patterns of Skill Premia." *Review of Economic Studies* 70: 199-230.

Bastos, P., and U. Kreickemeier. 2009. "Unions, Competition and International Trade in General Equilibrium." *Journal of International Economics* 79: 238-247.

Bastos, P., U. Kreickemeier and P. Wright. 2009. "Oligopoly, Open Shop Unions and Trade Liberalization." *International Journal of Industrial Organization* 27: 679-686.

Bastos, P., and J. Silva. 2008. "The Wage and Unemployment Impacts of Trade Adjustment." In: D. Greenaway, R. Upward and P. Wright, editors. *Globalisation and Labour Market Adjustment*. London, United Kingdom: Palgrave Macmillan.

Bernhofen, D. 2001. "Product Differentiation, Competition, and International Trade." *Canadian Journal of Economics* 34: 1010-1023.

Bertrand, M. 2004. "From the Invisible Handshake to the Invisible Hand? How Import Competition Changes the Employment Relationship." *Journal of Labor Economics* 22: 723-765.

Bertschek, I. 1995. "Product and Process Innovation as a Response to Increasing Imports and Foreign Direct Investment." *Journal of Industrial Economics* 43: 341-357.

Bloom, N., M. Draca and J. Van Reenen. 2009. "Trade-Induced Technological Change? The Impact of Chinese Imports on Innovation, Diffusion and Productivity." Stanford, United States: Stanford University Mimeographed document.

Brander, J. 1981. "Intra-Industry Trade in Identical Commodities." *Journal of International Economics* 11: 1-14.

Brander, J., and P. Krugman. 1983. "A Reciprocal Dumping Model of International Trade." *Journal of International Economics* 15: 313-321.

Broda, C., and D. Weinstein. 2006. "Globalization and the Gains from Variety." *Quarterly Journal of Economics* 121: 541-585.

Brulhart, M. 2009. "An Account of Global Intraindustry Trade, 1962-2006." *World Economy* 32: 401-459.

Bustos, P. 2005. "The Impact of Trade on Technology and Skill Upgrading: Evidence from Argentina." Barcelona, Spain: Universitat Pompeu Fabra. Mimeographed document.

Davis, D. 1996. "Trade Liberalization and Income Distribution." NBER Working Paper 5693. Cambridge, United States: National Bureau of Economic Research.

Dinopoulos, E., and P. Segerstrom. 1999. "A Schumpeterian Model of Protection and Relative Wages." *American Economic Review* 89: 450-472.

Dixit, A., and J. Stiglitz. 1977. "Monopolistic Competition and Optimum Product Diversity." *American Economic Review* 67: 297-308.

Ekholm, K., and K. Midelfart Knarvik. 2005. "Relative Wages and Trade-Induced Changes in

Technology." *European Economic Review* 49: 1637-1663.
Feenstra, R., and G. Hanson. 1996a. "Foreign Investment, Outsourcing and Relative Wages." In: R. Feenstra and G. Grossman, editors. *Political Economy of Trade Policy: Essays in Honor of Jagdish Bhagwati*. Cambridge, United States: MIT Press.
Feenstra, R., and G. Hanson. 1996b. "Globalisation, Outsourcing and Wage Inequality." *American Economic Review* 86: 240-245.
Fernandes, A., and C. Paunov. 2009. "Does Trade Stimulate Innovation? Evidence from Firm-Product Data." Washington, DC, United States: World Bank Research Department. Mimeographed document.
Goldberg, P., and N. Pavcnik. 2007. "Distributional Effects of Globalization in Developing Countries." *Journal of Economic Literature* 45: 39-82.
Gordon, J. 2000. "Has the New Economy Rendered the Productivity Slowdown Obsolete?" Evanston, United States: Northwestern University.
Gorodnichenko, Y., J. Svejnar and K. Terrell. 2010. "Globalization and Innovation in Emerging Markets." *American Economic Journal: Macroeconomics* 2: 194–226.
Greenaway, D., and D. Nelson. 2001. *Globalisation and Labour Markets*. Cheltenham, United Kingdom: Edward Elgar.
Helpman, E. 1981. "International Trade in the Presence of Product Differentiation, Economies of Scale and monopolistic competition: A Chambelin-Heckscher-Ohlin approach." *Journal of International Economics* 11: 305-340.
Helpman, H., and P. Krugman. 1985. *Market Structure and Foreign Trade*. Cambridge, United States: MIT Press.
Keller, W., and S. Yeaple. 2009. "Multinational Enterprises, International Trade, and Technology Diffusion: A Firm-Level Analysis of the Productivity Effects of Foreign Competition in the United States." *Review of Economics and Statistics* 91: 821–831.
Krugman, P. 1979. "Increasing Returns, Monopolistic Competition and International Trade." *Journal of International Economics* 9: 469-479.
Krugman, P. 2009. "The Increasing Returns Revolution in Trade and Geography." *American Economic Review* 99: 561-571.
Lancaster, K. 1979. *Variety, Equity and Efficiency*. New York, United States: Columbia University Press.
Lancaster, K. 1980. "Intra-Industry Trade under Perfect Monopolisitic Competition." *Journal of International Economics* 10: 151-175.
Lin, P., and K. Saggi. 2002. "Product Differentiation, Process R&D and the Nnature of Market Competition." *European Economic Review* 46: 201-211.
Lommerud, K.E., F. Meland and L. Sørgard. 2003. "Unionised Oligopoly, Trade Liberalisation and

Location Choice." *Economic Journal* 113: 782-801.
Lu, Y., and T. Ng. 2009. "Does Import Competition "Pull" Incremental Innovation?" Hong Kong, China: University of Hong Kong. Mimeographed document.
Melitz, M. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica* 71: 1695-1725.
Naylor, R. 1998. "International Trade and Economic Integration when Labour Markets are Generally Unionised." *European Economic Review* 42: 1251-1267.
Naylor, R. 1999. "Union Wage Strategies and International Trade." *Economic Journal* 109: 102-125.
Neary, P. 2002. "Foreign Competition and Wage Inequality." *Review of International Economics* 10: 680-682.
Neary, P. 2003. "Globalization and Market Structure." *Journal of the European Economic Association* 1: 245-271.
Neary, P. 2007. "Cross-Border Mergers as Instruments of Comparative Advantage." *Review of Economic Studies* 74: 1229-1257.
Neary, P. 2009. "International Trade in General Oligopolistic Equilibrium." Oxford, United Kingdom: University of Oxford. Mimeographed document.
Neary, P. 2010. "Two and a Half Theories of Trade." *World Economy* 33: 1-19.
Neary, P. and J. Tharakan. 2008. "Endogenous Modes of Competition in General Equilibrium." Oxford, United Kingdom: University of Oxford. Mimeographed document.
Norman, V. 1976. "Product Differentiation and Trade." Warwick, United Kingdom: University of Warwick, U.K. Economic Theory Study Group. Manuscript.
Revenga, A. 1992. "Exporting Jobs? The Impact of Import Competition on Employment and Wages in U.S. Manufacturing." *Quarterly Journal of Economics* 107: 255-284.
Rodriguez, F., and D. Rodrik. 2001. "Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Literature." In: B. Bernanke and K. Rogoff, editors. *NBER Macroeconomics Annual 2000*. Cambridge, United States: MIT Press.
Spence, M. 1976. "Product Selection, Fixed Costs, and Monopolistic Competition." *Review of Economic Studies* 43: 217-235.
Straume, O.R. 2002. "Union Collusion and Intra-Industry Trade." *International Journal of Industrial Organization* 20: 631-652.
Straume, O.R. 2003. "International Mergers and Trade Liberalisation: Implications for Unionised Labour." *International Journal of Industrial Organization* 21: 717-735.
Thoenig, M., and T. Verdier. 2003. "Trade-Induced Technical Bias and Wage Inequalities: A Theory of Defensive Innovation." *American Economic Review* 93: 709-728.
Verhoogen, E. 2008. "Trade, Quality Upgrading, and Wage Inequality in the Mexican Manufactur-

ing Sector." *Quarterly Journal of Economics* 123: 489-530.
Wacziarg, R., and J.S. Wallack. 2004. "Trade Liberalization and Inter-Sectoral Labor Movements." *Journal of International Economics* 64: 411-439.
World Trade Organization (WTO). 2003. *Trade Policy Review: Chile*. Report by the Secretariat. Geneva, Switzerland: WTO.
World Trade Organization (WTO). 2009. *Trade Policy Review: Chile* Report by the Secretariat. Geneva, Switzerland: World Trade Organization.
Yeaple, S. 2005. "A Simple Model of Firm Heterogeneity, International Trade, and Wages." *Journal of International Economics* 65: 1-20.

Figure 1. Weighted Import Tariffs, 1996-2006

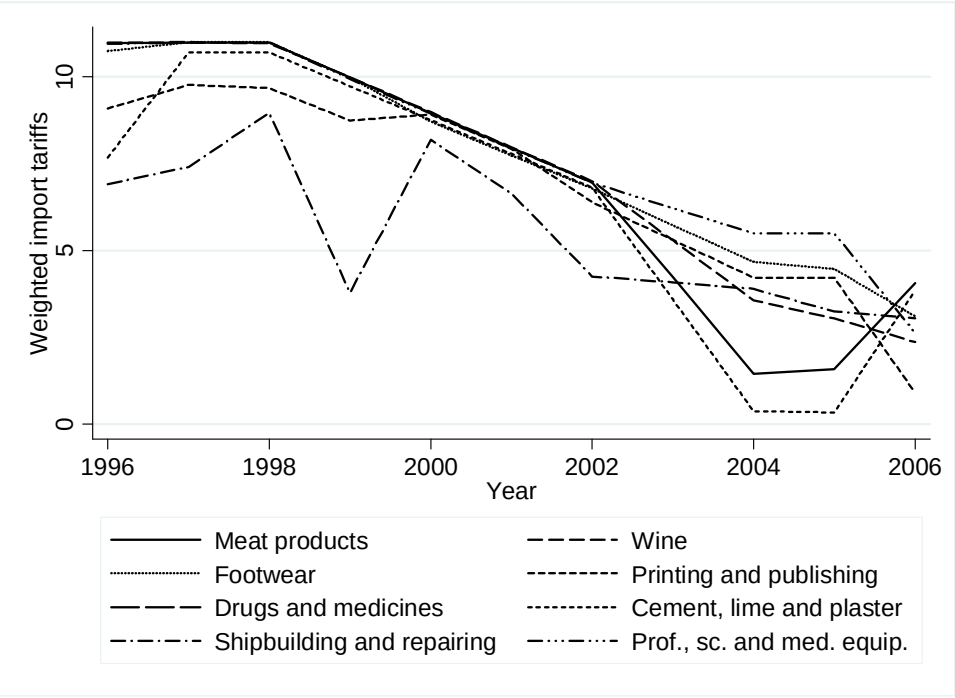

Figure 2. Import-Weighted Real Exchange Rates, 1996-2006

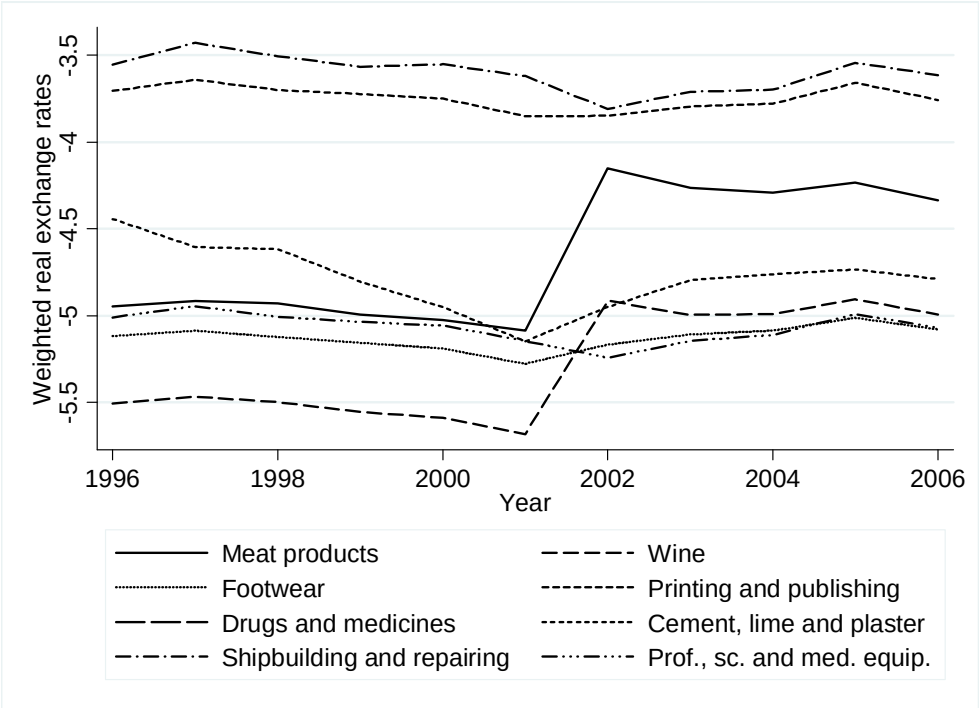

Table 1. Summary Statistics

Variable	Mean	SD
Skilled (non-manual) workers related to the production process (number of employees)	12.7	46.6
Unskilled (manual) workers related to the production process (number of employees)	37.3	89.5
Share of skilled (non-manual) workers among workforce related to the production process (%)	31.5	39.2
Total employment (number of employees)	68.1	144.7
Total production (billions of pesos)	3.0	21.3
Value added (billions of pesos)	1.6	9.8
Exports (billions of pesos)	0.7	6.6
Foreign owned capital (% of total)	4.4	19.4
Tariff	7.3	3.1
Real exchange rate (log)	-4.6	0.7
N	54591	

Notes: This table reports summary statistics on the panel data set used in the regression analysis. The period
of analysis is1996-2006.

Table 2. Baseline Estimates

Dependent variable:	Share of skilled (non-manual) workers among workforce related to the production process								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tariff	-0.924***	-0.942***	-0.941***				-0.849**	-0.865***	-0.864***
	(0.350)	(0.347)	(0.347)				(0.336)	(0.333)	(0.333)
Real exchange rate				1.876***	1.904***	1.903***	1.709***	1.733***	1.733***
				(0.565)	(0.566)	(0.566)	(0.549)	(0.551)	(0.551)
Total employment		-0.024***	-0.024***		-0.023***	-0.024***		-0.024***	-0.024***
		(0.003)	(0.003)		(0.003)	(0.003)		(0.003)	(0.003)
Production			0.003			0.004			0.003
			(0.006)			(0.006)			(0.006)
N	54591	54591	54591	54591	54591	54591	54591	54591	54591
R^2 (within)	0.033	0.035	0.035	0.033	0.035	0.035	0.034	0.036	0.036
F-statistic	49.17	52.76	49.35	44.42	47.51	44.7	47.64	51.14	48.07

Notes: The estimated method is OLS with plant-fixed effects. All regressions include 10 year-dummies. Standard errors clustered by industry-year are in parentheses (846 clusters). *** indicates significant at 1%; ** significant at 5%; * significant at 10%.

Table 3. Alternative Hypotheses

Dependent variable:	Share of skilled (non-manual) workers among workforce related to the production process				
	(1)	(2)	(3)	(4)	(5)
	All plants	All plants	Non exporters	All plants	No foreign capital
Tariff	-0.863***	-0.863***	-0.938**	-0.861***	-0.937***
	(0.333)	(0.333)	(0.365)	(0.332)	(0.336)
Real exchange rate	1.735***	1.735***	2.119***	1.743***	1.912***
	(0.550)	(0.550)	(0.661)	(0.550)	(0.562)
Total employment	-0.024***	-0.024***	-0.024***	-0.024***	-0.031***
	(0.003)	(0.003)	(0.006)	(0.003)	(0.003)
Value added	0.021	0.022	0.043**	0.020	0.030*
	(0.013)	(0.013)	(0.021)	(0.013)	(0.016)
Exports		-0.004			
		(0.017)			
Foreign capital (% of total)				0.042***	
				(0.014)	
N	54591	54591	43513	54591	51317
R^2 (within)	0.036	0.036	0.038	0.036	0.038
F-statistic	48.38	45.18	41.33	45.47	51.4

Notes: The estimated method is OLS with plant-fixed effects. All regressions include 10 year-dummies. Standard errors clustered by industry-year are in parentheses (846 clusters). *** indicates significant at 1%; ** significant at 5%; *** significant at 10%.

Table 4. Robustness Checks, Tobit Random Effects

Dependent variable:	Share of skilled (non-manual) workers among workforce related to the production process								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tariff	-1.572***	-1.595***	-1.581***				-1.489***	-1.511***	-1.495***
	(0.355)	(0.355)	(0.355)				(0.355)	(0.355)	(0.355)
Real exchange rate				2.332***	2.360***	2.411***	2.166***	2.191***	2.244***
				(0.606)	(0.605)	(0.605)	(0.607)	(0.607)	(0.607)
Total employment		-0.014***	-0.016***		-0.014***	-0.016***		-0.014***	-0.017***
		(0.003)	(0.003)		(0.003)	(0.003)		(0.003)	(0.003)
Production			0.067***			0.071***			0.069***
			(0.022)			(0.022)			(0.022)
N	54591	54591	54591	54591	54591	54591	54591	54591	54591
Log likelihood	-171754.1	-171744.58	-171739.81	-171756.51	-171747.1	-171741.83	-171747.74	-171738.06	-171732.98
X^2-statistic	1569.63	1590.59	1599.26	1564.6	1585.31	1594.93	1582.24	1603.53	1612.76

Notes: The estimated method is Tobit with plant random-effects. All regressions include 10 year-dummies. Standard errors in parentheses. *** indicates significant at 1%; ** significant at 5%; * significant at 10%.

Table 5. Robustness Checks, Lagged Tariffs and Exchange Rates

Dependent variable:	Share of skilled (non-manual) workers among workforce related to the production process								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tariff $_{t-1}$	-1.063***	-1.093***	-1.092***				-0.966**	-0.995***	-0.994***
	(0.395)	(0.389)	(0.389)				(0.382)	(0.376)	(0.376)
Real exchange rate $_{t-1}$				1.547***	1.579***	1.578***	1.297***	1.322***	1.321***
				(0.529)	(0.528)	(0.528)	(0.499)	(0.499)	(0.499)
Total employment		-0.024***	-0.024***		-0.023***	-0.024***		-0.024***	-0.024***
		(0.003)	(0.003)		(0.003)	(0.003)		(0.003)	(0.003)
Production			0.003			0.004			0.003
			(0.006)			(0.006)			(0.006)
N	54591	54591	54591	54591	54591	54591	54591	54591	54591
R^2 (within)	0.033	0.0352	0.0352	0.0333	0.035	0.035	0.034	0.035	0.035
F-Statistic	47.54	51.49	48.23	43.48	46.57	43.84	45.65	49.40	46.5

Notes: The estimated method is OLS with plant-fixed effects. All regressions include 10 year-dummies. Standard errors clustered by industry-year are in parentheses (846 clusters). *** indicates significant at 1%; ** significant at 5%; * significant at 10%.

Table A1. Occupational Categories in ENIA

Occupation	Definition
Skilled (non-manual) workers related to the production process	Professional, technical and skilled workers directly related to the production process, controlling and directing the process.
Unskilled (manual) workers related to the production process	Manual workers directly or indirectly linked to the production process.
Owners, partners and family workers	Owners and partners that participate actively in the plant's activities. Family workers without fixed pay dedicating over 15 hours per week to the plant.
Directors	Managers and directors hired to direct the plant (who are not owners of the plant).
Other staff not related to the production process	Workers responsible for administrative and accounting control, workers performing security and personal services, and salesman.