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THE CHINA PHENOMENON: PRICE, QUALITY OR VARIETY?

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Resumen

China ha experimentado un explosivo auge de sus exportaciones en los últimos quince años. En este trabajo, usando datos de importación desagregados por productos para Chile entre 1990 y 2005, analizamos las causas de tal desempeño exportador. Encontramos que este fuerte crecimiento se explica principalmente por un aumento de la calidad relativa de variedades exportadas por China, lo que incrementa la demanda y el número de variedades producidas en China. Los resultados muestran que los productos chinos son más baratos que los del resto del mundo, pero la pequeña reducción de sus precios relativos no contribuye significativamente al crecimiento de la penetración de importaciones desde China. Encontramos también evidencia de heterogeneidad a través de grupos de productos. En efecto, el aumento de la calidad y la reducción de precios relativos es mayor en productos diferenciados, en contraste con productos más homogéneos. Dado que las diferencias internacionales de precio reflejan diferencias de productividad y costo de factores, estos resultados sugieren que el aumento de productividad ha sido más alto en productos diferenciados, lo que coincide con el mayor crecimiento de la calidad de estos productos. Por lo tanto, nuestra conjetura es que el crecimiento de productividad seria el factor determinante de la mejora de la calidad de las variedades chinas, así como del incremento del número de variedades producidas y exportadas por China.

Abstract

China's exports have skyrocketed in the last 15 years. We use highly-disaggregated import data from Chile between 1990 and 2005 to decompose the causes of such export performance. We find that China's high export growth is mainly explained by an increase in the quality of its varieties relative to those from the rest of the world, which raises world demand for its varieties as well as it increases the number of varieties produced in China. Our results show that Chinese products are cheaper than those from the rest of the world, but the small decline in their relative price has a negligible contribution to the growth of China's penetration. There is heterogeneity across products, however. The increase in quality and the decline in product prices are more pronounced for highly-differentiated products. Because international product-price differences reflect productivity and factor cost differences, these results reveal that productivity growth has been higher in highly-differentiated products, which coincides with the pattern of quality growth. Therefore, we conjecture that productivity growth is behind the increase in the quality of Chinese varieties as well as the raise in number of varieties produced and exported by China.

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1. Introduction

China's penetration in world markets has skyrocketed since the 1990s. Total exports grew from US$ 63 billions in 1990 to US$ 762 billions in 2005, which represents an annual rate of growth of 18%, about twice the average growth rate in China's GDP. The potential forces behind such dramatic change are diverse, and they have different implications for the prospects of China's future growth as well as for the impact on third countries. For example, based on the evidence that China's exports are more sophisticated than exports of countries with similar income per capita, Rodrik (2006) concludes that China's active industrial policy explains an important part of the export miracle.[1] Other authors have argued that China's export pattern corresponds adequately to its comparative advantage in labor-intensive products. Once controlling for imports of high value-added parts and components, Branstetter and Lardy (2006) argue that China's exports reflect low costs of labor-intensive assembly.

The objective of this paper is to explore the causes of China's export phenomenon from a different perspective. Rather than focusing on whether China's export performance is the natural result of market liberalization and undistorted comparative advantage or whether it also reflects export-promoting policies, like FDI policies and/or exchange rate management, we provide a decomposition of China's export penetration into price, quality and variety components to obtain a quantitative assessment of the drivers of the Chinese export boom. In other words, we explore which part of China's penetration into external markets is explained by changes in relative prices vis-à-vis products from other countries, which part can be attributed to changes in the willingness to pay – quality – for Chinese products, and what part can be attributed to a change in the number of varieties produced in China relative to other countries. We think this decomposition constitutes an intermediate but nonetheless fundamental step into understanding the causes of China's export performance, as it sheds light on the relevant margins through which China has penetrated external markets.

For that, we use highly disaggregated 8-digit HS Chilean import data from all countries between 1990 and 2005. Using Chilean data has three advantages. First, the

[1] See also Schott (2006) for evidence that China's export structure is more sophisticated than that of countries with similar income per capita and factor endowments.

degree of trade openness is high and without significant cross-country cross-product trade distortions throughout the period.[2] Besides, Chile has not imposed quotas on textiles and clothing imports, which probably affects China's import penetration in developed countries' markets. Therefore, it is reasonable to assume that Chilean imports from China and other countries adequately reflect price changes, demand shifts (quality growth) and changes in the number of varieties produced without resorting to quantitative restrictions. Second, the small-economy assumption simplifies the identification strategy of the quality-variety margins. Finally, as shown below, the pattern of Chinese penetration in Chilean markets is similar to that in other countries, meaning that the results can be arguably interpreted as a reasonable decomposition of China's overall export performance.

Based upon the methodology developed by Hummels and Klenow (2005), we decompose China's import penetration relative to the Rest of the World (ROW) into Extensive and Intensive Margins. The Intensive Margin is further decomposed into a Price Index, which reflect the price gap between Chinese and ROW's products, and a Quantity Index that measures the relative penetration (in quantum) within each product. We show that China's penetration has increased steadily throughout the sample, and this is mainly due to a rise in the Intensive Margin. In particular, consumption of Chinese products (in quantum) has grown at an annual rate about 15.6 percentage points higher than imports from ROW while we observe a marginal decline in the average price ratio of Chinese products to those from the rest of the world from about 60% to 53% between 1990 and 2005.[3] The increase in China's quantity penetration without a significant fall in relative prices can result from: i) a very high price-elasticity of demand for varieties, ii)

[2] Chile's import tariffs throughout the period are flat and low, and the signature of Preferential Trade Agreements with its largest trade partners is a phenomenon of the 2000s. For example, the most important PTA's signed by Chile entered into force on Feb 1st, 2003 (European Union), January 1st, 2004 (United States), April 1st, 2004 (South Korea), and January 1st, 2006 (China).

[3] See Schott (2006) for evidence that China's export prices in the United States have declined relative to countries with similar per capita GDP. Some papers have interpreted international price differences in highly-disaggregated product categories as quality differences (see Schott, 2004). However, quality-adjusted prices may differ across countries (Hummels and Klenow, 2005, Hallak and Schott, 2005). For example, Hallak (2006) presents an analysis of how quality-adjusted price differences can explain high trade flows among rich countries, which not only have comparative advantage in high-quality products but also have higher preferences for high-quality products. See also Fan (2005).

an increase in the willingness to pay (quality) for Chinese varieties relative to those from the rest of the world, and/or iii) an increase in the relative (unobserved) number of varieties available from China. We explore the relevance of these explanations by developing a general equilibrium model where relative demand for a specific product – defined at the 8-digit level – depends upon product prices, product quality and the number of varieties of each product imported from each source. We do not observe the quality of different varieties; neither we observe the number of varieties of each good produced in different countries. We derive an expression for the number of varieties of each good produced in two countries in equilibrium as a function of relative income, relative factor costs, relative quality, relative productivity and trade costs.[4] We nest this expression into the determinants of import penetration and we estimate a panel that yields estimates for the trend of quality differences of varieties from China and ROW. The general-equilibrium strategy to distinguish quality from variety constitutes the first contribution of the paper.

The second contribution of the paper is related to the empirical results. We find that the fall in the relative price of Chinese varieties explains a minor part of the rise in China's penetration. The main driver of the increase in China's exports is the growth in the quality of its varieties relative to the rest of the world. The average growth in willingness to pay for Chinese varieties is estimated around 10.5% per year, which contributes to the increase in China's penetration through two channels: i) a shift of world demand toward Chinese varieties, and ii) a rise in the number of varieties produced in China. The evidence on the relevance of the home market effect, i.e., China's GDP growth has attracted the production of differentiated products, is mixed, and there is strong evidence that the increase in China's factor prices relative to the rest of the world has exerted a detrimental impact on the location of differentiated products in China. Overall, the 15.6% annual growth in quantity penetration can be approximately

[4] Besides the traditional home market effect (Krugman, 1980), the determinants of the number of varieties produced in different countries coincide with those assumed by other authors. For example, Hallak and Schott (2005) assume a negative relationship between quality-adjusted prices and the number of varieties exported by a country in order to distinguish both effects. Our model confirms the existence of such negative relationship, at least theoretically.

decomposed into: i) a 0.8% due to price changes, ii) a 10.7% due to quality improvements, and iii) a 3.6% due to increases in the number of varieties.

To check the robustness of our results, we exploit differences in the degree of differentiation across products. We show that there is heterogeneity for products differing in the degree of differentiation across varieties. Our estimations suggest that import penetration is significantly higher in highly-differentiated products, and so is the fall in the relative price of Chinese varieties. Interestingly, the growth in the quality of Chinese varieties is also significantly higher in highly-differentiated product categories, which means that the higher import penetration in highly-differentiated products in not only explained by a higher fall in the relative price of Chinese varieties but it also results from a higher increase in their quality. According to the model, international product price differences reflect not only differences in factor prices but also in productivity. Therefore, the fall in the price of Chinese varieties relative to ROW in a context of converging factor prices – as evident from income per capita convergence – reflects high productivity growth of Chinese producers, especially in highly-differentiated products. This coincides with the patterns of quality growth, suggesting that productivity growth – through its impact on quality and the number of varieties produced in China - plays a fundamental role in explaining China's trade patterns. Although we do not test this hypothesis, there is evidence favoring this link. For example, Brambilla (2006) provides evidence that productivity-advanced foreign producers introduce a much higher number of varieties that productivity-backward domestic firms in China's manufacturing sector. These results are also consistent with the evidence presented by Xu (2006), who argue that a significant part of China's export miracle is explained by quality upgrading of Chinese varieties.

The paper is divided as follows. Next section presents briefly the data. Section 3 presents the methodology to decompose China's import penetration into different margins, and in section 4 we develop the model and the empirical strategy. In section 5 we estimate the growth in China/ROW quality ratio and we also decompose the growth in China's import penetration at the aggregate level. Section 6 presents similar estimations allowing for cross-product heterogeneity. Finally, section 7 presents the conclusions.

2. The Data

The data are obtained from Chile's Customs office, and it comprises all import entries at 8-digit HS level (4,815 categories in 1990 and 6,702 in 2005). Throughout the paper, we refer to a product as a 8-digit level category, and each country produces different number of unobserved varieties of each product. For each product we have data for China and ROW (that comprises all countries in the world excluding China and Chile) on the CIF value of imports in current dollars and the quantity imported. We label China with the subscript c and ROW with the subscript r. Therefore, unitary import prices from country c in product j, defined at the 8-digit level, are computed as M_{cjt} / X_{cjt} where M_{cjt} is the CIF value of imports (in US dollars) from country c in product j in year t, and X_{cjt} is the quantity imported, i.e., pairs of shoes, pounds of folic acid, meters of carpets, etc. Table 1 reports a summary of the data.

[Insert Table 1]

We observe a significant increase in imports from China. In 1990, China represented 0.8% of total Chilean imports, while in 2005 this number was 8.5%, which represents an annual growth rate of 16.9%. These numbers coincide with the increase in China's total export growth in the same period (18% annually). The increase in the value of imports from China is accompanied by an increase in the number of 8-digit level products imported from China. The share of products that Chile imports from China rose from 21.5% in 1990 to 59.6% in 2005. For example, in 2005 Chile imported 2541 millions of US dollars from China, of which US$ 2538 millions were in common product categories with ROW and only US$ 3 millions were in exclusive 8-digit HS categories.

3. Import Margins

Based upon the work of Hummels and Klenow (2005), we analyze the structure of imports of Chile from China (c) and ROW (r). Import penetration of country c relative to country r is expressed as the Overall Share S, which is the ratio of total imports from c and r:

$$S_t = \frac{M_{ct}}{M_{rt}} = \frac{\sum_{j \in N_{ct}} M_{cjt}}{\sum_{j \in N_{rt}} M_{rjt}}, \quad (1)$$

where M_{ct} are total imports from country c in period t and M_{rt} represents total imports from r. M_{ct} is equal to the sum of imports across all 8-digit product categories j in which c is present, denoted by N_{ct}. Likewise, N_{rt} stands for 8-digit products with positive imports from r in period t.

The Overall Share S_t can be expressed as the product of two components: the Extensive Margin and the Intensive Margin. Intuitively, the ratio of imports from c to r depends upon the number of products j imported from each country and the average value of imports within common product categories. For example, $c's$ imports could be lower than rs' either because c exports fewer product categories than r or because imports from c are lower than imports from r within common categories. Analytically, the overall share in period t can be written as:

$$S_t = \frac{\sum_{j \in N_{ct}} M_{rjt}}{\sum_{j \in N_{rt}} M_{rjt}} \cdot \frac{\sum_{j \in N_{ct}} M_{cjt}}{\sum_{j \in N_{ct}} M_{rjt}} = E_t \cdot I_t \ . \quad (2)$$

The Extensive Margin E_t measures the percentage of imports from r that is subject to direct competition from Chinese products, i.e., the ratio of total imports from r in categories where c is present to total imports from r. The Intensive Margin I_t compares imports from c and r within common product categories; those imported from c, i.e., N_{ct}, and it can be further decomposed into a Quantity index and a Price index. Within the common set of products, the value of imports from c and r may differ because of differences in unit prices or because of differences in quantities imported. The Price index measures the (weighted) average ratio of c to r unit prices at each 8-digit level product j, where the weights are the shares of each product category in total imports of common categories. The Quantity index also weights the ratio of import quantities within each product according to their share in total imports. Analytically[5]:

$$I_t = P_t \cdot X_t , \tag{3}$$

where $P_t = \prod_{j \in N_{ct}} \left(p_{cjt} / p_{rjt} \right)^{\omega_{jt}}$ and $X_t = \prod_{j \in N_{ct}} \left(X_{cjt} / X_{rjt} \right)^{\omega_{jt}}$. p_{cjt} and p_{rjt} are CIF unit prices and X_{cjt} and X_{rjt} are imported quantities of product j from c and r respectively, and $\omega_{jt} = \left(\frac{\phi_{cjt} - \phi_{rjt}}{\ln \phi_{cjt} - \ln \phi_{rjt}} \right) \Big/ \sum_{j \in N_{ct}} \frac{\phi_{cjt} - \phi_{rjt}}{\ln \phi_{cjt} - \ln \phi_{rjt}}$ is the logarithmic mean of ϕ_{cjt} and ϕ_{rjt} (the share of product $j \in N_{ct}$ in total imports from c and r respectively). At the 8-digit level, P_{ct} is the ratio of c to r unit prices, and X_{ct} is the ratio of import quantities. At the aggregate level, P_{ct} and X_{ct} are weighted averages of 8-digit-level price and quantity ratios.

Table 2 reports the Overall Share S_t, the Extensive Margin E_t, the Intensive Margin I_t, the Price index P_t and the Quantity Index X_t computed for each year between 1990 and 2005. The Overall Share increased from 0.8% in 1990 to 9.3% in 2005, with an annual growth rate of 17.6%. In 2005, S_t is the product of an Extensive Margin of 47.8% and an Intensive Margin of 19.4%, meaning that almost 50% of r's imports were subject to direct competition from Chinese products, and that the value of imports from China was almost 20% that of r's within common categories. The Intensive Margin results from an average ratio of unit prices of 53% and an average ratio of imports quantities of 36.5%. These margins are similar to those computed by Hummels and Klenow (2005) for China's penetration in the U.S market in 1995: $S = 9.3\%$, $E = 70.4\%$, $I = 13.3\%$, $P = 56.3\%$ and $X = 23.6\%$.[6]

[5] See Sato (1976), Feenstra (1994), Hummels and Klenow (2005) and Broda and Weinstein (2006).

[6] Data from the U.S Census Bureau reveal that the Overall Share of China's imports to the United States grew at an annual rate of 12% between 1990 and 2005, which compares to the 17.6% figure for Chile. Also, the data on U.S imports from Feenstra et al (2002) at the 2-digit HS level reveal that the largest part of the growth in China's import penetration in the United States is explained by the growth in the Intensive Margin and that the price index of Chinese imports fell at an annual rate of 1.3% between 1990 and 2001.

[Insert Table 2]

Several elements are interesting from Table 2. The Overall Share increases continuously throughout the period. The Extensive Margin grows in the 1990s but it stagnates in 2000 at a level about 48%. In contrast, there is also a continuous increase in I_t. The rise in the Intensive Margin results from an increase in the Quantity index - with an average annual rate of growth of 15.6% - and a fall in the Price index, which fluctuates between 59.4% and 53% with an average rate of growth of -0.8%. Unless the price elasticity of demand is very high, factors other than relative prices changes are required to explain the higher growth in imports of Chinese goods relative to ROW. Notice also that although China's products are significantly cheaper than those from ROW, their consumption is significantly lower, also revealing that elements other than price differences determine the structure of imports. We explore two determinants discussed in the literature. The first one is related to differences in the willingness to pay for products from different sources. If varieties from different countries have different tangible or intangible attributes, the valuation of these varieties will differ and so do the willingness to pay for them. We refer to these differences as quality differences. Second, although we analyze trade data at a much disaggregated level (8-digit HS categories), countries may also differ in terms of the unobserved number of horizontal varieties produced and exported within each product category. Therefore, differences in the consumption level of 8-digit products may not reflect differences in quality but rather differences in the number of varieties imported from each source within each product. [7]

4. The Model

Consider that each country is inhabited by a representative individual who spends a fraction $(1-\delta)$ of his income in the consumption of a homogeneous good, and a fraction δ_j is spent in differentiated product j, so $(1-\delta)+\sum_j \delta_j = 1$. The sub-utility associated with the consumption in country z of product j is equal to:

$$U_j^z = \sum_k q_{kj} \cdot n_{kj} \cdot (x_{kj}^z)^{\theta_j}, \qquad \theta_j < 1 \tag{4}$$

[7] See Hummels and Klenow (2005) and Hallak and Schott (2005).

where q_{kj} represents a utility shifter that captures the characteristics of varieties of product j produced in country k (including z) and $\sigma_j = 1/(1-\theta_j)$ is the elasticity of substitution across varieties of product j. For simplicity, we eliminate the time subscript unless required for expositional purposes. Hereafter we refer to q_{kj} as a measure of the quality of varieties of good j produced in k at time t. The quality parameter is perceived equally from all individuals in the world (it does not have a superscript z), meaning that varieties are vertically differentiated in terms of quality. Consumption in z of each variety of good j produced in k is denoted x_{kj}^z, and n_{kj} is the total number of horizontal varieties of good j produced in (and exported by) k. We assume symmetry across varieties of the same product, so that z's imports from country k of good j are $X_{kj}^z = n_{kj} \cdot x_{kj}^z$. The resource constraint of the representative individual in country z is:

$$\delta_j \cdot Y^z = \sum_k n_{kj} \cdot p_{kj}^z \cdot x_{kj}^z \, , \tag{5}$$

where Y^z is the income level of country z and p_{kj}^z is the price in z of a variety of good j produced in country k (including trade costs). The first order condition of the representative consumer in country z with respect to consumption of a variety of good j from country k is:

$$\theta_j \cdot (x_{kj}^z)^{\theta_j - 1} = \frac{\lambda_j^z \cdot p_{kj}^z}{q_{kj}} \tag{6}$$

where λ_j^z is the marginal utility of income (the Lagrange multiplier). We assume there is an iceberg-type trade cost $\tau_{kj}^z > 1$ that represents the cost of shipping one unit of a variety of j from k to z (with $\tau_{kjt}^k = 1$), so that $p_{kj}^z = p_{kj} \cdot \tau_k^z$. Combining (6) across varieties of good j from two different sources (say c and r) we get the following relative demand condition:

$$\left(\frac{x_{cj}^z}{x_{rj}^z} \right)^{\theta_j - 1} = \left(\frac{p_{cj}^z}{p_{rj}^z} \right) \cdot \left(\frac{q_{rj}}{q_{cj}} \right). \tag{7}$$

Equation (7) states that consumption of a variety of good j from c relative to consumption of a variety of the same good from r depends upon the quality-adjusted product-price ratio: consumption is higher of the variety with lowest quality-adjusted price.

On the supply side, we assume that all countries produce the homogeneous good, whose production function is given by $s = h_k \cdot l_{ks}$ where h_k is a productivity parameter and l_{ks} is labor input. Assuming no trade costs in the homogenous good and assuming that the international price of good s is equal to 1, the income of country k is equal to $Y^k = h_k \cdot L_k$ where L_k is the fixed labor supply. Differentiated goods are produced using an increasing-return-to-scale production function with labor as the only input. In particular, $l_{kj} = f_j + m_{kj} \cdot x_{kj}$ where f is a fixed labor input and m_{kj} accounts for the product- and country-specific marginal labor input. We assume monopolistic competition, so in equilibrium each producer has zero profits. The world demand for each variety of good j produced in any country, say c, is $\sum_k x_{cj}^k \cdot \tau_{cj}^k$, so the optimal pricing condition for a producer of j in country c is:

$$p_{cj} = \frac{h_c \cdot m_{cj}}{\theta_j}.$$

As in Krugman (1980), the elasticity of demand is constant and equal to $\eta_{cj} = 1/(1-\theta_j)$, meaning that cross-country differences in supply product prices are uniquely determined by supply conditions. Therefore, product prices can be considered exogenous from the point of view of consumers in country z. In particular, $\left(p_{cj} / p_{rj}\right) = \left(h_c / h_r\right) \cdot \left(m_{cj} / m_{rj}\right)$, which shows that international differences in product prices reflect differences in factor prices and differences in technology. Although factor prices map one-to-one to income per capita, cross-country differences in product prices also reflect differences in the productivity parameter m_{kj}. In other words, convergence in factor prices may not lead to convergence in product prices if productivity growth in the differentiated-good sector dominates factor cost pressures - which in the model are determined according to productivity growth in the homogeneous-good sector.

Notice also that the demand equation (7) determines consumption per variety as a function of quality-adjusted prices. Customs data reports the quantity imported of each product (defined at the 8-digit level) from each source, but we do not have information regarding the number of varieties within each product. In other words, we do not observe x_{kj} but rather $X^z_{kj} = n_{kj} \cdot x^z_{kj}$. Plugging this expression into (7) we get:

$$\left(\frac{X^z_{cj}}{X^z_{rj}}\right) = \left(\frac{p^z_{cj}}{p^z_{rj}}\right)^{-\sigma_j} \cdot \left(\frac{q_{cj}}{q_{rj}}\right)^{\sigma_j} \cdot \left(\frac{n_{cj}}{n_{rj}}\right) \tag{8}$$

Equation (8) represents an equilibrium condition for relative consumption in z of products from different countries. The equilibrium ratio of the number of varieties of good j produced in China and ROW, i.e., $n_j = n_{cj} / n_{rj}$, is solved for by imposing world market clearing conditions in the market for each variety (see the appendix for details), and it is given by:[8]

$$\frac{n_{cj}}{n_{rj}} = n_j = f(\phi, m_j, q_j, \omega_c, \omega_z, \tau_j) \tag{9}$$

where $\phi = Y^c / Y^r$ is the relative size of both countries, $m_j = m_{cj} / m_{rj}$ is the ratio of labor requirements per variety in each country, $q_j = q_{cj} / q_{rj}$ is the quality ratio, $\omega_c = h_c / h_r$ is the ratio of unit labor costs in China and ROW, $\omega_z = h_z / h_r$ is the ratio of unit labor costs in Chile and ROW, and τ_j is the bilateral trade cost, that is assumed the same across country pairs, as if all three countries where located in the vertex of an equilateral triangle. Expression (9) highlights the determinants of differences in the number of varieties across countries within each product. If c and r are identical, i.e., $m_j = q_j = \omega_c = \phi = 1$, then $n_j = 1$ regardless of ω_z and τ_j, meaning that both countries produce the same number of varieties. More generally, the traditional home market effect

[8] This expression assumes that country z - Chile – is small enough, and that the (unobserved) quality of Chilean varieties and the (unobserved) price of Chilean varieties are similar to that of varieties from ROW, which means that productivity differences between Chile and the rest of the world are compensated with factor price differences. These assumptions are justified because the share of Chile in world output and employment is very small, and income per capita in Chile is similar to that in the rest of the world. They allow us to obtain a closed-form expression for n_j as a function of observed variables (with the exception of quality).

is present, as the number of varieties produced is higher in the larger country, i.e., $\partial n_j / \partial \phi > 0$ (Krugman, 1980). Unless country z is rich enough relative to r, i.e., high enough ω_z, a higher wage in country c, i.e., a high ω_c – driven by technological differences in the homogeneous good sector – decreases the number of varieties produced in c because higher prices discourage world consumption of varieties from c, so $\partial n_j / \partial \omega_c < 0$. Likewise, $\partial n_j / \partial m_j < 0$ meaning that production of the increasing return sector is enhanced by a high-productivity in the production of differentiated products, increasing the number of varieties.[9] Also, countries that produce high-quality goods also produce a higher number of varieties, i.e., $\partial n_j / \partial q_j > 0$. A higher quality attracts world demand, enhancing the location of varieties in countries with high quality. Finally, higher factor costs in country z shift the production of differentiated products toward the rest of the world, especially to the country with higher quality, higher productivity and lower factor prices, which means that $\partial n_j / \partial \omega_z > 0$ if $m_j^{1-\sigma_j} \cdot q_j^{\sigma_j} \cdot \omega_{cj}^{-\sigma_j} > 1$. Finally, it is important to notice that both c and r produce (and export) good j as long as n_j is positive. Therefore, expression (9) implicitly determines the conditions under which both countries produce good j. This is consistent with the evidence that countries do not produce all product categories.

5. Empirical Estimation

5.1 Estimation of Quality Differences

Plugging into (8) a first-order Taylor approximation of (9) (expression A4 in the appendix) and recalling that $m_j = p_j^z / \omega_c$ we get the following expression for the ratio of consumption in z of varieties of product j from countries c and r $X_j^z = X_{cj}^z / X_{rj}^z$:

$$\ln X_{jt}^z = b_j + \left(a_{0j} a_{1j} (1-\sigma_j) - 1\right) \cdot \ln p_{jt}^z + a_{0j} \cdot \ln \phi_t - a_{0j} a_{1j} \cdot \ln \omega_{ct}$$

[9] These two theoretical results are consistent with the evidence found in Romalis (2004) and Bernard, Redding and Schott (2007), who show that comparative advantage sectors have both low prices and high number of varieties. In terms of our model, a high number of varieties are expected in low-wage countries and in high-productivity countries, and both variables are positively correlated with low product prices. This is indeed the identification strategy used by Hallak and Schott (2005), who assume a negative relationship between quality-adjusted prices and the number of varieties exported.

$$+a_{0j}a_{1j}\sigma_j \cdot \ln q_{jt} + a_{0j}a_{2j}\ln\omega_{zt} + a_{3j}\cdot\ln\tau_{jt} \quad (10)$$

where the parameters a_{ij} are partial derivatives of n_{jt} with respect to its different determinants valued at the level of the variables around which the linearization is performed, and b_j is a product-specific fixed effect. We assume the following functional form for the unobserved ratio $q_{jt} = e^{\delta_{oj}+\delta_{1j}t}$, which means that the quality ratio has a product-specific intercept and a product-specific trend t (none of the results vary if we assume a non-linear trend in the quality ratio). We first estimate (10) imposing common coefficients across products so that $a_{ij} = a_i$ for all j and a common trend across products $\delta_1 = \delta_{1j}$ for all j. This is equivalent to assuming that all products belong to the same 8-digit level category (with the exception that we allow for a product-specific level in the quality gap δ_{0j} by including product fixed effects). We postpone the estimations of product-specific effects for next section. Therefore, we run the following panel regression:

$$\ln X^z_{jt} = \alpha_{0j} + \alpha_1\cdot t + \alpha_2\cdot\ln p^z_{jt} + \alpha_3\cdot\ln\phi_{jt} + \alpha_4\ln\omega_{cjt} + \alpha_5\ln\omega_{zjt} + \alpha_6\ln\tau_{jt} + \upsilon_{jt} \quad (11)$$

where the annual growth of the quality ratio is recovered as $\delta_1 = -\alpha_1/(\alpha_2+\alpha_4+1)$.

We measure relative size (ϕ_{jt}) as the PPP-adjusted GDP ratio between China and the rest of the world obtained from the World Development Indicators of the World Bank, and relative factor costs (ω_{cjt} and ω_{zjt}) as the PPP-adjusted income per capita ratio between China and the rest of the world and Chile and the rest of the world respectively (y^{chn}_{jt} and y^{chl}_{jt} in the tables). Strictly speaking, the rest of the world comprises only those countries that produce and export a specific product, meaning that ϕ_{jt}, ω_{cjt} and ω_{zjt} are product-specific. In other words, only some countries satisfy the conditions (quality, size, factor costs, and productivity) to produce varieties of a specific product. Indeed, equation (9) determines the ratio of the number of varieties produced in China and ROW (excluding Chile) when both China and at least some other country in the world satisfy these criteria. According to the model, Chile (and every country) imports varieties from all countries in the world that produce that product. Therefore, we measure total GDP ratio ϕ_{jt} and income per capita ratios ω_{cjt} and ω_{zjt} assuming that

ROW comprises only those countries from which Chile has positive imports in a specific 8-digit category. Because there is entry and exit of countries across years in each category that may not reflect entry and exit from production of that product category but rather that Chile does not import at all times from all countries that produce a good, we also compute income variables ϕ_{jt}, ω_{cjt} and ω_{zjt} considering those countries with positive imports in any 8-digit level category that belongs to the same 2-digit level HS product. We distinguish these two sets of variables as 8-digit and 2-digit income variables respectively, and we report the results of both specifications. Finally, the product-specific relative price p^z_{jt} is computed as the ratio of CIF unit values (which include transport costs), and we control for trade costs τ_{jt} using average nominal tariffs in Chile. Because we do not have data on product-specific tariffs, we use average tariffs as a proxy for the evolution of worldwide trade costs. Chilean import duties are flat across sources and products with the exception of some preferential trade agreements in the 2000s, so we believe that the lack of cross-product variation in trade costs is probably not problematic.[10] This proxy seems to be quantitatively reasonable for a reduction worldwide trade costs. For example, between 1990 and 2001 the annual rate of change in Chilean average tariffs was -2.7%, while the rate of change in average transport costs of U.S imports (computed as (CIF-FOB)/FOB using data from Feenstra et al., 2002) in the same period is about -2.6%.

Table 3 reports the results of regression (11). To avoid dealing with measurement and typing errors from customs, we exclude product-year observations with extreme unit prices. In particular, we only report the results including product-year observations that

[10] The role of trade costs in this model is threefold. Theoretically, we have assumed that trade costs are identical across any two countries. We do not have detailed data on transport costs for Chile across all destinations between 1990 and 2005, but based upon the distance of Chile to its main trading partners we believe this assumption is not unreasonable. Besides, CIF unit prices do include transport costs, meaning that the empirical implementation does not introduce distortions in relative product prices from different sources. A second consideration is whether the evolution of import duties in Chile are a good approximation of the evolution of trade costs. As mentioned in the text, there is some evidence supporting this. Moreover, trade costs are correlated with tariffs, which justify their inclusion as proxy for overall trade costs. Finally, the use of average tariffs eliminates cross-product heterogeneity. In the case Chile, the flat structure of tariffs (with the exception of preferential agreements in the 2000s) does not introduce cross-product distortions in trade costs.

satisfy $0.05 < p_{jt} < 20$, but none of the results of the paper vary if we consider alternative (if any) cutting points.[11] The results in all specifications are very similar with the exception of the home market effect, which is not significant when we use 2-digit level income variables. The price elasticity of quantity penetration (that not only accounts for the traditional shift along the demand curve but it also accounts for the effect of price differences in the number of varieties produced) is relatively small, confirming that the average decline in the relative price of Chinese products cannot explain the sharp increase in import penetration. Table 4 reports the estimated annual rate of growth of the quality ratio together with the 95% confidence interval. On average, the annualized rate of growth of quality ratio is about 10.5%, and it is very similar across all specifications.[12]

[Insert Tables 3 and 4]

5.2 Decomposition of Import Penetration

We estimate the contribution of each variable to the growth of the Intensive Margin noticing that the Intensive Margin in product j is $I_{jt} = X_{jt} \cdot p_{jt}$. Therefore, the contribution of each component in (11) to the growth in the Intensive Margin at the aggregate level can be approximated as: the contribution of changes in relative prices is $(1+\alpha_2)\cdot d\ln P_t$, the contribution of China's GDP growth is $\alpha_3 \cdot d\ln\phi_t$, the contribution of the growth in factor prices in China relative to the rest of the world is $\alpha_4 \cdot d\ln y_t^{chn}$, the contribution of the growth in factor prices in Chile relative to the rest of the world is $\alpha_5 \cdot d\ln y_t^{chl}$, the contribution of the growth in the quality ratio is α_1 and finally the contribution of the fall in overall trade costs is $\alpha_6 \cdot d\ln\tau_t$, where the coefficients are those reported in table 3 and the variables are measured using aggregate level. Table 5 presents this decomposition taking into account the annual rate of change in the aggregate Price index, the China-ROW GDP ratio, the China/ROW and the Chile/ROW income per

[11] The restriction $0.05 < p_{jt} < 20$ eliminates observations that represent 4% of total imports from the rest of the world in 2005 and 1.2% of imports from China in 2005.

[12] The results are also very similar if we include 6-digit rather than 8-digit level fixed effects (not reported). Because there was a reclassification of products, especially in 2002, which split 8-digit level product categories into new classifications in order to account for more detailed product descriptions, we control for this effect assuming that all products belonging to a common 6-digit level category are similar. In such a case, we estimate the model using 6-digit fixed effects.

capita ratio, and nominal average tariffs in Chile. The decline in the relative price of Chinese varieties has a negligible contribution to the increase in the Intensive Margin. On average, the fall in Chinese product prices explain 0.01 percent of the growth in the Intensive Margin. The increase in the quality of Chinese products relative to those from the rest of the world explains about 140% of the increase in the Intensive Margin if income variables are measured at the 8-digit level, and this effect increases if income variables are measured at the 2-digit level. In the former scenario, the increase in China's market size contributes to about 10 percent increase in the intensive margin, but this effect disappears in the latter case. The increase in factor costs in China relative to the rest of the world – measured using the income per capita gap – contributes significantly to a fall in the intensive margin, revealing that it exerts a strong negative impact on the production of varieties in China. The increase in income per capita in Chile explains 50% of the increase in the Intensive Margin, which shows that the increase in factor costs in Chile relative to the rest of the world (recall that we have assumed away quality differences between Chile and the rest of the world and that factor cost differences are totally compensated by technology differences) tends to favor production of differentiated products in China rather than ROW. Finally, the fall in trade costs have a small quantitative impact.

[Insert Table 5]

Finally, we can use the results in Tables 3 and 4 to estimate the differential impact of quality changes and the number of varieties on the quantity index. For that, we recover the aggregate level for σ implicit in the regression results and combine it with equation (8). The aggregate level for σ is given by $(1+\alpha_2+\alpha_4)/\alpha_4$, which is close to (but statistically higher than) 1 in all specifications. This number is low but it is not unreasonable considering that we have treated all imports as belonging to the same product category. We are not aware of estimates that treat all products as being varieties of the same good and therefore imposing a unique elasticity of substitution. For the sake of comparison, Broda and Weinstein (2006) show that the elasticity of substitution falls significantly at higher levels of aggregation, but they do not report estimates at the 1-digit level. In their sample, the median level of σ_j for products defined at the 7-digit level is 3.7, and it falls to 2.5 for products defined at the 3-digit level. Using their estimates, the median (mean) value of σ_j for Chilean 8-digit level import categories is 2.11 (2.83). Considering an aggregate value of σ of 1.014 (the average in all regressions), we decompose the growth in the quantity index between 2005 and 1990. The quantity index in 2005 was 8.8 times that of 1990, which represents a 15.6% annual growth rate. The price ratio in 2005 was 0.89 times that in 1990, meaning that the fall in Chinese product prices relative to those from ROW contributed to a 0.8% annual increase in the quantity index. Taking an average rate of growth of the quality ratio of 10.5% we get that the quality ratio in 2005 was 4.5 times the ratio in 1990, which means that improvements in the willingness to pay for Chinese products explain a 10.7% annual growth in the quantity index. By difference, the increase in the number of varieties between 2005 and 1990 is 83% ($8.8/(1.13 \cdot 4.6) = 1.71$), revealing a rate of growth of the China/ROW ratio of number of varieties of 3.6% annually. This result should be considered as a broad approximation of the contribution of the price, quality and variety margins to China's aggregate import penetration.

6. Product-level Analysis

The estimations in last section treat all products as belonging to the same product category, which is a strong assumption. We relax this assumption allowing for cross-product heterogeneity. Rather than estimating thousands of product-specific rates of growth in quality, we consider that differences in the rate of quality growth are related to the degree of differentiation across varieties within each product, measured either with the elasticity of substitution σ_j from Broda and Weinstein (2006) or the product classification of Rauch (1999). Consistent with our theoretical framework, we expect price and quality differences to be much more relevant in highly-differentiated products[13].

We first analyze the pattern of quantity import penetration and price differences across different products running the following regressions:

[13] In the case of homogeneous products, we should not expect significant differences in price and quality at very detailed product classifications. In such a case, perfect competition would imply that a country imports only from the cheapest source. We acknowledge that trade classifications may be to sparse to hide huge within-products heterogeneity, so we compare our results for group of products according to their degree of differentiation.

$$\ln Z_{jt} = \beta_{0j} + b_1 \cdot t + b_2 \cdot \sigma_j + b_3 \cdot \sigma_j \cdot t + \mu_{jt} \quad (12)$$

$$\ln Z_{jt} = \gamma_{0j} + c_1 \cdot t + c_2 \cdot t \cdot D_{ref} + c_3 \cdot t \cdot D_{Hom} + \varsigma_{jt} \quad (13)$$

where $\ln Z_{jt}$ is either $\ln X_{jt}$ or $\ln p_{jt}$, and D_{ref} and D_{Hom} are dummy variables that take a value of 1 if product j is classified by Rauch (1999) as reference priced or homogeneous respectively.

We are particularly interested in looking at how Chinese quantity penetration and relative prices varies across products with different degree of differentiation across varieties. In equation (12) we compute cross-product differences in the trend of quantity penetration and relative prices as: $\partial \ln Z_{jt} / \partial t = b_1 + b_3 \cdot \sigma_j$. Panel A in Table 6 reports the results for three different estimation techniques (pooled OLS, random effects, and fixed effects). In all three cases $b_1 + b_3 \cdot \sigma_j$ is negative for quantity penetration $(\ln X_{jt})$ and positive for relative prices $(\ln p_{jt})$, meaning that quantity penetration have increased more in differentiated products (low σ) compared to more homogeneous products (high σ), while the fall in the relative price of Chinese varieties is higher in differentiated products. Table 6, Panel B, confirms these findings using Rauch's conservative classification. The base category corresponds to differentiated goods, so the year variable measures the annual average change in quantity penetration and relative prices for these products. The negative sign for the interaction terms between year and the dummy for referenced and homogeneous goods indicates that quantity penetration has been lower in these products compared to differentiated products. The opposite is true for price changes. The positive sign for the interaction terms reveals that the decline in the relative price of Chinese referenced and homogeneous goods has been lower than the reduction in the relative price of differentiated products.

In sum, two main conclusions emerge from our estimations in Table 6. First, quantity penetration has been significantly higher in highly differentiated – low σ - products. Second, the fall in the relative price of Chinese varieties is also higher in differentiated products. This finding motivates our following empirical exercise, which is devoted to explore whether the higher quantity penetration in highly-differentiated products is due to the higher fall in relative prices of Chinese products, or whether cross-product differences is quality growth are relevant. A priori, we expect the increase in the relative quality of Chinese varieties to be higher in differentiated products. We analyze cross-product differences in quantity penetration estimating differences in the rate of growth of the quality ratio across products depending on their degree of differentiation. For that, we first include in the estimation of (11) an interaction term of all right-hand-side variables with σ_j. We therefore obtain an estimate of the average rate of growth of quality for product categories with different σ_j across varieties using both 8- and 2-digit income variables as discussed in last section (panel A and B respectively). The first column (common factor cost) in each Panel of Table 7 reports the point estimates (and standard errors) for products with σ_j in different percentiles, revealing that low-σ_j products have a higher rate of growth of the quality ratio that high-σ_j products. Note than we cannot reject (at 5%) the null hypotheses that products in the first and ninth deciles of the σ-distribution are different. The same is true, but at 10%, for products in the first and third quartile of the σ-distribution.

In columns 2 and 3 we control for cross-industry differences in capital intensity (k) and skill intensity (s). Cross-country factor cost ratios are measured as the income per capita ratio $\ln y_{jt}^{chn}$, but sectoral differences in factor intensities may bias the estimates of quality growth if some products have faced higher factor cost pressures due to differences in factor intensity. In other words, the effect of factor cost convergence in average costs may depend factor usage in each product, and we want to estimate quality growth across products controlling for differences in factor intensities. We do so by including interaction terms of $\ln y_{jt}^{chn}$ in (11) with k_i and s_i which are average capital/labor ratio and skill/unskilled labor ratio respectively in 2-digit HS industry i that product j belongs to.[14] The results are very similar to those shown in column (1) when

[14] We compute k_i and s_i using 4-digit SIC U.S. manufacturing data (from the NBER manufacturing Database) on factor usage and the concordance table between 4-digit SIC and 10-digit HS from Feenstra et al (2002). We compute average values of capital stock, skilled and unskilled labor between 1990 and 1996 for each 4-digit SIC industry and map them into 2-digit HS industries. For SIC industries that map into more than one 2-digit HS industry we assign the value of capital and employment according to the share of each 2-digit HS industry that each SIC industry maps into. For example, SIC industry 2044 maps into 12 10-digit HS categories that

we control for cross-industry differences in skill intensity, but differences in quality growth are not significant after controlling for capital per worker.

[Insert Table 6]

[Insert Table 7]

A similar procedure is used to estimate differences in the quality growth of products according to Rauch's conservative classification.[15] In this case, we include an interaction term of each right-hand-side variable in (11) with D_{ref} and D_{Hom}, and we compute the average rate of growth of the quality group for differentiated goods, reference priced goods and homogeneous goods. The results are reported in Table 8. Compared to results in Table 7, we find stronger evidence that quality growth is much higher in differentiated products, while the difference between reference priced products and homogeneous products is weaker. Also, the results do not depend on whether we control for cross-industry differences in factor intensity.

[Insert Table 8]

The results in Tables 7 and 8 provide evidence that products with largest import penetration have not only a largest decline in the relative price of Chinese varieties but have also a higher growth in their quality. What drives this result? The model suggests a close relationship between products prices, productivity and factor prices. The optimal pricing condition implies that relative product prices reflect cross-country differences in factor prices ω_{ct} and technologies m_{jt}. The continuous rise in China's factor prices throughout the period – reflected in the shrinkage of the per capita GDP gap between China and ROW – pressures Chinese product prices up, and productivity gains keeps Chinese products cheap relative to those from the rest of the world. But the relative strength of both effects differs across products. In highly-differentiated products, productivity gains are revealed to be high enough so that there is a higher fall in the relative price of Chinese low-σ_j varieties, even after controlling for cross-industry

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belong to the 2-digit HS10 category, into 2 10-digit categories that belong to HS11 and into 1 category HS23. We therefore assign 80% (=12/15) of capital and workers of industry 2044 to 2-digit industry HS10. We then sum all capital and labor in each 2-digit level HS industry to compute capital per worker k_i and the skill/unskilled labor ratio s_i.

[15] The results are very similar if we use the liberal classification.

differences in factor intensity. Conversely, the lower decline in the relative price of China's high-σ_j varieties reveals that productivity growth is relatively low in homogeneous goods. Interestingly, the higher growth in productivity in highly-differentiated products coincides with a higher increase in the quality or willingness to pay for those products, suggesting a close association between productivity and quality, as in Flam and Helpman (1987).

Testing this hypothesis is beyond the scope of this paper. Nevertheless, there is indirect evidence supporting it. The idea that productivity growth is behind the growth in China's exports is consistent with the evidence that a very large share of Chinese exports is from foreign invested firms, which have a productivity advantage vis-à-vis domestic firms. Also, there is evidence that the productivity gap between China's domestic enterprises and foreign firms located in China is closely associated with foreign investment penetration, showing at least indirectly that the productivity advantage of foreign enterprises – which is unevenly distributed across sectors – is an important determinant of its share in China's output and export performance.[16] Just as an example, it is well known that foreign firms' penetration in footwear industries in China is very high. This sector not only represents a high share in China's total exports but it is also the sector with lowest elasticity of substitution according to Broda and Weinstein (2006). Conversely, foreign firms' penetration in almost inexistent in petroleum industries, which have the highest elasticity of substitution. Other evidence follows from the mechanism through which productivity growth affect export performance. According to the model, the increase in the quality of Chinese products not only shifts world demand for its varieties but it also raises the number of varieties produced in China. Bambrilla (2006) presents a model that links productivity and the number of varieties introduced by different firms. The empirical evidence for China shows that high-productivity foreign firms produce a high number of varieties relative to productivity-backward domestic firms. Hence, we conjecture that the quality/productivity relationship reflects a high willingness to pay for products manufactured in China by high-productivity international affiliates. More research is required to confirm this hypothesis.

[16] See Claro (2006) and Whalley and Xin (2006).

7. Conclusions

In this paper we have analyzed the main drivers of Chinese export penetration using detailed import data in Chilean markets between 1990 and 2005. We offer two main conclusions. First, Chinese varieties are significantly cheaper than those from the rest of the world, and this gap is evident in the data since 1990. We observe a mild fall in the relative price of Chinese products relative to those from the rest of the world between 1990 and 2005, and this trend does not explain the increase in China's import penetration. We estimate that the growth in the quality of (willingness to pay for) Chinese varieties relative to those from the rest of the world explains the bulk of the growth in China's penetration, both through its direct impact in world demand for Chinese varieties and through attracting the production of differentiated goods in China. In other words, there has been an important increase in the quality of Chinese products as well as an important rise in the number of varieties available from China.

A second conclusion follows from analyzing the cross-product heterogeneity of import penetration. China's import penetration is higher in highly-differentiated products, which also have a higher fall in its relative price and a higher growth in quality. In a context of increasing factor prices, the fall in China's relative product price reflects a high rate of productivity growth. Higher productivity growth in differentiated products coincides with a growth in the quality of Chinese highly-differentiated varieties, suggesting a close link between productivity and quality. We do not provide a test for this hypothesis neither we show evidence regarding the causes of cross-product differences in productivity growth. However, we conjecture that the access of high-productivity foreign-invested enterprises into China – which are the main source of China's export growth – has increased significantly the willingness to pay for Chinese products and it has also increased significantly the number of varieties available from China.

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Appendix

Consider a world composed of 3 countries, z, c and r. Preferences are those described in equation (4) in the text and the budget constraint faced by each country associated with consumption of product j is that in expression (5). Solving for the consumer problem we get the following expression for consumption in c of a variety of good j produced in country k is:

$$x_{cj}^{k} = \frac{\delta_j \cdot h_c \cdot L_c \cdot \left(q_{kj} / p_{kj}\right)^{\sigma_j} \cdot \tau_{kj}^{c\ 1-\sigma_j}}{P_{cj}}$$

where p_{kj} is the supply price of a variety of good j produced in k, τ_{kj}^{c} is the iceberg-type trade cost from k to c, and P_{cj} is the price index in country c, which is given by $P_{cj} = \sum_k n_{kj} \cdot p_{kj}^{1-\sigma_j} \cdot q_{kj}^{\sigma_j} \cdot \tau_{kj}^{c\ 1-\sigma_j}$. Similar expressions can be derived for x_{zj}^{k} and x_{rj}^{k}.

The supply price set by a producer in country k is $p_{kj} = h_k \cdot m_{kj} / \theta_j$ and the output of each variety is $\bar{x}_{kj} = f_j \cdot (\theta_j - 1) / m_{kj}$. The equilibrium number of varieties produced in each country deriving world equilibrium conditions in differentiated products, which are given by:

$\bar{x}_{zj} = \sum_{\forall k} x_{kj}^{z} \cdot \tau_{kj}^{z}$,

$\bar{x}_{cj} = \sum_{\forall k} x_{kj}^{c} \cdot \tau_{kj}^{c}$, and

$\bar{x}_{rj} = \sum_{\forall k} x_{kj}^{r} \cdot \tau_{kj}^{r}$,

Solving for n_{cj} / n_{rj} yields

$$\frac{n_{cj}}{n_{rj}} = \frac{p_{rj}^{1-\sigma_j} \cdot q_{rj}^{\sigma_j}}{p_{cj}^{1-\sigma_j} \cdot q_{cj}^{\sigma_j}} \cdot g\left(h_z, h_c, h_r, m_{cj}, m_{zj}, m_{rj}, \varsigma, \gamma, \rho, L_z, L_c, L_r, \tau_{kj}^{z}, \tau_{kj}^{c}, \tau_{kj}^{r}\right) \qquad \text{(A1)}$$

where $\varsigma = (q_{zj} / p_{zj})^{\sigma_j}$, $\gamma = (q_{cj} / p_{cj})^{\sigma_j}$ and $\rho = (q_{rj} / p_{rj})^{\sigma_j}$. We simplify this expression assuming: i) L_z is small enough, ii) country z has the same quality as the rest of the world, i.e., $q_{zj} = q_{rj}$, iii) country z has the same price/quality ratio as country r, i.e., $\varsigma = \rho$, and iv) $\tau_{kj}^{d} = \tau_{kj}^{c} = \tau_{kj}^{r} = \tau_j$. These assumptions imply that supply prices in z and r are equal, so that productivity differences are compensated by factor price differences.

Also, these assumptions simplify expression (A1), yielding the following expression for n_{cj} / n_{rj} where all right-hand-side variables with the exception of quality are observables:

$$\frac{n_{cj}}{n_{rj}} = n_j = \frac{1}{m_j^{1-\sigma_j} \cdot \omega_c^{1-\sigma_j} \cdot q_j^{\sigma_j}} \cdot \left[\frac{\Gamma(\omega_c, \omega_z, q_j, m_j, \phi) \cdot (1+\tau_j^{1-\sigma_j}) - \tau_j^{1-\sigma_j}}{(1+\tau_j^{1-\sigma_j}) - \Gamma(\omega_c, \omega_z, q_j, m_j, \phi) \cdot \tau_j^{1-\sigma_j}} \right] \qquad \text{(A2)}$$

where $\omega_c = h_c / h_r$, $\omega_z = h_z / h_r$, $q_j = q_{cj} / q_{rj}$, $m_j = m_{cj} / m_{rj}$, $\phi = Y^c / Y^r$, and

$$\Gamma(\omega_c, \omega_z, q_j, m_j, \phi) = \phi \cdot \left(\frac{m_j^{1-\sigma_j} \cdot \omega_c^{-\sigma_j} \cdot q_j^{\sigma_j} \cdot (1+\tau_j^{1-\sigma_j}) - \tau_j^{1-\sigma_j} - \omega_z \cdot m_j^{1-\sigma_j} \cdot \omega_c^{-\sigma_j} \cdot q_j^{\sigma_j} \cdot \tau_j^{1-\sigma_j}}{1+\tau_j^{1-\sigma_j} - m_j^{1-\sigma_j} \cdot \omega_c^{-\sigma_j} \cdot q_j^{\sigma_j} \cdot \tau_j^{1-\sigma_j} - \omega_z \cdot m_j^{1-\sigma_j} \cdot \omega_c^{-\sigma_j} \cdot q_j^{\sigma_j} \cdot \tau_j^{1-\sigma_j}} \right) \qquad \text{(A3)}$$

Assuming that the conditions for the number of varieties produced in countries c and r to be positive are satisfied, i.e., $\Gamma(\omega_c, \omega_z, q_j, m_j, \phi, \tau_j) > 0$, these expressions reveal the main determinants of the relative number of varieties of good j produced in two countries. It is possible to show that the parameters are such that $\partial \ln n_j / \partial \ln \phi > 0$, and that $\partial \ln n_j / \partial \ln \omega_c < 0$, $\partial \ln n_j / \partial \ln m_j < 0$ and $\partial \ln n_j / \partial \ln q_j > 0$ if $\omega_z \cdot \tau_j^{1-\sigma_j} < 1$. Also, $\partial \ln n_j / \partial \omega_z > 0$ if $m_j^{1-\sigma_j} \cdot \omega_c^{-\sigma_j} \cdot q_j^{\sigma_j} > 1$. Finally, the sign of $\partial \ln n_j / \partial \ln \tau_j > 0$ depends upon parameter values.

First order Taylor approximations of (A2) and (A3) yield the following expression for the ratio of varieties produced in c and r

$$\ln n_j = a_{0j} \ln \phi + (\sigma_j - 1 - a_{0j} a_{1j} \sigma_j) \cdot \ln \omega_c + (\sigma_j - 1 + a_{0j} a_{1j} (1-\sigma_j)) \cdot \ln m_j$$
$$+ (a_{0j} a_{1j} \sigma_j - \sigma_j) \cdot \ln q_j + a_{0j} a_{2j} \cdot \ln \omega_z + a_{3j} \ln \tau_j \qquad \text{(A4)}$$

where a_{0j}, a_{1j}, a_{2j}, and a_{3j} are functions of $\tau_j, \sigma_j, m_j, q_j, \omega_c, \omega_z$ and ϕ evaluated at the point around which the Taylor approximation is performed. Equation (10) in the text follows from plugging (A4) into equation (8) and recalling that $p_j^z = p_{cj}^z / p_{rj}^z = m_j \cdot \omega_c$.

Table 1
Total Imports of Chile: 1990-2005
Millions of dollars

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Imports (CIF)																
Central Bank	7742	8207	10183	11134	11820	15900	17824	19662	18779	15144	18090	17179	17180	19326	24871	32637
Customs	7023	7515	9542	10641	11291	15061	16975	18330	17155	13703	16790	16134	15639	17549	22483	29932
China																
Customs	57	95	147	212	281	390	515	659	753	647	949	1014	1102	1290	1848	2541
Common	57	95	146	211	280	389	515	658	751	646	946	1013	1101	1289	1845	2538
Exclusive China	0	0	1	1	1	1	0	1	2	1	3	1	2	1	2	3
Rest of the World																
Customs	6966	7420	9395	10429	11010	14670	16460	17671	16402	13057	15841	15121	14536	16259	20635	27391
Common	2305	2109	2895	3944	3947	5893	6387	8052	7615	6541	7455	7496	6635	6984	9430	13091
Exclusive ROW	4661	5311	6501	6484	7063	8777	10073	9619	8787	6516	8386	7625	7901	9267	11205	14299
Number of Products (8-digit HS) Imported																
Total	4815	4874	4969	4949	4950	5037	5429	5163	5142	5197	5215	5151	6724	6670	6745	6702
Common	1024	1056	1242	1436	1471	1656	1795	1930	2090	2078	2256	2335	3154	3435	3712	3945
Exclusive China	11	9	10	9	7	9	8	14	13	12	20	11	28	35	47	49
Exclusive ROW	3780	3809	3717	3504	3472	3372	3626	3219	3039	3107	2939	2805	3542	3200	2986	2708

Source: Chile's Customs and Central Bank of Chile
Note:
a. Data from Customs differ from the official import data from the Central Bank for three reasons: First, imports for Defense and military purposes are not accounted for by customs while they are included in Central Bank's Statistics. Second, products that enter Chile through special tax-free zones but that are re-exported to third countries are included in Central Bank Statistics but they are excluded from Customs database. Finally, are similar discrepancy results from acquisitions of Chilean shipped overseas, which are not reported to customs offices.
b. There is a reclassification of import categories in 2002, which explains the jump in the number of categories imported. This reclassification mainly split some 8-digit product categories into several 8-digit product categories to account for more detailed description of products, keeping the same 6-digit product category.

Table 2
China Import Penetration 1990-2005
Percentage

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Annualized Rate of Growth
S_t	0.8	1.3	1.6	2.0	2.5	2.7	3.1	3.7	4.6	5.0	6.0	6.7	7.6	7.9	9.0	9.3	17.6
E_t	33.1	28.4	30.8	37.8	35.9	40.2	38.8	45.6	46.4	50.1	47.1	49.6	45.6	43.0	45.7	47.8	2.5
I_t	2.5	4.5	5.1	5.4	7.1	6.6	8.1	8.2	9.9	9.9	12.7	13.5	16.6	18.5	19.6	19.4	14.7
P_t	59.4	54.7	55.3	57.1	61.0	61.1	59.0	57.5	49.9	57.5	56.8	55.3	58.6	54.9	56.6	53.0	-0.8
X_t	4.1	8.2	9.1	9.4	11.6	10.8	13.7	14.2	19.7	17.2	22.4	24.4	28.3	33.6	34.6	36.5	15.6

Notes
See text for definition of variables

Table 3
Estimation of Quantity penetration of Chinese Imports

	8-digit level income variables		2-digit Level income variables	
Dependent Variable	Log X_{jt}	Log X_{jt}	Log X_{jt}	Log X_{jt}
Independent Variables				
Year	0.32	0.31	0.39	0.39
	0.02	*0.02*	*0.02*	*0.03*
Log p_{jt}	-1.04	-1.04	-1.04	-1.04
	0.01	*0.01*	*0.01*	*0.01*
Log ϕ_{jt}	0.32	0.32	-0.32	-0.23
	0.03	*0.03*	*0.27*	*0.31*
Log y^{chn}_{jt}	-2.94	-3.13	-3.38	-3.42
	0.44	*0.44*	*0.45*	*0.46*
Log y^{chl}_{jt}	*2.87*	*3.08*	*2.73*	*2.80*
	0.44	*0.44*	*0.44*	*0.46*
Log τ_{jt}		-3.73		-0.84
		1.18		*1.53*
Sample	31922	31922	31922	31922
R^2				
Within	0.39	0.39	0.39	0.39
between	0.20	0.20	0.15	0.15
overall	0.22	0.22	0.19	0.19
Restrictions	$0.05<p_{jt}<20$	$0.05<p_{jt}<20$	$0.05<p_{jt}<20$	$0.05<p_{jt}<20$

Notes
Standard Errors in Italics
All regression contain product-specific fixed effects

Table 4
Annual Rate of Growth of China/ROW Quality ratio q_{ct}/q_{rt}

8-digit Income level

Trade Barriers [a]	Mean [b]	95% Conf. Interval	
Yes	9.8	*8.3*	*11.3*
No	10.7	*8.9*	*12.4*

2-digit Income level

Trade Barriers [a]	Mean [b]	95% Conf. Interval	
Yes	11.2	*8.8*	*13.5*
No	11.5	*9.4*	*13.6*

Notes:
All regressions include product-year observations within the range $0.05<p_{jt}<20$
a: Yes means that the regression includes nominal average tariffs.
b: Annualized rate of growth of the quality gap.

Table 5
Decomposition of Annual Growth of the Intensive Margin
Percentage of average annual rate of growth

Contribution of [a]	8-digit level income variables			2-digit level income variables		
	Mean	*95% Conf. Interval*		Mean	*95% Conf. Interval*	
p_{jt}	0.1	*0.1*	*0.2*	0.1	*0.1*	*0.2*
ϕ_{jt}	10.1	*8.3*	*11.9*	-8.0	*-29.3*	*13.3*
y^{chn}_{jt}	-107.8	*-135.7*	*-79.8*	-125.6	*-156.0*	*-95.3*
y^{chl}_{jt}	49.3	*36.3*	*62.4*	48.0	*34.0*	*62.1*
q_{jt}	138.7	*122.7*	*154.8*	183.2	*149.6*	*216.7*
τ_{jt}	9.5	*3.8*	*15.1*	2.3	*-5.8*	*10.3*
Total	100.0			100.0		

Notes:
Based upon regressions that control for trade barriers
All regressions include product-year observations within the range $0.05<p_{jt}<20$
a: Measured as percentage of fitted value considering the observed average growth in the price index (-0.77%), China/ROW income ratio (7.2%), China/ROW income per capita ratio (7.7%), average Chilean tariff duties (-0.6%) and Chile/ROW income per capita ratio (3.9%).

Table 6
Across-product quantity penetration and price differences

Panel A: 8-digit HS level Elasticity of Substitution from Broda and Weinstein

Dependent Variable	$\ln X_{jt}$	$\ln X_{jt}$	$\ln X_{jt}$	$\ln p_{jt}$	$\ln p_{jt}$	$\ln p_{jt}$
Independent Variables						
σ_j	7.157	9.415		-3.462	-3.089	
	1.534	*1.042*		*0.530*	*0.471*	
Year	0.148	0.230	0.239	-0.010	-0.024	-0.028
	0.004	*0.003*	*0.003*	*0.002*	*0.001*	*0.002*
Year* σ_j	-0.004	-0.005	-0.005	1.74E-03	1.55E-03	1.43E-03
	0.001	*0.001*	*0.001*	*2.66E-04*	*2.36E-04*	*2.53E-04*
Sample	31936	31936	31936	31936	31936	31896
R^2						
Within		0.198	0.198		0.013	0.013
Between		0.002	0.002		0.000	0.005
Overall	0.038	0.038	0.001	0.003	0.002	0.001
Specification [a]	Pool	RE	FE	Pool	RE	FE

Panel B: Rauch's Conservative Classification of Products

Dependent Variable	$\ln X_{jt}$	$\ln X_{jt}$	$\ln X_{jt}$	$\ln p_{jt}$	$\ln p_{jt}$	$\ln p_{jt}$
Independent Variables						
Year	0.140	0.217	0.247	-0.006	-0.020	-0.027
	0.004	*0.003*	*0.003*	*0.001*	*0.001*	*0.001*
Year* D_{Ref} [b]	-2.2E-04	-3.2E-04	-1.3E-01	2.1E-04	2.4E-04	2.2E-02
	2.4E-05	*5.2E-05*	*8.2E-03*	*8.3E-06*	*1.6E-05*	*3.9E-03*
Year* D_{Hom} [c]	-5.2E-04	-7.7E-04	-2.8E-01	2.2E-04	2.7E-04	-1.2E-02
	8.5E-05	*1.6E-04*	*2.9E-02*	*2.9E-05*	*5.0E-05*	*1.4E-02*
Sample	31843	31843	31843	31843	31843	31843
R^2						
Within		0.195	0.206		0.012	0.013
Between		0.005	0.010		0.040	0.037
Overall	0.041	0.041	0.003	0.021	0.019	0.016
Specification [a]	Pool	RE	FE	Pool	RE	FE

Standard errors in italics

Notes

All regressions include product-year observations within the range $0.05 < p_{jt} < 20$

a: RE: Random Effects; FE: Fixed Effects

b: D_{Ref} is a dummy variable that takes a value of 1 if the product is classified as referenced price product by Rauch (1999); 0 otherwise

c: D_{Hom} is a dummy variable that takes a value of 1 if the product is classified as homogeneous product by Rauch (1999); 0 otherwise

Table 7
Across-product differences in Quality Growth
Product-specific elasticity of substitution σ_j from Broda and Weinstein (2006)

Panel A: 8-digit level income variables

Group	σ_j	Common factor cost [a]		k [b]		s [c]	
		Mean	s.e	Mean	s.e	Mean	s.e
10th Percentile	1.266	10.5	*1.0*	13.0	*1.7*	10.3	*1.0*
25th Percentile	1.407	10.4	*1.0*	12.9	*1.7*	10.3	*1.0*
50th Percentile	2.119	10.1	*0.8*	12.6	*1.5*	10.0	*0.9*
75th Percentile	2.785	9.8	*0.8*	12.3	*1.4*	9.8	*0.8*
90th Percentile	4.765	9.1	*0.7*	11.6	*1.3*	9.2	*0.7*
Test (Probability > F) [d]							
$q(10)=q(90)$		0.05		0.28		0.09	
$q(25)=q(75)$		0.08		0.31		0.12	

Panel B: 2-digit level income variables

Group	σ_j	Common factor cost		k		s	
		Mean	s.e	Mean	s.e	Mean	s.e
10th Percentile	1.266	12.0	*1.4*	24.5	*7.1*	11.0	*1.2*
25th Percentile	1.407	11.9	*1.4*	24.1	*6.8*	10.9	*1.2*
50th Percentile	2.119	11.4	*1.3*	22.4	*5.6*	10.6	*1.1*
75th Percentile	2.785	11.0	*1.2*	21.0	*4.8*	10.3	*1.1*
90th Percentile	4.765	10.0	*1.1*	17.6	*3.7*	9.4	*1.0*
Test (Probability > F)							
$q(10)=q(90)$		0.04		0.19		0.06	
$q(25)=q(75)$		0.06		0.25		0.08	

Notes:
All regressions include product-year observations within the range $0.05<p_{jt}<20$
a: Based on regression that include the independent variable log y^{chn}_{jt}
b: Include interactive term log $y^{chn}_{jt} * k_{jt}$ to control for cross-sector differences in capital intensity
c: Include interactive term log $y^{chn}_{jt} * s_{jt}$ to control for cross-sector differences in skill intensity
d: $q(\#)$ refers to the rate of quality growth of a product with a σ_j in the #th percentile

Table 8
Across-product differences in Quality Growth
Product conservative classification from Rauch (1999)

	8-digit income variables			2-digit income variables		
	Common factor cost [a]	k [b]	s [c]	Common factor cost [a]	k	s
Differentiated Products	11.18	13.46	10.82	12.89	22.01	11.43
	1.15	*1.86*	*1.10*	*1.78*	*5.81*	*1.46*
Reference priced Products	4.81	4.00	5.20	4.75	3.33	4.91
	0.25	*0.25*	*0.33*	*0.89*	*0.70*	*0.95*
Homogeneous Products	2.79	1.97	2.91	4.28	2.35	5.23
	0.80	*0.93*	*0.96*	*1.36*	*0.92*	*2.66*
Test (Probability > F) [a]						
q(Diff) = q(Ref)	0.00	0.00	0.00	0.00	0.00	0.00
q(Diff) = q(Hom)	0.00	0.00	0.00	0.00	0.00	0.04
q(Ref) = q(Hom)	0.02	0.03	0.02	0.77	0.39	0.91

Standard errors in Italics
Notes:
All regressions include product-year observations in which $0.05<p_{jt}<20$ and control for trade barriers.
a: Based on regression that include the independent variable log y^{chn}_{jt}
b: Include interactive term log $y^{chn}_{jt} * k_{jt}$ to control for cross-sector differences in capital intensity
c: Include interactive term log $y^{chn}_{jt} * s_{jt}$ to control for cross-sector differences in skill intensity

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