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DOES TRADE STIMULATE INNOVATION? EVIDENCE FROM FIRM-PRODUCT DATA

by

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PREFACE

What kinds of innovation policies make sense in emerging economies to ensure innovation contributes to economic development? Is it Costa Rican scientist Franklin Chang Díaz's plasma rocket, or the incremental efforts of thousands of small and medium enterprises to innovate based on the technological and organisational advances that have been developed elsewhere? These are some of the important questions posed by the InnovaLatino initiative. This paper, by the Development Centre's Caroline Paunov and Ana Margarida Fernandes of the World Bank, is part of our effort to answer these big questions, and serves as a background paper to the first project report. The authors answer some of these questions in the context of the newest OECD member country: Chile.

Over the past two decades, globalisation and the increased exposure to import competition has created a new economic environment for manufacturing producers in emerging economies. The authors remind us that incremental innovations – not only the rocket-science type – are particularly relevant to economic progress in a developing-country setting. This paper shows that incremental innovation – upgrading and differentiating one's products in response to increased competition from imported goods – is one way for producers to position themselves in domestic and international markets.

The paper's results show that tougher import competition does have a positive, significant, and robust impact on incremental innovation, as reflected in product-quality upgrading by Chilean firms. To the extent that these findings can be generalised to other emerging economies, they suggest that increased exposure to imports can be beneficial for innovation outcomes. Moreover, the paper finds that the mechanism driving this outcome is that firms react to the import pressure by innovating so as to differentiate their products as a way to escape competition. The findings, therefore, point to the importance of competition policy. In addition, the results indicate that easier access to imported inputs also has beneficial effects on innovation, which highlights the importance of learning from trade in stimulating innovation. However, the evidence also suggests that such benefits only arise if the right conditions hold: notably, firms must have skilled workers, and not all industries offer the same opportunities for this kind of innovative response. For economies to capture the dynamic benefits of trade the framework conditions matter.

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RÉSUMÉ

Cet article examine si le fait d'être en compétition avec des produits d'importation affecte la décision des entreprises de s'engager dans l'innovation incrémentale, qui se reflète dans une amélioration de la qualité des produits. Les résultats économétriques sont fondés sur de riches données chiliennes d'entreprises et de leurs produits. La qualité des produits est mesurée par leur valeur unitaire (leur prix) et le coût de transport des importations est utilisé comme une mesure exogène du degré de compétition des importations. Les estimations montrent un effet négatif du coût de transport sur la qualité des produits. L'article démontre que les incréments dans la valeur unitaire reflètent les incréments dans la qualité des produits et que la compétition explique nos résultats. Un accès plus aisé aux produits intermédiaires participe également à une amélioration de la qualité des produits.

Mots clés : Compétition des importations, coût de transport, innovation incrémentale, qualité des produits, valeur unitaire de la production, données d'entreprises, entreprises multi-produits, Chili.

Classification JEL: O31, F14, L6.

ABSTRACT

This paper investigates whether increased import competition leads firms to engage in incremental innovation reflected in product quality upgrading. The econometric analysis relies on a rich dataset of Chilean manufacturing firms and their products. Product quality is measured with unit values (prices) and imports' transport costs are used as an exogenous proxy for import competition. The estimates show a negative effect of transport costs on product quality. The paper provides explicit evidence that estimated increases in unit values capture product quality upgrading, and that competition effects of imports explain our results. Easier access to intermediate inputs also fosters quality upgrading.

Keywords: import competition, transport costs, incremental innovation, product quality, output unit values, firm-level data, multi-product firms, Chile

JEL Classification: O31, F14, L6.

I. INTRODUCTION

What are the dynamic effects of globalisation for manufacturing producers in emerging economies? The evidence on trade and growth at the micro level has focused nearly exclusively on the effects of trade liberalisation on firm productivity levels and growth (Tybout, 2000). There are, however, other important dimensions along which firms adjust to globalisation. Innovation is a major factor since it plays a crucial role for growth and welfare (Grossman and Helpman, 1991; Aghion and Howitt, 1998). Within the range of possible types of innovation, minor or incremental innovations have been shown to be important drivers of growth, particularly in emerging economies (Puga and Trefler, 2009). This paper addresses the dynamic effects of globalisation by exploring whether increased exposure to imports stimulates incremental innovation reflected in product quality upgrading for firms in an emerging economy. In order to render the evidence useful for policy design we also need to understand what mechanism explains quality upgrading. The hypothesis that we explore is that competition drives the effects: firms upgrade the quality of their products so as to differentiate them from those of their competitors.

While the idea of linking import competition to product quality upgrading is appealing, its empirical implementation faces two challenges. The first challenge concerns the measurement of product quality. To address it, we exploit a new dataset including rich information from census data on all the products manufactured by all Chilean firms during the 1997-2003 period and use unit values (prices) of products to measure their unobserved quality or sophistication. Increases in unit values correspond well to the definition of incremental innovation in the OECD Oslo manual (1997) which covers "existing product[s] whose performance has been significantly enhanced or upgraded".[1] The empirical trade literature takes for granted the idea that increases in unit values represent improvements in unobserved quality (Fontagné and Freudenberg, 1997). For example, Kugler and Verhoogen (2008), Iacovone and Javorcik (2008) and Lelarge and Nefussi (2008) use data on unit values of domestic and exported products to proxy for product or export quality at the plant level, while Brooks (2006), Kiyota (2008) and Schott (2008) use data on exports' unit values to proxy for export quality at the industry or country level. The role of product pricing as a signal for quality has also been examined by an extensive industrial organisation literature (e.g. Thomas *et al*., 1998; Fluet and Garella, 2002). The market for 'lemons' of Akerlof (1970) illustrates this clearly: in the presence of imperfect information, firms with high quality products need to introduce signals – higher prices – to convey to consumers the high quality of their products. Khandelwal (2009) criticizes the assumption that unit values equal

1. Pietrobelli and Rabellotti (2006) also equate product quality upgrading with "innovation to increase value-added" incremental innovation.

quality as being too strong as prices reflect also variations in costs but shows that the mapping of unit values to quality is actually appropriate in the industries with more scope for quality differentiation. In any case, in spite of the many arguments supporting the idea that unit values proxy for quality, we investigate the assumption empirically.

The second challenge concerns the difficulty in identifying causal effects of import competition on quality upgrading as upgrading can itself affect whether and how much foreign competitors choose to export to the domestic market. This challenge is particularly relevant in the case of our sample period for Chile during which a gradual and continuing process of trade integration – rather than a radical trade liberalisation episode – was under way. To address it, we rely on an effective trade barrier measure – imports' transport costs – which proxies for differences in import competition across industries that are exogenous to quality upgrading. While we are not the first to use imports' transport costs, we demonstrate why that measure is indeed a useful proxy for import competition in general and in the specific case of Chile. Our exercise contributes to the literature by providing evidence on the impact of trade openness on innovation beyond the initial effects of radical liberalisation. Our econometric approach exploits the variation in imports' transport costs across 4-digit industries and over time and consists of regressions of product unit values on a lagged measure of transport costs, firm-product and industry-year fixed effects, and firm and industry control variables. Importantly, our specifications identify the impact of transport costs by comparing unit values of a given product within a firm as transport costs change.

Our main finding is that stronger import competition leads to significant quality upgrading by Chilean firms. This result is obtained in regressions that use transport costs measures directly and is also confirmed in regressions that use import penetration ratios instrumented by transport costs measures. We prove that our estimated increases in unit values due to tougher import competition result from product quality improvements by showing that there is no impact of import competition from less advanced economies than Chile whose product quality is likely insufficient to challenge Chilean producers. Moreover, we show that the impact is significantly higher in industries with greater scope for quality differentiation and for firms with greater absorptive capacity. A different concern about our findings is that they seem puzzling relative to the "imports-as-market-discipline hypothesis" (Levinsohn, 1993). However, this puzzle is only one at first sight as the hypothesis predicts a negative effect of import competition on price-cost margins, hence focusing on the mark-up component of prices and not on the prices themselves. Using the methodology proposed by Roeger (1995), we explicitly test whether our main result contradicts the imports-as-market-discipline hypothesis. We find no contradiction as our results show an insignificant impact of import competition on Chilean firms' price-cost margins. Hence the estimated changes in firms' prices as a result of import competition are not related to changes in firms' mark-ups. Finally, our main finding is robust to a variety of tests on the validity of transport costs as an exogenous barrier to trade, the use of alternative outlier criteria, and the inclusion of additional or alternative control variables.

Our hypothesis of the mechanism driving our results is that import competition forces firms to innovate by offering better-quality products. We test for the validity of this hypothesis by considering alternative interpretations for our results. First, our results could be picking up the impact of access to better imported intermediate inputs on product quality. Accounting explicitly for the effects of intermediate inputs' transport costs, we show that the importance of stronger import competition for quality upgrading is maintained, even if the access to better inputs also has a significant positive effect. Second, our main findings could be explained by a strategic product market positioning story consisting of a decline in the quality of Chilean imports due to reductions in transport costs (as predicted by Hummels and Skiba (2004)) and Chilean firms improving the quality of their products to fill out the product space (as predicted by Vogel (2008)). However, the story is not supported by our data as the quality of Chilean imports (proxied by their unit values) did not change with transport costs in a manner consistent with the Hummels and Skiba (2004) prediction. Third, our results could reflect an increase in access to export markets if reductions in transport costs for Chilean imports are correlated with decreases in transport costs for Chilean exports. However, our evidence does not support this theoretically plausible explanation as the effects of import competition on product quality are stronger for firms that do not export and for products that are not exported.

Our paper relates to the vast theoretical and empirical literature on the impact of product market competition – of domestic or foreign origin – on firm performance, notably on technological and innovation outcomes.[2] On the theoretical side, Schumpeter (1942) argues in a seminal contribution that producers facing less competition are best placed to innovate since getting adequate returns for one's innovation requires some form of temporary monopoly power. Rodrik (1992) shows that by reducing the firm's market share import competition actually decreases its incentives to innovate. In contrast, stronger competition may foster innovation as producers need to escape their innovating peers to stay in business (Nickell, 1996). Goh (2000), Thoenig and Verdier (2003), Atkeson and Burstein (2007), Ederington and McCalman (2008), and Bustos (2009) show that stronger import competition increases firms' incentives to upgrade their technology and innovate.[3] In Thoenig and Verdier (2003) in particular, firms engage in defensive skill-intensive innovations desiring to reduce future threats of imitation or leapfrogging by competitors. Finally, Aghion *et al*. (2005, 2006) show that the relationship between competition and innovation has an inverted U-shape based on a model which allows for counteracting 'escape competition' effects as well as 'Schumpeterian' effects of competition on innovation depending on firm or industry distance to the technological frontier. While the studies on competition and innovation are not clear-cut about the sign of that relationship, many models suggest that stronger import competition leads to innovation. This is the hypothesis that we will test in the paper focusing on incremental innovation reflected in product quality upgrading.

On the empirical side, studies on the effects of import competition on firm performance or innovative behavior have mostly focused on total factor productivity (TFP) as it captures

2. Tybout (2000) surveys the literature on firm adjustments to import competition while Ahn (2002) reviews the literature on competition and innovation.
3. Note that the models considered in the various papers are very different: Goh (2000), Thoenig and Verdier (2003), and Rodrik (1992) consider representative firm models whereas Atkeson and Burstein (2007), Ederington and McCalman (2008), and Bustos (2009) consider dynamic heterogeneous firm models.

process innovation. The studies generally find a positive and significant effect of stronger import competition on firm TFP (e.g. Harrison, 1994; Pavcnik, 2002; Fernandes, 2007). Studies examining the effects of import competition on firm product innovation outcomes are rare. Focusing on firms in developed countries, the effect of broad import competition on the involvement in product upgrading or innovation measured by an affirmative answer to the question: 'Did you introduce new or significantly improved goods' is estimated by Bertschek (1995) and Baldwin and Gu (2004). Lelarge and Nefussi (2008) estimate the impact of import competition from low-wage countries on research and development (R&D) spending, while Bloom *et al*. (2009*a*) look at the impact of Chinese import competition on patents. These studies find a positive and significant effect of import competition on innovation outcomes To the best of our knowledge only two studies, Bustos (2009) and Teshima (2009), focus on firms in developing countries but, in contrast to our study, they examine the effects of import competition on a more radical type of innovation, R&D spending.[4]

Our study's contributions to the literature are three-fold. First, ours is the first paper to examine the impact of import competition on a measure of incremental innovation based on firm-product data. In emerging economies where most producers lag behind the world's technology frontier and often improve upon products imported from developed economies, incremental innovation is much more prevalent than the radical R&D-intensive innovation considered in previous studies. We measure incremental innovation using direct quantitative information on firms' product prices rather than subjective perception-based measures of product upgrading as in previous studies. Second, we analyze the effects of import competition on quality upgrading for the universe of Chilean manufacturing products whereas most previous studies focus on the quality of exported products only. Since 86% of the products manufactured by Chilean firms are sold only in the domestic market, this feature of the analysis is important. Furthermore, exported products may differ in many respects from domestically sold products, thus estimates obtained focusing exclusively on the former may be biased. Third, our identification of the effects of import competition on product quality relies on the use of a measure of transport costs that can be considered to be exogenous to quality upgrading.

Our findings indicate that increased exposure to import competition may be beneficial by promoting the innovativeness of producers as a solution to escape competitive pressures from abroad (Pietrobelli and Rabellotti, 2006). Our evidence also suggests that such benefits only arise if the right conditions hold: it requires firms to dispose of skilled personnel and will occur mostly in industries whose attributes offer opportunities for such innovativeness. This gives some support to the idea that the industries in which an economy specializes matter – at least when it comes to benefitting from competition though incremental innovation.[5] While our findings focus on import competition, we believe that they also point to the benefits of competition policy more generally as a central factor to promote innovation. Note that we also find support for another

4. Bustos (2009) uses a measure of expenditures on R&D, computers, software, technology transfers, and patents.
5. Without advocating active industrial policies per se, we note that our findings are in line with the conclusions of Hausman et al. (2007) on the importance of a country's specialisation patterns for its development.

explanation for quality upgrading, which is the benefits from easier access to foreign inputs. The latter supports the large literature on learning from embodied foreign technologies as a central channel to stimulate indigenous innovation in emerging economies (e.g. Rivera-Batiz and Romer, 1991; Goldberg *et al*., 2008).

The remainder of the paper proceeds as follows. Section II describes the data. Section III presents the empirical specification and discusses the use of transport costs as an exogenous proxy for import competition. Section IV discusses our main results, evidence of quality upgrading, and robustness tests. Section V presents alternative explanations for our results. Section VI concludes.

II. DATA

II.1. Firm Unit Values and Other Information

In our analysis, we use a dataset with information on products at the firm level from 1997 to 2003 that is merged with the annual manufacturing census of Chilean firms with more than 10 employees (ENIA).[6] Both datasets are provided and collected by the Chilean National Statistical Office. The products dataset includes information for each firm and year on the physical quantity sold and the sales value of each of 1 817 products at the 7-digit ISIC level (revision 2). Appendix Table 1 provides some examples of 7-digit ISIC level categories to illustrate the level of detail of the products. The ENIA census described in detail in Fernandes and Paunov (2008) is an unbalanced panel of firms capturing entry and exit that includes information on basic firm characteristics such as employment or ownership, and on accounting variables such as sales.

For each product p7 of firm i in year t we construct a unit value as $UV_{it}^{p7} = S_{it}^{p7} / Q_{it}^{p7}$, where S is the value of sales and Q is the physical quantity sold. A unit value measures the average price charged by a firm for each product in a year. Our dataset reports the physical quantities of the 1 817 products in 20 different measurement units, some of which are shown in Appendix Table 1. The unit values of products measured in different units (e.g. kilogram, litre) are not comparable. To obtain our final estimating sample, we address two measurement unit-related issues: *i)* a few firms do not report the measurement unit of their products' quantity, and *ii)* some firms report their products' quantity in a different unit than the unit in which the majority of firms report product quantities. The unit values of both types of firms cannot be compared to those of other firms producing the same 7-digit product and are thus excluded from the final sample. Further, to eliminate potential outliers we exclude observations with unit values above (below) the 75th (25th) percentile plus (minus) by 1.5 times the inter-quartile range of the distribution of unit values for any 7-digit product.[7] Appendix 2 describes the cleaning procedures and some tests performed to assess the goodness of the products dataset. Our final sample combining the products dataset with the ENIA census includes 51 349 firm-year-product observations corresponding to 5 705 firms with the average number of products manufactured per firm being 2.1. Navarro (2008) shows that many stylised facts based on the Chilean products

6. Note that the ENIA dataset provides information by plant and not by firm. However, according to Pavcnik (2002) more than 90% of firms during the 1979-1986 period are single-plant firms. Hence plant information corresponds to a large extent to firm information and we use the term firm throughout the paper.

7. While we base our main results on the exclusion of outliers for product categories, our main findings are maintained when the exclusion of outliers is done for product-year categories.

dataset are similar to those obtained for a US products dataset by Bernard *et al*. (2009*a*) and an Indian products dataset by Goldberg *et al*. (2009).[8]

The maintained assumption in our paper is that an increase in unit values proxies for firm product quality upgrading. Table 1 shows average coefficients of variation in unit values for selected 4-digit industries. They show a substantial degree of heterogeneity in unit values across firms and point to some interesting differences across industries. Industries with homogeneous products and thus less scope for quality differences such as cement or petroleum refineries are characterised by low average coefficients of variation. In contrast, industries where quality is expected to play an important role such as electrical machinery, motorcycles, and professional equipment are characterised by higher coefficients of variation. These statistics seem to support our maintained assumption that unit values proxy for the quality of Chilean manufactured products. In Section IV.3 we will provide econometric evidence in support of that assumption.

Table 1: **Heterogeneity in Unit Values within Selected 4-digit Industries**

4-digit ISIC		Coefficient of Variation
3111	Slaughtering, preparing and preserving meat	4.6%
3114	Canning, preserving and processing of fish, crustaces and similar	9.7%
3134	Soft drinks and carbonated waters industries	5.0%
3212	Manufacture of made-up textile goods	51.4%
3220	Manufacture of wearing apparel	81.9%
3312	Manufacture of wooden and can containers	37.2%
3420	Printing, publishing and allied industries	30.3%
3530	Petroleum refineries	5.5%
3620	Manufacture of glass and glass products	47.9%
3610	Manufacture of pottery, china and earthenware	22.9%
3692	Manufacture of cement, lime and plaster	7.4%
3831	Manufacture of electrical industrial machinery	34.6%
3844	Manufacture of motorcycles and bicycles	70.5%
3851	Manufacture of professional and scientific, and measuring and controlling equipment n.e.c.	86.6%
3901	Manufacture of jewellery and related articles	28.2%

Notes: The table shows for each 4-digit industry the simple average across all sample years of the industry's yearly coefficients of variation in unit values. For each 4-digit industry and year, the yearly coefficient of variation in unit values is obtained as a weighted average of the coefficients of variation in unit values for each of its 7-digit products using as weights the share of each 7-digit product in the 4-digit industry's total sales in the year.

II.2. Transport Costs

Our measure of transport costs is based on detailed information provided by the Latin American Integration Association (ALADI) on freight costs excluding insurance costs and the free on board customs value (fob) of Chilean imports for each 8-digit Harmonized System (HS)

8. For example, the average shares of the most important product, the second most important product, and so on, in total sales of Chilean multi-product plants are strikingly similar to those of US and Indian multi-product plants.

1996 nomenclature code, exporting country, and year from 1997 to 2003. First, we compute for 8-digit HS code m from exporting country c in year t ad-valorem freight rates as the ratio of freight costs ($freight_{mct}$) to the fob value of Chilean imports (fob_{mct}): $fr_{mct} = freight_{mct} / fob_{mct}$. Second, we aggregate these freight rates from the 8-digit HS code, exporting country, and year level to the 4-digit ISIC (revision 2) and year level using: *i)* a concordance between 8-digit HS and 4-digit ISIC codes and *ii)* weights given by Chile's 8-digit HS fob imports from each exporting country and year as a ratio to Chile's total imports in the corresponding 4-digit ISIC code in that year. Appendix 2 provides more details on the construction of the transport costs measure TC_t^{k4}.[9] We discuss at length the appropriateness of transport costs as an exogenous proxy for import competition across industries in Section III.2.

9. Since some countries may not export a product to Chile due to prohibitive transport costs, our measure is a lower bound for transport costs accounting only for those of exports that actually occur (Hummels, 2001). However, as this feature of our measure is common to products in all industries, it does not impair our analysis which focuses on differences in the relative, rather than the absolute, magnitude of transport costs across 4-digit industries and time.

III. EMPIRICAL FRAMEWORK

III.1. Baseline Specification

Using the unit values and transport costs measures as defined above we propose the following specification to examine the impact of import competition on product quality:

$$\log UV_{it}^{p7} = \beta * TC_{t-1}^{k4} + \gamma * X_{it} + f_i * I^{p7} + I^{m3} * I_t + \varepsilon_{it}^{p7} \quad (1)$$

where $\log UV_{it}^{p7}$ is the log of the unit value for 7-digit product p7 manufactured by firm i in year t, TC_{t-1}^{k4} are transport costs for 4-digit industry k4 to which the firm's product p7 belongs in year t-1, X_{it} is a vector of controls to be specified below, $f_i * I^{p7}$ are firm-7-digit product fixed effects, $I^{m3} * I_t$ are 3-digit industry m3-year fixed effects, and ε_{it}^{p7} is an independent and identically distributed (i.i.d.) residual. The hypothesis that we test in the paper is whether β is negative which would indicate a positive impact of import competition on product quality.

III.2. Transport Costs: An Exogenous Proxy for Import Competition

III.2.1. A Proxy for Import Competition

Our paper is not the first to use imports' transport costs as a proxy for import competition: Bernard *et al*. (2006*a*) use transport (combined with tariffs) in a study of the responses of US manufacturing industries to stronger import competition. Notwithstanding, it is important to discuss the reasons that support the idea that transport costs are an adequate proxy for import competition in general and in the case of Chile during our sample period. First, transport costs are an important friction to international trade and due to their size and variability play an important role in shaping patterns of trade across goods and partners.[10] Transport costs represent currently a greater share of total trade costs than the tariffs for most countries due to the trade liberalisation efforts of the last decades (Anderson and Wincoop, 2004). Second, since the 1980s' trade liberalisation, Chile reduced tariffs significantly and

10. Hummels (2001) shows that within disaggregate product categories, exporters with the lowest freight rates have the largest import shares based on data for the United States, New Zealand, Argentina, Brazil, Chile, Paraguay and Uruguay.

imposed a uniform tariff structure across industries.[11] Hence, transport costs, rather than tariffs, capture the differential obstacles to trade faced by Chilean industries (Moreira and Blyde, 2006). More importantly, we show that for Chilean industries during our sample period reductions in transport costs led indeed to increases in import competition. Table 2 presents the results from estimating the specification $IMP_t^{k4} = \alpha_{TC} * TC_{t-1}^{k4} + I_t + I^{m3} + u_t^{k4}$, where IMP_t^{k4} is the import penetration ratio of 4-digit industry k4 in year t, TC_{t-1}^{k4} are transport costs, I_t are year fixed effects, I^{m3} are 3-digit industry fixed effects, and u_{it}^{k4} is an i.i.d. residual.[12]

Table 2: **Effects of Transport Costs on Import Penetration**

	Dependent Variable: 4-Digit Industry Import Penetration Ratio		
		IV	IV
	(1)	(2)	(3)
Transport Costs $_{t-1}$	-0.571***	-0.970***	-1.377**
	(0.211)	(0.285)	(0.629)
Year Fixed Effects	Yes	Yes	Yes
3-Digit Industry Fixed Effects	Yes	Yes	Yes
Instrument		Fuel price*transport cost first year	Fuel price*distance*import share first year
Number of Observations	465	462	462
R-Squared	0.72		

Notes on IV-Regression reported in (6): Transport costs are instrumented using measures explained further in the appendix. Results on the underidentifcation test (Kleinberg LM statistic) are 17.10 (with a P-Value of 0.00) for IV-regressions reported in column (2) and 6.845 (with a P-Value of 0.01) for those in column (3). The F-test of excluded instruments is 31.72 (with a P-Value of 0.00) and 9.88 (with a P-value of 0.00) for columns 2 and 3 respectively.

The results from OLS estimation in column (1) show that as transport costs decline, import penetration ratios increase significantly. An expansion in an industry's imports may reduce its transport costs if the transportation of larger shipments benefits from economies of scale.[13] To mitigate this potential reverse causality, we present in columns (2)-(3) the results from instrumental variables (IV) estimation where transport costs are instrumented by fuel prices – that capture important time-varying shocks to the cost of transportation – interacted with

11. Chile's uniform tariff continued to decline from 11% in 1998 to 6% in 2003 but with no variation across industries. Chile signed important trade agreements with the EU and the US (Chumacero et al., 2004). However, those entered into force only after the end of our sample period.
12. The import penetration ratio is given by the ratio between imports and the sum of total imports and total domestic sales in the industry as detailed in Appendix 2.
13. Hummels (2007) argues that scale economies led to important reductions in shipping prices over the last decades. Indeed, simple correlations between our disaggregate freight rates and the quantity exported for products with more than 30 exporting countries are negative and significant providing suggestive evidence of the presence of economies of scale in transportation. These results make use of quantity data from COMTRADE described further below.

variables allowing those shocks to differentially affect products depending on their transportation intensity.[14] The IV results show a negative and significant effect of transport costs on import penetration. We can therefore argue with confidence that transport costs are an adequate proxy for import penetration across Chilean 4-digit industries.

III.2.2. Endogeneity Issues

Our imports' transport costs measure is computed based on freight costs that exclude insurance costs. This is an advantage relative to the measure used by Bernard *et al*. (2006*a*) as it avoids one source of endogeneity: the fact that insurance costs increase with the value – and likely with the quality – of exported products. Since our transport costs measures capture the costs incurred by imports from the exporting country until arrival to the point of entry into Chile, they are immune to political economy forces that could pressure for increased trade openness and/or investments in domestic infrastructure as a result of domestic quality improvements. This is an advantage of our measure over tariff-based analyses of the effects of import competition.

While the arguments above suggest that transport costs are exogenous to quality upgrading in Chile, we pursue this issue further given that our analysis does not rely on a radical trade liberalisation episode but rather on a gradual and continuing process of trade integration captured by the variability of transport costs across 4-digit industries and over time. Table 3 illustrates that variability.[15] It is important to show that the origins of this variability are exogenous to product quality upgrading in Chile. The variability in transport costs can originate in variability of the underlying disaggregate freight rates TC_{ict} across exporting countries and 8-digit HS products.[16] This latter variability can be explained by factors such as infrastructure quality in the exporting country, the distance shipped, the mode of transportation and its quality, market power in the shipping industry, and the type of product being shipped (e.g. heavy versus light) (Limão and Venables, 2001; Hummels, 2007; Hummels *et al*., 2009). All these factors can be confidently considered to be exogenous to Chilean products' unit values.

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14. The variables are transport costs in the first sample year or distance weighted by the import share in the first sample year, described in detail in Appendix 2.
15. For certain industries transport costs increase in parts of the sample period which could be due to increases in fuel costs, port congestion, and their differential effect across countries and products despite technological progress.
16. The coefficient of variation of the ratio of fr_{mct} to the average of fr_{mct} by 8-digit HS product and year is 0.99 and that of the ratio of fr_{mct} to the average of fr_{mct} by exporting country and year is 0.64.

Table 3: **Transport Costs for Selected 4-digit Industries and Years**

4-digit ISIC		1997	1999	2002
3112	Manufacture of dairy products	7.98%	6.46%	6.25%
3118	Sugar factories and refineries	10.67%	15.67%	14.02%
3212	Manufacture of made-up textile goods except wearing apparel	6.69%	7.74%	8.60%
3220	Manufacture of wearing apparel except footwear	4.98%	5.35%	5.13%
3312	Manufacture of wooden and cane containers and small cane ware	9.15%	6.29%	6.11%
3320	Manufacture of furniture and fixtures, except primarily of metal	13.72%	12.25%	13.98%
3122	Manufacture of prepared animal feeds	15.61%	12.91%	12.74%
3133	Malt liquors and malt	19.49%	12.61%	15.66%
3140	Tobacco manufactures	8.19%	8.46%	8.79%
3215	Cordage, rope and twine industries	4.33%	5.08%	6.39%
3233	Manufacture of leather and leather substitutes, except footware and wearing apparel	8.29%	9.85%	9.06%
3240	Manufacture of footwear, except vulcanised or moulded rubber and plastic footwear	5.20%	5.50%	5.81%
3412	Manufacture of containers and boxes of paper and paperboard	15.14%	10.52%	10.41%
3512	Manufacture of fertlizers and pesticides	11.21%	11.91%	10.95%
3551	Tyre and tube industries	7.95%	7.69%	8.25%
3560	Manufacture of plastic products not elsewhere specified	10.27%	10.04%	9.13%
3620	Manufacture of glass and glass products	13.49%	14.31%	13.84%
3720	Non-ferrous metal basic industries	4.64%	4.58%	4.06%
3822	Manufacture of agricultural machinery and equipment	6.51%	5.36%	6.21%
3831	Manufacture of electrical industrial machinery and apparatus	4.85%	4.63%	4.80%
3852	Manufacture of photographic and optical goods	3.36%	3.36%	3.85%
3420	Printing, publishing and allied industries	8.04%	8.74%	8.24%
3522	Manufacture of drugs and medicines	3.30%	3.07%	3.31%
3610	Manufacture of pottery, china and earthenware	11.85%	15.67%	13.97%
3710	Iron and steel basic industries	10.59%	10.06%	10.15%
3812	Manufacture of furniture and fixtures primarily of metal	12.20%	11.35%	12.94%
3813	Manufacture of structural metal products	9.80%	7.65%	8.05%
3844	Manufacture of motorcycles and bicycles	8.69%	10.56%	11.49%

Note: The table shows for each 4-digit industry transport costs aggregated from the level of the 8-digit HS code, exporting country, and year to the level of the 4-digit ISIC and year using as weights the share of each 8-digit HS code and country in Chile's fob imports from that 4-digit ISIC industry in that year.

However, the variability in transport costs might also originate in compositional effects given the way in which the measure is constructed, described in Section II.2. A change in the composition of exporters or products exported to Chile changes the 4-digit transport costs measure even if all disaggregate freight rates are unchanged. This would be problematic if the change in exporters or products responded directly to quality upgrading in Chile.[17] Our data

17. One possible reverse causality argument is that domestic improvements in product quality could motivate certain countries to stop exporting or to export smaller volumes to Chile. This would bias downward our estimated effect of transport costs on unit values – making it appear smaller than what it might be in reality – if these changes led to a reduction in our transport costs measure. By construction our transport costs measure would decline if *i)* the countries that stop exporting had relatively high freight rates and represented a large share of imports in the industry, and/or *ii)* the

shows that among the relationships that could impact more substantially the transport costs measure – Chile's most important import relationships – very few start or stop during the sample period.[18] We test further the importance of compositional effects in Section IV.4 by using transport costs measures based on the freight rates of the top exporters to Chile and show that they do not drive our results. Moreover, domestic improvements in product quality could lead countries to increase the quality of their exports to Chile to keep up with local competition. Such an increase proxied by an increase in Chilean imports' unit values – i.e. the ratio of imports fob to the quantity imported – would result from imports fob increasing more than the quantity imported. Since imports fob are the denominator of our disaggregated freight rates, our transport costs measure would decline. Such decline due to an increase in Chilean imports' quality could bias downward our estimated effect of transport costs on unit values – making it appear smaller than what it might be in reality. To examine the validity of this concern, we compute changes in Chilean imports' quality during our sample period using unit values at the 4-digit ISIC and exporting country level based on data from COMTRADE.[19] The median and average annual changes in imports' unit values are 0% and 0.9%, respectively. Hence, the quality of imports to Chile does not seem to have changed substantially over the sample period to sustain concerns of reverse causality.[20] Notwithstanding, we approach this concern further in Section IV.4 by considering an alternative measure of transport costs per unit. This measure avoids the problem that by construction a potential increase in Chilean imports' quality could lead to a decline in our ad valorem transport costs measure.

To mitigate any remaining potential endogeneity concerns and allow the effect of import competition to occur with a lag, we consider the one-year lag of the variable TC as shown in Equation (1) following Bernard *et al*. (2006*a*).

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countries sending smaller volumes faced as a result lower freight rates and represented a substantial share of imports in the industry (that would remain large even as exports were reduced). As discussed in the text there is no evidence of *i)*. Regarding *ii)*, if economies of scale in transportation are at work, a reduction in shipment size would very likely be associated with higher not lower freight rates. Hence this reverse causality argument would if anything result in an increase in our transport costs measure and thus bias our estimates upward making it more difficult to obtain a negative effect of transport costs on quality.

18. Considering all of Chile's import relationships at the country-4-digit industry level, 4 960 pairs, only 49% last the entire sample period. Focusing on the top 10 exporting countries to Chile for each 4-digit industry, 4 400 out of 4 764 observations (94%) correspond to relationships that last the entire sample period.
19. Unit values are computed as the ratio of Chilean imports fob to the quantity imported from COMTRADE for each 6-digit HS product and exporting country between 1997 and 2003. The COMTRADE data on imports fob is similar to the ALADI data used to construct our transport costs measure summed up from the 8-digit to the 6-digit HS level.
20. Note that conceptually it would be equally possible that countries start exporting lower quality products to Chile judging the market there to be too tough on the higher-quality end. That would result in an increase in our transport costs measure which would not be of great concern as it would simply make it more difficult to estimate a negative effect of transport costs on quality. In any case, our evidence on Chilean imports' unit values shows that this possibility did not materialize.

III.2.3. Appropriate Level of Disaggregation

Transport costs in Equation (1) are measured at the 4-digit ISIC level. A measure at a more aggregate level may not adequately capture the degree of import competition faced by firms. For example, 3-digit ISIC industry 311, food manufacturing, includes 4-digit industries ranging from fruit and vegetable canning to bakery. If we considered a transport costs measure at the 3-digit level, a reduction in the transport costs of imported bakery products would erroneously suggest that fruit and vegetable canning products also faced stronger import competition, when such products are not exactly substitutes. Certainly, one could argue that measuring transport costs at the 4-digit level for bakery products (ISIC 3117) is still too aggregate. At that level, the measure implies that a reduction in the transport costs of cookie products strengthen the competition faced by cake products too. Cake products may indeed be challenged by imports of cookie products because consumers may decide to substitute cake for cookie products. If import competition was measured at a more disaggregate level – i.e. distinguishing cake from cookie products – then one might wrongly ignore that cross-effect.

Importantly, using a measure at the 4-digit level also reduces potential concerns of a spurious correlation between reductions in transport costs and quality upgrading in Chile due to demand shocks. Suppose that pencils are a 7-digit ISIC product manufactured by Chilean firms and that a positive shock to the demand for pencils increases their unit values domestically. Suppose also that transport costs were measured at the 7-digit level. As response to the demand shock foreign producers could react by exporting more pencils to Chile, this would likely reduce the transport costs on pencils (either because freight costs themselves decline due to scale economies or because imports fob increase). This would result in transport costs and quality (both at the 7-digit level) being spuriously correlated due to the demand shock. The consideration of a transport cost measure at the 4-digit level rather than at the more disaggregated 7-digit level helps to mitigate this type of demand-driven spurious correlation problem. This constitutes a central reason for our choice of using a transport costs measure at the 4-digit level, in addition to the fact that the 4-digit level allows for a reasonable degree of substitutability across products.

III.3. Additional Remarks on the Empirical Specification

We now discuss briefly other issues associated with the estimation of Equation (1). First, our specification needs to account for the fact that 49% of Chilean firms manufacture multiple 7-digit products. Among these multi-product firms in any given year, 55% manufacture products within a single 4-digit industry whereas the rest manufacture products across at least two different 4-digit industries.[21] Our specification allows firms manufacturing 7-digit products in various 4-digit industries to face a different degree of import competition – through different transport costs – in each of the 4-digit industries to which their products belong.

Second, Equation (1) controls for crucial firm-product fixed effects. Firms differ in the diversity of products they manufacture, the ways in which they manufacture them, and

21. Thus, in any given year about 78% of Chilean plants manufacture products within a single 4-digit industry.

management quality which affects their incentives and possibilities for quality upgrading, maybe differently across products. Given the presence of multi-product firms in the sample, such firm-product fixed effects, rather than firm fixed effects, are what accounts for unobservable firm-product heterogeneity. Their use implies that our main coefficient of interest β is identified on the basis of within-firm changes in the unit value of a given product as transport costs change.

Third, since unit values are prices, they reflect a combination of quality and cost attributes such as input prices and their increase may reflect to some extent an increase in firm market power. Higher costs of production at the firm level may, depending on the degree of competition in the market, lead to increases in unit values unrelated to quality improvements. Controlling for costs is thus important for our main specification and we include the following proxies for production costs: average wages paid by the firm, the share of skilled labor in the firm's total workforce, unit prices paid for electricity by the firm, and the share of imported material inputs in total firm material inputs, further detailed in Appendix 2. Firm size may play a role for quality upgrading by allowing the corresponding fixed costs to be spread over a larger scale and granting easier access to the financing necessary for upgrading, mimicking the role that size plays for radical innovation (Cohen and Klepper, 1996). The vector of controls thus includes a measure of the firm's market share in each of the 4-digit industries to which its products belong and three size dummies based on the firm's total employment, as described in Appendix 2. The downside to including both firm cost as well as market power controls is that doing so raises some endogeneity concerns. For this reason we will examine whether our results hold when these controls are excluded and we will show that this is indeed the case.

Fourth, omitted variables at the industry level correlated with transport costs but also with product quality could bias the estimate of β. The knowledge spillovers generated by FDI in an industry could drive firms, particularly those domestic-owned, to upgrade product quality. However, higher FDI in an industry could also have a negative effect on quality for domestic-owned firms through market-stealing effects. If stronger domestic competition in an industry has 'escape' effects as in Aghion *et al*. (2005), then it would likely be associated with quality upgrading in that industry. To control for these possibilities, we include in the vector of controls the share of total employment in the firm's main 4-digit industry accounted for by foreign-owned firms and the Herfindahl index for each of the 4-digit industries to which the firm's products belong. Bernard *et al*. (2006*b*) show that multi-product firms can adjust their product range and thus respond differently to increased trade openness relative to single-product firms. We include in the vector of controls a dummy identifying multi-product firms to account for potential differences in their unit values relative to those of single-product firms.

Finally, technological progress, inflation, or other shocks experienced by Chilean industries are accounted for by including 3-digit industry-year fixed effects. These may in particular account for different trends in the prices of materials or capital goods faced by firms in different 3-digit industries which could affect the prices at which they sell their final products.

We believe that Equation (1) allows us to identify an unbiased effect of increased import competition on product quality upgrading at the firm level due to the exogenous nature of transport costs and the set of control variables and fixed effects included.[22]

22. Active innovation promotion programmes may affect firms' incentives and possibilities to engage in quality upgrading. However, our specification would need to account for such programmes *only* if they targeted specific industries and could therefore be systematically correlated with transport costs. The Chilean National Fund for Technological and Productive Development (FONTEC) – a public programme in place since 1991 – helped finance innovation projects for manufacturing firms (Benavente *et al*., 2007). However, the programme did not target specific industries within the manufacturing sector.

IV. RESULTS

IV.1. Main Results

Table 4 presents the results from estimating Equation (1) showing two types of Huber-White standard errors robust to heteroskedasticity. Since our regressions explain firm-product unit values with more aggregate 4-digit transport costs measures, we follow Moulton (1990) and use standard errors clustered by 4-digit industry and year. But we also allow inference to be done based on standard errors clustered by 4-digit industry that allow for serial correlation within industries.[23] All specifications include firm-product fixed effects and 3-digit industry-year fixed effects.

Table 4: **Effects of Transport Costs on Unit Values**

	Dependent Variable: Log of Firm-Product Unit Value				
	(1)	(2)	(3)	(4)	(5)
Transport Costs $_{t-1}$	-1.749**	-1.743**	-1.702**	-1.734**	-1.689**
	(0.677)	(0.679)	(0.686)	(0.673)	(0.681)
	[0.806]	[0.809]	[0.812]	[0.798]	[0.804]
Firm Cost Controls	No	No	No	Yes	Yes
Other Firm Controls	No	Yes	No	No	Yes
Industry Controls	No	No	Yes	No	Yes
Firm*Product Fixed Effects	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	41979	41979	41966	41938	41929
R-Squared	0.97	0.97	0.97	0.97	0.97

Notes: Robust standard errors clustered by 4-digit industry and year in round parentheses and clustered by 4-digit industry in square parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. Firm cost controls include the log of average wages, the share of skilled labor in total labor, the log of unit electricity prices paid by the firm, and the share of imported inputs in total inputs. Other firm controls include size dummies, a dummy for multi-product firms, and the firm's market share at the 4-digit level. Industry controls include the share of employment in foreign-owned firms in total 4-digit industry employment and the normalised Herfindahl index at the 4-digit industry level.

The estimates in column (1) show that import competition has a positive effect on product quality when firm cost controls, other firm characteristics, and industry characteristics are

23. Our results are also robust to the consideration of standard errors clustered by product-year and by firm-year. In the tables that follow Table 4 we show for simplicity only the standard errors clustered by 4-digit industry and year. However all results are robust to the consideration of standard errors clustered by 4-digit industry.

ignored. In column (2), the specification includes only firm characteristics in addition to transport costs. The estimate of β is negative and significant and its magnitude is unchanged. Columns (3) and (4) show the results from specifications where in addition to transport costs either only industry characteristics or only firm cost controls are included, respectively. The estimates of β are again maintained. Column (5) shows our preferred specification which includes the three types of controls. The fact that our preferred results do not change if firm cost and market power controls are excluded, reassures us that the potential endogeneity concerns associated with those controls are not driving our results. Also, note that the control variables are contemporaneous relative to firm unit values but qualitatively similar results are obtained when one-year lagged control variables are considered.

Given that unit values are in logarithms and transport costs are measured in fractional terms, the estimate of β implies that a 3 percentage point reduction (slightly less than a one standard deviation) in transport costs would lead to an average increase in unit values of almost 5.2% within firms and products. Such reduction in transport costs would be associated with the following increases in actual unit values: e.g. *i)* from an average of USD 86 to USD 108 for bicycles; *ii)* from an average of USD 227 to USD 299 for domestic ovens and *iii)* from an average of USD 16 454 to USD 26 996 for fabricated motor vehicles.[24]

While Section III.2 shows that transport costs are an adequate proxy for import competition, we also estimate Equation (1) substituting import penetration ratios of 4-digit industries for transport costs. Then, a positive β indicates that stronger import competition stimulates firm quality upgrading. Table 5 presents the corresponding results where again all specifications include firm-product and 3-digit industry-year fixed effects.

24 . These averages are for the year 2000 and the unit values are expressed in USD using the corresponding average peso-USD exchange rate obtained from the Central Bank of Chile. Providing an economic magnitude for the average product is not possible due to the lack of comparability of unit values across products measured in different units.

Table 5: **Effects of Import Penetration on Unit Values**

	Dependent Variable: Log of Firm-Product Unit Value					
						IV-Reg
	(1)	(2)	(3)	(4)	(5)	(6)
Import Penetration $_t$	0.211**	0.201**	0.199**	0.209**	0.185**	1.706*
	(0.089)	(0.089)	(0.090)	(0.089)	(0.089)	(0.962)
Firm Cost Controls	No	No	No	Yes	Yes	Yes
Other Firm Controls	No	Yes	No	No	Yes	Yes
Industry Controls	No	No	Yes	No	Yes	Yes
Firm*Product Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	50797	50797	50787	50764	50754	43590
R-Squared	0.96	0.96	0.96	0.96	0.96	

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses in columns (1)-(5) and clustered by 4-digit industry in column (6). ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. Firm cost controls include the log of average wages, the share of skilled labor in total labor, the log of unit electricity prices paid by the firm, and the share of imported inputs in total inputs. Other firm controls include size dummies, a dummy for multi-product firms, and the firm's market share at the 4-digit level. Industry controls include the share of employment in foreign-owned firms in total 4-digit industry employment and the normalised Herfindahl index at the 4-digit industry level. In column (6) import penetration is instrumented using our lagged transport costs measure and industry-specific exchange rates described in Appendix 2. The p-value of the corresponding F-test for excluded instruments is 0.03, the p-value of the corresponding over-identification test (Hansen J-statistic) is 0.24 and the p-value of the under-identification test (Kleibergen-Paap LM statistic) is 0.06. The standard errors in column (6) are clustered by 4-digit industry rather than by 4-digit industry and year since the latter is not feasible due to a lack of degrees of freedom.

Columns (1)-(5) reproduce the specifications in columns (1)-(5) of Table 4, i.e. progressively adding firm and industry controls. The estimates show that import competition has a positive and significant effect on product quality. However, import penetration ratios may be endogenous as the decisions of foreign exporters are likely to be affected by Chilean firms' product innovation choices. Hence, we present in column (6) the results from an IV specification where import penetration ratios are instrumented by lagged transport costs and industry-specific exchange rates described in Appendix 2. The results show a positive effect of import penetration on product quality that is significant at a 10% confidence level.

IV.2. Unit Values and Quality

The maintained assumption in this paper is that increases in unit values are a proxy for product quality upgrading and represent incremental innovation. For certain consumer products such as automobiles or washing machines, it is clear that higher prices are directly correlated with higher quality. This explains why so many studies in the trade literature have taken for granted the idea that increases in export unit values represent improvements in quality. The summary statistics on the heterogeneity in Chilean products' unit values presented in Table 1 support this argument. Industries with little scope for quality differences show low relative variation in unit values while industries where quality is expected to play an important role such as professional equipment (which includes information technology products) exhibit a much higher variability in unit values. The role of prices as a signal for quality has been considered in the industrial organisation literature. In the presence of imperfect information, prices are a good signal for quality since firms often choose intentionally their level as to reveal to consumers the higher quality of their products. Fluet and Garella (2002) show theoretically that in markets with strong vertical product differentiation (i.e. those with substantial quality differences within product categories) firms may base their signaling on prices only. Thomas *et al*. (1998) provide empirical evidence showing that higher prices are used for quality signaling purposes in the US automobile industry.

We should note, however, that Khandelwal (2009) criticizes the assumption that unit values equal quality by arguing that prices could also reflect variations in manufacturing costs. Based on a model that allows consumers to have preferences for vertical attributes (quality) as well as horizontal attributes (e.g. colour given a fixed quality) of products, he shows that conditional on price (imported) products with higher market share are assigned higher quality or the mapping of prices to quality is not direct but depends on market share (desirability of the product) too. However, he does show that the mapping of unit values to quality is very appropriate in the industries with more scope for quality differentiation.

Given the potential criticisms we now explore whether our assumption that price increases reflect quality improvements following stronger impact competition is indeed justified. Hummels and Klenow (2005) show that richer countries tend to export higher quality products. We start by testing empirically a simple hypothesis related to that finding: stronger import competition due to increased imports from relatively poor countries is unlikely to lead to product quality upgrading as their products have lower quality than those of Chilean firms. This hypothesis is likely to be verified particularly for the reductions in transport costs of exporting countries very much behind Chile's level of economic development such as those with a GDP per capita less than 50% of Chile's. Accordingly, we obtain transport costs measures separately for less advanced countries $TC_{it-1}^{k4\ lessadv}$ and for more advanced countries $TC_{it-1}^{k4\ moreadv}$ and we estimate the following specification: [25]

$$\log UV_{it}^{p7} = \overline{\beta}_{TCL} * TC_{it-1}^{k4\ lessadv} + \overline{\beta}_{TCM} * TC_{it-1}^{k4\ moreadv} + + \gamma * X_{it} + I^{p7} + I^{m3} * I_t + f_i + \varepsilon_{it}^{p7}, \qquad (2)$$

where all variables other than the transport costs are defined as before. The results are reported in column (1) of Table 6 and confirm the simple hypothesis: i.e. only reductions in transport costs of advanced countries lead to quality upgrading and the difference between the effects of transport costs for both groups of countries is significant. One may argue that although these less advanced exporters to Chile do not export high quality products they could still spur innovation there. Bloom *et al*. (2009*a*, 2009*b*) find such evidence for the impacts of Chinese import competition on innovation in Europe and present a model that rationalizes such impacts. We, therefore, take these results as merely suggestive and undertake a series of alternative tests.

25. We define less and more advanced countries based on their GDP per capita in constant 2005 USD in any year relative to Chile's GDP per capita in that year using data from the World Development Indicators. The results are qualitatively similar if the average GDP per capita in constant 2005 USD for the 1997-2003 period is used instead.

Table 6: **Effects of Transport Costs on Unit Values – Evidence of Quality Upgrading**

	Dependent Variable: Log of Firm-Product Unit Value					
	(1)	(2)	(3)	(4)	(5)	(6)
Transport Costs of Less Advanced Countries $_{t-1}$	-0.014					
	(0.063)					
Transport Costs of More Advanced Countries $_{t-1}$	0.968*					
	(0.523)					
Transport Costs $_{t-1}$ * Rauch Differentiated Industries		-2.618**				
		(1.038)				
Transport Costs $_{t-1}$ * Rauch Non-Differentiated Industries		-1.142*				
		(0.605)				
Transport Costs $_{t-1}$ * Industries with Larger Advertising Intensity			-2.207***			
			(0.716)			
Transport Costs $_{t-1}$ * Industries with Smaller Advertising Intensity			-0.528			
			(0.645)			
Transport Costs $_{t-1}$ * Industries with Larger Patent Stock				-2.099***		
				(0.681)		
Transport Costs $_{t-1}$ * Industries with Smaller Patent Stock				0.074		
				(0.453)		
Transport Costs $_{t-1}$ * Industries with Lower Demand Elasticity					-2.095***	
					(0.628)	
Transport Costs $_{t-1}$ * Industris with Higher Demand Elasticity					1.310	
					(1.060)	
Transport Costs $_{t-1}$ * Firms with Higher Skilled Labor Share						-2.642**
						(1.237)
Transport Costs $_{t-1}$ * Firms with Lower Skilled Labor Share						-0.496
						(0.531)
Firm Cost Controls	Yes	Yes	Yes	Yes	Yes	Yes
Other Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm*Product Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
P-value for F-Test of Difference in Coefficients across Groups	0.07	0.12	0.08	0.00	0.01	0.10
Number of Observations	41367	39481	41929	41929	38895	38184
R-Squared	0.97	0.97	0.97	0.97	0.97	0.96

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. The regressions include our transport costs measure interacted with alternative sets of dummy variables described in the text. The firm cost controls, other firm controls, and industry controls included in the regressions are similar to those in column (5) of Table 4. In column (1), following Rauch (1999), the differentiated goods 4-digit industries are those that are neither: *i)* homogenous – traded in organised exchanges (e.g. steel) nor *ii)* reference-priced. In column (2), the industries with larger advertising intensity are those whose advertising intensity is higher than the median intensity across all US industries. In column (3), the industries with larger patent stocks are those whose patent stocks are larger than the median patent stock across all US industries. In column (4), the industries with lower import demand elasticity are those whose import demand elasticity taken from Broda *et al*. (2006) is below the median across Chilean industries. In column (5), the firms with higher skilled labor share are those whose share of skilled labor in total wages in the first sample year is below the median across Chilean firms.

To provide further support that our estimates refer indeed to product quality, we examine whether the effects of transport costs on unit values are stronger for industries whose product attributes suggest more opportunities for quality improvements or for firms with characteristics likely to be associated with those improvements. We estimate a variant of Equation (1) given by:

$$\log UV_{it}^{p7} = \beta_1 * TC_{t-1}^{k4} * group1 + \beta_2 * TC_{t-1}^{k4} * group2 + \gamma * X_{it} + f_i * I^{p7} + I^{m3} * I_t + \varepsilon_{it}^{p7} \quad (3)$$

where the effect of transport costs is allowed to differ across industries or firms belonging to group 1 and industries or firms belonging to group 2, and all other variables are defined as before.

Column (2) of Table 6 reports the results from estimating Equation (3) considering as group 1 (group 2) differentiated goods industries (non-differentiated goods industries) according to the classification proposed by Rauch (1999).[26] Bastos and Silva (2009) show that the classification scheme is well suited to capture quality differentiation. Our estimates show that the impact of transport costs on quality is larger in magnitude for firms in differentiated goods industries, with the difference in coefficients being significant at slightly more than the 10% confidence level.

Column (3) of Table 6 reports the results from estimating Equation (3) considering as group 1 (group 2) industries with a larger (smaller) advertising intensity. The scope for vertical quality differentiation is assumed to be higher in industries with a 'larger' advertising intensity as in Kugler and Verhoogen (2008). Using data from the 1976 US Federal Trade Commission Line of Business Survey, we compute the ratio of advertising expenditures to total sales for large firms in US industries and use those as a benchmark for our Chilean 4-digit industries.[27] The advertising intensity of an industry is 'larger' if it is higher than the median intensity in the sample. Our findings indicate that the response of quality to import competition is significantly larger for firms in industries with a greater scope for vertical differentiation.

Column (4) of Table 6 shows the results considering as group 1 (group 2) industries with larger (smaller) patent stocks in the US We assume that industries with 'larger' patent stocks in the US present more incremental innovation opportunities for Chilean firms. We use data from the OECD patents database on the number of international patent applications by US 2-digit ISIC revision 3 industries cumulated over time to generate patent stocks.[28] The patent stock of an industry is 'larger' if it is higher than the median patent stock in the sample. Our estimates show that the effect of transport costs on quality is significantly more negative for firms in industries with larger patent stocks, thus more innovation opportunities.

Column (5) of Table 6 reports the results from estimating Equation (2) considering as group 1 (group 2) industries with lower (higher) elasticities of substitution. We use the import

26. According to Rauch's classification, differentiated products are those that are neither *i)* homogenous – traded in organised exchanges (e.g. steel) nor *ii)* reference-priced – having listed prices in trade publications (e.g. some chemical products) and require a more important degree of buyer-seller interaction. To use Rauch's classification, we establish a correspondence between his 4-digit SITC rev. 2 codes and our 3-digit ISIC rev. 2 codes. For the printing industry (ISIC 342), we are unable to establish an unambiguous correspondence and thus drop it from the regression.

27. We use a concordance provided by Eric Verhoogen to obtain advertising intensities at the ISIC revision 2 4-digit level starting from the FTC 4-digit classification.

28. These are patent applications filed under the Patent Cooperation Treaty (PCT) classified according to the international patent classification that is concorded to the 2-digit ISIC revision 3 industry level by Schmoch *et al.* (2003). To obtain patent stocks at the 2-digit ISIC revision 2 level, we use a concordance included in our Chilean census dataset. The patent stock is computed using the perpetual inventory method cumulating annual patents since 1989 and using a depreciation rate of 15%, following that used to compute R&D stocks by Griffith *et al.* (2006).

demand elasticities for Chile estimated by Broda *et al*. (2006).[29] The 'lower' is the elasticity of substitution across imported products within an industry the greater is the extent of product differentiation. The import demand elasticity of an industry is 'lower' if it is below the median elasticity in the sample. The effect of import competition on quality is found to be significantly stronger for firms in industries with lower import demand elasticity, thus more scope for product differentiation.

Human capital is a key component of a firm's absorptive capacity to new technology and knowledge necessary for product quality upgrading (Cohen and Levintahl, 1989). Column (6) of Table 6 shows the results from estimating Equation (2) defining group 1 (group 2) to include firms whose wage share of skilled labor in their first sample year is larger (smaller) than the sample median. The estimates and the F-test show that increased import competition leads to a significantly stronger increase in unit values for firms with larger skill shares.

The findings in Table 6 provide substantial evidence to support our assumption that increases in unit values are a good proxy for product quality improvements. Hence, by focusing on incremental product innovation outcomes, our main findings complement nicely those obtained for radical innovation outcomes as a response to increased import competition from for firms in Argentina and Mexico by Bustos (2009) and Teshima (2009), respectively.

IV.3. The Imports-as-Market-Discipline Hypothesis

For a skeptical reader for whom our evidence in Section IV.2 is not sufficient to prove the validity of our assumption that unit values capture the quality of Chilean manufacturing products, our main findings in Table 4 may appear puzzling. Taken literally, our regressions show that Chilean product prices increase with import competition. Yet, the most obvious advantage of more competitive markets is their disciplining effect forcing firms to price closer to marginal costs. Competition through increased imports may be an even more powerful price-reducing mechanism. Trade models with imperfect competition predict that firms' mark-ups are a decreasing function of the elasticity of demand and stronger import competition tends to increase the elasticity of demand (e.g. Helpman and Krugman, 1985; Melitz and Ottaviano, 2008). The prediction of the "imports-as-market-discipline" hypothesis is, therefore, of a negative effect of import competition on mark-ups or price-cost margins. One needs to be cautious when interpreting our results on prices as that hypothesis predicts a reduction in mark-ups not necessarily in prices per se. Hence, before concluding that our results in Table 4 are truly puzzling and at odds with the "imports-as-market-discipline" hypothesis, we need to examine the impact of import competition on Chilean firms' price-cost margins.

Price-cost margins are not observable since marginal costs are not observable; hence we follow the widely used methodology proposed by Roeger (1995) to estimate them. The

29. While these elasticities are commonly used to measure the scope of horizontal differentiation, Khandelwal (2009) argues that they are conceptually related to vertical differentiation given the specific estimation method used by Broda et al. (2006). We use a concordance between HS and ISIC to establish a correspondence between their 3-digit HS codes and 4-digit ISIC rev. 3 codes. Those are then matched to our 7-digit ISIC products using a correspondence from 4-digit ISIC rev. 3 codes to ISIC products provided by the INE.

methodology computes the difference between the primal Solow residual in the presence of imperfect competition (Hall, 1988) and the corresponding dual Solow residual derived from a cost function. This difference eliminates firm unobserved productivity which is associated with an endogeneity bias in production function estimation and results in an equation providing consistent estimates for price-cost margins.[30] We allow average price-cost margins to vary with transport costs and with the degree of domestic competition faced by each firm in its main 4-digit industry.[31] Our estimable equation is given by:

$$\Delta Z_{it}^{k4} = \beta_1 \Delta X_{it}^{k4} + \beta_2 \Delta X_{it}^{k4} * TC_{t-1}^{k4} + \beta_3 \Delta X_{it}^{k4} * H_t^{k4} + \delta_1 TC_{t-1}^{k4} + \delta_2 H_t^{k4} + f_i + I_t + \eta_{it} \quad (4)$$

where ΔZ_{it} and ΔX_{it} are computed based on the growth of firm nominal sales, wage bill, intermediate costs, and capital as described in Appendix 3, TC_{t-1}^{k4} is defined as before, H_t^{k4} is the Herfindahl index in 4-digit industry k4, I_t are year fixed effects, f_i are firm fixed effects, and η_{it} is an i.i.d. residual.[32] The estimate of β_1 is the average price-cost margin while those of β_2 and β_3 show how average price-cost margins change with transport costs and with the degree of domestic competition, respectively.[33]

The results from estimating Equation (4) by firm fixed effects are shown in Table 7 with standard errors clustered by 4-digit industry. Columns (1) and (3) show that the average price-cost margins of Chilean firms are negatively related with transport costs. However, the effects are insignificant. In contrast, columns (2)-(3) show that average price-cost margins are positively and significantly linked to domestic competition. Hence, we find no evidence to support or reject the "imports-as-market-discipline" hypothesis: price-cost margins and mark-ups of Chilean firms simply do not vary significantly with import competition. This is not surprising given that the pro-competitive price-lowering effects from imports likely occurred much earlier than our sample period after the radical trade liberalisation of the early 1980s.[34] Note that while many

30. We refer the reader to Roeger (1995) and Konings et al. (2005) for details on the derivation of that equation.
31. Firm-level estimates of price-cost margins cannot be obtained due to insufficient degrees of freedom.
32. For comparability with the estimates of Equation (1) transport costs are lagged one year. However, the results are qualitatively similar including current transport costs or including all variables lagged one year.
33. Note that this analysis uses only firm aggregates in terms of sales and inputs but does not use information at the firm-product level. However, Navarro (2008) shows that Chilean multi-product firms tend to have leading products that represent a very large share of overall production and sales of the firm. Therefore, even for multi-product firms, these results can be considered at least suggestive of the effects on the firm's main product's price-cost margin.
34. Indeed, Tybout (1996) studies the impact of radical trade liberalisation on Chilean firms' price-cost margins during the 1979-1986 period and finds significant negative effects on price-cost margins.

empirical studies find negative effects of import competition on price-cost margins not all studies find robust evidence.[35]

Table 7: ***Effects of Transport Costs on Price-Cost Margins***

	Dependent Variable: ΔZ_t (in Equation (4))		
	(1)	(2)	(3)
ΔX_t	0.506***	0.454***	0.492***
	(0.029)	(0.016)	(0.029)
ΔX_t* Transport Costs $_{t-1}$	-0.417		-0.413
	(0.340)		(0.324)
ΔX_t* Herfindahl Index $_t$		0.178**	0.177**
		(0.084)	(0.081)
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Number of Observations	18282	18282	18265
R-Squared	0.42	0.42	0.42

Notes: Robust standard errors clustered by 4-digit industry in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. The computation of the dependent variable ΔZ_{it} and of ΔX_{it} is described in Appendix 3. In columns (1) and (3) the transport costs measure is included in levels and interacted with ΔX_{it}.

Stronger import competition has no effect on Chilean firm mark-ups but is linked to average product price increases. The increase in price-cost margins that would result from higher prices must have been counteracted by higher costs incurred by firms. If no meaningful changes to firms' production processes or operations occurred, such explanation would be implausible. If anything, one would expect costs to decrease as firms might, as a result of import increases, access cheaper foreign inputs. However, if higher prices are charged for higher quality products, then the higher costs incurred by firms were necessary to achieve those quality improvements or to signal the quality of their products. This reasoning is in agreement with the firm heterogeneity model proposed by Johnson (2009) where fixed and marginal costs of production increase with the level of product quality chosen by firms. Manova and Zhang (2009) also argue that in response to stronger competition firms may reduce their mark-ups but also increase product quality. If quality upgrading requires fixed costs or more expensive inputs, both marginal and fixed costs may increase and if this effect is sufficiently strong it can dominate any mark-up adjustment and lead to increases in output prices.

35. Konings *et al.* (2001) for example find insignificant effects of import competition on the price-cost margins of firms in Belgium. Moreover, the estimated contribution of trade to reducing price-cost margins seems relatively modest (Boulhol, 2009).

IV.4. Additional Findings and Robustness

Our main results reported in Table 4 are for the full unbalanced panel containing both the entry and exit of firms as well as the entry and exit of products. It is interesting to investigate how these factors impact on our results. Table 8 shows results for two different sub-samples.

Table 8: **Effects of Transport Costs on Unit Values – Extensions**

Panel A: Sample of Continued Products

	Dependent Variable: Log of Firm-Product Unit Value				
	(1)	(2)	(3)	(4)	(5)
Transport Costs $_{t-1}$	-1.955***	-1.971***	-1.904**	-1.944***	-1.914***
	(0.727)	(0.720)	(0.737)	(0.722)	(0.722)
Firm Cost Controls	No	Yes	No	No	Yes
Other Firm Controls	No	No	Yes	No	Yes
Industry Controls	No	No	No	Yes	Yes
Firm*Product Fixed Effects	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	18677	18677	18674	18656	18656
R-Squared	0.96	0.96	0.96	0.96	0.96

Panel B: Sample of Continuing Firms and Continued Products

	Dependent Variable: Log of Firm-Product Unit Value				
	(1)	(2)	(3)	(4)	(5)
Transport Costs $_{t-1}$	-2.131***	-2.113***	-2.053***	-2.127***	-2.031***
	(0.602)	(0.599)	(0.621)	(0.591)	(0.608)
Firm Cost Controls	No	Yes	No	No	Yes
Other Firm Controls	No	No	Yes	No	Yes
Industry Controls	No	No	No	Yes	Yes
Firm*Product Fixed Effects	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of Observations	12125	12125	12125	12113	12113
R-Squared	0.95	0.95	0.95	0.95	0.95

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. Firm cost controls include the log of average wages, the share of skilled labor in total labor, the log of unit electricity prices paid by the firm, and the share of imported inputs in total inputs. Other firm controls include size dummies, a dummy for multi-product firms, and the firm's market share at the 4-digit level. Industry controls include the share of employment in foreign-owned firms in total 4-digit industry employment and the normalised Herfindahl index at the 4-digit industry level. The regressions in Panel A are estimated for the sub-sample of all firms but only products that the firm neither starts producing nor discontinues during its years in the sample while those in Panel B are estimated for the sub-sample of firms included in the sample during the entire sample period and for each of those firms only the products that they produce during the entire sample period.

In Panel A, we use a sub-sample of all firms but only the products that firms neither start producing nor discontinue during their years in the sample (continued products). The effect of transport costs on product quality is significant and more negative than in Table 4. The difference in magnitudes suggests that products with less upgrading potential are likely to be discontinued by firms and new products are also less subject to upgrading as a result of import competition after their initial introduction. In Panel B, we use a sub-sample including only firms that are in the sample during the entire sample period (continuing firms) including for each of those firms only their continued products. Transport costs have again a significant effect on product quality that is more negative than in Panel B. This difference in magnitudes suggests that the 'well-established' products of continuing firms are more prone to quality upgrading as a response to increased import competition than the continued products of firms which just started operations or those of firms in their years shortly before exit.

While for brevity Table 4 and the tables thereafter do not report the estimated coefficients on the control variables included in our regressions, two findings are noteworthy. Firms with larger market shares exhibit significantly higher unit values. However, this market power effect does not eclipse the importance of increased import competition in generating quality improvements. Also, firms in industries with stronger foreign presence exhibit on average higher unit values. These potential knowledge spillovers from FDI seem to complement – not eliminate – the effects of import competition on quality upgrading.

We conduct an extensive set of tests to verify the robustness of the results from our preferred specification in column (5) of Table 4. First, we address two potential endogeneity concerns related to the effects of compositional changes on our transport costs measure discussed in Section III.2.2. The first concern is the potential change in transport costs if exporters stop supplying the Chilean market. Column (1) of Table 9 shows the results from estimating Equation (1) including a measure of transport costs constructed using only the freight rates of the top 10 exporters to Chile for each 8-digit HS product category in each year. The effect of transport costs on product quality is still negative and significant. Column (2) shows that our results are also maintained if we add an even more restricted measure of transport costs constructed using only the freight rates of the top 3 exporters to Chile (United States, Argentina and Brazil). Since major exporters are less likely to discontinue their products, the results in columns (1)-(2) are assuring that compositional effects of our transport costs measure do not drive our results. The second concern is the potential effect of changes in the quality of imported products. While in Section III.2 we show that there was no major change in that quality, we examine this issue further by considering transport costs per unit. These are obtained based on freight rates per unit defined as: $fru_{mct} = freight_{mct} / impqt_{mct}$, where freight costs rates are at the 6-digit HS level and $impqt_{mct}$ denotes the quantity of HS 6-digit product m imported from country c at time t taken from COMTRADE. Given that all import quantities are measured in tons, we can aggregate these disaggregated freight rates per unit to the 4-digit ISIC and year level as described in Section III.2. An important disadvantage of these transport costs per unit measures is that the COMTRADE database has many missing values for the quantities imported. In order to use a transport costs measure that does reflect the import competition faced by a given 4-digit industry, we construct our transport costs per unit measure only for the 4-digit industries where more than 80% of imports fob in any one year have information on the corresponding quantities. The results from estimating Equation (1) including the log of the transport costs per unit measure are reported in column (3) of Table 9 and show that our main finding is qualitatively maintained.

Table 9: **Effects of Transport Costs on Unit Values – Robustness**

	Dependent Variable:									
	Log of Firm-Product Unit Value			*Estimated Average Firm Unit Value*	*Log of Firm-Product Unit Value*					
	Alternative Transport Costs Measures				*Alternative Outlier Criteria for Unit Values*		*Additional Firm Control*		*Alternative Competition Measures*	
	Include Only Top 10 Exporters by Product-Year	*Include Only Top 3 Exporters by Product-Year*	*Transport Costs per Unit*	*Second Stage Regression in 2-Stage Procedure*	*Exclude Top/Bottom 10% of Unit Values by Product*	*Windsorize Unit Values Based on Quartiles Criterion by Product*	*Exporter Status*	*Foreign Ownership Status*	*Share of Top 5 Firms in 4-digit Industry*	*Adding Regional Competition Measures*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Transport Costs $_{t-1}$	-1.214**	-0.545*	-0.074*	-5.119***	-1.667**	-1.449**	-1.695**	-1.704**	-1.705**	-1.740***
	(0.578)	(0.320)	(0.039)	(1.880)	(0.801)	(0.725)	(0.679)	(0.675)	(0.705)	(0.663)
Firm Cost Controls	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Other Firm Controls	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Firm*Product Fixed Effects	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	41414	41371	24276	19546	36733	44157	41942	41942	41705	39290
R-Squared	0.965	0.965	0.978	0.32	0.969	0.956	0.965	0.965	0.965	0.966

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. Firm cost controls include the log of average wages, the share of skilled labor in total labor, the log of unit electricity prices paid by the firm, and the share of imported inputs in total inputs. Other firm controls include size dummies, a dummy for multi-product firms, the firm's market share at the 4-digit level, a dummy for the firm's exporter status (in column (7)) and a dummy for foreign ownership (in column (8)). Industry controls include the share of employment in foreign-owned firms in total 4-digit industry employment and the normalised Herfindahl index at the 4-digit industry level (except in column (9) where the sales share of the largest 5 firms at the 4-digit level is included). In column (10) a regional Herfindahl index at the 4-digit industry-level and regional firm market shares are also included. The transport costs measure used in columns (1) and (2) are computed based only on the freight rates of, respectively, the top 10 and top 3 exporting countries to Chile for each 8-digit HS product in each year. The procedure to obtain the average firm unit values used as dependent variable in column (4) follows Kugler and Verhoogen (2008) and is described in the text. The outlier criteria used in columns (5)-(6) are described in the text.

Second, a possible concern with our estimates is that the coefficient on transport costs is driven by the larger weight of multi-product firms that have by definition more observations per year than single-product firms. To address this possibility, we follow the two-stage regression procedure proposed by Kugler and Verhoogen (2008). First, we regress firm unit values (the dependent variable in Equation (1)) on firm-year, product-year, and year fixed effects. For any given year, the estimated firm-year fixed effect provides an average firm unit value identified by the differences between a firm's unit value(s) and those of other firms producing the same product(s) in that year. Second, these time-varying estimated average firm unit values are regressed on our transport cost measures along with 3-digit industry-year fixed effects.[36] In this regression a single-product firm and a multi-product firm included in the sample during the same number of years have equal weight. Column (4) of Table 9 presents the results from this regression which indicates that our main finding is qualitatively maintained.

Third, we consider alternative criteria to eliminate outliers in our dependent variable. Columns (5)-(6) of Table 9 show the estimates of Equation (1) for two samples based on the following outlier criteria: excluding the top and bottom 10% of unit values for any product or replacing the observations with unit values above (below) the 75th (25th) percentile plus (minus) by 1.5 times the inter-quartile range by those cut-off values. The estimates show that the significant effect of declines in transport costs on quality upgrading is maintained.

Fourth, exporters as well as foreign-owned firms may produce higher-quality products thus exhibit higher unit values relative to domestic-owned firms, regardless of import competition. Columns (7)-(8) of Table 9 show that the estimate of β is robust to the addition of an indicator for the firm's exporter status or the firm's foreign ownership status. Measuring competition in the domestic market is inherently difficult. Column (9) of Table 9 shows that the effect of import competition is robust to using as measure of competition the sum of the market shares of the 5 firms with the largest market shares in each of the 4-digit industries to which a firm's products belong.[37] Moreover, within-country costs of transportation, among several other factors, may give firms in certain regions stronger market power. Hence, we show in column (10) of Table 9 the results from a specification where we add regional Herfindahl indexes and market shares. Our estimate of β remains qualitatively unchanged.

36. We refer the reader to Kugler and Verhoogen (2008) for further details on this two-stage procedure, in particular on the non-identification of some of the firm-year fixed effects.

37. In unreported regressions we also find robust effects of transport costs when we replace the firm's market share in each of its 4-digit industries by that in each of its 5-digit or 6-digit industries, or in each of its 7-digit products. Also we find the results to be maintained when the firm market share is defined relative to the sum of domestic output and imports in the 4-digit industry in each year. These results are available from the authors upon request.

V. ALTERNATIVE INTERPRETATIONS

So far we presented our findings as evidence that increased import competition across industries stimulated product quality upgrading by Chilean firms. However, our findings could be given alternative interpretations to which we turn next.

V.1. Input Quality

One alternative interpretation for our results is that they are picking up the access to better production inputs and their positive impact on product quality. An important benefit from increased trade openness for firms in developing countries is indeed the access to greater variety and better quality of inputs (e.g. Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991; Goldberg *et al.*, 2008; Kugler and Verhoogen, 2009). According to the quality complementarity hypothesis proposed by Kugler and Verhoogen (2008) input quality and productivity jointly determine the quality of firm output. This suggests in our case that if lower transport costs across Chilean industries led (as would be expected) to an increase in the quality of inputs available to Chilean firms, this would be an important alternative explanation for the resulting upgrades in output quality.[38] To address this possibility we consider the role of intermediate inputs' transport costs for Chilean firms' quality choices. Transport costs on intermediate inputs are computed for each 4-digit industry j as the following weighted average: $TCInputs_t^j = \sum_{m=1}^{M} \alpha_j^m * TC_t^m$ where TC_t^m is the transport costs measure on final output (used in the regressions so far) and α_j^m is the share of intermediate inputs from industry m in the total intermediates used for production by industry j taken from the 1996 Chilean input-output table.[39]

Column (1) of Table 10 presents the results from estimating a variant of Equation (1) where we include only transport costs on intermediate inputs. Transport costs on intermediate inputs have a negative and significant effect on product quality. It is indeed the case that there is a positive impact from increased access to foreign inputs on quality upgrading by Chilean firms.

38. Our specifications control for the share of intermediate inputs used by Chilean firms that are imported, but that is insufficient to ensure that the input channel is not what underlies the negative coefficient on transport costs. The reason is that higher quality imported inputs and higher quality domestic inputs are likely to be complementary. So, if input expenditures grow with input quality, the imported input share could be unchanged but the underlying domestic and imported inputs used by firms could be of better quality with consequences for output quality.

39. The correlation between transport costs on final output and transport costs on intermediate inputs is 0.54.

To explore whether this implies that our main finding is in fact explained through the effects of inputs, we show in column (2) the results from a specification where both transport costs on final output as well as on intermediate inputs are included. The results show very clearly that while input quality driven by reduced transport costs on inputs may be an alternative channel for the impact of transport costs on quality it is certainly not the only one. Rather, the effects of import competition measured by the coefficient on transport costs on output are still significant. Notice that the p-value for a test in the difference across coefficients indicates that such difference is not significant: i.e. better input quality may help explain the quality upgrading effects of lower transport costs but does not eliminate the importance that stronger product market competition through imports had for Chilean firms.[40]

Table 10: **Effects of Transport Costs on Unit Values – Inputs**

	Dependent Variable: Log of Firm-Product Unit Value	
	(1)	(2)
Transport Costs for Intermediate Inputs $_{t}$	-4.514***	-3.888**
	(1.413)	(1.615)
Transport Costs $_{t-1}$		-1.509**
		(0.749)
Firm Cost Controls	Yes	Yes
Other Firm Controls	Yes	Yes
Industry Controls	Yes	Yes
Firm*Product Fixed Effects	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes
P-value for F-Test of Difference in Coefficients across Transport Costs Measures		0.20
Number of Observations	41964	41929
R-Squared	0.97	0.97

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. The construction of the measure of transport costs for intermediate inputs is described in the text. The firm cost controls, other firm controls, and industry controls included in the regressions are similar to those in column (5) of Table 4.

V.2. An Alternative Argument Based on Hummels and Skiba (2004) and Vogel (2008)

The effect of lower transport costs on product quality upgrading might also be rationalised by a strategic product market positioning argument based on a combination of the predictions derived by Hummels and Skiba (2004) and by Vogel (2008). Hummels and Skiba (2004) derive a theoretical relation between transport costs and the quality composition of trade whereby a per unit transport cost raises the relative demand for high quality exports. For our purposes, this prediction would suggest that reductions in transport costs led to a decline in the quality of Chilean imports. To be precise, what Hummels and Skiba (2004) show is that the quality of exports varies positively with transport costs per unit, not with ad-valorem costs such

40. Schor (2004) and Amiti and Konings (2007) also find the effects of both input tariffs and output tariffs to be significant in their analysis of TFP for firms in Brazil and Indonesia, respectively.

as those we use in most specification. However, despite this fact we consider the possibility that ad-valorem transport costs could also affect the quality of exports. Vogel (2008) proposes a model of endogenous product choice where firms differentiate themselves horizontally (in product attributes or geographic space) and vertically (in quality space) so as to fill out the product space. Combining the two ideas one could argue that Chilean firms increased the quality of their products to fill out the product space as the quality of imports declined with reductions in transport costs. The effect of transport costs on product quality would in this case be the outcome of spatial competition rather than reflecting import competition per se.

In Section III, we showed that the quality of Chilean imports did not change substantially during our sample period based on unit values of imports at the 4-digit ISIC and exporting country level. This would suggest that the argument made above is unlikely to hold. But to probe further into that argument, we present in Table 11 the results from a specification where time-varying unit values of imports at the 6-digit HS product and exporting country level are explained by either ad-valorem or per unit transport costs at the same level of disaggregation. This specification follows that estimated by Hummels and Skiba (2004) – i.e. it includes exporting country GDP per capita – but controls for product-exporting country and year fixed effects given its panel dimension. IV estimation is used where the instrument for transport costs is fuel prices interacted with transport costs in the first sample year.[41] The reason for using IV is that since more expensive goods have more onerous handling requirements, transport costs may increase with export unit values, rather than the reverse. The results show that the relationship between transport costs of either type and unit values of Chilean imports is insignificant. Hence, lower transport costs do not seem to have changed the unit values of Chilean imports in a manner consistent with the Hummels and Skiba (2004) mechanism.

Table 11: **Effects of Transport Costs on Import Unit Values**

	Dependent Variable: Log of Unit Value of Imports at 6-digit HS Level	
	IV	IV
	(1)	(2)
Transport Costs at 6-digit HS Level $_t$	-0.088	
	(0.269)	
Transport Costs per Unit at 6-digit HS Level $_t$		0.00007
		(0.00007)
GDP per Capita of Exporting Country	Yes	Yes
Country*6-digit HS Product Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Number of Observations	82640	78271

Notes: Robust standard errors in parentheses. The instrument in column (1) is fuel prices interacted with transport costs in the first sample year and the instrument in column (2) is fuel prices interacted with transport costs per unit in the first sample year. The regressions are based on a sample covering only the top 10 exporters for each 6-digit HS product and year. The p-value of the F-test of excluded instruments is 0.00 and the p-value of the under-identification test (Kleibergen-Paap LM statistic) is 0.00 for the IV regressions in columns (1)-(2).

41. Fuel prices are described in Appendix 2. Transport costs at the level of the 6-digit HS product and exporting country in the first sample year are used.

V.3. Market Access

In the analysis we assume implicitly that a reduction on transport costs is equivalent to a unilateral trade liberalisation that increases imports. However, reductions in the transport costs of imports into Chile may be correlated with reductions in the transport costs faced by Chilean exports. Hence, an alternative interpretation of the negative effect of transport costs on quality is that they reflect the effects of a symmetric increase in export market access and not those of product market competition. Verhoogen (2008) shows that such an increase led to quality upgrading by Mexican firms.

To address this concern, we estimate Equation (1) considering only the sub-sample of Chilean firms that do not export during our sample period. Column (1) of Table 12 presents the corresponding results that show a negative and significant impact of transport costs on product quality. The same is obtained considering an even more restricted sub-sample of non-exporting firms that are fully domestically-owned in column (2). Interestingly, for these two sub-samples the impact of transport costs is substantially more negative than that in column (5) of Table 4 for the full sample of firms. This means that an increase in import competition elicits the strongest quality upgrading response from the firms that are less exposed to international competition through other channels such as exports or multinational parent linkages. Such firms may already have been forced to undertake quality upgrading explaining why increased import competition provides a weaker incentive for further upgrading.

Table 12: **Effects of Transport Costs on Unit Values – Market Access**

	Dependent Variable: Log of Firm-Product Unit Value		
	Sample of Non-Exporting Firms	*Sample of Domestic Non-Exporting Firms*	
	(1)	(2)	(3)
Transport Costs $_{t-1}$	-2.337***	-2.457***	
	(0.880)	(0.894)	
Transport Costs $_{t-1}$ * Exported Products			0.420
			(0.689)
Transport Costs $_{t-1}$ * Non-Exported Products			-2.480***
			(0.779)
Firm Cost Controls	Yes	Yes	Yes
Other Firm Controls	Yes	Yes	Yes
Industry Controls	Yes	Yes	Yes
Firm*Product Fixed Effects	Yes	Yes	Yes
3-Digit Industry*Year Fixed Effects	Yes	Yes	Yes
P-value for F-Test of Difference in Coefficients across Groups			0.00
Number of Observations	32227	31333	41929
R-Squared	0.97	0.97	0.97

Notes: Robust standard errors clustered by 4-digit industry and year in parentheses. **, and * indicate significance at 1%, 5%, and 10% confidence levels, respectively. The firm cost controls, other firm controls, and industry controls included in the regressions are similar to those in column (5) of Table 4. In column (3) exported products are defined by a time-varying dummy that indicates whether a firm exports the product in a given year.

To address the issue of export market access further, we estimate a variant of Equation (3) defining group 1 to include products that are exported (at least partially) and group 2 to include products that are sold exclusively in the domestic market. The results are shown in column (3) of Table 12. Interestingly, the estimates and F-test show that the impact of transport costs on quality is significantly more negative for domestically sold products. It is possible that once these domestically sold products achieve sufficiently high quality, firms are able to sell them in export markets also, which is indeed the finding for Mexican firms by Iacovone and Javorcik (2008). This result points to the importance of using data both for domestically sold as well as exported products to study the link between import competition and quality. Overall our findings suggest that we can exclude the possibility that the negative effect of transport costs on product quality is due to an export market access effect as the evidence points to benefits mainly for firms with no exporting experience and for products that are not exposed to export markets.

VI. CONCLUSIONS AND POLICY RELEVANCE

So, does trade stimulate innovation? We investigate this question using a rich dataset of Chilean firms and products and a regression framework where increases in unit values proxy for product quality improvements and transport costs are the exogenous measure of import competition. Our results show that tougher import competition does have a positive, significant, and robust impact on incremental innovation reflected in product quality upgrading by Chilean firms. To the extent that these findings can be generalised to other emerging economies, they suggest that increased exposure to imports can be beneficial for innovation outcomes. Moreover, we find that the mechanism driving this outcome is that firms react to the import pressure by innovating so as to differentiate their products as a way to escape competition. Our findings, therefore, point to the importance of competition policy more generally. In addition, our results indicate that easier access to imported inputs also has beneficial effects on innovation, which points to the importance of learning from trade in stimulating innovation. However, our evidence also suggests that such benefits only arise if the right conditions hold: it requires firms to dispose of skilled personnel and will occur mostly in industries whose attributes offer opportunities for such innovativeness. This implies that for the dynamic benefits of trade to materialize the framework conditions do matter. A dimension that goes beyond what is studied in this paper is that, obviously, firms undertaking innovation may transform their production processes and this could have consequences for labor markets that may need to be addressed. Our evidence suggests, along the lines of Verhoogen (2008) that import competition may result in an increase in within-firm wage inequality if quality upgrading itself requires an increase in the demand for skilled labor. Two other aspects are left for future research. On the empirical side, studying the heterogeneity in firms' reactions to import competition is relevant. On the theoretical side, our findings suggest that the recent models of multi-product firms such as those of Bernard *et al*. (2006*b*), Eckel and Neary (2006), and Volker and Yeaple (2008) that examine changes in firms' product mix as a response to reductions in trade costs have yet to exploit other interesting margins of adjustment such as the possibility of quality upgrading.

ANNEXES

Appendix 1: Examples of 7-Digit Products for Selected 4-digit Industries

4-digit ISIC		7-digit ISIC	Product Description	Unit of Measurement	Average Annual Unit Value Changes
3117	Manufacture of bakery products	3117101	Bread of any kind, size and quality (except sweet bread)	in tons	2.89%
		3117201	Cookies, with and without sugar and filled	in tons	4.28%
		3117301	Noodles, pasta including macaroni	in tons	0.22%
		3117402	Mixed dough (for different types of cakes)	in tons	-11.42%
3311	Sawmills, planing and other wood mills	3311307	Finished parquet excluding plastic parquet	in square meters	1.28%
		3311302	Wooden boards for prefabricated houses	in square meters	-13.16%
		3311306	Wooden doors with or without glass	in units	0.10%
		3311124	Sawing wood	in cubic meters	5.94%
3320	Manufacture of furniture and fixtures, except primarily of metal	3320908	Sofas and armchairs of the type used in ceremonies	in units	31.79%
		3320910	Wooden tables for computers and typewriters	in units	10.08%
		3320906	Wooden household furniture	in units	26.47%
		3320913	Office furniture	in units	-5.45%
3483	Manufacture of motor vehicles	3843201	Fabricated motor vehicles	in units	0.41%
		3843409	Wheels and related parts and vehicle accessories	in units	5.78%
		3843421	Heating appliances for motor vehicles	in units	-2.68%
		3843422	Metallic frames for trucks, special frames	in units	19.27%
3559	Manufacture of rubber products n.e.c.	3559324	Gloves of caoutchouc	one pair	13.63%
		3559327	Sports shoes	one pair	5.51%
		3559320	Caoutchouc sheating for mining	in tons	17.00%
		3559332	Articles made of caoutchouc for vehicles	in tons	26.81%
3829	Machinery and equipment except electrical n.e.c.	3829056	Cablecars	in units	20.74%
		3829032	Gas regulators	in units	-4.56%
		3829060	Moving staircases	in units	26.01%
		3829002	Pumps for liquids for manual use	in units	13.71%

Notes: For each 7-digit product and year, we compute the average logarithmic unit value by pooling across all firms that manufacture that product. Then across any two consecutive years we compute the difference in average log unit values to obtain the annual change in unit values. The statistic in the table shows the simple average of those annual changes.

Appendix 2: Data Issues

Appendix 2.1: Firm and Products Data

We combine a products dataset at the 7-digit level for the period 1997-2003 and the annual manufacturing census of Chilean firms with more than 10 employees (ENIA) for the same period. In the products dataset, products are identified by a classification based on ISIC Rev. 2 and Rev. 3. More detail on the products data is provided in Navarro (2008). We obtain products at the 7-digit level building up from what Navarro (2008) refers to as 'ENIA products'.

Specifically, for each firm reporting more than one entry for a 7-digit product in a given year (Z entries) we sum the information on sales values and product quantities of those Z entries for that firm as long as all the Z entries' quantities are reported in the same unit. The sum provides us with a single entry for that 7-digit product for that firm in that year. If the entries' quantities are reported in multiple units, we drop those products from the analysis. Note that these deletions occur in a very small number of cases. Also note that if aggregated to the 4-digit level, our 7-digit products correspond exactly to the United Nations product classification.

For our analysis, we use information on sales values and product quantities sold for each 7-digit product, firm, and year. We exclude from the final sample (i) firms that do not report the measurement unit for their products' quantities and (ii) firms that report their products' quantities in a different unit than the unit in which the majority of firms report. We also exclude from the sample the observations with unit values above (below) the 75th (25th) percentile plus (minus) by 1.5 times the inter-quartile range of the unit values' distribution for any 7-digit product. After applying these data cleaning procedures our final sample includes 51 349 firm-year-product observations.

We test the goodness of our products data by identifying firms with irregular product 'drops' (i.e. products that disappear from production and then reappear again) and firms with product 'jumps' (i.e. products that are produced only once in the intermediate years of firm presence in the sample). These tests, which follow Bernard *et al*. (2008), are satisfactory in that product 'drops' and product 'jumps' are relatively infrequent. We also perform another test which compares the standard deviations of 'purged' unit values for 4-digit industries with the same standard deviations obtained for a Colombian products dataset by Kugler and Verhoogen (2008). 'Purged unit values' are the residuals from regressions of log unit values on product fixed effects or from regressions of log unit values on product-year fixed effects. Our standard deviations are somewhat larger than theirs but are sufficiently within bounds to be explained by the fact that we consider a different country with a distinct profile of manufacturing production.

We use variables from the ENIA census to compute the proxies for costs of production included in our regressions. Firm average wages are obtained as the ratio of total wages paid to the firm's employees. Firm skill share is defined as the ratio of the number of skilled workers (a sum of managers, administrative personnel and qualified production workers) to the total number of workers employed by the firm. Firm electricity unit prices are computed as the log of the ratio of electricity expenditure to the quantity of electricity purchased. To eliminate outliers in each of these variables, we follow a 'winsorising' procedure whereby we replace the top and bottom 5th percentile of observations in each year by the value of the cut-off observations at the 5th and 95th percentile in that year, respectively. Firm share of imported materials is computed as the ratio of the expenditure in imported materials and primary inputs to the overall expenditure in materials and primary inputs. The three size dummies are defined based on total employment: small firms have less than 50 employees, medium firms have 50 to 200 employees, and large firms have more than 200 employees.

Regarding the industry control variables included in the regressions, since total employment of a firm is not allocated across the production of each of its products, the share of total employment accounted for by foreign-owned firms is computed for the firm's main 4-digit industry, which is for multi-product firms the industry to which the major product belongs. The major product accounts for the largest share (which could be less than 50%) of the firm's total sales.

Appendix 2.2: Transport Costs Data

We use a transport costs dataset from the ALADI secretariat for the period 1997-2003 that includes the freight value (excluding insurance costs) and the free on board customs value (fob) of Chilean imports for each 8 digit HS code, exporting country, and year. For each 8-digit HS code, exporting country, and year we compute a freight rate as the ratio of the freight costs to the fob imports. Our measure of transport costs is given by a weighted average of the freight rate aggregated from the level of the 8-digit HS code, exporting country, and year, to the level of the 4-digit ISIC and year using as weights Chile's fob imports from each country and year. To convert import flows between 8-digit HS codes and 4-digit ISIC codes we use a correspondence obtained from http://www.macalester.edu/research/economics /PAGE/ HAVEMAN/Trade.Resources/TradeConcordances.html. Our dataset includes all Chilean imports originating in 169 countries. Taking the overall value of imports for the entire period 1997-2003, the top 10 exporters to Chile are the United States, Brazil, Argentina, China, Germany, Japan, France, Mexico, South Korea, and Italy.

Appendix 2.3: Import Penetration Data and Instruments

The import penetration ratio of a 4-digit ISIC industry is computed as the ratio between total imports of the industry and the sum of total imports and total domestic sales of the industry. Imports at the 4-digit ISIC level are taken from the COMTRADE database and total domestic sales are the sum of total sales across firms from the ENIA dataset.

The two instruments for transport costs used in the regressions of import penetration on transport costs whose results are reported in Table 3 are defined making use of fuel prices obtained – following Backus and Crucini (2000) – as the simple average of spot crude prices in three major markets (Brent, Dubai, and West Texas) taken from IEA (2008).The instrument used in column (2) is the interaction between fuel prices and the 8-digit HS product's freight rate in the first sample year which is aggregated up to the 4-digit and year level as a weighted average using the aforementioned concordance and weights that are the share of each 8-digit HS product and exporting country in Chile's total imports in the corresponding 4-digit ISIC industry in the first sample year. The instrument used in column (3) is the interaction between fuel prices and a distance measure which is aggregated up to the 4-digit and year level as a weighted average using the aforementioned concordance and weights that are the share of each 8-digit HS product and exporting country in Chile's total imports in the corresponding 4-digit ISIC industry in the first sample year. The distance measure is taken from CEPII (http://www.cepii.fr/anglaisgraph/bdd/distances.htm) and consists of geodesic distances calculated following the great circle formula, which uses latitudes and longitudes of the most important cities/agglomerations (in terms of population). By first sample year we mean the first year when an 8-digit HS product and exporting country pair appears in the ALADI dataset.

Appendix 2.4: Industry-Specific Exchange Rates

Industry-specific exchange rates are computed following Goldberg (2004) as the weighted average of the bilateral nominal exchange rates between Chile and each of its trading partners where the weights are given by the share of each partner country in total Chilean exports for a given 4-digit ISIC industry prior to our sample period in 1996. Bilateral nominal exchange rates are computed based on International Financial Statistics data from the IMF and export shares are based on COMTRADE data at the 4-digit ISIC level.

Appendix 3: Methodology and Data Issues for Price-Cost Margins

The difference between the primal Solow residual and the corresponding dual Solow residual derived from a cost function results in the equation below which follows Konings *et al*. (2005):

$$\left(\frac{\Delta Y_{it}}{Y_{it}}+\frac{\Delta P_{Y\,it}}{P_{Y\,it}}\right)-\alpha_{Lit}\left(\frac{\Delta L_{it}}{L_{it}}+\frac{\Delta P_{L\,it}}{P_{L\,it}}\right)-\alpha_{Mit}\left(\frac{\Delta M_{it}}{M_{it}}+\frac{\Delta P_{M\,it}}{P_{M\,it}}\right)-(1-\alpha_{Lit}-\alpha_{Mit})\left(\frac{\Delta K_{it}}{K_{it}}+\frac{\Delta P_{K\,it}}{P_{K\,it}}\right)$$
$$=\beta_{it}\left[\left(\frac{\Delta Y_{it}}{Y_{it}}+\frac{\Delta P_{Y\,it}}{P_{Y\,it}}\right)-\left(\frac{\Delta K_{it}}{K_{it}}+\frac{\Delta P_{K\,it}}{P_{K\,it}}\right)\right] \quad \text{(A1)}$$

where β_{it} is the price-cost margin for firm *i* in year *t*, $\left(\Delta Y_{it}/Y_{it}+\Delta P_{Y\,it}/P_{Y\,it}\right)$ is nominal sales growth, $\left(\Delta L_{it}/L_{it}+\Delta P_{L\,it}/P_{L\,it}\right)$ is wage bill growth, $\left(\Delta M_{it}/M_{it}+\Delta P_{M\,it}/P_{M\,it}\right)$ is intermediate costs growth, $\left(\Delta K_{it}/K_{it}+\Delta P_{K\,it}/P_{K\,it}\right)$ is capital stock growth, and α_{Lit}, α_{Mit} are labor and intermediates shares in total nominal sales. Equation (A1) assumes constant returns to scale: $(1-\alpha_{Lit}-\alpha_{Mit})$ is the cost share of capital. To reach Equation (2) in the text we designate the left hand side of Equation (A1) by ΔZ_{it}, and the right hand side parentheses term by ΔX_{it}, we interact ΔX_{it} separately with the transport costs measure and with the Herfindahl index, we include in Equation (A1) the transport costs measure and the Herfindahl index levels as well as year fixed effects and we add an i.i.d. stochastic residual η_{it}. Equation (2) in the text is estimated for the sample of firms in the ENIA dataset during the 1997-2003 period. For firms with discontinuous data we include only the observations across consecutive years for which yearly growth rates of variables can be computed. The sample differs from that used for the unit values regressions since the observations are dropped based on the following criteria: *i)* we exclude from the sample firms with missing sales, wage bill, intermediate costs, or capital variables; *ii)* we impute sales, wage bill, intermediate costs, or capital to correct for non-reporting by a firm in a single year (which occurs in fewer than 30 firm-year observations); *iii)* we exclude from the sample firms whose sales growth, wage bill growth, or capital growth is larger than (smaller than) 400%; *iv)* we exclude from the sample firms whose sales (wage bill) growth ranges between 100% and 300% (-300% and -100%) but is not accompanied by corresponding high (low) growth rates of intermediate costs (total employment). After applying these data cleaning procedures our final sample includes 31 318 firm-year observations.

To compute ΔZ_{it} and ΔX_{it}, we use firm-level information on nominal sales and on total wage bill and compute their corresponding logarithmic growth rates. Nominal intermediate costs are obtained as the sum of materials costs and electricity costs and the corresponding logarithmic growth rate is calculated. Capital stocks are computed using the perpetual inventory method (PIM) as described in Fernandes and Paunov (2008) and the corresponding logarithmic growth rate is computed. We define the rental price of capital to be equal to the product of the aforementioned investment goods price deflator and the sum of the real interest rate and a depreciation rate as in Konings *et al*. (2005). Similarly, data on the lending interest rate and the consumer price index taken from the IMF financial statistics is used to compute the real interest rate. The depreciation rate used is the simple average of the rates used by Fernandes and Paunov (2008) for three types of capital goods: 3% for buildings, 7% for machinery and equipment, and 11.9% for transport equipment. Using an alternative depreciation rate equal to 10% provides almost similar results. The share of labor (*intermediates*) in sales is given by the ratio of the wage bill (*intermediate costs*) to total nominal sales.

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