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The Long and Short (of) Quality Ladders

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Prices are typically used as proxies for countries' export quality. I relax this strong assumption by exploiting both price and quantity information to estimate the quality of products exported to the United States. Higher quality is assigned to products with higher market shares conditional on price. The estimated qualities reveal substantial heterogeneity in product markets' scope for quality differentiation, or their "quality ladders". I use this variation to explain the heterogeneous impact of low-wage competition on US manufacturing employment and output. Markets characterized by relatively short quality ladders are associated with larger employment and output declines resulting from low-wage competition.

1. INTRODUCTION

The quality of products manufactured by countries affects many economic outcomes in international and development economics. Past studies have consistently found that product quality influences cross-border trade; richer countries consume and export higher quality products than developing countries.[1] The ability of developing countries to transition from low-quality to high-quality products is therefore seen by some as a necessary (but certainly not a sufficient) condition for export success and, ultimately, economic development.[2] In addition, quality upgrading features prominently in current debates about the role of international trade in driving wage inequality. But while this research suggests a positive association between quality upgrading and income *per capita*, Verhoogen (2008) and Goldberg and Pavcnik (2007) argue that quality upgrading also affects the variance of income through changes in the relative demand for skilled labour. Quality specialization may therefore partly explain why inequality has risen in developing countries following trade liberalizations, in contrast to Stolper–Samuelson predictions. Differences in the quality space may also affect how closely countries' products compete with one another and therefore have implications for the impact of trade on industry employment and output (Leamer, 2006).

1. The demand-side explanation, initially posited by Linder (1961), has been supported by Hallak (2006) and Verhoogen (2008). Studies by Hummels and Klenow (2005) and Schott (2004) provide systematic evidence that richer countries export higher quality products. Baldwin and Harrigan (2007), Hallak and Sivadasan (2009), Kugler and Verhoogen (2008) and Johnson (2009) also document the role of product quality in influencing production and trade patterns.

2. Kremer (1993) provides microeconomic foundations for the quality production function and its implications for economic development (see also Verhoogen, 2008; Kugler and Verhoogen, 2008). Endogenous growth models that highlight the importance of product quality include Grossman and Helpman (1991). Hausmann and Rodrik (2003), Rodrik (2006) and Hidalgo *et al*. (2007) highlight the importance of export quality for economic performance.

These studies stress the importance of understanding why product quality varies across countries and over time, and how it is influenced by policy. The challenge faced by this literature is that product quality is unobserved. Research in the international trade literature has attempted to deal with this problem by using prices (or unit values) as a proxy for quality. This approach, while convenient, requires strong assumptions since prices could reflect not just quality, but also variations in manufacturing costs. For example, in 1999, the United States imported Malaysian and Portuguese women's trousers (HS 6204624020) at unit values (inclusive of transportation and tariff duties) of \$146 and \$371, respectively. If prices are assumed as perfect proxies for quality, Malaysian trousers would possess about half the quality of Portuguese trousers. However, the annual wage in the apparel sector for Malaysia and Portugal was \$3100 and \$5700, respectively (UNIDO, 2005). So the difference in unit values may instead be a reflection of these different factor prices. Why would a consumer ever purchase expensive Portuguese trousers if they, in fact, possess lower quality? One explanation is that a fraction of consumers have a preference for the horizontal attributes of Portuguese trousers (for instance, the cut or colour patterns). Indeed, US consumers imported more than 82,000 dozens of Malaysian trousers compared to only 865 dozens from Portugal. Idiosyncratic preferences for products' horizontal attributes can therefore break the direct mapping from prices to quality which has been traditionally assumed.

This paper estimates the quality of US imports using a procedure that relaxes the strong quality-equals-price assumption. The quality measures are derived from a nested logit demand system, based on Berry (1994), that embeds preferences for both horizontal and vertical attributes.[3] Quality is the vertical component of the estimated model and captures the mean valuation that US consumers attach to an imported product. The procedure utilizes both unit value and quantity information to infer quality and has a straightforward intuition: conditional on price, imports with higher market shares are assigned higher quality. Importantly, the procedure requires no special data beyond what is readily available in standard disaggregate trade data. It is also easy to implement; here, I estimate separate demand curves for approximately hundreds of manufacturing industries. Moreover, the procedure recovers quality at the finest level of product aggregation available (for the US data, this is the ten-digit HS level).[4]

The inferred qualities indicate that developed countries export higher quality products relative to developing countries. This finding is consistent with Schott (2004) who uses unit values as a proxy for quality. However, the estimates also reveal substantial heterogeneity in product markets' scope for quality differentiation, or quality ladders, which I measure as the range of qualities within the product market. In markets with a larger scope for quality differentiation, or a "long" quality ladder, unit values are relatively more correlated with the estimated qualities. In these markets, prices appear to be appropriate proxies for quality. In contrast, prices appear to be less appropriate proxies for quality in markets with a narrow range of estimated qualities ("short" ladder markets). This provides suggestive evidence that expensive imports in short-ladder markets co-exist with cheaper rivals as a result of horizontal product differentiation. That is, although the *average* US consumer attaches a low valuation to the expensive import, there is a fraction of consumers who still value the product. This heterogeneity underscores the drawback in invoking the quality-equals-price assumption, particularly for products characterized by short quality ladders.

3. Other studies within international trade that use a nested logit structure include Goldberg (1995) and Irwin and Pavcnik (2004), although these papers do not focus on the quality of imported products.

4. An alternative procedure developed by Hallak and Schott (2007) relies on similar intuition to infer countries' export quality to the United States, but their methodology prevents estimating quality at the finest level of disaggregation due to data limitations.

TABLE 1

Low-wage countries

Afghanistan	Chad	Haiti	Niger
Albania	China	India	Pakistan
Angola	Congo	Kenya	Rwanda
Armenia	Equatorial Guinea	Lao PDR	Samoa
Azerbaijan	Ethiopia	Madagascar	Sierra Leone
Bangladesh	Gambia	Malawi	Sri Lanka
Benin	Georgia	Mali	Sudan
Burkina Faso	Ghana	Mauritania	Togo
Burundi	Guinea	Moldova	Uganda
Cambodia	Guinea-Bissau	Mozambique	Vietnam
Central African Republic	Guyana	Nepal	Yemen

Notes: The table provides the list of low-wage countries used in the paper. Low-wage countries are defined as countries with less than 5% of US *per capita* GDP.
Source: Bernard, Jensen and Schott (2006).

I use this heterogeneity in ladder lengths to demonstrate that quality specialization has important implications for the US labour market. The public's fear of globalization is often rooted in the vulnerability or, to use Edward Leamer's terminology, the contestability of jobs. According to Leamer, the contestable jobs are those where "wages in Los Angeles are set in Shanghai" (Leamer, 2006, p. 5). A recent study by Bernard, Jensen and Schott (2006) provides evidence that the probability of US plant survival and employment growth are negatively associated with an industry's exposure to import penetration, particularly from low-wage countries.[5] However, while low-wage competition negatively affects output and employment growth, the impact is heterogeneous across industries. For instance, between 1980 and the mid-1990s, electronics (SIC 36) experienced greater low-wage import penetration than fabricated metals (SIC 34) but experienced a smaller employment decline.[6]

Using a simple model developed in Section 2, I demonstrate that the impact of low-wage competition on US industries will vary with the industry's quality ladder. My argument is related to a body of research that rejects standard model predictions of factor price equalization (FPE).[7] These studies show that if countries inhabit different cones of (quality) diversification, with developing countries exporting low-quality products, then developed countries will be insulated from wage movements in developing countries. However, if markets vary in their scope for quality differentiation, developed countries will experience heterogeneity in their exposure to developing countries. In long-ladder markets, developed countries can insulate themselves from the South by using comparative advantage factors (e.g. skill, capital, and/or technology) to specialize atop the quality ladder. In short-ladder markets, however, developed countries will be directly exposed to Southern competition because quality upgrading is infeasible. Thus, a market's scope for vertical differentiation is important for understanding Leamer's notion of contestable jobs.

5. Other studies examining the negative relationships between trade and employment include Sachs and Shatz (1994), Freeman and Katz (1991) and Revenga (1992). Bernard, Jensen and Schott (2006) explicitly connect the relationship between employment and trade with low-wage countries, defined as nations with less than 5% of United States *per capita* GDP. I use their definition of low-wage countries in this paper (see Table 1).

6. One potential explanation is differences in capital intensity, but in 1980, electronics was less capital intensive than fabricated metals. Indeed, this paper offers evidence that capital intensity only partly explains the heterogeneity in US employment outcomes due to import competition.

7. For instance, see Melitz (2003) and Bernard *et al*. (2007).

I find robust support for this hypothesis by matching US industry data and import competition to quality ladders constructed from the estimated qualities. Consistent with Bernard, Jensen and Schott (2006), I find that industry employment is negatively associated with import penetration, particularly from low-wage countries. However, the empirical results confirm that import penetration has a weaker impact on employment in industries with long quality ladders: a ten percentage point increase in low-wage penetration is associated with a 6% employment decline in an industry characterized by an average quality ladder length. A similar increase in competition in a long-ladder industry (one standard deviation above the mean) results in only a 1.4% employment decline. Differential impacts on industry output are similar. Importantly, the impact of import competition on short- and long-ladder industries is similar in magnitude to the differential impact on low- and high-capital-intensive industries. In other words, even after controlling for the differential impact through traditional channels, such as capital and skill intensities (see Sachs and Shatz, 1994; Bernard, Jensen and Schott, 2006), the quality ladder remains an important determinant of an industry's vulnerability to low-wage competition. Moreover, the heterogeneous effect is not precisely captured if one simply uses variations in unit values.

These results complement the literature studying the relationship between quality specialization and labour markets. But while existing studies focus predominantly on developing countries (see Goldberg and Pavcnik, 2007; Verhoogen, 2008; Kaplan and Verhoogen, 2005), the evidence here suggests that quality specialization is also important for developed countries. Quality ladders may therefore help identify those markets that are likely to be contested by competition from low-wage countries.

The remainder of the paper is organized as follows. Section 2 offers a simple model to illustrate that exposure to low-wage competition is greater in markets with short quality ladders. In Section 3, I discuss the approach used to infer quality from trade data. The data and quality estimation results are presented in Section 4. Section 5 applies the quality estimates to test the implications of quality specialization for US employment. I conclude in Section 6.

2. A MODEL OF CONTESTABLE JOBS

This section develops a simple model that delivers two comparative static results. First, the impact of foreign competition on domestic market shares is larger from low-wage countries. Second, the impact will depend on the market's quality ladder length. I then use the empirical quality measures derived in Section 3 to assess the predictions of the model.

The model is partial equilibrium and analyses firms in two regions, North (N) and South (S), where the Southern firms freely export to the North. The wages in each country are determined by an outside sector and are therefore treated as exogenous: $w_{\mathrm{N}} > w_{\mathrm{S}}$. Each region has J homogeneous firms that compete by manufacturing horizontally and vertically distinct varieties. Following Krugman (1980) and Melitz (2003), horizontal differentiation is costless, so in equilibrium, all firms produce horizontally distinct varieties. But as in Flam and Helpman (1987), vertical (e.g. quality) differentiation depends on a Ricardian-type comparative advantage given by region c's technology, Z_c. I assume that Northern firms have access to better technology than the South: $Z_{\mathrm{N}} > Z_{\mathrm{S}}$. Firm j uses this technology to manufacture a variety subject to a marginal cost function that is increasing with quality (λ_j): $w_c + \frac{\lambda_j^2}{2Z_c}$, for $c \in \{N, S\}$.[8]

8. One can think of this marginal cost function as arising from a fixed-proportions technology that combines labour and capital in the proportion 1 to $\frac{\lambda^2}{2Z}$ (with the rental rate on capital being implicitly treated as one).

The consumers who live in the North have discrete choice preferences. Consumer n observes the domestic and Southern varieties and chooses the variety j that provides her with the highest indirect utility:

$$V_{nj} = \theta\lambda_j - \alpha p_j + \epsilon_{nj}. \tag{1}$$

Quality is defined as an attribute whose valuation is agreed upon by all consumers: holding prices fixed, all consumers would prefer higher quality objects. The vertical component can be interpreted as the clarity or sharpness of a television screen or it can reflect the perceived quality that results from advertising. In either case, quality represents any attribute that enhances consumers' willingness to pay for a variety. An alternative interpretation is that λ represents a shift parameter in the variety's demand schedule: holding price p_j fixed, demand shifts out when the quality improves (Sutton, 1991). The empirical identification of quality relies on this latter intuition. The parameter θ reflects the consumers' valuation for quality and, as shown below, represents a proxy for the market's quality ladder in the model.

Horizontal product differentiation is introduced in (1) through the consumer-variety-specific term, ϵ_{nj}. Following standard practice in the discrete choice literature, ϵ_{nj} is assumed to be distributed i.i.d. type-I extreme value. Unlike the vertical attribute, the horizontal attribute has the property that some people prefer it while others do not, and on average, it provides zero utility.[9] Denote the mean valuation for variety j as $\delta_j \equiv \theta\lambda_j - \alpha p_j$. Under the distributional assumption, the market share of variety j is given by the familiar logit formula

$$m_j = \frac{e^{\delta_j}}{\sum_k e^{\delta_k}}. \tag{2}$$

A firm from region c maximizes profits in the Northern market by choosing price and quality by solving the following problem:

$$\max_{p_j,\lambda_j} \left[p_j - w_c - \frac{\lambda_j^2}{2Z_c} \right] \frac{e^{\delta_j}}{\sum_k e^{\delta_k}}. \tag{3}$$

The market is characterized by monopolistic competition with a sufficiently large number of firms so that no one firm can influence the market equilibrium prices and qualities. The optimal price charged by variety j is therefore[10]

$$p_j^* = \frac{1}{\alpha} + w_c + \frac{\lambda_j^{*2}}{2Z_c}, \qquad \forall j \in c. \tag{4}$$

Under this pricing rule, firms charge a markup ($\frac{1}{\alpha}$) over their marginal cost. The optimal quality choice equates the marginal benefit of choosing quality to its marginal cost:

$$\lambda_j^* = \frac{\theta Z_c}{\alpha}, \qquad \forall j \in c. \tag{5}$$

9. For example, comfort is a quality attribute since, *ceteris paribus*, all consumers prefer more comfort to less. An article of clothing's fashion or style is a horizontal attribute since at equal prices, not all consumers would purchase the same style (e.g. stripes vs. solids).

10. If a firm takes into account the impact of its decision on the denominator in (2), the optimal price is given by $p_j^* = \frac{1}{\alpha(1-m_j)} + w_c + \frac{\lambda_j^{*2}}{2Z_c}$. As discussed in Anderson *et al*. (1992), monopolistic competition assumes there are a sufficiently large number of varieties so that the market share of any one variety is negligible. The optimal price is therefore given by (4).

Equations (4) and (5) indicate that all firms within a region choose the same price and quality (but recall that all firms differentiate their varieties in the (costless) horizontal dimension). I therefore drop the subscript j and index the representative firm's choice in each region by N or S. Note also that the market share in (2) simplifies to $m_c = \frac{e^{\delta_c}}{J(e^{\delta_N}+e^{\delta_S})}, c \in \{N, S\}$ and the aggregate market share in each region is $M_c = Jm_c$. The optimal price and quality choice implies that the mean valuation consumers attach to the representative firm in region c is

$$\delta_c^* \equiv \theta\lambda_c^* - \alpha p_c^* = \frac{\theta^2 Z_c}{2\alpha} - \alpha w_c - 1, \qquad c \in \{N, S\}. \tag{6}$$

The Northern firms manufacture the higher quality varieties since $Z_N > Z_S$.[11] Below, I verify that more advanced countries indeed export higher quality products using the newly proposed quality measures, which provides a justification for this assumption. These higher quality Northern firms will also have larger market shares if

$$\frac{\theta^2}{2\alpha}(Z_N - Z_S) > \alpha(w_N - w_S), \tag{7}$$

since this implies that $\delta_N^* > \delta_S^*$. This condition in (7) holds if consumers' valuation for quality is sufficiently high or the North's technological prowess is sufficient to overcome its disadvantage in manufacturing costs. This assumption is consistent with substantial theoretical and empirical work arguing that higher quality, or more productive, firms have higher output (and market shares).[12]

I define the market's quality ladder as the difference between the highest and lowest quality (Grossman and Helpman, 1991). As discussed below, the empirical measures cannot separately identify λ from the consumers' valuation for quality (θ). I therefore define the market's quality ladder as

$$Ladder(\theta) \equiv \theta\lambda_N^* - \theta\lambda_S^* = \frac{\theta^2}{\alpha}(Z_N - Z_S). \tag{8}$$

The market's quality ladder can be indexed by θ and so, as the valuation for quality increases, the quality ladder increases, or lengthens. The scope for quality differentiation will therefore vary according to the consumers' valuations for quality in each market.[13] Moreover, as the quality ladder increases, the market share gains are disproportionately distributed to the manufacturers of the higher quality variety ($\frac{\partial\delta_N^*}{\partial\theta} > \frac{\partial\delta_S^*}{\partial\theta}$).

This simple model abstracts away from the endogenous "lengthening" of the ladder that may occur in a long-run equilibrium with technological progress or shifts in consumer preferences. Instead, I assume that the quality ladder is fixed, which may be appropriate in the short to medium run, and mitigate endogeneity concerns in the empirical analysis by assigning markets their initial quality ladder length. This assumption is consistent with the data which reports a persistence between a market's initial ladder length and its final period length. That is, on average, markets with initially "short" ladders are not "long" by the end of the sample, implying

11. Since quality is a monotonic function of technology, prices are sufficient statistics for quality in this model. However, if $Z_N = Z_S$, all qualities would be identical, but the North would charge higher prices because of higher manufacturing costs. Thus, empirically, prices alone may confound differences in quality and quality-adjusted manufacturing costs.

12. For instance, see Leamer (1987) and Schott (2003).

13. The ladder length could also vary by changing Z_N and the predictions of the model do not change. Hence, the contestable-jobs hypothesis does not hinge on the source of the market's scope for quality differentiation.

that the quality ladder length is an intrinsic attribute of a market, characterizing its scope for quality differentiation.[14]

I can now analyse how the aggregate Northern market share changes with Southern wages, and how this impact varies according to a market's quality ladder length. The first result shows that the North loses market share as Southern manufacturing wages decline:

$$\frac{\partial M_{\mathrm{N}}}{\partial w_{\mathrm{S}}} = -M_{\mathrm{N}} M_{\mathrm{S}} \frac{\partial \delta_S^*}{\partial w_{\mathrm{S}}} > 0 \tag{9}$$

since

$$\frac{\partial \delta_S^*}{\partial w_{\mathrm{S}}} = -\alpha. \tag{10}$$

Thus, Southern firms become more competitive as their manufacturing costs fall and this gain comes at the expense of lower market shares for the Northern firms. This comparative static is quite intuitive and is supported by existing empirical evidence. For instance, Bernard, Jensen and Schott (2006) show that output and employment for US plants are negatively associated with import competition, but the impact is much larger when import competition originates from countries with less than 5% of US *per capita* GDP.

Importantly, this model adds quality differentiation to show that the intensity of competition within a market depends on the quality ladder length. In particular, while (9) indicates that the North's market share falls as Southern wages decline, it suffers a smaller loss in markets characterized by longer quality ladders (high θ markets). This is seen by differentiating (9) with respect to θ:

$$\frac{\partial^2 M_{\mathrm{N}}}{\partial w_{\mathrm{S}} \partial \theta} = -\theta M_{\mathrm{N}} M_{\mathrm{S}} \left(M_{\mathrm{N}} - M_{\mathrm{S}}\right) \left(Z_{\mathrm{N}} - Z_{\mathrm{S}}\right) < 0, \tag{11}$$

since $M_{\mathrm{N}} > M_{\mathrm{S}}$. This derivative shows that in long-ladder markets (high θ), the sensitivity of Northern market shares to Southern competitiveness is reduced. As a result, a decrease in the South's wage results in a smaller decline of the North's market share in long ladders.

The model shows that trading with the South can generate a differential impact on two markets that are otherwise identical but vary according to their quality ladders. This result is related to more general models of international trade that predict a breakdown of FPE when countries are fully specialized in production. In contrast to a single-cone equilibrium, where endowments are such that all countries produce all goods, the conditions required for FPE are not met in multi-cone equilibrium because countries specialize in varieties tailored to their endowments.[15] Schott (2004) has extended this analysis to *within* product specialization where endowment differences cause countries to specialize in different segments of a product's quality ladder. The model here sharpens this analysis by arguing that the scope for quality specialization varies across markets.

3. EMPIRICAL IMPLEMENTATION

This section describes the procedure that infers quality using price and quantity information from standard disaggregate trade data. The estimated qualities are then used to verify predictions from the model.

14. A market's intrinsic scope for quality differentiation is closely related to the escalation principle developed in Sutton (1998).

15. For evidence in favour of the hypothesis that countries inhabit multiple cones of diversification, see Leamer (1987), Davis and Weinstein (2001) and Schott (2003).

The methodology is based on the nested logit framework by Berry (1994). The nested logit has the advantage over the logit in (1) because it partially relaxes the independence of irrelevant alternatives (IIA) property by allowing for more plausible correlation structures among consumer preferences. To understand why this is important, suppose a consumer is choosing between a Japanese wool shirt and an Italian cotton shirt. If a Chinese cotton shirt enters the market, a logit or CES framework would predict that the market shares for both imports would fall by the same percent. However, we might expect the Italian cotton shirt's market share to adjust more than the Japanese shirt because the Chinese shirt is also cotton. The nested logit allows for more appropriate substitution patterns by placing varieties into appropriate nests.

In order to delineate the nests, I rely on the structure of the US trade data. Feenstra, Romalis and Schott (2002) have compiled US import data which contain five-digit SITC *industries* that have been mapped to ten-digit HS *products* denoted by h. The products serve as the nests. An import from country c within a product is called a *variety*.

I model consumer preferences for a single industry and therefore suppress industry subscripts. Following Berry (1994), consumer n has preferences for HS product h exported by country c (e.g. variety ch) at time t. The consumer purchases the one variety that provides her with the highest indirect utility, given by

$$V_{ncht} = \lambda_{1,ch} + \lambda_{2,t} + \lambda_{3,cht} - \alpha p_{cht} + \sum_{h=1}^{H} \mu_{nht} d_{ch} + (1-\sigma)\epsilon_{ncht}. \tag{12}$$

Quality is defined as $\lambda_{1,ch} + \lambda_{2,t} + \lambda_{3,cht}$ since it reflects the valuation for variety ch that is common across consumers (notice that these terms are not subscripted by n). This quality term is decomposed into three components. The first term, $\lambda_{1,ch}$, is the time-invariant valuation that the consumer attaches to variety ch. The second term, $\lambda_{2,t}$, captures for secular time trends common across all varieties. The $\lambda_{3,cht}$ term is a variety-time *deviation* from the fixed effect that is observed by the consumer but not the econometrician. This last term is potentially correlated with the variety's cost, insurance, and freight (c.i.f.) unit value, p_{cht}.

The horizontal component of the model is captured by the random component, $\sum_{h=1}^{H} \mu_{nht} d_{ch} + (1-\sigma)\epsilon_{ncht}$. The logit error ϵ_{ncht} is assumed to be distributed Type-I extreme value and explains why a variety that is expensive and has low quality is ever purchased. The former term interacts the common valuation that consumer n places on all varieties within product h, μ_{nht}, with a dummy variable d_{ch} that takes a value of 1 if country c's export lies in product h. This term generates the nest structure because it allows consumer n's preferences to be more correlated for varieties within product h than for varieties across products.[16]

An "outside" variety completes the demand system. The purpose of the outside variety is to allow consumers the possibility not to purchase any of the inside varieties. For instance, consumers may choose to purchase a domestic variety (or to simply not make any purchase) if the price of all imports rises. The utility of the outside variety is given by

$$u_{n0t} = \lambda_{1,0} + \lambda_{2,t} + \lambda_{3,0t} - \alpha p_{0t} + \mu_{n0t} + (1-\sigma)\epsilon_{n0t}. \tag{13}$$

The mean utility of the outside variety is normalized to zero; this normalization anchors the valuations of the inside varieties. In the context here, one can think of the outside variety as the

16. As discussed in Berry (1994), Cardell (1997) has shown that the distribution of $\sum_{h=1}^{H} \mu_{nht} d_{ch}$ is the unique distribution such that if ϵ is distributed extreme value, then the sum is also distributed Type-I extreme value. The degree of within-nest correlation is controlled by $\sigma \in (0, 1]$. As σ approaches 1, the correlation in consumer tastes for varieties within a nest approaches 1, and as σ tends to zero, the nested logit converges to the standard logit model.

domestic substitute for imports, and I therefore set the outside variety market share to 1 minus the industry's import penetration.[17] Note that the choice of the outside variety proxy affects the absolute growth rate of import qualities but not the relative growth rate because the estimation includes year-fixed effects that are common to all varieties. Once the outside variety market share (s_{0t}) is known, I can compute the total industry output: $MKT_t = \sum_{ch\neq 0} q_{cht}/(1 - s_{0t})$, where q_{cht} denotes the import quantity of variety ch. The imported variety market shares are then calculated as $s_{cht} = q_{cht}/MKT_t$.

The consumer chooses variety ch if $V_{ncht} > V_{nc'h't}$. Under the distributional assumptions for the random component of consumer utility, Berry (1994) has shown that the demand curve implied by the preferences in (12) is

$$\ln(s_{cht}) - \ln(s_{0t}) = \lambda_{1,ch} + \lambda_{2,t} + \alpha p_{cht} + \sigma \ln(ns_{cht}) + \lambda_{3,cht}, \quad (14)$$

where s_{cht} is variety ch's overall market share and ns_{cht} is its market share within product h (the nest share).[18]

Since the trade data do not record detailed characteristics of varieties, I exploit the panel dimension of the data by specifying a time-invariant component of quality ($\lambda_{1,ch}$) with variety-fixed effects, and the common quality component ($\lambda_{2,t}$) with year-fixed effects. This implies that the quality measure cannot separate the technology of the variety from the consumers' valuation for quality. However, Section 2 demonstrated that separately identifying the channel is not important for the model's predictions. The third component of quality, $\lambda_{3,cht}$, is not observed and plays the role of the estimation error. Since $\lambda_{3,cht}$ and the nest share are potentially correlated with the variety's price, instrumental variables are required to identify the parameters.

3.1. *Identification and hidden varieties*

Identifying the price coefficient in (14) typically relies on rival variety characteristics as instruments (Berry, Levinsohn and Pakes, 1995). Yet, even if variety characteristics were available in the import data, the assumption of exogenous characteristics may be problematic if firms simultaneously choose prices and characteristics (as in the model). Fortunately, the import data provide variety-specific unit transportation costs that can serve as instruments for the c.i.f. price. Although transportation costs are obviously correlated with c.i.f. prices, one may be concerned that they are correlated with quality because of the "Washington Apples" effect: distant countries may ship higher quality goods in order to lower per unit transport costs (Hummels and Skiba, 2004). This raises concerns that trade costs may be correlated with a variety's quality. However, the exclusion restriction remains valid as long as transportation costs do not affect *deviations* from average quality, $\lambda_{3,cht}$. In other words, if an Australian firm chooses to export higher quality varieties to the United States because of distance, the instruments remain valid as long as shocks to transportation costs do not affect deviations from the firm's average quality

17. Bernard, Jensen and Schott (2006) provide SIC-level import penetration from 1989 to 1996. I obtain import penetration from 1997 to 2001 at the NAICS level (I thank Spencer Amdur for constructing these data). Since I run the estimations at the SITC level, I map the import penetration values to the SITC (rev. 2) level.

18. If one adopts a logit demand system, the nest share disappears from equation (14). To understand why nesting may be important for inferring quality, reconsider the example discussed above. Suppose that the Japanese wool and Italian cotton shirts are identical in every dimension (including price) and evenly split the market. We would infer their qualities also to be equal. Now suppose an identical Chinese cotton shirt enters. If preferences are more correlated within a nest, the new market shares for both cotton shirts would be one-fourth each and the Japanese wool shirt would capture the remaining half. However, we do not want the inferred quality of the existing varieties to fall simply because varieties within nests are closer substitutes than varieties across nests. The nested logit alleviates this concern because the nest share (ns_{cht}) adjusts to account for the changes in market shares simply due to correlated preferences.

choice. Indeed, the Washington Apples phenomenon in Hummels and Skiba (2004) identifies the impact of distance on prices using cross-country variation in distance rather than variation in transportation costs over time.[19] I also include exchange rates and the interaction of distance to the United States with oil prices as additional instruments; these instruments vary at the country-year level.

The ns_{cht} is also endogenous and so, to identify σ, I instrument this term with the number of varieties within product h and the number of varieties exported by country c. These count measures will be correlated with the nest term and uncorrelated with $\lambda_{3,cht}$ if variety entry and exit occur prior to exporting firms' quality choice. This assumption is now standard in the literature that estimates discrete choice demands curves (e.g. see Berry, Levinsohn and Pakes, 1995).[20]

A second issue that arises in estimating (14) is that the market shares are likely to be an aggregation of even more finely classified imports. As noted in Feenstra (1994), a country's large market share may simply reflect the fact that it exports more *unobserved* or *hidden* varieties within a product. To illustrate this potential problem, suppose that China and Italy export identical varieties at identical prices and split the market equally at the (unobserved) 12-digit level, but that China exports more 12-digit varieties (such as more colours). Aggregation to the observed ten-digit level would assign a larger market share at identical prices to China. From (14), China's estimated quality would be biased upward simply because of the hidden varieties. I therefore follow predictions from Krugman (1980), among others, and use a country's population as a proxy for countries' hidden varieties.[21] The demand curve that adjusts for the hidden varieties is given by

$$\ln(s_{cht}) - \ln(s_{0t}) = \lambda_{1,ch} + \lambda_{2,t} + \alpha p_{cht} + \sigma \ln(ns_{cht}) + \gamma \ln pop_{ct} + \lambda_{3,cht} \quad (15)$$

where pop_{ct} is the population of country c. I estimate separate demand curves in (15) for each industry.

The quality of variety ch at time t is defined using the estimated parameters:

$$\lambda_{cht} \equiv \hat{\lambda}_{1,ch} + \hat{\lambda}_{2,t} + \hat{\lambda}_{3,cht}. \quad (16)$$

Equation (15) shows that inferring quality relies on the intuitive idea that the quality of an imported variety is its relative market share after controlling for exporter size and price. Thus, a variety's quality will rise if its price can rise without losing market share. While it is possible that many factors could affect market shares, it is important to note that this set is made much smaller by conditioning on prices. For example, a variety may have a large market share if the exporting country is geographically close to the United States. However, the price includes transportation costs and therefore the quality estimate is not capturing purely gravity effects such as distance. A similar argument can be made regarding free trade agreements: even though Mexican and Canadian import shares are high because of NAFTA, this effect will operate through prices, which are inclusive of tariffs.[22]

19. In Section 5.1.1, I show that the results are also robust to including unit tariff costs as instruments.

20. Moreover, the model above is developed under monopolistic competition where a firm's quality choice is chosen independently of the actions (and number) of its competitors.

21. In Section 5.1.1, I show that the results are robust to using GDP as the proxy for hidden varieties.

22. Note that defining quality based on residuals is analogous to the literature that infers total factor productivity from firm-level estimations. If one remains concerned about what the residual $\lambda_{3,cht}$ captures, I show that the results are not sensitive to excluding the residual from the definition of quality in Section 5.1.1.

4. DATA AND QUALITY ESTIMATION RESULTS

I estimate regression (15) on US product-level import data from 1989 to 2001 (Feenstra, Grossman and Helpman, 2002). In addition to import quantities and values, the data record tariffs and transportation costs. A variety's unit value is defined as the sum of the value, total duties, and transportation costs divided by the import quantity and deflated to real values using the CPI. I restrict the sample to the manufacturing industries (SITC 5-8) and exclude the homogeneous goods defined by Rauch (1999) since these products, by definition, exhibit no quality differentiation. Since the import data are extremely noisy (General Accounting Office, 1995), I trim the data along two dimensions. The first trim excludes all varieties that report a quantity of one unit or a total value of less than $7500 in 1989 dollars. The second trim removes varieties with extreme unit values that fall below the 5th percentile or above the 95th percentile within the industry.[23]

Table 2 reports basic summary statistics by two-digit SIC sectors. Column 1 indicates the number of industries and column 2 reports the total number of products. Column 3 reports the (weighted) average income *per capita* by sector; the average apparel and leather imports

TABLE 2

Summary statistics

Sector (SIC-2)	Industry (SITC-5) (1)	Products (HS-10) (2)	Average GDP (3)	Skill intensity (4)	Capital intensity (5)	Ladder length (6)
20 Food	8	37	16,881	0.39	81.4	2.04
22 Textile	85	1,642	13,304	0.15	48.7	2.62
23 Apparel	68	2,560	7120	0.18	11.2	2.28
24 Lumber	20	262	12,634	0.20	36.3	1.81
25 Furniture	5	72	11,849	0.25	22.1	1.66
26 Paper	38	216	19,766	0.30	126.0	1.88
27 Printing	16	55	17,574	0.87	33.2	1.33
28 Chemicals	231	2,558	20,094	0.75	166.1	2.46
29 Petroleum	7	21	10,952	0.51	509.1	2.64
30 Rubber and plastic	45	515	14,119	0.29	48.5	2.32
31 Leather	17	403	6088	0.19	18.6	1.68
32 Stone and ceramic	57	357	15,133	0.29	78.6	2.15
33 Primary metal	98	1,372	16,864	0.29	157.1	2.21
34 Fabricated metal	78	599	17,364	0.35	53.0	1.42
35 Industrial machinery	169	1,632	21,035	0.57	63.1	2.40
36 Electronic	100	1,325	15,551	0.56	57.7	2.01
37 Transportation	43	372	23,096	0.52	68.6	2.08
38 Instruments	60	715	21,843	0.96	45.3	2.40
39 Miscellaneous	76	375	10,804	0.38	29.7	2.17

Notes: The table provides summary statistics for the two-digit SIC (1987 revision) sectors. Column 1 reports the number of SITC (revision 2) industries. Column 2 reports the total number of HS products. Column 3 reports the weighted average of exporter *per capita* GDP. Columns 4 and 5 report skill (ratio of production to non-production workers) and capital intensity. Column 6 reports the (log) weighted average industry ladder [see equation (20)].
Source: NBER Manufacturing Database, Feenstra, Grossman and Helpman (2002), World Development Indicators and author's calculations.

23. Twelve per cent of the SITC industries record imports in multiple units. For these industries, the products of the majority unit are kept, which comprise about 80% of the observations within a multiple-unit industry. Baseline results are not sensitive to varying price cutoffs or trimming observations below $5000 or $10,000.

TABLE 3

Quality estimation results

Statistic	Mean	Median	First quarter	Third quartile
OLS price coefficient	−0.053	−0.003	−0.023	−0.0002
IV price coefficient	−0.089	−0.009	−0.070	−0.0003
*Own price elasticity	−1.28	−0.58	−1.44	−0.20
Coefficient on conditional market share	0.42	0.46	0.09	0.81
Coefficient on population	1.17	0.68	−1.04	3.81
T-statistic of quality estimates	10.33	3.90	1.34	10.66
Over identifying restrictions p-value	0.234	0.116	0.015	0.371
First stage F-stat p-value, price	0.029	0.000	0.000	0.004
First stage F-stat p-value, nest share	0.031	0.000	0.000	0.006
R-squared	0.24	0.14	0.04	0.40
Observations per estimation	1176	509	223	1168
Estimations with stat. sig. price coefficient			0.71	
Observations with stat. sig. price coefficient			0.81	
Total estimations			1059	
Total observations across all estimations			1,245,006	

Notes: The top panel reports estimation statistics of running equation (15) separately for each of the 1059 manufacturing industries. The bottom panel reports statistics that apply to the entire sample. The regressions cluster standard errors by exporting country. The asterisk denotes that the elasticity is computed conditional on a negative price coefficient and $\sigma \varepsilon (0,1]$.

originate from countries with the lowest average *per capita* income, while imports into transportation, industrial machinery and chemicals are dominated by relatively richer countries. Columns 4 and 5 report skill and capital intensity from the NBER Manufacturing Industry Database (Bartelsman, Becker and Gray, 1996).

The estimating equation in (15) is run separately for 1059 SITC (rev. 2) manufacturing industries with standard errors clustered by exporting country. The results of these regressions are summarized in Table 3. The bottom panel shows that 71% of the regressions, or 81% of the total 1.245 million observations in the entire sample, have a negative and statistically significant price coefficient. Rows 1 and 2 in the top panel indicate that the average IV price coefficient is about 68% lower than the OLS price coefficient, suggesting that the instruments are moving the price coefficient in the intuitive direction. Row 3 reports summary statistics for the own-price elasticities. While the average own-price elasticity is low, this is not surprising given that the parameters in (15) are estimated using variation within varieties over time. Rows 4–6 indicate that the average and median regression pass the over-identifying restrictions test and have low first-stage F-statistic p-values. Row 7 reports the coefficients on population. Row 8 reports that 57% of the estimations report a statistically significant $\hat{\sigma}$ indicating the appropriateness of the nested logit structure. Row 9 reports that the quality estimates are precisely estimated, which is not surprising since these estimates are the sum of two fixed effects plus a residual.[24]

4.1. *Factor endowments and quality specialization*

The inferred qualities offer support for previous studies that have found, using prices as a proxy for quality, that more capital- and skill-intensive countries export higher quality varieties (see, e.g. Schott, 2004; Hallak, 2006). This relationship is seen in the following specification which

24. The standard errors are obtained by simulating draws from the asymptotic distribution of the estimated parameters.

TABLE 4

Quality and factor endowments

	Quality$_{cht}$			Unadjusted quality$_{cht}$	
Regressors	(1)	(2)	(3)	(4)	(5)
	0.801***			0.025	0.085**
Log (PCGDP$_{ct}$)	0.221			0.054	0.036
		0.804***			
Log (K/L$_{ct}$)		0.210			
			0.274		
Log (education$_{ct}$)			0.207		
					0.783***
China dummy					0.081
Product × year FEs	Yes	Yes	Yes	Yes	Yes
R-squared	0.20	0.21	0.32	0.49	0.49
Observations	1,244,475	1,172,510	512,329	1,244,475	1,244,475

Notes: Table regresses the quality estimates on (log) *per capita* GDP, (log) capital–labour ratios and percentage of workforce with tertiary education. Regressions include product-year fixed effects. Robust standard errors are clustered by exporting country. Column 4 uses quality estimates that do not control for hidden varieties [qualities obtained from estimating equation (14)]. Column 5 also uses the unadjusted quality measures and includes a China indicator variable. Regressions include product-year fixed effects. Robust standard errors are clustered by exporting country. Significance levels: ***0.01; **0.05; *0.10.
Source: World Bank's World Development Indicators.

relates quality to exporters' GDP *per capita*

$$\lambda_{cht} = \alpha_{ht} + \beta \ln Y_{ct} + \nu_{cht}, \tag{17}$$

where λ_{cht} is the estimated quality of country c's export in product h at time t and Y_{ct} is country c's GDP *per capita*. The inclusion of a product-year dummy, α_{ht}, indicates that the regression considers the cross-sectional relationship between quality and income within products. Table 4 reports that the coefficient on exporter income is positive and significant. Richer countries, on average, export higher quality varieties within products. Columns 2 and 3 re-run (17) using capital–labour ratios and the fraction of a country's workforce with tertiary education. The coefficient on capital–labour endowment is positive and significant, so more capital-intensive countries also tend to export higher quality varieties within products. The coefficient on the education variable is positive, but not statistically significant, but the precision may be low due to lack of data.

These results are consistent with the model's prediction that more advanced countries will manufacture higher quality products. This specification can also be used to check the importance of correcting for exporter size when inferring quality from market shares and prices. Column 4 re-runs (17) using quality estimates that have not been adjusted for hidden varieties (that is, qualities estimated from (14) rather than (15)). Notice now that there is no statistically significant relationship between exporter income and the unadjusted quality estimates. The main reason why this occurs is China. When controlling for hidden varieties, the quality estimates report that China's export quality is below average. However, the unadjusted quality estimates indicate that China has above average quality. This is seen in column 5 which includes a China dummy in the regression of unadjusted quality estimates on exporter income; the coefficient on income is now positive and statistically significant. These results illustrate the importance of controlling for hidden varieties when inferring quality from price and quantity information.[25]

25. Feenstra (1994) and Hallak and Schott (2007) have made a similar point.

4.2. *Quality ladders*

I construct the quality ladder from the estimated qualities as the difference between the maximum and minimum quality within a product:

$$Ladder_h = \lambda_h^{\max} - \lambda_h^{\min}. \tag{18}$$

Regression (17) provides evidence that richer countries sit atop the quality ladder. The quality ladder will change over time as countries increase R&D expenditure and/or gain access to improved technology. To mitigate endogeneity concerns, I fix the product's quality ladder at the length measured in the first period that the product appears in the sample.[26] One concern of fixing the quality ladder is that "short" ladders could become "long" or vice versa. However, there is persistence in a product's ladder length over time. The correlation coefficient between a product's initial ladder length and its end of sample length is 0.7. This suggests that the scope for quality differentiation is an intrinsic feature of products.

In a vertical product market, Bresnahan (1993) has shown that prices and quality are isomorphic since all consumers agree on the rankings of goods. However, as discussed earlier, the mapping between prices and quality is less clear when products also possess horizontal attributes. The following specification assesses the relationship between the inferred qualities and prices across products of varying ladder lengths

$$\ln p_{cht} = \alpha_{ht} + \beta_1 \lambda_{cht} + \beta_2 (\lambda_{cht} \times \ln Ladder_h) + \nu_{cht}. \tag{19}$$

p_{cht} is the unit value of country c's export in product h at time t and α_{ht} denote product-year fixed effects. Column 1 of Table 5 reports that the interaction coefficient, β_2, is positive and significant.[27] This regression shows that in markets characterized by long quality ladders, there

TABLE 5

Relationship between quality and price

	ln(price$_{cht}$)	
Regressors	(1)	(2)
Quality$_{cht}$	−0.021*	−0.025*
	0.012	0.014
Quality$_{cht}$ × log (Ladder$_h$)	0.005**	0.006**
	0.002	0.003
Quality$_{cht}$ × BW Sigma$_h$		9.40E-05
		7.20E-05
Product × year FEs	Yes	Yes
R-squared	0.87	0.86
Observations	1,245,006	1,165,703

Notes: Column 1 regresses variety quality on (log) price and its interaction with the product's baseline quality ladder. Column 2 includes quality interacted with the elasticity of substitution measures obtained from Broda and Weintein (2004). Products with elasticities above the 90th percentile (elasticities greater than 76.9) are excluded. Robust standard errors are clustered by exporting country. Significance levels: ***0.01; **0.05; *0.10.

26. The main results of the paper actually rely on the inter-decile range which is more robust to outliers than the range. In Section 5.1.1, I show that the results are robust to defining the ladder using the full range, the inter-quartile range, and the standard deviation of qualities.

27. Note that the negative β_1 coefficient is a consequence of how quality is defined (see equation (15)): *conditional* on market shares, price and the estimated quality measures are positively correlated.

is a relatively steeper gradient between prices and the estimated qualities. This is consistent with the quality-equals-price assumption frequently made in the literature. However, this correlation weakens as the ladder length declines, implying that prices may be imperfect proxies for quality in short-ladder markets. Regression (19) therefore indicates that the *average* consumer does not attach a high valuation to expensive imports in short-ladder products. For example, the estimated qualities reveal that while Canadian footwear is 27% more expensive than average imported footwear, it has below average quality. Horizontal attributes can explain why these expensive, but low-quality, Canadian shoes are purchased. Thus, inferring quality from prices alone would instead attach a high quality rank for Canadian footwear.

Two graphs further illustrate this point. Figure 1 plots the relationship between quantities, unit values, and the estimated qualities for two products: "Transmission Receivers Exceeding 400 MHz" (HS 8525203080) and "Footwear with Plastic Soles, Leather Uppers" (HS 6403999065). The graphs are ordered by unit values, which also roughly correspond to exporter *per capita* GDP. For transmission receivers (top panel), unit values and quality are positively correlated, indicating that the average consumer assigns a higher valuation to more expensive varieties. For this product, it appears that the quality-equals-price assumption is tenable.

The bottom panel plots leather shoes. Here, exporters of expensive varieties, like Belgium, are associated with relatively low quality. The reason lies in the export quantities (square dots). Belgium has a very low market share, even conditioning on its price. Taking into account Belgium's market share and export price, the quality estimates indicate that the average consumer attaches a low valuation to Belgian leather shoes. On the other hand, France exported the second most expensive variety in this HS classification and obtained a relatively high market share given its price; it is therefore assigned a high quality estimate. China also has a high estimated quality since, conditional on its price, it also has a high market share. Consistent with casual evidence, footwear exported by Spain, Italy, and Germany is of relatively high quality: these countries' footwear is expensive but secure high market shares. These two figures therefore suggest that the direct mapping from prices to quality may be more reasonable for some product markets rather than others.

Conceptually, the quality ladder (a proxy for vertical differentiation) and the CES elasticity of substitution (the measure of horizontal differentiation in standard trade models) appear related. In column 2 of Table 5, I include the interaction of quality with the elasticities of substitution estimated by Broda and Weinstein (2006).[28] The interaction coefficient is not significant, suggesting no systematic relationship between prices and qualities according to the elasticity of substitution. There are several potential explanations for this finding. First, the logit and CES demand systems yield identical aggregate demand curves only if prices and income are in logs (Anderson, De Palma and Thisse, 1987). Perhaps more importantly, our estimation methods differ substantially. The approach here relies on supply-shifters to identify the demand curve. In contrast, Broda and Weinstein (2006) assume that the demand and supply curve error terms are uncorrelated and use heteroskedasticity to identify the parameters. Moreover, they rely on variation across varieties within a product, while the estimations here use within-variety variation. Their methodology also constrains their estimates to lie within an interval. So while conceptually similar, the quality ladder and elasticities from Broda and Weinstein (2006) are difficult to compare in practice.

28. I exclude extremely large elasticities of substitution (above the 90th percentile, or elasticities greater than 76.9).

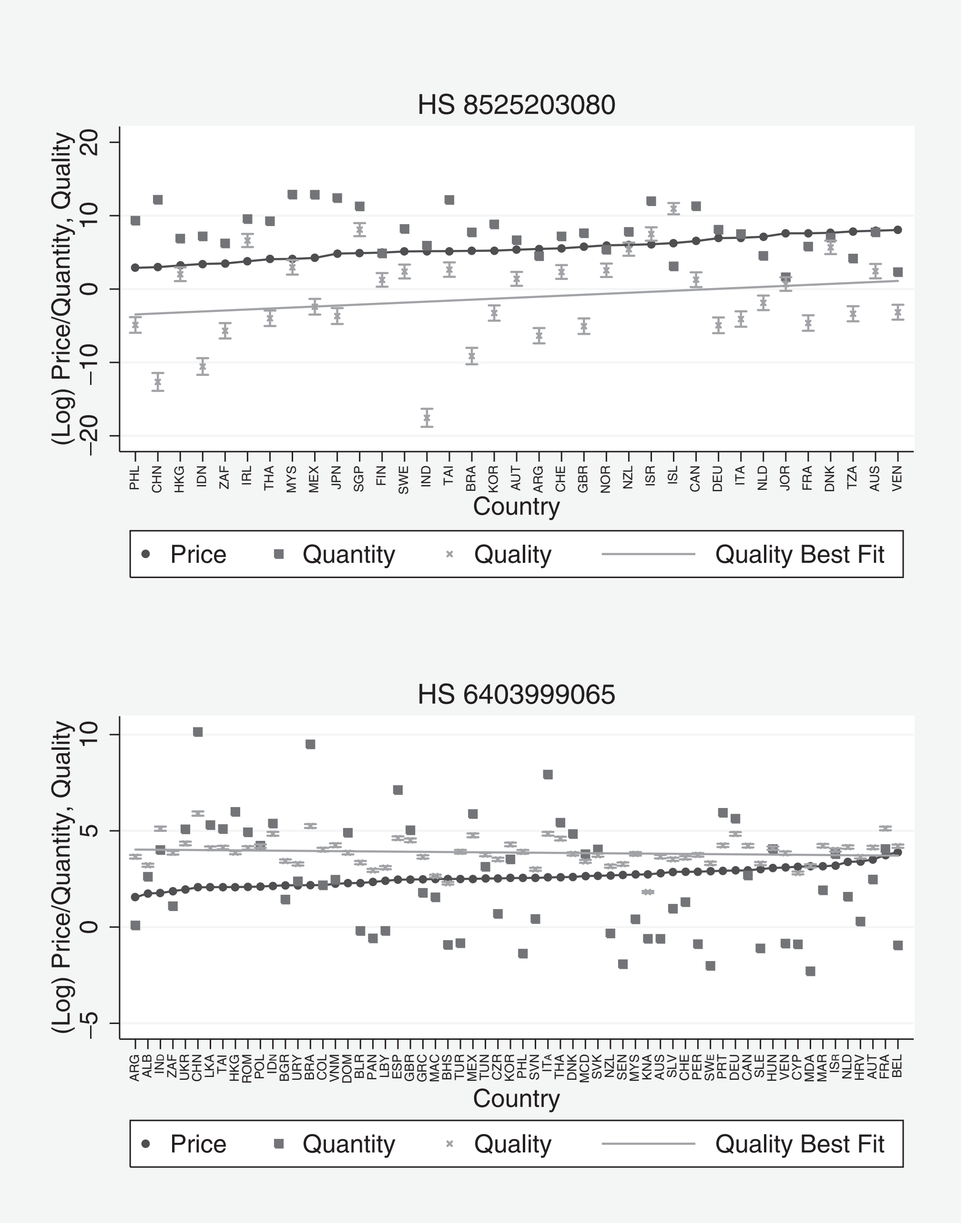

FIGURE 1

Prices, market shares, and quality. The graph plots countries' export price, quantity, and quality (with 95% confidence interval) in HS 8525203080 (transmission receivers exceeding 400 MHz) and HS 6403999065 (footwear with plastic soles, leather uppers) in 2001. Countries are ordered by unit value

Finally, it is important to note that the quality ladders are constructed not only from developing country imports, but also imports from highly developed countries like Japan, Germany, and Canada. The quality ladder is therefore likely to represent the true quality frontier of a product. But while most countries export apparel and footwear products, there is a negative correlation between the average number of varieties within an HS product and industry capital intensity. Based on equation (15), a country's variety has zero market share if consumers assign a negative, infinite consumer valuation (or if the price is infinite). In the next section, I demonstrate that quality ladder lengths are positively correlated with industry capital intensity. Putting these two findings together indicates that the selection bias that occurs because not all countries export more capital-intensive products will underestimate the quality ladder for these products. As a result, accounting for the selection bias (see e.g. Helpman, Melitz and Rubinstein, 2006) is not a major concern since the selection bias works against the results below. In other words, the quality ladders are underestimated for the markets that are least affected by low-wage competition.

5. LONG AND SHORT QUALITY LADDERS

5.1. *Quality ladders and US manufacturing employment*

With the quality ladders in hand, I can now examine the contestable-jobs hypothesis outlined in Section 2 by linking the impact of import penetration on US manufacturing employment with the quality ladder. Since US employment data is unavailable at the ten-digit HS level, I construct a four-digit SIC (rev. 1987) industry quality ladder, $IndLadder_m$, to match to industry-level US employment data. The industry ladder is defined as the weighted average of the (initial year) product ladders within the SIC industry:

$$IndLadder_m = \sum_{h=1}^{H_m} w_h Ladder_h, \tag{20}$$

where H_m denotes the number of products in SIC industry m, $Ladder_h$ is the product's baseline ladder (defined in (18)). The variable w_h is the product's (real) import share within an SIC in the product's initial year. Again, by relying on initial year values, the industry ladder becomes a time-invariant measure.

Summary statistics for the quality ladders are shown in the final column of Table 2. Table 6 examines how standard industry characteristics correlate with the quality ladder. Column 1 regresses the industry quality ladder in (20) on skill intensity, capital intensity, and total factor productivity.[29] The results report a positive and statistically significant correlation with capital intensity and total factor productivity (TFP), suggesting that capital-intensive and high-productivity industries are also associated with longer quality ladders. Column 2 includes measures of marketing expenses and R&D taken from the 1975 Federal Trade Commission (FTC) Line of Business survey.[30] The quality ladders have a positive and significant correlation with the R&D measure but not the marketing expense variable. So while the quality measures cannot directly separate consumer valuation from technology, this regression suggests that the variation is driven predominantly by the latter.

29. Skill intensity is measured as the ratio of non-production to production workers. Capital intensity is the ratio of capital stock to total employment. See Bartelsman, Becker and Gray, (1996) for details on the measurement of total factor productivity.

30. These two measures have been used by Kugler and Verhoogen (2008), Sutton (1998) and Antras (2003) to measure the importance of marketing expenses and R&D for an industry.

TABLE 6

Quality ladder and industry characteristics

	Log (IndLadder$_m$)			
Regressors	(1)	(2)	(3)	(4)
Log (K/L$_m$)	0.133**	0.124**		0.138**
	0.051	0.057		0.060
Log (Skill$_m$)	−0.015	−0.105		−0.121
	0.067	0.080		0.080
Log (TFP$_m$)	1.052*	0.934		0.833
	0.600	0.577		0.580
(Marketing intensity)$_m$		0.052		0.238
		0.866		0.853
(R&D intensity)$_m$		6.036**		4.295
		2.708		2.662
(Broda–Weinstein elasticity)$_m$			0.016	0.015
			0.011	0.011
(Coefficient of variation of unit values)$_m$			0.362	0.366
			0.230	0.258
R-squared	0.03	0.05	0.02	0.05
Observations	325	306	325	306

Notes: Column 1 regresses the industry quality ladder [defined in equation (20)] on four-digit SIC factor intensities: capital intensity, skill intensity, and total factor productivity. Capital intensity is the ratio of capital stock to total employment. Skill intensity is measured as the ratio of non-production to production workers. Total factor productivity is obtained from a five-factor model (Bartelsman, Becker and Gray, 1996). Factor intensities measured at 1989 values. Column 3 includes marketing expense to sales and R&D to sales ratios obtained from the 1975 FTC Line of Business survey. Column 3 includes industry-level elasticity of substitution (obtained from Broda and Weinstein, 2006) and industry-level coefficient of variation of unit values; these two product-level variables are aggregated to the industry level using the same weights in (20). Robust standard errors with significance levels: ***0.01; **0.05; *0.10.

In column 3, I correlate the quality ladder with a measure of price dispersion and the Broda and Weinstein elasticities.[31] Both measures report no statistically significant correlation with the quality ladder. So while the price dispersion measure is positively correlated with the quality ladder, the correlation is noisy. This is consistent with earlier arguments that price dispersion may be more appropriate proxies for quality in some markets rather than others. Finally, column 4 includes all observable industry characteristics. The capital intensity and R&D intensity measures remain positive and statistically significant (p-value on R&D coefficient is 0.108). One interesting feature of these regressions is that the R-squareds are extremely low. Thus, most of the variation in quality ladders cannot be explained by these widely used industry characteristics.

Following Bernard, Jensen and Schott (2006), I link employment outcomes with two measures of import penetration: imports originating from countries with less than 5% of US *per capita* GDP (*LWPEN*) and the rest of the world (*OTHPEN*). Total import penetration is defined as $I_{mt}/(I_{mt} + Q_{mt} - X_{mt})$, where I_{mt} is the value of imports in four-digit SIC industry m at time t, Q_{mt} is the industry's domestic production, and X_{mt} represents US exports. *LWPEN* is the

31. I aggregate the product-level elasticities and the product-level unit value dispersion (the coefficient of variation) to the industry level using (20). The Broda–Weinstein elasticities are not available for all products, so I assign missing values with average elasticities over coarser HS codes.

product of total import penetration and the value share of imports originating from low-wage countries

$$LWPEN_{mt} = \frac{I_{mt}^{\text{low}}}{I_{mt} + Q_{mt} - X_{mt}}. \tag{21}$$

OTHPEN is defined analogously as

$$OTHPEN_{mt} = \frac{I_{mt} - I_{mt}^{\text{low}}}{I_{mt} + Q_{mt} - X_{mt}}. \tag{22}$$

The following specification, which is an industry-level regression based on Bernad *et al.* (2006), regresses employment outcomes on the quality ladder and import penetration:

$$\ln Emp_{mt} = \alpha_m + \alpha_t + \beta_1 OTHPEN_{mt} + \beta_2 LWPEN_{mt} + \beta_3 \left(LWPEN_{mt} \times \ln IndLadder_m\right) + \nu_{mt}. \tag{23}$$

Note that the specification includes both industry (α_m) and year (α_t) fixed effects. If the data are consistent with the comparative static prediction in (9), we should observe $\beta_2 < \beta_1 < 0$; higher import penetration is negatively correlated with industry employment, and the correlation is stronger with low-wage penetration. The second prediction of the model is that impact of low-wage penetration will depend on the quality ladder (see (11)). The interaction between *LWPEN* and *IndLadder* captures this effect. The prediction is that $\beta_3 > 0$, implying that long-ladder industries with high exposure to low-wage countries suffer smaller employment declines.[32]

Column 1 of Table 7 reports the baseline results. The coefficients are statistically significant and have the predicted signs. Import penetration negatively affects employment, and imports from low-wage countries have a larger impact than imports originating from the remaining (richer) countries. The interaction coefficient is positive and precisely estimated, supporting the model's prediction that vulnerability to low-wage penetration declines in industries with longer quality ladders.

The point estimates are also economically significant. If low-wage penetration increases by ten percentage points, employment in an average ladder industry declines by 6%. In contrast, low-wage penetration is associated with only a 1.4% employment loss in a long-ladder industry (one standard deviation above the mean). For a specific example, if *LWPEN* were to increase by ten percentage points in the household slippers industry (SIC 3142), employment would fall 13% more than in household audio and video equipment (SIC 3651), an industry characterized by a three times longer quality ladder.

In column 2, I include a ladder–*OTHPEN* interaction to determine if the effects of imports originating from more advanced countries are also dampened in long ladders. This interaction is statistically significant, but its economic magnitude is smaller than the ladder–*LWPEN* interaction term.

Given that the quality ladder is positively correlated with industry capital intensity and TFP (see Table 6), one concern is that the quality ladder simply proxies these variables. If this is true, then the results in columns 1 and 2 simply confirm the findings of previous studies arguing that, for instance, more capital-intensive industries are less susceptible to import competition. To address this concern, I include the interaction of initial industry capita intensity with *LWPEN* in column 3.[33] More capital-intensive industries are less vulnerable to low-wage

32. Note that the predictions for the signs of $\beta_1, \beta_2, \beta_3$ are opposite from the model because in the model, an increase in wages is analogous to a decline in *LWPEN*.

33. Since this variable is itself endogenous, the regression assigns an industry's capital intensity at its initial period level. This implies that the coefficient on capital intensity is not identified because of the industry fixed effects.

TABLE 7

Employment regressions

	Log (employment$_{mt}$)							
	OLS				IV			
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OTHPEN$_{mt}$	−0.493***	−1.175***	−0.475***	−0.495***	−1.774	−1.094	−0.979**	−0.745
	0.157	0.406	0.132	0.157	1.295	2.869	0.436	0.545
LWPEN$_{mt}$	−1.894***	−2.190***	−4.643***	−1.897***	−7.162**	−8.495	−11.713***	−5.429***
	0.256	0.360	1.194	0.267	2.983	5.511	3.010	1.753
Log (IndLadder$_m$) × LWPEN$_{mt}$	0.609**	0.716***	0.600**	0.617**	4.620*	5.714	2.879***	3.033**
	0.216	0.234	0.276	0.239	2.414	4.453	0.885	1.462
Log (IndLadder$_m$) × OTHPEN$_{mt}$		0.317**				−0.535		
		0.136				1.772		
Log (K/L$_m$) × LWPEN$_{mt}$			0.918**				2.223**	
			0.361				0.932	
Log (TFP$_m$) × LWPEN$_{mt}$				0.329				7.003*
				0.870				3.726
Over identification p-value	–	–	–	–	0.48	0.43	0.38	0.40
Kleibergen–Paap F-statistic	–	–	–	–	0.61	0.61	18.40	3.52
Industry-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.112	0.120	0.124	0.112	0.013	0.009	0.018	0.020
Observations	2585	2585	2585	2585	2585	2585	2585	2585

Notes: The dependent variable for each regression is the four-digit SIC industry (log) employment. The first column regresses employment on import penetration from the rest of the world (OTHPEN), low-wage import penetration (LWPEN), and the interaction of LWPEN with the industry quality ladder. Column 2 includes the OTHPEN–ladder interaction. Column 3 includes the interaction of LWPEN with initial industry capital intensity (in 1989) and column 4 includes the interaction of LWPEN with initial industry TFP (in 1989). Columns 5–8 present the IV results. The instruments are weighted average tariff rates, exchange rates, and freight rates for low-wage countries and the rest of the world. Robust standard errors are clustered at the two-digit SIC. Significance levels: ***0.01; **0.05; *0.10.

imports, as expected, but the quality ladder interaction remains positive and significant. Moreover, the magnitudes of the point estimates are about the same. Employment in a short ladder is predicted to fall 4.5% more, *ceteris paribus*, than its long-ladder counterpart. Likewise, a low capital-intensive industry would contract 8% more than a highly intensive industry because of low-wage competition. Column 4 interacts initial industry TFP with *LWPEN* and the results continue to hold. Finally, (unreported) results are also robust to including both capital intensity and TFP interactions.

While using the initial-period ladder and factor intensities mitigates endogeneity concerns, import penetration may be endogenous. For instance, international trade may be filling a void created by a decline in domestic industries caused by other factors, such as structural changes in the economy. The simultaneity would bias the import penetration coefficients downward in (23). I therefore instrument the penetration measures with industry-year weighted averages of exchange rates, where the weights are the country's share of industry value in 1989, for low-wage countries and the rest of the world. Tariffs and freight rates also serve as instruments. These two instruments are constructed by dividing total duties and freight costs for each set of countries divided by their total import value for each industry and year.

Column 5 of Table 7 presents the baseline IV specification. The first column shows the baseline specification. Instrumenting actually causes the coefficient on *LWPEN* to increase in magnitude, which suggests measurement error in the variable.[34] The quality ladder now generates an even larger impact of competition on employment. For example, a ten percentage point increase in *LWPEN* leads to a 9% employment decline in a short-ladder industry (one standard deviation below the mean) compared to a 27% employment gain in the average industry. While β_3 is not significant at conventional levels when including the $OTHPEN \times \ln IndLadder$ interaction in column 6, the magnitude and signs are consistent with earlier results. Column 7 includes the interaction of low-wage penetration with industry capital intensity and the point estimates imply that employment in a short-ladder is predicted to fall 23% more, *ceteris paribus*, than its long-ladder counterpart while a low capital-intensive industry would contract 19% more than a highly capital-intensive industry. Column 8 shows that the result is robust to allowing for a heterogeneous response across industries with different TFP, and (unreported) results are also robust to allowing for both capital and TFP interactions in the regression. These findings indicate that even industries with similar observable characteristics may exhibit heterogeneous impacts from international trade because of inherent differences in vertical specialization.

The point estimates suggest large impacts, but they are consistent with an argument emphasized by Leamer (2000): even low import volumes can have a significant impact on US firms if international trade equalizes product prices. The results indicate that this argument is particularly salient for short-ladder products. Indeed, the extent to which domestic goods overlap with foreign goods, and the source of the foreign imports, is precisely what determines which industries are vulnerable to competition in the framework here. The magnitude of the employment effects are also consistent with Bernard, Jensen and Schott (2006), whose conservative estimates indicate that a ten percentage point increase in *LWPEN* raises the probability of US plant death by 17%. Moreover, the raw data reveal large correlations between employment outcomes and rising low-wage import penetration. For example, the household slippers industry's quality ladder is about two-thirds of the average and between 1989 and 1996, employment fell more than 50%, while low-wage penetration simultaneously rose 25 percentage points. Import competition therefore can have large impacts on domestic firms in short-ladder industries.

Finally, Table 8 re-runs (23) with industry output as the dependent variable to show that employment outcomes are not simply an artifact of US firms substituting labour with capital. The table shows that the *Ladder* interaction is positive and significant across all specifications (excluding column 6) and the magnitudes are comparable with the employment regressions. For example, using the point estimates in column 1, the impact of low-wage penetration on output growth in a short versus long ladder is 5% more. Thus, the results offer strong evidence that long-ladder industries contract less than short-ladder industries given the same level of low-wage import penetration.

5.1.1. Robustness checks. I perform a number of robustness exercises to check the sensitivity of the results. The first check re-runs the IV specifications using two-digit SIC–year pair fixed effects. This specification controls for sector-specific shocks that may be correlated with the quality ladder, and the results for employment and output are reported in Table 9. The magnitude of the coefficients declines, not surprisingly, yet the interaction coefficients remain statistically significant. Thus, the results are robust to a very flexible specification that uses only within-sector variation to identify heterogeneous effects of import competition across quality ladder lengths.

34. Bernard, Jensen and Schott (2006) also find that instrumenting import penetration causes the magnitude of the coefficients to increase in their employment regressions.

TABLE 8

Output regressions

	Log ($Output_{mt}$)							
	OLS				IV			
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$OTHPEN_{mt}$	−0.508**	−1.050**	−0.485**	−0.487**	−0.430	1.159	0.231	0.321
	0.200	0.497	0.181	0.190	1.980	3.834	0.284	0.857
$LWPEN_{mt}$	−2.008***	−2.243***	−5.483**	−1.978***	−7.941**	−11.054	−16.195***	−6.619**
	0.354	0.404	1.942	0.281	4.016	7.713	3.593	2.603
Log ($IndLadder_m$) × $LWPEN_{mt}$	0.699**	0.783**	0.687*	0.634**	5.687*	8.241	3.671***	4.439**
	0.307	0.308	0.367	0.301	3.227	6.300	1.371	1.971
Log ($IndLadder_m$) × $OTHPEN_{mt}$		0.252				−1.248		
		0.186				2.178		
Log (K/L_m) × $LWPEN_{mt}$			1.160				3.562***	
			0.749				1.379	
Log (TFP_m) × $LWPEN_{mt}$				−2.589***				8.813*
				0.800				4.973
Over-identification p-value	–	–	–	–	0.21	0.18	0.44	0.36
Kleibergen−Paap F-statistic	–	–	–	–	0.61	0.61	18.40	3.52
Industry-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.181	0.185	0.195	0.184	0.006	0.003	0.016	0.015
Observations	2585	2585	2585	2585	2585	2585	2585	2585

Notes: The dependent variable for each regression is the four-digit SIC industry (log) output. The first column regresses output on import penetration from the rest of the world (OTHPEN), low-wage import penetration (LWPEN), and the interaction of LWPEN with the industry quality ladder. Column 2 includes the OTHPEN−ladder interaction. Column 3 includes the interaction of LWPEN with initial industry capital intensity (in 1989) and column 4 includes the interaction of LWPEN with initial industry TFP (in 1989). Columns 5−8 present the IV results. The instruments are weighted average tariff rates, exchange rates, and freight rates for low-wage countries and the rest of the world. Robust standard errors are clustered at the two-digit SIC. Significance levels: ***0.01; **0.05; *0.10.

The next set of robustness checks re-run the baseline specification in (23) using alternative measures of the quality ladder. Each row of Table 10 reports the *LWPEN*−ladder coefficient from the OLS and IV employment regressions. The first sensitivity check addresses the Washington Apples concern that, while transport costs are correlated with c.i.f. prices, they may be correlated with the unobserved portion of quality, $\lambda_{3,cht}$ (see discussion in Section 3.1). The first row of Table 10 addresses this concern by including per-unit tariffs as an additional instrument, and the results on the ladder interaction are robust in both the OLS and IV specifications.

Constructing the quality ladders hinges on the disaggregate detail of US import data. One concern might be that the ladder lengths simply reflect aggregation differences if products in some industries are defined more coarsely than others. Another worry could be that the product-level ladders are just proxies for the number of countries exporting that product code. To ensure that the results are not sensitive to these concerns, rows 2 and 3 re-run the employment regressions using these count definitions of the ladder. The second row defines the product-level ladder as the number of countries (varieties) within the product and then aggregates to the industry level according to (20). Row 3 counts the number of products within the four-digit industry code to construct the industry-level ladder. Both measures represent proxies for potential differences in the coarseness of product definitions across industries. However, the

TABLE 9

Employment and output regressions, SIC_2 –year fixed effects: IV

Regressors	IV–Log (Employment$_m$) (1)	(2)	(3)	IV–Log (Output$_m$) (4)	(5)	(6)
$OTHPEN_{mt}$	−0.720	−0.512	−0.499	−0.066	0.209	0.188
	1.234	0.496	0.675	1.529	0.345	0.699
$LWPEN_{mt}$	−4.398***	−10.558**	−4.531***	−4.486***	−13.000***	−4.471**
	1.344	4.625	1.680	1.307	2.124	1.874
Log ($IndLadder_m$) × $LWPEN_{mt}$	2.706**	2.148**	2.764**	3.275**	2.082**	3.045**
	1.360	0.954	1.357	1.590	1.059	1.204
Log (K/L_m) × $LWPEN_{mt}$		2.121			2.946***	
		1.440			0.890	
Log (TFP_m) × $LWPEN_{mt}$			6.777			6.452
			4.717			4.583
Over-identification p-value	0.36	0.35	0.59	0.281	0.339	0.435
Kleibergen–Paap F-statistic	1.13	2.91	36.40	1.13	2.91	36.4
Industry-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Two-digit SIC × year FEs	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.008	0.018	0.005	0.006	0.000	0.007
Obs.	2585	2585	2585	2585	2585	2585

Notes: The dependent variables for each regression in columns 1–3 and columns 4–6 are the four-digit SIC industry (log) employment and output, respectively. Each regression includes two-digit SIC–year pair fixed effects. The first column regresses employment on import penetration from the rest of the world (OTHPEN), low-wage import penetration (LWPEN), and the interaction of LWPEN with the industry quality ladder. Column 2 includes the interaction of LWPEN with initial industry capital intensity (in 1989) and column 3 includes the interaction of LWPEN with initial industry TFP (in 1989). Columns 4–6 present the IV results. The instruments are weighted average tariff rates, exchange rates, and freight rates for low-wage countries and the rest of the world. Robust standard errors are clustered at the two-digit SIC. Significance levels: ***0.01; **0.05; *0.10.

OLS and IV coefficients are imprecisely measured. This provides evidence that the baseline results are not driven by the coarseness of data.

Empirical studies typically use unit values as proxies for quality. Table 6 demonstrated that, while price dispersion is associated with the quality ladder, the correlation is noisy. This is consistent with evidence that prices may be better proxies for quality only in markets characterized by a high degree of vertical product differentiation. In Row 4 of Table 10, I use this alternative price-based quality ladder to assess the model predictions. The interaction coefficient is positive for both the OLS and IV specifications, which is consistent with the model's predictions, but only the IV result is significant at conventional levels. Row 5 of Table 10 takes the opposite approach and constructs the ladder using within-product market share dispersion. While the OLS coefficient is statistically significant, the IV coefficient, which accounts for potential endogeneity concerns, is very imprecisely estimated. This is not surprising; high quality is not assigned to products simply with high market shares, but rather high market shares conditional on price.

Row 6 defines quality exclusive of the residual from the estimating equation in (15), $\lambda_{cht} = \hat{\lambda}_{1,ch} + \hat{\lambda}_{2,t}$, and then constructs the industry ladder using (18) and (20). This measure addresses potential concerns that the residual term ($\lambda_{3,cht}$) may be capturing factors other than quality. However, the table shows that the results are robust to defining quality without this term.

Row 7 of Table 10 constructs the quality ladder for quality estimates obtained from specification (15) where population is replaced by GDP as the proxy for exporter size. The results are not sensitive to using this alternative proxy either.

TABLE 10

Employment regressions, robustness checks

	Regression method	
LWPEN−ladder interaction	OLS	IV
(1) Quality identified from baseline instruments and tariffs	0.501*	2.755**
	0.271	1.328
(2) Product count	0.000	−0.005
	0.001	0.005
(3) Variety count	−0.440	0.690
	0.348	0.948
(4) Price	1.285	7.436*
	1.227	4.129
(5) Market share	12.664***	21.512
	3.415	21.914
(6) Quality excluding residuals	0.646***	4.571*
	0.217	2.435
(7) GDP−quality ladder	0.992**	5.563***
	0.348	1.986
(8) Broda−Weinstein ladder	−0.910*	−1.591
	0.471	1.141
(9) Exclude MFA products	0.484**	2.711**
	0.232	1.378
(10) Range	0.639**	3.888***
	0.233	1.339
(11) Inter-quartile range	0.650**	5.236**
	0.239	2.667
(12) Standard deviation	0.751**	5.061**
	0.271	2.417

Notes: Table re-runs the employment regression in equation (23) and reports the industry ladder interaction with LWPEN coefficient for alternative definitions of the quality ladder. Row 1 re-estimates equation (15) to include tariffs as additional instruments. Row 2 constructs the ladder from the number of countries (i.e. varieties) within the product and then aggregates to the industry according to equation (20). Row 3 counts the number of products within the four-digit industry code. Rows 4 and 5 construct the ladder from the dispersion of prices and market shares within products, respectively. Row 6 defines the ladder from quality estimates exclusive of the residual: $\lambda_{cht} = \lambda_{1,ch} + \lambda_{2,t}$. Row 7 re-runs equation (15) but uses GDP instead of population to control for hidden varieties. Row 8 constructs the quality ladder from the HS-level elasticities of substitution estimated by Broda and Weinstein (2006). Row 9 excludes HS codes that were subject to quotas under the MFA in the construction of the industry ladders; the HS codes that were subject to quotas are taken from Brambilla, Khandelwal and Schott (2008). The remaining rows use the full-range, inter-quartile range, and standard deviation of qualities within products. Robust standard errors are clustered at the two-digit SIC for each regression. Significance levels: ***0.01; **0.05; *0.10.

The next robustness check uses the dispersion measure constructed from the Broda and Weinstein elasticities. The OLS coefficient in row 8 is significant at the 10% level and has an intuitive sign: industries with higher substitutability experience relatively smaller employment growth. However, the IV coefficient is not statistically significant. The finding that the results are noisy is not surprising given the earlier results that show no systematic relationship between the quality ladders and the Broda and Weinstein elasticities substitution. Moreover, the Broda–Weinstein measure becomes statistically insignificant if I also include the quality ladder interaction, which remains positive and statistically significant. This is further evidence that exposure to low-wage competition is more sensitive to differences in vertical, rather than horizontal, differentiation.

The unit values used in the baseline regressions do not control for non-tariff barriers, such as voluntary export restraints or quotas, because of data limitations. The major non-tariff barriers during this period were quotas imposed on textile and apparel imports under the Multifiber Arrangement (MFA) and its successor, the Agreement on Textile and Clothing (ATC). I therefore re-run the regressions using industry quality ladders that exclude products that were covered by the MFA/ATC. These HS codes are obtained from Brambill, Khandelwal and Schott (2008). Row 9 indicates that the results are not sensitive to excluding products that were subject to import quotas.

Finally, the remaining rows of Table 10 construct quality ladders using alternative measures of dispersion: range, inter-quartile range, and the standard deviation of the estimated qualities. All coefficients in both the OLS and IV regressions are positive and statistically significant. In short, this section shows that the heterogeneous impact of low-wage penetration across industries of varying quality ladders is robust to several critiques and alternative measures of industries' quality ladders.

6. CONCLUSION

This paper develops a procedure to infer the quality of countries' exports to the United States. Rather than restricting the inference to just prices, as is typically the case, I incorporate both price and market share information to construct a measure of quality that accounts for both horizontal and vertical differentiation. While obviously more complicated than simply using prices, the method suggests that the scope for quality differentiation varies substantially across products. Thus, products with large variation in prices could nonetheless possess little differences in quality.

I illustrate the importance of heterogeneity in the scope for quality differentiation by revisiting the impact of trade on US industry outcomes. The model predicts that, if countries are unable to exploit comparative-advantage factors to manufacture vertically superior goods, employment and output in these products are likely to shift to lower cost countries. I find support for this theory by matching the quality ladders to US industry employment outcomes resulting from increased foreign competition. The impact of low-wage import penetration on employment varies inversely with the industry's quality ladder.

In addition to this application, the quality estimates can offer insights into other theories related to international trade, economic development and industrial organization. For instance, Amiti and Khandelwal (2009) use the quality measures to show, consistent with the theory developed by Aghion *et al*. (2009), that the relationship between a country's pattern of quality upgrading and its level of domestic competition depends on the country's distance to the world quality frontier. Chari and Khandelwal (2009) use these quality estimates to provide evidence that quality specialization also plays a role in determining rates of protection across industries (in addition to the well-understood determinants of industry lobbying).

The approach taken in this paper also may be particularly useful in assessing the role of product quality in influencing trade patterns. For instance, a recent paper by Fajgelbaum, Grossman and Helpman (2009) develops a tractable framework for studying trade in horizontally and vertically differentiated products using a nested logit demand system. In their words, "the close affinity between our analytical framework and the empirical literature on discrete-choice demands makes the model ripe for empirical application". This remains to be done in future work.

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