Trade Liberalization and Quality Upgrading:
Evidence from the U.S. Consumer Expenditure Data

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Abstract: This paper studies the effect of trade liberalization on product quality estimated using household-level data from 1988-2003 U.S. Consumer Expenditure Survey. It finds that trade liberalization with developing countries decreases the product quality consumed in the U.S. in the beginning of the period, but quality upgrading of these countries' exports weakens the effect later. Furthermore, this paper provides indirect evidence that increased foreign direct investment flows into developing countries facilitate the quality upgrading of these countries' exports by reducing the technology gap in producing quality.

JEL Classification: F1

Keywords: quality differentiation, quality upgrading, trade liberalization

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1. Introduction

A growing body of theoretical[1] and empirical literature examines how product quality differentiation determines trade patterns. The evidence suggests that quality product differentiation is important in international trade and economic development. Empirical studies showed that countries with higher per-capita income export goods with higher unit values in higher quantities (Schott – 2003, Hummels and Klenow – 2005). Also, richer countries import more from other countries that produce high-quality goods (Hallak – 2006). Moreover, countries with more similar income distributions have more similar distribution of imported product quality (Choi, et al. - 2009). These empirical studies have focused on the role of quality differentiation in determining trade patterns with little emphasis on how trade liberalization affects the product quality over time.

In this paper, I investigate the impact of United States (U.S.) trade policy on product quality from 1989 to 2002. To do so, the paper estimates product quality for 66 consumer durable goods by employing Bils and Klenow (2001)'s methodology. Next, it provides indirect evidence that developing countries upgrade the quality of their exports to the American market. Further, the paper explores whether the developing countries upgrade the quality of their exports by innovating or by utilizing better foreign technology and/or inputs.

[1] The seminal paper of Flam and Helpman (1987) is representative for the theoretical literature on product quality differentiation.

Examining how product quality responds to changes in the trading environment has important welfare implications. It contributes to our better understanding of the welfare consequences of greater economic integration. Furthermore, quality upgrading of developing countries' exports may have a negative effect on employment and wages in developed countries because of intensified low-wage competition (Verhoogen – 2008, Khandelwal – 2009).

To examine how product quality evolves over time, unit export prices alone are unsatisfactory because they can vary for reasons other than quality. Thus, it is crucial to obtain product quality estimates using the publicly available data. Recently, Hallak and Schott (2010) estimated exporter and year-specific quality for the manufacturing sector. Their method relies on both unit export values and quantities: two exporters with the same export unit values but higher quantities must have different levels of quality.

However, the unit values of the aggregate sector could hide considerable price heterogeneity. Within an importer country, households prefer and buy different levels of quality. Bils and Klenow (2001) utilized 1980-1996 U.S. survey data on consumer durable goods purchases and found that there is a positive relationship between household income and unit prices (i.e. Quality Engel Curves have positive slopes). This paper employs their methodology to estimate the yearly quality Engel slopes for 66 consumer durable goods using U.S. Consumer Expenditure Surveys (CEX) from 1988 to 2003. The estimated slopes are positive

and significant; suggesting that, holding quantity equal to unity, richer American households buy more expensive goods, which must be of higher quality. Also, the Quality Engel slopes vary considerably across products and time.

Could trade liberalization explain the variation in product quality consumed in the U.S.? To guide the empirical work to answer the question, this paper incorporates Bils and Klenow (2001)'s preference structure in the model of quality differentiation with multiple goods and two countries developed by Choi, et al. (2009)[2]. In the model, the country with more advanced technology of producing quality (i.e. North) specializes in high-quality goods and imports low-quality goods from the country with less advanced technology (i.e South). Trade liberalization in the North has a composition effect on the mix of product quality consumed[3] (some higher-quality Northern varieties are replaced by lower-quality imported varieties). As a consequence, the share of low-quality products consumed in total consumption increases, and the average quality consumed decreases. However, if trade liberalization in the North is followed by a reduction in the technology gap between North and South, then the average quality consumed in the North falls by less or can even increase because all imported varieties have upgraded quality.

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[2] The model builds on the quality differentiation model from the seminal paper of Flam and Helpman (1987).

[3] This prediction is consistent with Fajgelbaum, et al. (2009) who develop a richer model of quality differentiation by allowing consumers to have both heterogeneous incomes as well as tastes.

To examine these predictions, this paper employs 1989-2002 "U.S. Imports of Merchandise" to obtain tariff rates for the 10-digit Harmonized System (HS) products and match them to the CEX durable goods. Furthermore, it draws data on per-capita GDP, foreign direct investment, and patents filed by residents in developing countries from World Bank World Development Indicators (1989-2002) to provide indirect evidence on the potential channel of quality upgrading.

The findings are consistent with the model. Trade liberalization decreases the average quality consumed in the U.S. absent a reduction in the technology gap. But, as developing countries move up the quality ladder, trade liberalization has the opposite effect. Also, the paper provides indirect evidence that the reduction in the technology gap takes place through technology transfer facilitated by the increasing foreign direct investment in these developing countries during the 1990s rather than by increasing their own innovation.

This paper relates, and contributes to two lines of research. First, it complements a growing literature examining how product quality changes over time. Hallak and Schott (2010) estimate the quality of manufacturing for top world exporters, and they find a strong quality convergence across exporter countries. Compared to their paper, this work finds evidence for quality upgrading for more disaggregated consumer goods, and it also explores the potential channel through which developing countries are catching up in terms of their technology of producing quality. Verhoohen (2008) also finds evidence for

quality upgrading in Mexico following an exchange rate shock but his primary interest lies in examining the effect on wage inequality.

Second, the paper also relates to another line of research interested in the effect of import quotas (Boorstein and Feenstra – 1987, Feenstra – 1988) and per-unit transport costs (Hummels and Skiba – 2004) on the quality composition of trade. These studies find that import quotas and higher per-unit transport costs increase import quality.

The paper proceeds as follows. The next section introduces the theoretical model and its predictions to guide the empirical analysis. Section 3 discusses the data, empirical strategy, and results. Section 4 concludes.

2. The Model

The purpose of the model in this section is to guide empirical work and to link changes in trade policy to changes in product quality. There are multiple vertical differentiated goods and one homogeneous numeraire good. Let k=1,2,...K index the vertical differentiated goods. There are two countries, North and South.

A consumer in both countries chooses quantities of the numeraire good, y, and the desired quality z_k of a single unit of the differentiated good in order to maximize[4]:

$$(1) \quad U(y,z) = \frac{y^{1-\alpha}}{1-\alpha} + \sum_{k=1}^{K} \frac{z_k^{1-\alpha_k} - 1}{1-\alpha_k}$$

where $\alpha \in (0,1)$ represents the elasticity of utility with respect to quantity of the numeraire good - y; and $\alpha_k \in (0,1)$ represents the elasticity of utility with respect to quality of differentiated good k. The smaller is α_k, the faster utility increases with the quality of good k consumed.

The vertical differentiated goods are produced with marginal costs:

$$(2) \quad MC_k(z_k) = w z_k^{1+\gamma_K},$$

where w represents the cost that is common to all quality levels and $1+\gamma_k$ is the elasticity of marginal cost with respect to quality level produced and $\gamma_k > 0$. Without loss of generality, (2) assumes a log-linear relationship between marginal costs and z_k. Also γ_k represents the sophistication of the technology employed in producing z_k. The higher is γ_k, the faster marginal costs increases with producing the vertical differentiated good. In other words, lower values of γ_k indicate technology improvement.

[4] The utility function is similar to the function adopted in Bils and Klenow (2001).

Under the assumption of perfectly competitive markets at each quality level and costly trade, the consumers face the following vector of prices for each quality level:

(3) $p(z_k) = \tau_k MC(z_k)$,

where $\tau_k > 1$ is the ad-valorem trade cost if good k is imported and $\tau_k = 1$ if good k is domestically produced. Since the consumer buys only one unit of the differentiated good, the expenditure on good k equals the price of good k.

2.1. Identical Technologies and Costless Trade

First, consider that technology is identical in both North and South, i.e. the marginal cost in (2) is the same for all countries. The consumer with income I maximizes the utility in (1) subject to the following budget constraint:

$$y + \sum_{k=1}^{K} p_k(z_k) \leq I .$$

The optimal quality of good k is increasing on consumer's expenditures on the numeraire good and decreasing in the wage level:

(4) $$\log z_k = \frac{\alpha}{\alpha_k + \gamma_k} \log y - \frac{1}{\alpha_k + \gamma_k} \log w - \frac{1}{\alpha_k + \gamma_k} \log(1 + \gamma_k)$$

The above expression shows that, conditional on buying good k, the richer consumer (i.e. higher y) will choose a higher-quality variety. The elasticity of quality with respect to non-durables expenditures is increasing in the taste for

quality of good k (lower α_k) and the level of technology employed to produce good k (lower γ_k).

Plugging equation (4) into (3) under the assumption of costless trade, we get:

(5) $\log p_k(z_k) = \frac{\alpha(1+\gamma_k)}{\alpha_k+\gamma_k}\log y - \frac{1-\alpha_k}{\alpha_k+\gamma_k}\log w - \frac{1+\gamma_k}{\alpha_k+\gamma_k}\log(1+\gamma_k)$

Equation (5) is a log-linear relationship between the price of good k and the expenditure on the numeraire good, y. The slope of the "quality Engel curves"[5], $\frac{\alpha(1+\gamma_k)}{\alpha_k+\gamma_k}$, is decreasing in γ_k.

2.2. Different Technologies and Costly Trade

Now I allow different technologies to produce the vertical-differentiated products k across countries:

(6) $MC_k^i(z_k) = w^i z_k^{1+\gamma_k^i}$, i=N,S

where $w^N > w^S$, the marginal cost of producing all quality levels is higher in the North than in the South (due to factor prices or Ricardian technology differences); $\gamma_k^N < \gamma_k^S$, indicates the degree to which a country has comparative advantage in producing high or low qualities.

[5] The overall Engel curve is the product of the quality Engel curve and the quantity Engel curve. In the model, for the sake of simplicity, the quantity of each vertical-differentiated good consumed equals one and the overall Engel curve coincides with the quality Engel curve.

The supply price of quality z in the North is:

$p(z_k) = \min\left[w^S \tau_k z_k^{1+\gamma_k^S}, w^N z_k^{1+\gamma_k^N} \right]$. Given the structure of comparative advantage, the South specializes in low-quality goods and the North specializes in high-quality goods and there is a break-even quality $\bar{z}$ such that $w^S \tau_k \bar{z}_k^{-1+\gamma_k^S} = w^N \bar{z}_k^{-1+\gamma_k^N}$:

$$(7)\quad \log \bar{z}_k = \frac{1}{\gamma_k^S - \gamma_k^N} \log\left(\frac{w^N}{w^S \tau_k} \right).$$

The break-even quality is decreasing in trade costs at a rate that depends on the technological gap between North and South. As the technology gap narrows, the effect of trade liberalization on the break-even quality becomes stronger.

With this pattern of specialization, North imports low-quality goods produced with Southern technology and consumes high-quality goods produced with Northern technology. The relationship between the expenditure on good k and y becomes a two-segment log-linear relationship. Since the slope $\frac{\alpha(1+\gamma_k)}{\alpha_k + \gamma_k}$ decreases in γ_k, the second segment is steeper than the first segment.

The share of imports in total consumption of vertical-differentiated goods is decreasing in trade costs and in the technological gap between North and South. The average quality of goods consumed depends on the share of imports in total consumption of vertical-differentiated goods, but also on the quality of the imports. Thus, ceteris paribus, lower trade costs decrease the average quality of the goods consumed in the North because the share of imported lower-quality

goods increases (i.e. composition effect). Improvements in Southern technology, ceteris paribus, increase the share of imports and the quality of the imported goods but it will have an ambiguous effect on the average quality of goods consumed in the North (i.e. all goods imported from the South will have a higher quality but the Northern consumer will substitute some imported quality levels for goods produced with Northern technology). When trade liberalization is followed by a reduction in the technology gap, the quality upgrading in the South weakens the negative effect of trade liberalization on the average quality of products consumed in the North.

3. Empirics

To examine how trade liberalization affects the quality of the goods consumed in the U.S., the paper, first, employs Bils and Klenow (2001)'s methodology to estimate the "quality Engel curves" for each good and year in the sample. This paper focuses on a different time period (i.e. 1989-2002) than Bils and Klenow (2001) [6]. I choose this time period for two reasons. First, this time period was characterized by rapid economic integration of developing countries in the world economy through trade but also through foreign direct investment. Second, detailed U.S. tariff rates are only available starting from

[6] As a check, table 2 also reports the quality Engel slopes corresponding to Bils and Klenow (2001)'s time period 1980-1996. The slopes are very similar.

1989. In the second stage, this paper relates the changes in product quality estimates to changes in trade policy.

3.1 Data

To estimate the "quality Engel curves" for 66 consumer durable goods[7], the empirics employ 1988-2003 U.S. Consumer Expenditure Surveys (CEX). The CEX has a rotating sample of about 5,000 households for each year consisting of four quarterly surveys. The surveys contain information on expenditures on unit purchases for each of the 66 durable goods consumed in the U.S[8].

In the second stage, this paper employs U.S. trade data from the 1989-2002 "U.S. Imports of Merchandise" CD-ROM, published by the U.S. Bureau of the Census, to investigate how trade liberalization affects the quality of goods consumed in the U.S.. The trade dataset contains U.S. imports collected from electronically submitted Customs forms, covering an average of 223 exporters and commodity detail at 10-digit level HS classification. The data includes country of origin, value, quantity, freight and duties paid. I match the 66 durable goods from CEX data with 10-digit level HS categories based on their description. For some goods, there is not a one-to-one mapping and, in these cases, I combine the CEX goods such that they correspond to the 10-digit HS categories. For each good of the remaining 63 durable goods, I calculate simple average ad-valorem

[7] The definition of durable goods in this paper as well as in Bils and Klenow (2001) is different than that in National Income and Product Account, in that it includes textiles, apparel, and footwear.

[8] These goods constitute over 80 percent of U.S. spending on consumer durables.

tariff rate[9] across all exporter – 10-digit HS categories available.

This section also draws per-capita GDP from World Bank World Development Indicators (WDI) to group exporters into three cohorts following Schott (2003): low-income countries have their per-capita GDP below the 30th percentile of the world income distribution, middle-income countries have their per-capita GDP within the 30th percentile and 70th percentile, and high-income countries have their per-capita GDP above the 70th percentile of the world distribution. Furthermore, to investigate the potential channel of quality upgrading, this paper employs data on foreign direct investment and patents filed by residents also from World Bank WDI

3.2. Quality Engel Slope Estimation – first stage

The first stage implements a methodology developed by Bils and Klenow (2001). Their paper identified and estimated quality Engel curves making use of household-level data on purchases of durable goods. For each year t and each good k, this paper estimates a separate quality Engel curve. The identification of a good's quality relies on how the unit price of a good is related to the household's total nondurable consumption. Since the CEX data does not distinguish between goods domestically produced and imports, the quality

[9] For each 10-digit HS in the sample, the ad-valorem tariff rate=1+ duties/value of trade.

estimate represents the average quality of the mix of goods consumed in the U.S. in a given year.

The starting point for the empirical specification is equation (5). Including a measurement error and ignoring the variables that do not vary across households (i.e. production costs common to all quality levels):

(8) $\log p_{hkt} = \alpha + \theta_{kt} \log y_{ht} + \beta_{kt} \log H_{ht} + \varepsilon_{hkt}$,

where p_{hkt} and y_{ht} denote a household h reported unit price of good k in period t and non-durable consumption in period t, respectively. Following Bils and Klenow (2001), in addition to household's non-durable consumptions indicated by the model, this paper includes dummies for region and city (versus rural) to control for price differences across space. Also, it includes other household-specific variables H_{ht} to capture heterogeneity across household in their preferences. These household characteristics are: the number of persons and the number of children in the household, the average age of the household head and that age squared, and dummy variables for single male-headed households and for single female-headed households[10].

Similar to Bils and Klenow (2001), this section estimates the goods' quality by two-stage least squares, where y_{ht} represents the household's

[10] The model described in section 2 assumes similar tastes across households for each product. However, this could be an oversimplified assumption and I attempt to correct for the potential heterogeneity in households' tastes by incorporating some household characteristics.

nondurable expenditures in the last two quarters, then instrument for this expenditures using the household's nondurable expenditures in the first two quarters[11]. For each good in the sample, the regressions are estimated with three years of combined data, and they include year dummies. For example, the 1989 quality Engel curves would be based on data from 1988, 1989, and 1990. In doing so, the estimation smoothes out the coefficients and each good's quality is the average quality for the three years and it is centered in the year for which the results are presented[12].

Table 1 provides summary statistics for all the estimated quality Engel slopes for each product. Most products have coefficients positive and statistically significant at 10% level or better. The steepest average quality Engel slopes are for curtain and drapes, jewelry, window coverings, and rugs. For these products, a 1-percent increase in the nondurable spending increase the price by almost 1-percent. Clothes washers, clothes dryers, microwave ovens, sewing machines, and vacuums have the flattest average quality Engel slopes. These estimates are consistent with Bils and Klenow (2001)'s findings. The model in section 2 assumes away horizontal product differentiation where higher prices reflect higher

[11] As discussed in Bils and Klenow (2001), there might be concerns of measurement error in a household's response for non-durable consumption that might bias estimates toward zero. To correct this problem, they estimate the slopes by running two stage least squares.

[12] The number of households buying a good varies significantly across years. Using three years of data, there are a larger number of households in the sample to identify the yearly quality Engel slope for each product.

mark-ups instead of higher quality. However, the estimated quality slopes are valid even in the presence of horizontal differentiated products as long as the markups are not correlated with households' consumption on non-durables[13].

A number of goods had too few households buying in a given year and their quality Engel slopes are insignificant at 10% and some have negative and insignificant slopes. These goods with insignificant estimated slopes at 10% level are: baby furniture and equipment (1994), clothes dryers (1993-1998), clothes washers (1992-1994, 1996, 1997) hard flooring (1989, 1993-1995,1998), microwave ovens (1989, 1990, 1992-1994), musical equipment (1994), playground equipment (1991, 1995, 1998-2000, 2002), sewing machines (1989-1995, 1997), typewriters (1994-1999), vacuums (1989-1993), and window air conditioners (1991-2002). Taking these goods with negative quality slopes out (i.e. clothes dryers, clothes washers, microwave ovens, sewing machines, typewriters, window air conditioners and vacuums) leaves 55 goods in the sample employed in the second stage.

The remaining goods have varying degree of variation over the period 1989-2002[14]. Baby furniture and equipment, camping equipment, musical equipment, and color televisions have the highest degree of variation while apparel and accessories have the lowest. Also, there is a great deal of variation in the estimated slopes across the goods in the sample.

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[13] Goldberg(1996) does not find evidence for correlation between the price of cars and a household's income.

[14] Figure 1 presents trends in product quality for selected products.

3.3. Second stage: Explaining the trends in product-quality

The second stage investigates whether trade liberalization can explain the variation across goods and years in product quality. As discussed in section 2, trade liberalization with developing countries decreases the quality consumed in the U.S. if the technology gap between the U.S. and these exporters remains unchanged. However, if in the same time the technology gap narrows, then trade liberalization will have a weaker negative or even a positive effect on the average quality consumed in the U.S.

During the 1990s, average tariffs on goods in the sample (except for trucks and women's sweaters and vests) were declining with the highest average yearly negative growth rate being after 1995. The decline rates vary a lot across goods with some goods experiencing full trade liberalization between 1995 and 2002 while others such as textiles and apparel have experienced very little change in tariff rates. A majority of the goods, that had the average tariff cut to zero during the period, also experience a great deal of variation in the estimated quality slopes, in contrast with textile and apparel, that have the lowest degree of variation in the slopes. Table 3 provides more detail on the changes of U.S. trade policy over the period.

To explore the effects of trade liberalization on the quality of goods consumed in the U.S., this paper estimates the following specification:

(9) $\log \widehat{\theta_{kt}} = \alpha_k + \beta_1 pGDP_t + \beta_2 X_t + \beta_3 \log \tau_{kt} + \beta_4 \log \tau_{kt} * X_t + \varepsilon_{kt}$,

where $\widehat{\theta_{kt}}$ denote the estimated quality Engel slopes for good k in year t, τ_{kt} denotes the simple average ad-valorem tariff rate for good k in year t, and X_t is a dummy which takes values of 0 before 1995 and 1 after 1995 [15] or the log of FDI flows into Low- and Middle-Income countries and/or the log of patents filed by residents in Low- and Middle-Income countries. Recall that, in the model, θ_k depends on the quality preference parameters (α_k,α) and the technology parameter (γ_k). Equation (9) includes product fixed effects to control for the varying consumers' quality preference across goods but constant over time, and U.S. per-capita GDP to partially control for year-specific factors common to all goods. Also, by controlling for product fixed effects and year-specific factors, the estimates provide indirect evidence on how the technology of producing quality varies over time.

To correct for heteroskedasticity across goods, this paper estimates equation (9) by running weighted least squares, where the weights are the inverse of the estimated standard errors. According to the model in section 2, if the technology gap between North and South remains unchanged overtime then β_3 is positive and β_4 is insignificantly different from zero. However, if the technology

[15] Eyeballing the trends, there was a clear break in the product quality trends for many products around 1995.

gap decreases, β_4 is negative, lowering the effects of trade liberalization on the average quality consumed in U.S..

Table 4 presents the regressions results for the specifications with the 1995 dummy. The relative tariff is the ratio of the simple average ad-valorem tariff rates on products originating from low- and middle-income countries to simple average ad-valorem tariff rates on products originating from high-income countries. In the first column of table 4, I regress log of estimated product quality on log of relative tariff. Controlling for product fixed effects, the relative tariff has a positive but statistically insignificant effect on quality. The reason why the relative tariff could be statistically insignificant could be due to omitted variable bias such as changes in exporters' product quality over the period. In column (3), I include an interaction term between the log of relative tariff and 1995 dummy to investigate whether the effect of relative tariff changes during the period. As expected, both the log of relative tariff and the interaction term are statistically significant. Before 1995, 1- percent decrease in relative tariff rate decreases quality by 0.97%. However, after 1995, the effect is the opposite: 1-percent decrease in relative tariff increases quality by 0.93%. This could indicate that developing countries are upgrading their technology of producing quality. However, the 1995 dummy may be picking other factors that change over time unrelated to changes in developing countries' technology.

Thus, instead of including the 1995 dummy, I introduce the log of the FDI into developing countries in an attempt to identify how developing countries upgrade the quality of their exports. In column (3) of table 5, controlling for product fixed effects, the main effect of the relative tariff is positive and the interaction term is negative. This indicates, that tariff liberalization with developing countries decreases the product quality but the effect is weakened by an increase in FDI inflows. The FDI flows could facilitate a technology transfer improving the quality of developing countries' exports. Based on the estimates, and using the values of FDI in 1989, 1995 and 2002, 1-percent decrease in relative tariff lowers quality by 1.08% in 1989, but increases quality by 0.55% in 1995, and by 0.83% in 2002.

Do developing countries upgrade their exports' quality by innovating or by using better foreign technology and/or inputs? To investigate this question, table 6, column (2) introduces log of patents filed by residents in low- and middle-income countries as a proxy for the extent of innovation happening in these countries. Controlling for product fixed effects, the main effect of the relative tariff is positive and the interaction term is negative. This indicates, that tariff liberalization with developing countries decreases the product quality but the effect is weakened by an increase in the number of patents filed by residents in these countries. However, if the regression incorporates both FDI flows and patents data to disentangle the channel of quality upgrading, the effect of patents

on the elasticity of product quality with respect to relative tariff is statistically insignificant while the effect of FDI remains significant. This indicates that developing countries upgrade their quality by utilizing foreign technology acquired through FDI, a potential channel of technology transfer, rather than domestic innovation.

Overall the empirical results are consistent with the theoretical predictions in section 2. That is, tariff liberalization with developing countries reduces the quality consumed in the U.S., but the effect is reversed as developing countries move up the quality ladder. The potential channel of quality upgrading is by acquiring better technology through inflows of foreign direct investment into these countries.

4. Conclusion

This paper estimates the yearly quality Engel slopes for durable goods using 1989-2002 U.S. Consumer Expenditure data relying on a methodology developed by Bils and Klenow (2001). Guided by theoretical predictions, the empirics examine the effects of trade liberalization on U.S. estimated quality. The findings support the theory: trade liberalization with developing countries decrease quality, however, the effect is weakened by developing countries' acquiring better technology and upgrading the quality of their exports. Moreover,

the rapid quality upgrading is facilitated by an increase in inflows of foreign direct investment in these countries.

These effects have important welfare implications. Absent quality upgrading, trade liberalization with developing countries benefits disproportionately lower-income households who consume low-quality goods. The rapid quality upgrading of developing countries' exports could benefit all households but with negative effects for employment and output in some industries since foreign competition is intensified.

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Table 1: Yearly Quality Engel Slope Estimates – Summary Statistics

Good	Mean	St. Dev.	Min	Max
Baby furniture and equipment	0.42	0.15	0.21	0.61
Bedroom furniture	0.65	0.14	0.39	0.82
Bicycles	0.50	0.08	0.32	0.60
Calculators	0.56	0.15	0.39	0.89
Camping equipment	0.47	0.12	0.29	0.64
Carpeting	0.69	0.21	0.34	1.01
Cars	0.68	0.10	0.47	0.83
Clocks	0.75	0.13	0.50	0.97
Clothes dryers	0.19	0.14	-0.05	0.40
Clothes washers	0.21	0.13	-0.05	0.37
Color Televisions	0.35	0.10	0.20	0.52
Curtains and drapes	1.20	0.14	0.94	1.36
Eyeglasses and contacts	0.29	0.05	0.22	0.38
Fishing and hunting equipment	0.62	0.07	0.50	0.74
Footwear	0.57	0.03	0.52	0.61
Hand tools	0.61	0.08	0.50	0.75
Hard flooring	0.68	0.30	0.17	1.10
Heaters	0.35	0.06	0.25	0.48
Jewelry	1.07	0.09	0.93	1.21
Kitchen/dining room furniture	0.79	0.13	0.50	0.94
Lamps and lights	0.78	0.08	0.65	0.90
Lawn and garden equipment	0.39	0.12	0.21	0.61
Living room furniture	0.64	0.07	0.55	0.76
Luggage	0.76	0.05	0.66	0.85
Mattress and springs	0.55	0.10	0.43	0.69
Men's and boys' coats and sportcoats	0.53	0.07	0.43	0.68
Men's and boys' sleepwear	0.34	0.07	0.25	0.45
Men's and boys' sweaters	0.50	0.06	0.40	0.57
Men's pants	0.47	0.05	0.39	0.53
Men's suits	0.67	0.04	0.56	0.73
Microwave ovens	0.23	0.17	-0.02	0.44
Musical equipment	0.47	0.13	0.22	0.74
Office furniture	0.67	0.16	0.46	0.95
Outdoor furniture	0.85	0.10	0.72	1.03
Personal care appliances	0.40	0.05	0.31	0.48
Photographic equipment	0.72	0.13	0.51	0.88
Playground equipment	0.64	0.30	0.29	1.22
Power tools	0.36	0.09	0.22	0.50
Radios	0.35	0.14	0.14	0.61
Refrigerators and freezers	0.37	0.08	0.27	0.50
Rugs	0.92	0.11	0.74	1.08
Sewing machines	0.24	0.35	-0.22	0.73
Small kitchen appliances	0.43	0.04	0.35	0.48
Sofas	0.63	0.07	0.46	0.71
Sports and exercise equipment	0.58	0.08	0.46	0.70
Stereos	0.42	0.10	0.25	0.61

Table 1: Yearly Quality Engel Slope Estimates – Summary Statistics

Good	Mean	St. Dev.	Min	Max
Stove and ovens	0.41	0.11	0.28	0.67
Telephones	0.54	0.10	0.45	0.79
Tires	0.36	0.03	0.30	0.41
Trucks	0.64	0.20	0.31	0.89
Typewriters	0.43	0.28	0.00	0.97
Vacuums	0.23	0.11	0.07	0.39
Watches	0.69	0.08	0.59	0.85
Window air conditioners	0.18	0.14	-0.11	0.52
Window coverings	0.98	0.10	0.75	1.13
Winter/water sports equipment	0.84	0.22	0.44	1.12
Women's and girls' active sportswear	0.48	0.03	0.42	0.53
Women's and girls' coats	0.45	0.04	0.37	0.51
Women's and girls' dresses	0.55	0.04	0.50	0.64
Women's skirts and pants	0.49	0.03	0.44	0.52
Women's sleepwear	0.43	0.04	0.34	0.52
Women's suits	0.65	0.04	0.57	0.70
Women's sweaters and vests	0.53	0.02	0.48	0.57

Note: Estimation of equation (8)

Table 2: Quality Engel Slope (Comparison to Bils and Klenow – 2001's estimates)

Good	Quality (1980-2003)			Quality 1980-1996			Bills-Klenow Quality		
	Est.	*S.e.*	*#HHD*	*Est.*	*S.e.*	*#HHD*	*Est.*	*S.e.*	*#HHD*
Baby furniture and equipment	0.41	(0.04)	7,371	0.37	(0.05)	5,219	0.46	(0.04)	4,915
Bedroom furniture	0.59	(0.04)	8,755	0.54	(0.05)	5,857	0.70	(0.05)	6,649
Bicycles	0.46	(0.04)	6,919	0.43	(0.05)	4,784	0.43	(0.05)	5,401
Boys' and girls' footwear	0.45	(0.01)	33,577	0.48	(0.01)	22,729	0.50	(0.01)	20,525
Boys' coats, suits, and sport coats	0.35	(0.02)	14,049	0.37	(0.03)	9,606	0.48	(0.02)	9,124
Calculators	0.46	(0.05)	5,525	0.39	(0.06)	4,114	0.35	(0.04)	4,625
Camping equipment	0.49	(0.06)	4,227	0.48	(0.07)	2,828	0.50	(0.06)	3,237
Carpeting	0.72	(0.07)	5,345	0.78	(0.08)	4,115	0.75	(0.08)	4,835
Cars	0.67	(0.03)	17,140	0.69	(0.04)	11,969	0.94	(0.03)	13,483
Clocks	0.68	(0.04)	6,468	0.68	(0.05)	4,548	0.74	(0.04)	5,218
Clothes dryers	0.19	(0.04)	3,226	0.18	(0.05)	1,962	0.32	(0.05)	2,235
Clothes washers	0.21	(0.03)	4,329	0.18	(0.04)	2,766	0.28	(0.04)	3,205
Color Televisions	0.3	(0.02)	12,795	0.27	(0.03)	8,110	0.41	(0.03)	10,346
Curtains and drapes	1.14	(0.04)	11,230	1.14	(0.05)	8,163	0.93	(0.04)	9,251
Eyeglasses and contacts	0.28	(0.02)	25,916	0.26	(0.02)	16,619	0.27	(0.02)	18,901
Fishing and hunting equipment	0.63	(0.04)	8,232	0.65	(0.05)	5,875	0.66	(0.04)	6,903
Hand tools	0.61	(0.03)	12,623	0.63	(0.04)	9,009	0.55	(0.03)	10,298
Hard flooring	0.65	(0.12)	1,728	0.49	(0.14)	984	0.64	(0.15)	1,088
Heaters	0.33	(0.03)	7,895	0.34	(0.04)	5,679	0.41	(0.03)	6,530
Jewelry	1.11	(0.02)	31,659	1.16	(0.03)	22,135	1.13	(0.02)	25,439
Kitchen/dining room furniture	0.73	(0.05)	6,551	0.7	(0.06)	4,478	0.84	(0.06)	5,131
Lamps and lights	0.76	(0.03)	11,445	0.81	(0.04)	7,667	0.81	(0.04)	8,695
Lawn and garden equipment	0.36	(0.04)	11,061	0.35	(0.05)	7,171	0.25	(0.05)	8,112
Living room furniture	0.57	(0.03)	13,957	0.56	(0.04)	9,366	0.75	(0.04)	8,731
Luggage	0.73	(0.03)	8,553	0.73	(0.04)	5,827	0.90	(0.04)	6,614
Mattress and springs	0.53	(0.04)	7,890	0.52	(0.04)	5,240	0.62	(0.04)	5,911
Men's and boys' sleepwear	0.38	(0.02)	13,651	0.41	(0.02)	9,248	0.37	(0.02)	9,592
Men's and boys' sweaters	0.5	(0.01)	25,981	0.52	(0.02)	18,143	0.46	(0.01)	18,378
Men's coats and sportcoats	0.6	(0.02)	24,168	0.63	(0.02)	16,392	0.61	(0.02)	18,837
Men's footwear	0.52	(0.01)	38,801	0.53	(0.01)	26,409	0.52	(0.01)	30,682
Men's pants	0.47	(0.01)	45,980	0.5	(0.01)	29,838	0.45	(0.01)	34,812
Men's suits	0.66	(0.03)	10,229	0.65	(0.03)	7,537	0.68	(0.02)	8,663
Microwave ovens	0.23	(0.03)	5,037	0.11	(0.03)	3,201	0.16	(0.03)	3,567
Musical equipment	0.46	(0.07)	6,072	0.46	(0.09)	4,163	0.37	(0.07)	4,814
Office furniture	0.63	(0.06)	3,877	0.72	(0.08)	2,070	0.71	(0.07)	2,311
Outdoor furniture	0.86	(0.05)	7,435	0.85	(0.06)	5,095	0.93	(0.05)	5,731
Personal care appliances	0.37	(0.02)	13,228	0.36	(0.03)	9,146	0.34	(0.02)	10,389
Photographic equipment	0.71	(0.04)	8,990	0.63	(0.05)	5,904	0.65	(0.04)	6,665
Playground equipment	0.52	(0.12)	1,694	0.56	(0.15)	1,118	0.68	(0.13)	1,263
Power tools	0.35	(0.04)	8,636	0.34	(0.05)	5,526	0.26	(0.04)	6,247
Radios	0.37	(0.03)	9,371	0.38	(0.03)	7,222	0.37	(0.03)	8,224
Refrigerators and freezers	0.37	(0.04)	6,100	0.4	(0.05)	3,775	0.46	(0.04)	4,365
Rugs	0.91	(0.05)	8,492	0.92	(0.06)	5,090	1.07	(0.05)	5,757
Sewing machines	0.33	(0.10)	1,511	0.18	(0.12)	1,037	0.19	(0.10)	1,202
Small kitchen appliances	0.41	(0.01)	26,960	0.39	(0.02)	17,817	0.39	(0.02)	20,270

Table 2: Quality Engel Slope (Comparison to Bils and Klenow – 2001's estimates)

Good	Quality (1980-2003)			Quality (1980-1996)			Bils-Klenow Quality		
	Est.	*S.e.*	*#HHD*	*Est.*	*S.e.*	*#HHD*	*Est.*	*S.e.*	*#HHD*
Sofas	0.61	(0.04)	7,227	0.63	(0.05)	4,622	0.76	(0.04)	5,347
Sports and exercise equipment	0.58	(0.03)	21,512	0.6	(0.03)	14,808	0.59	(0.03)	16,989
Stereos	0.45	(0.04)	4,037	0.45	(0.05)	3,321	0.34	(0.04)	4,953
Stove and ovens	0.4	(0.05)	3,700	0.41	(0.06)	2,229	0.41	(0.06)	2,563
Telephones	0.55	(0.02)	14,938	0.61	(0.04)	8,679	0.59	(0.03)	9,379
Tires	0.37	(0.01)	32,524	0.38	(0.02)	22,085	0.42	(0.02)	25,597
Trucks	0.57	(0.05)	7,258	0.71	(0.07)	3,914	0.93	(0.06)	4,489
Typewriters	0.49	(0.09)	1,952	0.51	(0.11)	1,438	0.57	(0.09)	1,610
Vacuums	0.25	(0.04)	7,010	0.23	(0.05)	4,528	0.24	(0.04)	5,045
Watches	0.68	(0.02)	21,870	0.68	(0.03)	15,367	0.68	(0.02)	17,489
Window air conditioners	0.12	(0.06)	1,951	0.11	(0.08)	1,231	0.26	(0.08)	1,435
Window coverings	0.99	(0.05)	6,967	0.98	(0.06)	4,742	1.11	(0.06)	5,256
Winter/water sports equipment	0.84	(0.07)	3,929	0.94	(0.09)	2,203	0.81	(0.05)	6,523
Women's & girls' active sport wear	0.48	(0.01)	31,409	0.47	(0.02)	22,324	0.47	(0.01)	21,695
Women's and girls' coats	0.46	(0.01)	36,642	0.48	(0.02)	24,680	0.57	(0.01)	27,068
Women's and girls' dresses	0.58	(0.01)	51,894	0.6	(0.01)	35,622	0.67	(0.01)	34,502
Women's footwear	0.62	(0.01)	52,362	0.63	(0.01)	35,553	0.62	(0.01)	41,274
Women's skirts and pants	0.49	(0.01)	51,579	0.51	(0.01)	33,191	0.52	(0.01)	38,565
Women's sleepwear	0.43	(0.01)	28,551	0.46	(0.02)	19,792	0.44	(0.01)	22,475
Women's suits	0.63	(0.02)	15,117	0.65	(0.02)	10,059	0.72	(0.02)	11,373
Women's sweaters and vests	0.52	(0.01)	34,485	0.53	(0.01)	23,016	0.50	(0.01)	26,358
Mean	0.53			0.53			0.57		
Median	0.51			0.52			0.54		
Standard Deviation	0.20			0.22			0.23		
Maximum	1.14			1.16			1.13		
Minimum	0.12			0.11			0.16		

Notes: Estimation of equation (8) by pooling across all years in the sample.

Table 3: U.S. Tariff Rates

Good	1989 Tariff (%)	1994 Tariff (%)	2002 Tariff (%)	% Tariff Growth Rate		
				1989-2002	1989-1994	1995-2002
Baby furniture and equipment	3.80	3.36	2.43	-2.77	-2.33	-3.45
Bedroom furniture	3.44	2.07	0.00	-7.69	-7.98	-12.50
Bicycles	9.16	9.39	7.80	-1.14	0.50	-2.11
Calculators	3.41	3.08	0.00	-7.69	-1.91	-12.50
Camping equipment	6.24	6.51	4.27	-2.43	0.86	-4.30
Carpeting	7.08	6.57	3.32	-4.08	-1.43	-6.18
Cars	2.31	2.09	1.75	-1.88	-1.95	-2.04
Clocks	8.88	5.78	5.03	-3.34	-6.99	-1.62
Color Televisions	4.78	4.32	1.88	-4.67	-1.95	-7.07
Curtains and drapes	11.30	10.61	9.22	-1.41	-1.22	-1.63
Fishing and hunting equipment	4.27	4.11	3.59	-1.22	-0.75	-1.58
Footwear	14.84	14.12	14.07	-0.40	-0.97	-0.04
Hand tools	4.13	3.85	2.48	-3.08	-1.37	-4.46
Hard flooring	3.96	3.78	3.03	-1.81	-0.92	-2.48
Heaters	3.97	3.53	1.21	-5.35	-2.25	-8.20
Jewelry	5.88	4.19	2.88	-3.92	-5.74	-3.91
Kitchen/dining room furniture	3.97	2.16	0.06	-7.58	-9.13	-12.18
Lamps and lights	4.55	3.65	2.65	-3.22	-3.96	-3.44
Lawn and garden equipment	0.48	0.47	0.00	-7.69	-0.38	-12.50
Living room furniture	3.98	2.16	0.00	-7.69	-9.14	-12.50
Luggage	12.69	11.86	9.91	-1.69	-1.30	-2.06
M/B pants	18.82	15.30	16.51	-0.94	-3.74	0.99
M/B sleepwear	11.55	9.06	8.79	-1.84	-4.31	-0.37
M/B sportcoats	23.70	21.59	18.37	-1.73	-1.78	-1.86
M/B sweaters	17.57	14.71	16.48	-0.47	-3.26	1.51
Mattress and springs	4.07	3.64	2.21	-3.52	-2.10	-4.92
Men's suits	18.23	15.20	15.94	-0.97	-3.32	0.60
Musical equipment	6.03	3.66	2.52	-4.48	-7.87	-3.89
Office furniture	3.62	2.44	0.00	-7.69	-6.52	-12.50
Outdoor furniture	3.80	2.91	0.00	-7.69	-4.71	-12.50
Personal care appliances	3.66	3.53	1.95	-3.60	-0.73	-5.59
Photographic equipment	3.76	3.18	0.59	-6.49	-3.11	-10.19
Playground equipment	6.90	5.20	0.00	-7.69	-4.93	-12.50
Power tools	3.82	3.18	3.15	-1.35	-3.35	-0.13
Radios	4.63	4.34	1.34	-5.47	-1.26	-8.65
Refrigerators and freezers	2.11	2.11	0.10	-7.34	0.08	-11.94
Rugs	8.86	8.48	4.44	-3.84	-0.86	-5.95
Small kitchen appliances	3.77	3.26	2.50	-2.60	-2.72	-2.92
Sofas	2.20	1.73	0.00	-7.69	-4.28	-12.50
Sports and exercise equipment	3.41	2.79	1.48	-4.36	-3.64	-5.87
Stereos	3.88	3.76	1.48	-4.75	-0.60	-7.57
Stove and ovens	3.31	2.97	0.47	-6.61	-2.04	-10.55
Telephones	5.70	5.36	0.00	-7.69	-1.18	-12.50
Tires	2.87	2.17	0.00	-7.69	-4.91	-12.50

Table 3: U.S. Tariff Rates						
Good	**1989 Tariff (%)**	**1994 Tariff (%)**	**2002 Tariff (%)**	**% Tariff Growth Rate**		
				1989-2002	**1989-1994**	**1995-2002**
Trucks	2.65	7.75	9.04	18.59	38.57	2.08
W/G active sportswear	19.29	16.75	16.42	-1.14	-2.64	-0.24
W/G coats, jackets and furs	15.20	13.50	14.04	-0.58	-2.23	0.50
W/G dresses	14.01	12.61	11.57	-1.34	-2.01	-1.03
W/G skirts	12.69	12.73	11.72	-0.59	0.07	-0.99
W/G sleepwear	11.44	9.80	9.61	-1.23	-2.87	-0.25
Watches	28.46	5.09	4.43	-6.50	-16.42	-1.63
Window coverings	6.16	5.47	4.99	-1.46	-2.22	-1.10
Winter/water sports equipment	6.25	3.45	0.96	-6.51	-8.95	-9.02
Women's suits	17.28	15.10	14.63	-1.18	-2.52	-0.39
Women's sweaters and vests	14.95	13.57	16.28	0.68	-1.84	2.49

Data Source: 1989-2002 U.S. Imports of Merchandise CD-ROM

Table 4: Second Stage - Weighted Least Squares I

LHS Variable: Log of Estimated Product Quality			
	(1)	(2)	(3)
Log of Relative Tariff	0.53	0.66	0.97*
	(0.35)	(0.42)	(0.58)
1995 Dummy		0.04	0.03
		(0.03)	(0.03)
1995 Dummy*Log of Relative Tariff			-1.90**
			(0.78)
Log of US GDP per capita	-0.41***	-0.61***	-0.48***
	(0.11)	(0.17)	(0.18)
Constant	3.80***	5.86***	4.53**
	(1.12)	(1.71)	(1.82)
R-squared	0.75	0.75	0.75
Number of observations	770	770	770
Product Fixed Effects	Yes	Yes	Yes
Number of goods	55	55	55
Number of years	14	14	14

Notes:
1. Robust standard errors in parentheses (*** p<0.01; ** p<0.05; * p<0.1)
2. Standard errors are clustered by good.
3. The regressions are weighted by the standard errors of the quality estimates.
4. Relative tariff is the ratio of the U.S. tariff on imports originating from Low- and Middle-Income countries to the U.S. tariff on imports from High-Income countries.

Table 5: Second Stage - Weighted Least Squares II

LHS Variable: Log of Estimated Product Quality			
	(1)	(2)	(3)
Log of Relative Tariff		0.62	12.72**
		(0.40)	(5.43)
Log of FDI into Low- and			-2.20**
Middle-Income Countries* Log of Rel. Tariff			(0.96)
Log of FDI into	0.02	0.03	0.02
Low- and Middle-Income Countries	(0.03)	(0.04)	(0.03)
Log of US GDP per capita	-0.48***	-0.53***	-0.43**
	(0.17)	(0.17)	(0.18)
Constant	4.43***	4.80***	3.87**
	(1.59)	(1.62)	(1.69)
R-squared	0.75	0.75	0.75
Number of observations	770	770	770
Product Fixed Effects	Yes	Yes	Yes
Number of goods	55	55	55
Number of years	14	14	14

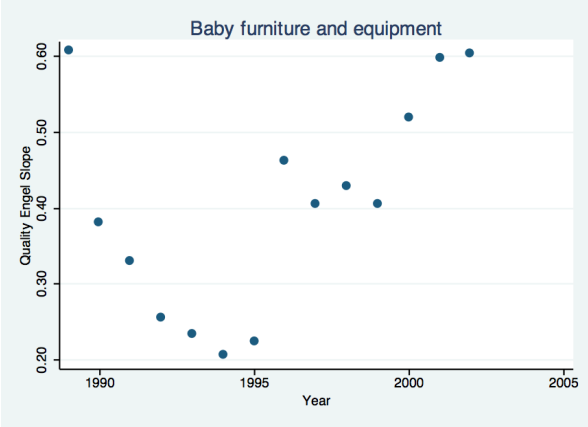
Notes:
1. Robust standard errors in parentheses (*** p<0.01; ** p<0.05; * p<0.1)
2. Standard errors are clustered by good.
3. The regressions are weighted by the standard errors of the quality estimates
4. Relative tariff is the ratio of the U.S. tariff on imports originating from Low- and Middle-Income countries to the U.S. tariff on imports from High-Income countries.

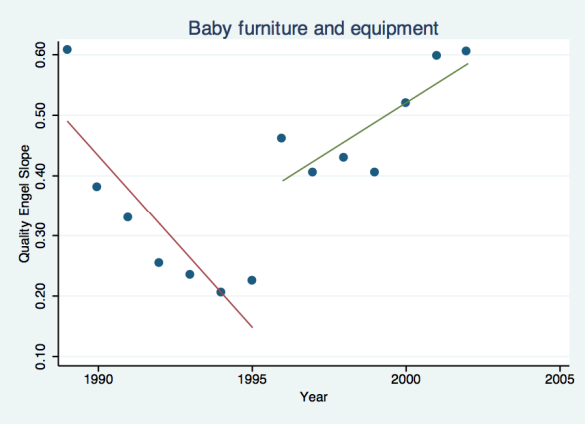
Table 6: Second Stage - Weighted Least Squares III

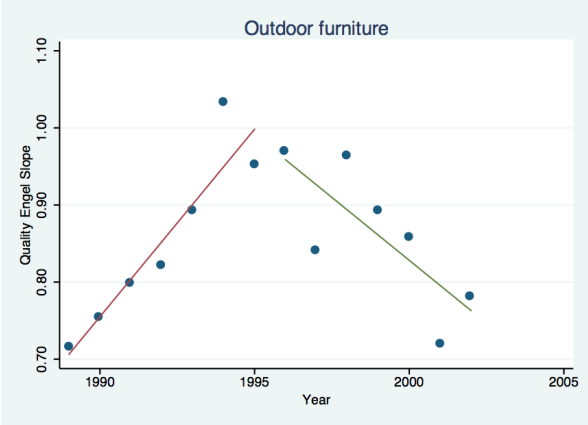
LHS Variable: Log of Estimated Product Quality				
	(1)	(2)	(3)	(4)
Log of Relative Tariff	0.53	13.88**	0.63	17.49***
	(0.37)	(5.70)	(0.44)	(6.44)
Log of FDI into Low- and Middle-Income Countries* Log of Rel. Tariff				-1.77*
				(0.99)
Log of FDI into Low- and Middle-Income Countries			0.03	0.02
			(0.04)	(0.04)
Log of Patents filed by residents in Low- and Middle-Income Countries* Log of Rel. Tariff		-1.26**		-0.67
		(0.54)		(0.51)
Log of Patents filed by residents in Low- and Middle-Income Countries	-0.00	0.00	0.00	0.00
	(0.02)	(0.02)	(0.02)	(0.02)
Log of US GDP per capita	-0.41***	-0.39***	-0.54***	-0.44**
	(0.12)	(0.12)	(0.20)	(0.21)
Constant	3.80***	3.49***	4.94***	3.89**
	(1.16)	(1.18)	(1.81)	(1.90)
R-squared	0.75	0.75	0.75	0.75
Number of observations	770	770	770	770
Product Fixed Effects	Yes	Yes	Yes	Yes
Number of goods	55	55	55	55
Number of years	14	14	14	14

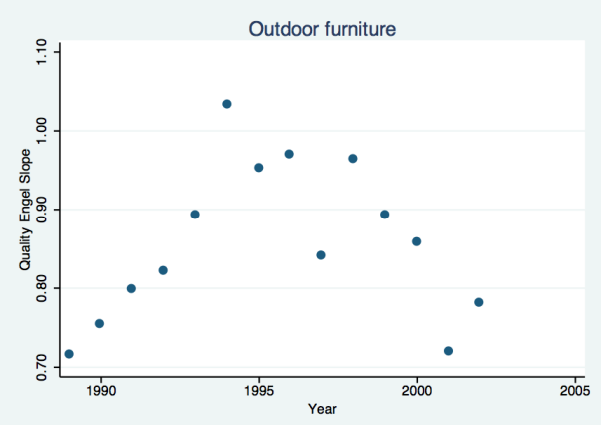
Notes:
1. Robust standard errors in parentheses (*** p<0.01; ** p<0.05; * p<0.1)
2. Standard errors are clustered by good.
3. The regressions are weighted by the standard errors of the quality estimates
4. Relative tariff is the ratio of the U.S. tariff on imports originating from Low- and Middle-Income countries to the U.S. tariff on imports from High-Income countries.

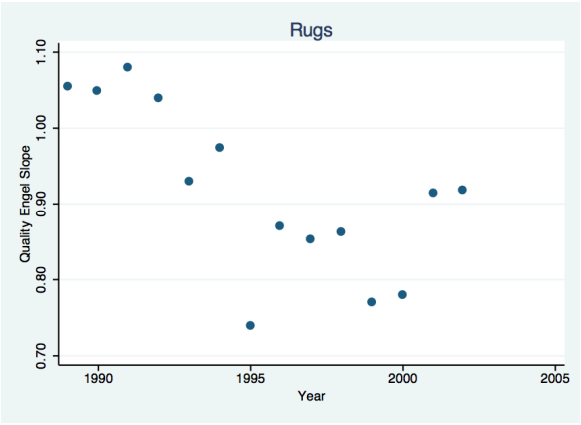
Figure 1: Trends in Quality Engel Slopes (Selected Products)

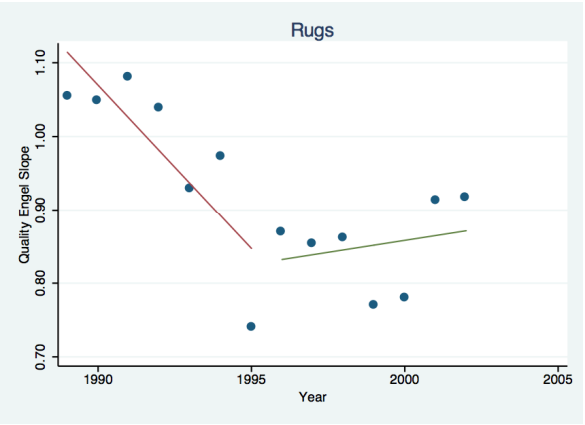


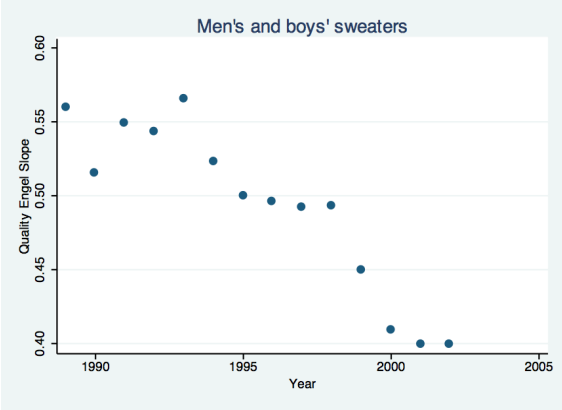


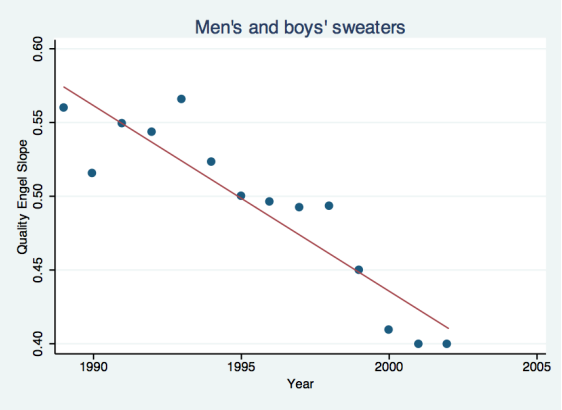




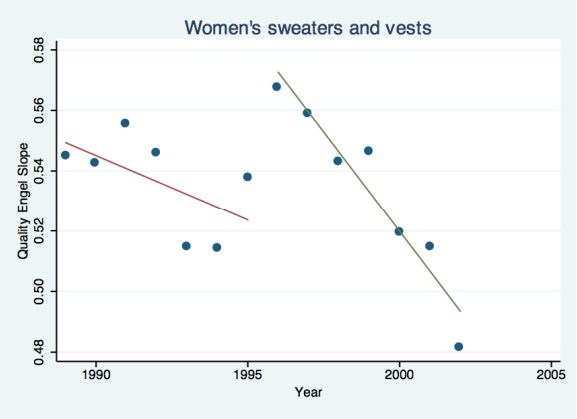


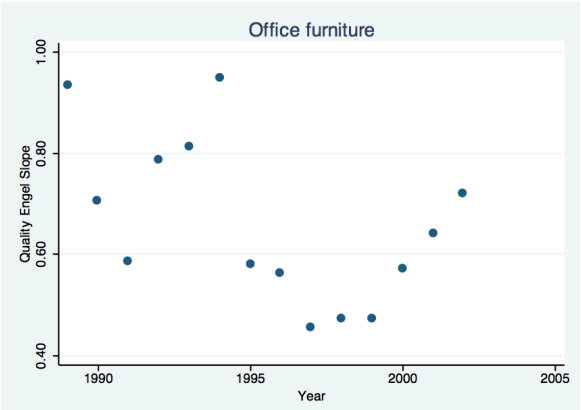


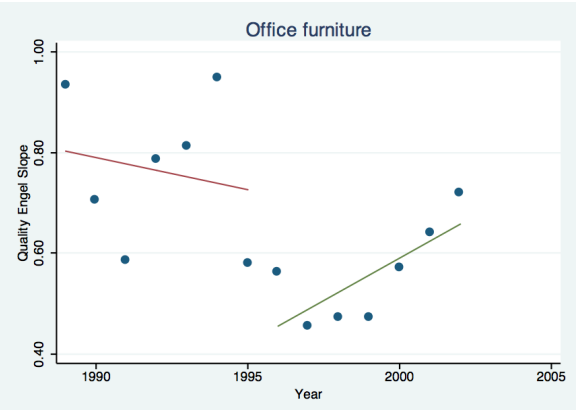

Men's and boys' sweaters
Quality Engel Slope
0.40
0.45
0.50
0.55
0.60
1990
1995
2000
2005
Year


Men's and boys' sweaters
Quality Engel Slope
0.40
0.45
0.50
0.55
0.60
1990
1995
2000
2005
Year


Women's sweaters and vests
Quality Engel Slope
0.48
0.50
0.52
0.54
0.56
1990
1995
2000
2005
Year


Women's sweaters and vests
Quality Engel Slope
0.48
0.50
0.52
0.54
0.56
0.58
1990
1995
2000
2005
Year


Office furniture
Quality Engel Slope
0.40
0.60
0.80
1.00
1990
1995
2000
2005
Year


Office furniture
Quality Engel Slope
0.40
0.60
0.80
1.00
1990
1995
2000
2005
Year