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Abstract

This paper develops new estimates of export quality, based on bilateral data, which are far more extensive than previous efforts. The data cover 166 countries and hundreds of products over 1962–2014. The analysis finds that quality upgrading is particularly rapid during the early stages of development. There is significant cross-country heterogeneity in the growth rate of quality. Within any given product line, quality converges over time to the world frontier. Institutional quality, liberal trade policies, foreign direct investment inflows, and human capital all promote quality upgrading, although their impacts vary across sectors. The results suggest that reducing barriers to entry into new sectors can allow economies to benefit from rapid quality convergence over time.

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Export Quality in Advanced and Developing Economies: Evidence from a New Data Set*

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1. INTRODUCTION

Economic development requires the transformation of a country's economic structure. This involves diversifying into new sectors; reallocating resources towards more productive firms; and, critically, improving the *quality* of goods produced. Producing higher-quality varieties of existing products helps build on existing comparative advantages to boost export revenues and productivity. Yet the potential for quality upgrading varies by product (Khandelwal, 2010), and has been found to be higher in manufactures than in agriculture and natural resources. For countries at an early stage of development, diversification into new products may therefore be a precondition to reaping large gains from quality improvement.

This paper makes three contributions to the debate on quality upgrading. First, we develop new estimates, based on bilateral data, which are far more extensive than previous efforts, covering 166 countries and hundreds of products over the period 1962–2014. Second, we present a series of stylized facts about export quality and how it varies along the development path. In particular, we illustrate changes in quality over time, both for the entire sample and for selected countries of interest, and we discuss the relationship between quality and income. Throughout, we examine separately the quality of primary goods and of manufactures, and we disaggregate manufacturing into several sub-sectors. Finally, we begin the task of harvesting this data set to analyze the determinants of quality upgrading.

The paper is related to a rapidly expanding literature on diversification and quality upgrading. Schott (2004) finds significant country within-product quality differences, based on shipment-level U.S. customs data.[4] In particular, quality varies systematically with exporters' relative factor endowments and production techniques. He argues that intra-industry trade is largely trade in goods of different quality. Sutton and Trefler (2011), elaborating on Hausmann et al. (2007), find that between 1980 and 2005 low-income countries moved into more "sophisticated" products[5], but produced them at low quality levels. As a result, diversification has not led to a significant boost in GDP per capita. Put differently, diversification and quality upgrading should be viewed as complementary in the development process. Hwang (2007) argues that countries need to enter sectors with long "quality ladders" that they can climb.[6] Relatedly, Hausmann and Hidalgo (2010) demonstrate that, if production of any given good requires a combination of capabilities, then the returns to acquiring new production capabilities can increase with the number of a country's existing capabilities. Thus, quality upgrading underpins the growth process to the extent that it implies new capabilities. In addition, the proximity in "capabilities space" between goods already being produced and higher value-added goods is also important (Hausmann and Klinger, 2006).[7]

This literature, however, faces a key challenge: export quality cannot be directly observed and needs to be estimated. Unit values, defined as the ratio of export values to quantity for any given product category, are observable. Schott (2004) and Hummels and Klenow (2005) showed that these unit values increase with

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[4] For instance, unit values for cotton shirts imported from Japan are 30 times higher than those from the Philippines.

[5] Defined as those products predominantly produced by high-income economies. While higher-income countries also tend to produce higher-quality varieties, the concepts of quality and sophistication are quite different. Quality refers to the relative price of a country's varieties *within* their respective product lines. Product sophistication, as in Hausmann et al. (2007), assesses the composition of the aggregate export basket.

[6] Starting production of higher-quality varieties need not imply abandoning production of lower-quality varieties, particularly if the latter are better suited to some destination. Mukerji and Panagariya (2009) note that the United States produces goods at a large variety of quality levels. Nonetheless, the *average* quality within 4-digit product categories, which is the focus of our study, tends to be higher in higher-income economies.

[7] Regarding proximity, Bahar, Hausmann, and Hidalgo (2014) documents that the probability of a country exporting a new type of good is significantly (over 50 percent) larger if a neighboring country is a successful exporter of the same good.

GDP per capita. However, unit values are at best a noisy proxy for export quality, because they are also driven by other factors, including production cost differences. The strategies recently developed for quality estimation (including Khandelwal, 2010; Hallak and Schott, 2011; and Feenstra and Romalis, 2014) typically model demand, and in some cases also supply, using explicit microeconomic foundations. However, these methodologies do not allow calculation of a set of quality estimates with large country and time coverage, owing to their significant data requirements.

As a result, much work remains to be done in establishing stylized facts about product quality and, in particular, in linking growth in quality to economic development. Existing work has focused mainly on other questions. For instance, Khandelwal's (2010) primary aim in calculating quality ladders is to show that U.S. sectors with short quality ladders are exposed to larger employment and output declines resulting from low-wage competition. Hallak (2006) focuses on showing that higher-income economies import more from countries producing high-quality goods. Hallak and Schott (2011) and Feenstra and Romalis (2014) are mainly concerned with decomposing changes in unit values into changes in quality and pure trade-price changes.

This paper yields a series of notable findings, many of them worthy of further research. Quality upgrading is particularly rapid during the early stages of development. There is significant cross-country heterogeneity in the growth rate of quality. Within any given product line, quality converges over time to the world frontier. Institutional quality, liberal trade policies, FDI inflows, and human capital all promote quality upgrading, although their impact varies across sectors. The results suggest that reducing barriers to entry into new sectors can allow economies to benefit from rapid quality convergence over time.

2. Estimating Product Quality: Methodology and Data

Unit values are used by much of the literature to measure product quality because they are readily observable, but suffer from three shortcomings. First, unit values may reflect production costs, or pricing strategies (that is, firms' choice of mark-up) rather than quality. Second, changes over time in unit values may reflect changes in quality-adjusted prices, in response to supply or demand shocks, rather than changes in quality.[8] Third, if the composition of goods within a product category varies across exporters, the cross-country differences in unit values among the exporters may reflect these differences in composition, rather than differences in quality.[9] The quality estimates presented here address the first two shortcomings; the last one cannot be addressed if one is to maintain broad country and time coverage.[10]

The literature that goes beyond unit values does not provide a set of quality estimates that are well suited for analyzing developments in developing countries. Khandelwal (2010) requires data on market shares of imports relative to corresponding domestic varieties. These are only available for few countries and for limited time periods. Hallak and Schott (2011) require extensive data on tariffs, which are unavailable even for many relatively large countries before 1989.[11] Feenstra and Romalis (2014) require for each product two different unit-value observations, one derived from importer-reported (CIF) and one from exporter-reported (FOB) data. However, exporter-reported data are not available for many developing-country

[8] Hallak and Schott's (2011) results suggest for instance that Malaysia continually upgrades quality, but this does not show in unit values because of falling world prices for electronics, the country's main export.

[9] Similarly, quality measures will be affected by introduction of new products, if the initial quality level produced in these new products varies substantially from the average quality of existing products in the category.

[10] Other papers that focus exclusively on U.S. data (such as Khandelwal, 2012) can address this last issue by using HS 10-digit data. However, data at such a high level of disaggregation are not widely available for developing countries.

[11] Also, data on tariffs in the Long Time Series TRAINS database, which goes back to the 1970s, do not cover low-income countries well.

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exports, especially for early years, limiting their analysis to the 1984–2008 period. Consequently, a reduced-form approach, which circumvents data constraints, is more suitable for our purposes.

Our methodology estimates quality based on unit values, but with important adjustments to capture the impact of production costs and pricing strategies. The methodology is a modified version of Hallak (2006), which sidesteps data limitations to achieve maximum country and time coverage.[12] First, for any given product, the trade price (equivalently, unit value) p_{mxt} is assumed to be determined as follows:

$$\ln p_{mxt} = \zeta_0 + \zeta_1 \ln\theta_{mxt} + \zeta_2 \ln y_{xt} + \zeta_3 \ln Dist_{mx} + \xi_{mxt}, \tag{1}$$

where the subscripts m, x, and t denote, respectively, importer, exporter, and time period. Prices reflect three factors. First, unobservable quality θ_{mxt}. Second, exporter income per capita y_{xt}; this is meant to capture cross-country variations in production costs systematically related to income. With high-income countries typically being capital-abundant, we expect $\zeta_2 < 0$ for capital-intensive sectors and $\zeta_2 > 0$ for labor-intensive sectors.[13] Third, the (great circle) distance between importer and exporter, $Dist_{mx}$. This accounts for selection bias: typically, the composition of exports to more distant destinations is tilted towards higher-priced goods, because of higher shipping costs.[14]

Next, we specify a quality-augmented gravity equation:

$$\mathrm{Ln}(Imports)_{mxt} = FE_m + FE_x + \alpha \ln Dist_{mx} + \beta I_{mxt} + \delta \ln\theta_{mxt} \ln y_{mt} + \varepsilon_{mxt} \tag{2}$$

Here, FE_m and FE_x denote, respectively, importer and exporter fixed effects. $Dist_{mx}$ is as defined above. The matrix I_{mxt} is a set of standard trade determinants from the gravity literature.[15] The exporter-importer-specific quality parameter θ_{mxt} enters interacted with the importer's income per capita y_{mt}. If $\delta > 0$, then greater income increases the "demand for quality". This equation is estimated separately for each product, because preference for quality and trade costs may vary across products.

The estimation equation is obtained by rearranging (1) to express the unobservable quality parameter ($\ln\theta_{mxt}$) in terms of observables, and substituting this into (2), yielding:

$$\ln(Imports)_{mxt} = FE_m + FE_x + \alpha \ln Dist_{mx} + \beta I_{mxt} + \zeta_1' \ln p_{mxt} \ln y_{mt} + \zeta_2' \ln y_{xt} \ln y_{mt} + \zeta_3' \ln Dist_{mx} \ln y_{mt} + \xi'_{mxt} \tag{3}$$

where $\zeta_1' = \frac{\delta}{\zeta_1}$, $\zeta_2' = -\frac{\delta\zeta_2}{\zeta_1}$, $\zeta_3' = -\frac{\delta\zeta_3}{\zeta_1}$, and $\xi'_{mxt} = -\frac{\delta\zeta_0 + \delta\xi_{mxt}}{\zeta_1} \ln y_{mt} + \varepsilon_{mxt}$.

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[12] The key difference is that we directly use unit values at the SITC 4-digit level, whereas Hallak gathers unit values at the 10-digit level and then normalizes them into a price index for each 2-digit "sector".

[13] This approach builds on Schott (2004), who showed that unit values for any given product vary systematically with exporter relative factor endowments, as proxied by GDP per capita.

[14] Hallak (2006) uses distance to the United States instead of distance to the importer, because it only focuses on prices of exports to the United States. Harrigan, Ma, and Shlychkov (2011) find that the correlation between export prices and distance is due to a composition, or "Washington apples", effect. They also find that U.S. firms charge higher prices to larger and richer markets.

[15] It includes indicator variables for a common border, a common language, the existence of a preferential trade agreement, a colonial relationship, and a common colonizer.

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This equation is estimated separately for each of the 835 product categories in the data set, yielding 835 sets of coefficients. The equation is estimated using two-stage least squares. ξ_{mxt} is a component of p_{xmt}, so that the regressor $\ln p_{xmt} \ln y_{mt}$ is correlated with the disturbance term ξ'_{mxt}. We therefore use $\ln p_{xmt-1} \ln y_{mt}$ as an instrument for $\ln p_{xmt} \ln y_{mt}$.[16]

The results are used to calculate a set of bilateral quality estimates for each country's exports. Rearranging (1), and using the estimated coefficients, quality is calculated as the unit value adjusted for differences in production costs and for the selection bias stemming from relative distance:[17]

$$Quality\ estimate_{mxt} = \delta \ln \theta_{mxt} + \frac{\delta \zeta_0}{\zeta_1} = \zeta_1' \ln p_{mxt} + \zeta_2' \ln y_{xt} + \zeta_3' \ln Dist_{mx} \qquad (4)$$

As is standard, quality θ_{mxt} and importers' preference for quality δ are not separately identified.[18]

This estimation yields quality estimates for more than 20 million product-exporter-importer-year combinations.[19] To enable cross-product comparisons and aggregation into a multi-level database, all quality estimates are first normalized by the "world frontier", defined as the 90th percentile in the relevant product-year combination. As a corollary, changes in quality over time are all defined relative to the world frontier. After normalization, the quality estimates are aggregated across all importers for each country, using current trade values as weights. The estimates are then aggregated to higher SITC levels (SITC 4-, 3-, 2-, and 1-digit, as well as country-level totals); aggregations are also produced based on the BEC classification, as well as for the 3 broad sectors of agriculture, non-agricultural commodities, and manufactures.[20] At each aggregation step, the normalization to the 90th percentile is repeated, and trade values are used as weights.

The data set is a significantly extended version of the UN–NBER data set. Starting with the COMTRADE database, we construct a trade data set for 1962–2014 by supplementing importer-reported data, generally considered more reliable, with exporter-reported data where the former do not exist.[21] We ensure consistency over time and in aggregating to broader categories by using the methodology of Asmundson

[16] Where a unit value for the preceding year is not available (for instance, because the good was not traded), we use the unit value in the closest available preceding year, going back up to 5 years. If unit values are not available in any of the preceding 5 years, the observation is excluded from the estimation.

[17] In (4), the term $-\frac{\delta \xi_{mxt}}{\zeta_1}$ is set to its expectation of zero: it cannot be separately identified, as it constitutes part of ξ'_{mxt}. As pointed out in Hallak (2006), ξ_{mxt} may reflect omitted factors affecting export prices in (1), such as sector-specific technological advantages not well proxied by GDP per capita, and could persist over time. This should be borne in mind when interpreting the results.

[18] The preference for quality parameter δ will vary across sectors. Therefore, when quality estimates are later aggregated across sectors, the procedures necessarily also aggregate across these heterogeneous preferences for quality. The level term $-\frac{\delta \zeta_0}{\zeta_1}$ is of no significance, given our subsequent normalization of the quality estimates.

[19] This number is smaller than the 45.3 million potential combinations in the data set because of: (i) missing observations for other regressors, primarily per capita income; and (ii) elimination of outliers (see fn. 22).

[20] Changes in the higher-level (including country-level) quality estimates will in general reflect both quality changes *within* disaggregated sectors, and reallocation *across* sectors with different quality levels. If the composition of exports is shifting toward product lines characterized by low quality levels, it is possible for the quality of any given product to be rising sharply, but country-level quality to rise slowly (or indeed decline).

[21] The only exceptions to this methodology are export flows as reported by the United States, which take precedence over importer-reported flows.

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(forthcoming). This data set is analogous to the UN–NBER data set, but provides longer time coverage. The data set contains 45.3 million observations on bilateral trade values and quantities at the SITC 4-digit (Revision 1) level. Any given importer-exporter-product-year combination will have more than one observation for the same 4-digit category whenever import quantities are reported using more than one set of units. In this case, the multiple sets of import quantities are considered distinct "SITC 4-digit-plus" products, so that comparable unit values may be obtained within each product category. The total number of "SITC 4-digit-plus" products is 835, based on 625 underlying SITC 4-digit categories.[22] Information on preferential trade agreements is drawn from the World Trade Organization's Regional Trade Agreements database, and other gravity variables are drawn from CEPII (Head and Mayer, 2013). Data on income per capita are drawn from the Penn World Tables version 9.0 (Feenstra et al., 2015).

Reassuringly, the estimation results mirror closely those of Hallak (2006). All coefficients have the expected sign, and are statistically significant in the majority of specifications (Table 1). Moreover, the coefficients are closely comparable to those in Hallak (2006), except for those on the price-importer income interaction, which is as expected because our trade price vector is defined differently.[23]

3. Export Quality across Products, Countries, and Time

This section illustrates some stylized facts about export quality and provides a flavor of the richness of the data set. First, we compare our quality estimates with standard unit value measures. Second, we focus on a couple of specific sectors to highlight how informative it is to examine jointly developments in quality, unit values, and market share. Third, we show how a country's position on "quality ladders" may indicate large quality upgrading potential or, conversely, an increased need for horizontal diversification. Fourth, we discuss how our measure of quality varies along the development path, again establishing a comparison with unit values. Fifth, we analyze changes in product quality over time, highlighting the significant heterogeneity across regions and countries.

A. Comparison of Quality Estimates with Unit Values

Unit values are much more dispersed than quality. This is the case even after eliminating extreme values (Figure 1). Quality and unit values are correlated, but only at lower quality levels. Once a country's quality level reaches about 80–85 percent of the world frontier value, quality and unit values are no longer correlated. Thus, quality increases beyond that level do not tend to be associated with price increases, possibly because higher efficiency in production reduces costs. Quality increases are particularly strongly correlated with price increases in agricultural goods.

Quality evolves gradually. Focusing on the early (1962–80), middle (1980–95), and most recent (1995–2014) periods, changes in quality within each period of more than 20 percent relative to other countries are rare (Figure 2). Changes in quality also tend to be much smaller than changes in unit values. Moreover, for all sectors as well as manufacturing alone, increases in quality are in many cases not accompanied by increases in unit values. Some countries have seen considerable increases in quality accompanied by stable unit values: here, quality increases offset price declines on constant-quality products, for instance in the computer and electronics sectors.

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[22] SITC 4-digit-plus products were dropped if they met either of two criteria for smallness. First, the product comprised less than 1 percent of total observations or trade value of the corresponding SITC 4-digit product. Second, the product had less than 1,000 observations, and comprised less than 25 percent of total observations or trade value of the corresponding SITC 4-digit product. In addition, outliers were eliminated by excluding any observation with: (i) a quantity of 1; or (ii) a total trade value of less than $7,500 at 1989 prices; or (iii) a unit value above the 95th or below the 5th percentile in 1989 prices within any given product.

[23] Hallak (2006), using U.S. data only, computes Fisher price indexes for each SITC 2-digit sector starting from 10-digit sectors. In this paper, we use directly unit values of SITC 4-digit-plus products.

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B. Export Quality over Time: Examples from Specific Sectors

We now illustrate our export quality estimates using examples drawn from the car and apparel sectors. We focus on cars because most readers are likely to recognize the brands and have some intuition as to their relative quality. We consider apparel because it is a key export for many developing countries, particularly during the early stages of development, and typically constitutes one of the first beachheads in the manufacturing sector.

Estimates of quality in the passenger motor cars sector (SITC 7321) are intuitive and, combined with price movements, help explain developments in market shares.[24] The quality of U.S. exports has on average been at the world frontier, but has displayed some slight fluctuations over time (Figure 3). Meanwhile, prices oscillated around 90 percent of the world frontier, and the U.S. world export market share has been stable since the early 1990s after a long-term decline up to this point. German car exports have featured high quality and high prices throughout since the late 1970s. During the 2000s, German car exports regained much of the market share that they lost during the 1980s. Some countries boosted the quality of their car exports as they developed. For instance, Japanese cars experienced strong quality upgrading through 1990, reaching world frontier levels. Meanwhile, prices rose only moderately during this period, allowing for increases in market share. Since then prices have risen slightly higher with constant quality, possibly explaining some loss of market share to competitors. Quality of Korean cars was low until the early 1980s. Since then Korean autos have experienced ongoing and substantial quality upgrading. As Korean prices remained relatively low, their market share increased.

Analysis of the apparel sector (SITC 84) also shows how the relationship between quality and prices influences market shares. China increased its relative quality of apparel exports substantially since 1980, from 75 percent to 95 percent of the world frontier (Figure 4). This was accompanied by a similarly drastic increase in export market share, and enabled prices to rise slightly, although they remain low at 40 percent of the world frontier value. Bangladesh also recorded a strong increase in its market share, but given that quality increases were much less than in China, no price increases could be realized. India mirrors Bangladesh closely. Italy maintained world frontier quality throughout the sample period, but its market share declined as prices rose. Finally, the Republic of Korea and Thailand are examples of countries which in the past increased their market shares against a backdrop of rising quality and mostly stable prices. Subsequently, however, these countries have been diversifying away from the textile sector. They now retain higher-quality segments of the apparel market, as quality remains stable or continues to increase, but record falling market shares.

C. Export Quality along the Development Path

Overall, export quality is correlated with income per capita. This holds both at the aggregate level, and for manufacturing, agriculture, and non-agricultural commodities separately (Figure 5).[25] These findings are consistent with Hummels and Klenow (2005) and Sutton and Trefler (2011). They hold also when controlling for country fixed effects, so as to focus purely on within-country changes over time; in other words, export quality increases as countries grow richer. Quality increases with income particularly sharply during the early stages of development, until GDP per capita reaches $10,000. Quality convergence then continues at a diminishing rate. In contrast, unit values increase with income at a relatively constant rate: the slope of the non-parametric best-fit curve linking unit values and income is quite constant across different income levels, particularly for manufacturing (Figure 5 and Figure 6).

Among high income countries, average export quality levels only vary within a narrow band. In contrast, among and within developing countries, and in particular low-income countries, average quality levels vary

[24] Market share is measured as a country's exports as a percentage of total world exports of that product.

[25] The correlation between income and unit values for non-agricultural commodities is relatively weak.

widely, even when controlling for income. This suggests that some economies could reap particularly large gains from quality upgrading, while for others diversification may be a priority. Those countries with low average quality have considerable scope to upgrade quality even within existing export sectors. Other developing countries may already enjoy relatively high export quality, but consistent with their low incomes this is in sectors with short quality ladders or low productivity. These economies could benefit from diversification into sectors with new opportunities for quality upgrading.

These broad facts hold also when focusing on two subsamples: small states, and commodity exporters (Figure 6).[26] Small states follow patterns similar to those in other countries: quality rises with income, and particularly sharply at income levels below $10,000. In commodity exporters, there also is potential for quality upgrading during the development process, as countries shift toward more processed products within each commodity category. However, the process may be more constrained by exogenous factors (such as the grade of available minerals) than in manufacturing.

The results indicate significant scope for quality upgrading in not just manufacturing, but also agriculture. As countries develop, the quality of agricultural products on average increases substantially. Further, the length of quality ladders varies substantially across subsectors in both agriculture and manufacturing (Figure 7).[27] All this suggests that early development need not be driven by the establishment of a manufacturing base. Although soil and climate may impose some limitations, the finding that sharp increases in quality can be registered in agricultural and commodity exports is particularly important since in many developing countries a large share of the labor force remains concentrated in agriculture.

D. Quality Ladders: Potential for Quality Upgrading

A country's position on sectoral world quality ladders indicates the potential for further quality upgrading in its existing product basket. To illustrate, we analyze the position of China, Malaysia, Tanzania, and Vietnam on these quality ladders, alongside the composition of their current export baskets (Figure 8). Overall, both the length of the quality ladder, and a country's relative position on the ladder, can vary considerably across sectors.

Tanzania and Vietnam are examples of countries with considerable quality upgrading potential within existing export sectors. Tanzania has experienced strong growth during the last decade. Yet, Tanzania's exports are concentrated in primary and agricultural exports, and within those sectors the country is generally in the bottom half of the quality ladder, suggesting large potential for quality upgrading. Horizontal diversification, for instance towards manufactures, may create additional opportunities for quality upgrading. Vietnam's exports, on the other hand, are already heavily tilted towards manufactures, particularly the miscellaneous manufactures sector, which includes apparel and footwear. However, as in Tanzania, there is still much potential for further quality upgrading in these sectors.

Some of the more mature Asian countries may require horizontal diversification to enable further quality upgrading. Malaysia is heavily specialized in exports of electronics, a subcategory of the machinery and transport equipment sector, but is already coming close to the world frontier in this sector. To enable further quality upgrading, it may first need to diversify. This diversification could occur across SITC 1-digit

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[26] Countries are classified as small states if their population is smaller than 1.5 million in either 2010 or 2011, using Penn World Tables (2010) and *World Development Indicators* (2011) data. This classification does not include fuel exporters that are high income (as per World Bank definition), including in particular Bahrain, Brunei, and Equatorial Guinea. Countries are classified as commodity exporters, following the IMF *World Economic Outlook* classification, if commodities on average exceed 50 percent of total exports.

[27] For instance, red wine, Arabica coffee, and shrimp and prawns constitute examples of agricultural products with particularly long quality ladders (cf. Lederman and Maloney, 2012, Box. 5.1).

sectors, as well as within the machinery and transport equipment sector. China's position in most sectors lies between Vietnam and Malaysia. Some quality upgrading potential has already been realized, but more remains.

E. Quality Upgrading by Income Group and Region

In middle-income countries, export quality in manufacturing has been gradually increasing for several decades; these countries have converged toward the world quality frontier since the 1980s (Figure 9). Quality convergence in agriculture only commenced later, in the 2000s, after a prolonged period of divergence.

In low-income countries as a whole, export quality in manufacturing has stagnated during the last three decades. In agriculture, there have been signs of quality upgrading during the last decade, after a prolonged gradual decline. In non-agricultural commodities, average quality has deteriorated substantially relative to the world frontier since the 1980s. This suggests that low-income countries have increasingly focused on raw material exports, as opposed to developing processing activities in the context of vertically integrated industries. In contrast, in high-income countries, export quality increased further from already high levels, both for all products and for commodities.

At the regional level, East Asia has exhibited particularly fast quality upgrading (Figure 10). The quality convergence was particularly impressive in manufactures. Quality of commodities also increased, particularly in the 1970s and 1980s, as a result of the development of vertically integrated industries engaged in elementary processing. Again, agriculture only followed with a substantial lag, with quality starting to increase only since 2000.

Sub-Saharan Africa is still lagging behind, but there are now tentative signs of quality convergence. Manufacturing export quality has increased sharply since the late 1990s, and prolonged quality divergence in agriculture has seemingly halted. In contrast, in South Asia, there are no strong signs of quality convergence in any large sector. In the Middle East and North Africa, manufacturing quality increased from the 1960s through the 1980s, but stagnated thereafter; in agriculture, no sustained quality increases have occurred, although there are signs of some upgrading since 2000. In Latin America, export quality has stagnated for several decades.[28] That said, during the last decade some signs of convergence have appeared in both manufacturing and agriculture.

Even within regions, there is considerable cross-country heterogeneity in the pace of quality upgrading. Within Asia, several countries, such as Japan, Korea, China, India, Indonesia, and Vietnam, have converged or are converging fast towards the world quality frontier (Figure 11).[29] Bangladesh, Pakistan, and Sri Lanka are converging at a slower pace, although with signs of an acceleration during the last decade. Meanwhile, in countries such as Malaysia and Thailand, quality convergence has slowed since the mid–1990s.

In Africa, the patterns of convergence are even more heterogeneous, with particularly large fluctuations in quality indexes in countries whose exports are strongly driven by a few products. Upward trends in quality can be noted since the early 2000s in a series of countries including Senegal, Ghana, Uganda, Nigeria, and South Africa. In the Arab Republic of Egypt, quality increased over an extended period, but more recently

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[28] In a similar vein, Lederman and Maloney (2012) argue that both Latin America and the Middle East & North Africa are already near the quality frontier for many of their exports, consisting largely of natural-resource based goods, and thus benefit little from quality upgrading in existing exports.

[29] The "fast convergers" are defined as those countries where average quality converged to the world frontier by at least 5 percentage points between 1994–96 and 2008–10. Alternative thresholds yield similar results.

stagnated. In many countries, including Morocco, Côte d'Ivoire, and Cameroon, quality has largely stagnated throughout the sample period.

As an additional observation, developing countries' potential for quality upgrading does not appear to be limited by low demand for quality in their destination markets. Data limitations prevent a formal hypothesis test. That said, while lower-income countries do tend to serve markets that on average import lower-quality products, the differences do not seem substantial enough to act as a constraint on quality upgrading (Figure 12 and Figure 13). On average, the lower-income the exporter, the greater the gap between its export quality and the average quality demanded by its trade partners in those products that the exporter sells to them. Likewise, in countries with slower convergence, export quality is substantially lower than the average quality of their trade partners' imports. All this suggests that policy should focus on creating a domestic environment broadly conducive to quality upgrading; lowering barriers to entry into higher-quality export markets constitutes a less urgent priority.

F. Import Quality

For any given product, estimates of the quality of exports from country *i* to country *j* may also be interpreted as estimates of the quality of imports of country *j* from country *i*, and aggregated over all exporting countries to yield estimates of country *j*'s average quality of imports of this given product. We now present some such estimates, in a manner analogous to our earlier discussion of export quality.

Focusing first on individual sectors, in passenger cars, Germany and Korea saw marked increases over time in the quality of their imports (Figure 14). In contrast, Japan and the United States saw more limited changes over time. In broad terms, this is consistent with relative trends in income growth. In the apparel sector, country-level changes over time in import quality were more limited (Figure 15). In general, import unit values fluctuate more sharply than import quality, likely again reflecting problems in using unit values to measure quality.

Turning to broader product categories, import quality is correlated with income levels, but less strongly than export quality (Figure 16 and Figure 17). This trend holds for both manufacturing and agricultural imports, although not for commodities. Further, the gap in import quality between low-income countries and middle-income or high-income countries is widening over time. Differences in import quality across regions are likewise correlated with differences in regional income levels; in general, import quality is lowest in Sub-Saharan Africa and South Asia (Figure 18).

4. Determinants of Quality Upgrading

This section turns to analyzing the determinants of the growth rate of product quality through product-level cross-country panel regressions.

A. Estimation Strategy and Data

We estimate separate regressions for manufacturing, agriculture, and other natural resources, since determinants can be expected to vary by sector. The estimation equation is:

$$Growth\_Quality_{ipt} = \text{FE} + \delta_1 \ln Initial\_Quality_{ipt} + \delta_2\, Determinants_{ipt} + \varepsilon_{ipt}, \qquad (5)$$

where i, p, and t index, respectively, the exporting country, product, and time period. $Growth\_Quality$ denotes the annualized growth rate of quality, calculated as the difference between (the logarithms of) quality levels in the initial and final years of 10-year non-overlapping periods.[30] FE relates to different sets of fixed effects, discussed below.

[30] These 10-year non-overlapping periods are 1962–71, 1972–81, 1982–91, 1992–2001, and 2002–2010.

Other explanatory variables relate to initial conditions and are observed in the first year of any 10-year non-overlapping period. *Initial_Quality* denotes the initial product quality level. *Determinants* denotes the vector of potential determinants, which includes in our baseline specification initial GDP per capita, initial FDI inflows, initial institutional quality, initial human capital, and indexes measuring the levels of initial trade and agricultural liberalization (see Table 2 for all summary statistics).

GDP per capita is drawn from the World Bank's *World Development Indicators*. FDI inflows are measured as a percentage of GDP, and the data are drawn from the IMF's *International Financial Statistics*. Institutional quality is measured using the "Constraints on the Executive" variable from the Polity IV data set.[31] Human capital is measured using the secondary-school completion rate from the World Bank's *World Development Indicators*. The indexes measuring initial trade and agricultural liberalization are de jure indicators drawn from Prati et al. (2013).[32]

To contain any omitted variable bias, we include sets of fixed effects to control for any other observables or unobservables that may drive quality growth. The basic specification includes fixed effects for country, product, and time. Country fixed effects control for quality growth being faster in some countries, for instance owing to unobserved institutional circumstances, such as the quality of business organizations or other mechanisms to exploit knowledge spillovers. Product fixed effects allow for quality improvements being easier to attain in some products. Time fixed effects detect changes over time in the global average speed of quality growth, for instance reflecting advances in information and communications technology or reductions in transportation costs.

The extended specification instead includes country-product and product-time fixed effects.[33] Country-product effects account, for instance, for unobserved institutional circumstances in a specific country favoring quality upgrading, but only in some types of products. Similarly, product-time fixed effects allow global developments to have different impacts on average quality growth in different products.

B. Results

The first key finding is that the quality of individual products converges unconditionally across countries over time. Specifically, in a bivariate regression, the growth rate of product quality depends negatively on the initial quality level (Table 3 and Figure 19). This implies that new, low-quality entrants into a sector see their quality rise over time relative to other countries. The speed of unconditional convergence toward the world quality frontier equals 3.5 percent per year when fixed effects are not included. The convergence speed tends to increase as more detailed fixed effects are introduced. This highlights the significant heterogeneity in the data, and in particular the presence of considerable obstacles to quality upgrading in specific sectors within specific countries. Evidence of within-product quality convergence also suggests that managing to enter 'long quality-ladder' sectors today could increase a country's future potential to climb up the value chain, supporting growth.

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[31] Similar results are obtained if the Kaufmann-Kraay-Mastruzzi indicators are used.

[32] Both indexes vary between zero and unity. The trade liberalization measure is based on average tariff rates: zero means the tariff rates are 60 percent or higher, while unity means the tariff rates are zero. The agricultural liberalization index measures the extent of public intervention in the market of each country's main agricultural export commodity; it includes the presence of export marketing boards and the incidence of administered prices. Both indexes are available from 1960 onwards.

[33] We do not include country-time fixed effects, because the determinants we are primarily interested in only vary along the country-time dimension.

(continued…)

Next, we introduce other potential determinants of quality upgrading. We present results from both the basic specification (with country, product, and time fixed effects) and the extended, preferred specification (with country-product and product-time fixed effects), for each of the three broad sectors—agriculture, manufacturing and commodities (Table 4).[34] For all sectors, the basic specification is statistically rejected at high significance levels in favor of the extended specification, based on both F and Hausman tests.[35] Relatedly, the goodness of fit is significantly higher in the extended specification. This confirms the significant country-product– and product-time–specific heterogeneity in the quality data. The discussion therefore focuses on the extended specification, unless otherwise stated.

Quality convergence is robust to which set of determinants is included.[36] Conditional quality convergence occurs at a rapid 6–7 percent per year in the basic specification, and an even faster 13–14 percent per year in the extended specification, with little difference across sectors. The difference across specifications again suggests the presence of significant, persistent, country-product–specific obstacles to quality upgrading—obstacles that are neutralized by the country-product fixed effects in the extended specification. In both specifications, the initial quality level is the single most important observable determinant of quality growth: since it varies across country-product combinations, it can explain some of the large heterogeneity across this dimension. That said, quality convergence for individual products need not imply quality convergence for countries' overall export baskets, owing to the presence of country or country-product fixed effects.

Quality upgrading is easier to achieve in higher-income economies, after controlling for their higher initial quality levels, and when using the fuller controls of the extended specification. This is true in both manufacturing and agriculture, although not in other natural resources. One interpretation is that advanced economies, given their more advanced communication technologies and favorable network effects,[37] can reap greater knowledge spillovers and implement quality improvements more easily. However, the magnitude of this effect, in both manufacturing and agriculture, is small relative to the impact of convergence: a one standard deviation increase in GDP per capita only increases quality growth by 0.5 percent per year.

For lower-income economies, the (positive) effect on quality upgrading of low initial quality will therefore generally dominate the (negative) effect of low income. This provides additional intuition for the earlier finding that quality convergence is particularly rapid at lower levels of development.

Institutional quality, which also tends to be greater in higher-income countries, again matters for quality upgrading in both manufacturing and agriculture, but not in other natural resources. The impact of institutions increases in magnitude and statistical significance in the extended specification. Even then, the magnitude of the impact is quite small: a one standard deviation improvement in institutions leads to a 0.1 percent additional quality convergence per year.

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[34] Results vary considerably across sectors, limiting the usefulness of regressions on the full sample covering all three sectors. We nonetheless present these latter results in Appendix Table A.1.

[35] Appendix Table A.2 introduces country-product and product-time fixed effects separately, and confirms that country-product heterogeneity is especially important.

[36] This is demonstrated in more detail in an earlier working paper version of this paper (see Henn et al., 2013, Table 3).

[37] For instance, an advanced economy's size may sustain larger agglomerations of industry, which can bring benefits including more specialized and deeper labor markets, or cheaper and more direct shipping and air travel options.

(continued…)

Increasing human capital by one standard deviation also accelerates quality convergence by 0.1 percent per year, but only in manufacturing. An increase in FDI inflows of 1 percentage point of GDP is associated with a 0.06 percent per year increase in export quality in the other natural resource sector.[38] This effect can be economically significant in resource-dependent developing countries, where natural-resources FDI is high relative to GDP. In manufacturing, the effect is also statistically significant but economically negligible.

Trade liberalization leads to faster quality upgrading, particularly in agriculture but also in manufacturing, in both the basic and extended specifications. A one standard deviation increase in trade liberalization accelerates quality convergence by 0.2 percent per year in agriculture and 0.1 percent per year in manufacturing. Agricultural liberalization leads to faster agricultural quality upgrading only in the basic specification (a one standard deviation increase boosts quality convergence by 0.1 percent per year).

Fixed effects account for much of the observed sample variation in the pace of quality upgrading. This is challenging to interpret, but suggests that unobservable dimensions of institutional and policy performance may have important implications. Relatedly, a country moving into a new product line should not automatically expect rapid quality growth.

C. Robustness

We now present two robustness checks. The first varies the time period over which quality growth is calculated. The second includes financial openness variables as additional determinants of quality upgrading.

We start by adopting a single cross section from the beginning to the end of the sample (Table 5, left half). Since this drops the time dimension, only country and product fixed effects can be included. The results are therefore most appropriately compared with the earlier basic specification. These cross-sectional results again highlight the importance of unconditional convergence in quality levels. Initial quality levels are the only determinant that retains statistical significance across all sectors. The speed of convergence toward the world quality frontier is estimated at 5 percent per year; these estimates incorporate the effect of country-product specific barriers, which are not separately controlled for. Agricultural liberalization also has an effect on agricultural quality upgrading; the magnitude of the estimates here is twice as large as in the basic specification with 10-year periods.

We also use observations on 5-year non-overlapping periods, rather than the earlier 10-year periods (Table 5, right half). Here, both country-product and product-year fixed effects are included, as in the earlier extended specification. The results broadly confirm those of the extended specification, although with a lower goodness of fit. The main difference is that the speed of unconditional convergence increases to 20–23 percent per year. This likely reflects the greater potential for measurement error when using short time periods. The magnitudes of the other estimated effects change only slightly, with the statistical significance of the coefficients remaining virtually unchanged from the extended specification. The effects are greater for initial GDP per capita and education, and smaller for trade liberalization, in those sectors where these impacts were previously found to be statistically significant. The effect of institutional quality is greater in agriculture, but lower in manufacturing.

The second robustness check adds to the extended specification two measures of de jure financial openness: a domestic financial liberalization index, and an external capital account openness index, drawn from Prati

[38] The effects of both human capital and FDI inflows are only observed after country-product heterogeneity is controlled for.

(continued…)

et al. (2013).[39] These indexes are only available from 1973 onwards, and correspondingly reduce our estimation sample.[40] These financial variables have no effect on quality upgrading in agriculture and other natural resources (Table 6). They have a statistically significant negative impact on manufacturing, suggesting that excessively rapid financial liberalization could hamper quality upgrading. However, the economic magnitude of the impact is small: for instance, a one standard deviation increase in domestic financial liberalization only reduces quality growth by 0.1 percent per year.

Inclusion of the financial variables only has a minimal effect on the estimated coefficients for other determinants. The speed of convergence increases marginally, to around 15 percent per year for all sectors. In addition, human capital and trade liberalization have a slightly greater effect on quality upgrading in manufacturing.

5. Conclusion

We develop a new data set on export quality. This data set is far more extensive than previous efforts, covering 166 countries over 1962–2014, and providing breakdowns up to the SITC 4-digit and BEC 3-digit levels, for a total of more than 20 million quality estimates. Our estimates, based on sector-specific quality-augmented gravity equations, explicitly recognize that high product prices are not necessarily an indicator of high quality, but may rather reflect supply-side considerations such as high production costs. The estimates also control for selection bias, such that only higher-priced items are shipped to far-away destinations.

Average country-level quality is strongly correlated with income per capita. Further, quality upgrading is particularly rapid during the early stages of development, until a country reaches a GDP per capita of about $10,000. Convergence in export quality continues at a slower pace until GDP per capita reaches $20,000, and levels off thereafter.

Substantial cross-country differences in the pace of quality upgrading suggest that policies may have a significant impact. At the regional level, product quality in Sub-Saharan Africa and South Asia is lower, and has been growing more slowly, than in East Asia. But there is considerable heterogeneity within regions, with quality rising far more rapidly in Ghana or Uganda than in Côte d'Ivoire or Cameroon.

Analysis of countries' position on sectoral quality ladders shows that some middle-income countries that have increased quality sharply in the past, such as Malaysia and to a lesser extent China, may now have less scope left to upgrade quality within existing export sectors. These countries may profit from horizontal diversification, which would also enable future upgrading. Other countries, such as Tanzania or Vietnam, still have considerable quality-upgrading potential within existing export sectors.

Diversification and quality upgrading can thus be thought of as complementary. Removing barriers to entry into new sectors could boost growth in many developing countries by increasing the potential for future quality upgrading. Sectors with long "quality ladders" may hold particular potential given our finding that, within any given product line, quality converges across countries over time at a rapid pace. Importantly for

[39] Both indexes are scaled to vary from zero to unity. The domestic financial liberalization index is an average of six sub-indexes. The first five refer to the banking system and cover: (i) credit controls, such as subsidized lending and directed credit; (ii) interest rate controls, such as floors or ceilings; (iii) competition restrictions, such as entry barriers and limits on branches; (iv) the degree of state ownership; and (v) the quality of banking supervision and regulation. The sixth sub-index relates to securities markets: it captures the extent of legal restrictions on the development of domestic bonds and equity markets, and the existence of independent regulators. The capital account openness index measures a broad set of restrictions on financial transactions for residents and non-residents, as well as the use of multiple exchange rates. See Prati et al. (2013) and Abiad et al. (2010) for details.

[40] In this case the non-overlapping time periods are 1973–81, 1982–91, 1992–2001, and 2002–2010.

low-income countries, there is also substantial potential for quality upgrading in agriculture, where large parts of their labor force are concentrated.

Both economies' policies and underlying characteristics affect the speed of quality upgrading, with an impact that varies across sectors. Institutional quality and trade liberalization are important for quality upgrading in both manufacturing and agriculture. FDI inflows are associated with quality upgrading in manufacturing as well as in natural resources, while increased education mainly promotes quality upgrading in manufacturing. However, the impact of these policies is quantitatively small relative to the impact of quality convergence. We find no evidence that lack of demand for quality in a country's existing destination markets on average constrains quality upgrading.

Finally, there is much country- and product-level heterogeneity in the pace of quality upgrading, even controlling for a wide range of observables. Future research should focus on identifying more clearly the drivers of this heterogeneity.

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Table 1. Imports: quality-augmented gravity equations

	In percent of SITC 4-digit-plus sectors				Median coefficient value	
	Positive Coefficients		Negative Coefficients			
	Significant	Insignificant	Significant	Insignificant	This paper	Hallak (2006)
Common preferential trade agreement	82	9	6	3	0.45	0.38
Colonial relationship	80	11	6	3	0.43	0.79
Common colonizer	50	20	16	14	0.20	0.29
Common language	71	14	9	5	0.28	0.53
Common border	82	9	6	3	0.38	0.33
Ln (distance)	6	8	10	76	-1.02	-1.04
Ln (distance) * Ln (importer GDP per capita)	61	14	10	16	0.04	-0.02
Ln (exporter GDP per capita)* Ln (importer GDP per capita)	90	5	4	2	0.10	0.08
Ln (unit value) * Ln (importer GDP per capita)	238	82	438	93	-0.01	0.19

Note: All equations estimated using two stage least squares.

Table 2. Quality growth: summary statistics of data

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Growth Rate of Quality	0.001268	0.089368	-5.608547	5.964081
Ln Initial Quality	-0.201023	0.280277	-8.454018	1.044727
Ln Initial GDP per capita	7.723025	1.585803	3.565800	11.626510
Initial Institutional Quality	2.080978	14.636410	-88	7
Initial Human Capital	19.153060	13.310290	0.027734	69.751091
Initial Trade Lib. Index	0.715041	0.231503	0	1
Initial Agricultural Lib. Index	0.471090	0.382185	0	1
FDI inflows as % of GDP	2.362129	4.948364	-34.756802	136.193100
Initial Domestic Fin. Lib. Index	0.520379	0.298308	0	1
Initial Ext. Capital Account Lib.	0.599943	0.373698	0	1

Note: The annualized growth rate of (product) quality is expressed in annualized natural units. The indexes of liberalization of trade, agriculture, the domestic financial sector, and the external capital account are *de jure* indicators that range between 0 and 1, with higher values corresponding to greater liberalization (see Prati et al., 2013, and Abiad et al., 2010). Institutional quality is proxied by the "Constraints on the Executive" variable from the Polity IV data set. GDP per capita and human capital, as proxied by the secondary-school completion rate, are drawn from the World Bank's *World Development Indicators*. Foreign Direct Investment as a percentage of GDP is drawn from the IMF's *International Financial Statistics*.

Table 3. Quality growth & unconditional quality convergence: panel regressions

Fixed effects	None	Country	Country, Product	Basic Spec. 1/	Country-Prod.	Extended Spec. 2/
Ln(Initial Quality)	-3.49***	-4.38***	-6.33***	-6.33***	-14.5***	-13.3***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.07)	(0.06)
Observations	244,742	244,742	244,742	244,742	244,742	244,742
R-squared	0.0551	0.0710	0.1046	0.1058	0.5494	0.7609

Notes: All equations estimated using observations averaged of 10-year non-overlapping periods. The dependent variables is the annualized growth rate of product quality. *, **, and *** denote statistical significance at the 10 percent, 5 percent and 1 percent level, respectively. All coefficients and standard errors are multiplied by 100 for presentation purposes.
1/ Includes country, product and time fixed effects.
2/ Includes country-product and product-time fixed effects.

Table 4. Determinants of quality growth: panel regressions

	Basic specification 1/			Preferred specification 2/		
	Manufacturing	Agriculture	Natural Res.	Manufacturing	Agriculture	Natural Res.
Ln(Initial Quality)	-7.22***	-6.62***	-5.72***	-13.9***	-13.9***	-13.4***
	(0.07)	(0.11)	(0.20)	(0.12)	(0.17)	(0.34)
Ln(Initial GDP p.c.)	0.0508	-0.0059	-0.167	0.319***	0.355***	-0.0626
	(0.0400)	(0.0011)	(0.190)	(0.0305)	(0.0877)	(0.1560)
Initial Institutional Quality	0.0018	0.0056*	0.0087	0.0048***	0.0077***	0.0048
	(0.0013)	(0.0031)	(0.0058)	(0.0009)	(0.0023)	(0.0046)
Initial Human Capital	0.0000	0.0000	-0.0070	0.0059***	0.0053	-0.0071
	(0.0027)	(0.0071)	(0.0127)	(0.0018)	(0.0050)	(0.0094)
Initial FDI inflows	0.0076***	0.0145**	-0.0131	0.0062**	0.0070	0.0596***
	(0.0027)	(0.0071)	(0.0134)	(0.0028)	(0.0073)	(0.0152)
Initial Trade Lib.	0.2090**	0.7360***	-0.0351	0.3950***	0.8000***	0.2390
	(0.0009)	(0.2490)	(0.4230)	(0.0657)	(0.1890)	(0.3440)
Initial Agric. Lib.		0.3220*			0.0435	
		(0.179)			(0.1380)	
Observations	98,746	29,802	8,365	98,746	29,802	8,365
R-squared	0.115	0.144	0.146	0.838	0.839	0.834

Notes: All equations estimated using observations averaged of 10-year non-overlapping periods. The dependent variables is the annualized growth rate of product quality. *, **, and *** denote statistical significance at the 10 percent, 5 percent and 1 percent level, respectively. All coefficients and standard errors are multiplied by 100 for presentation purposes.
1/ Includes country, product and time fixed effects.
2/ Includes country-product and product-time fixed effects.

Table 5. Robustness I: varying the time window for calculating quality growth

	Cross-section 1/			5-year non-overlapping windows 2/		
	Manufacturing	Agriculture	Natural Res.	Manufacturing	Agriculture	Natural Res.
Ln(Initial Quality)	-5.04***	-5.02***	-4.67***	-20.3***	-22.6***	-22.2***
	(0.12)	(0.16)	(0.47)	(0.11)	(0.19)	(0.35)
Ln(Initial GDP p.c.)	0.0933	-0.0103	0.1640	0.4940***	0.6880***	0.0778
	(0.0598)	(0.1610)	(0.3440)	(0.0317)	(0.1070)	(0.1780)
Initial Institutional Quality	0.0012	0.0027	-0.0047	0.0017**	0.0140***	-0.0002
	(0.0022)	(0.0055)	(0.0105)	(0.0007)	(0.0025)	(0.0041)
Initial Human Capital	0.0011	0.0215	0.0327	0.0106***	0.0104	-0.0136
	(0.0064)	(0.0164)	(0.0375)	(0.0020)	(0.0064)	(0.0113)
Initial FDI inflows	0.0033	-0.0078	-0.0127	-0.0059**	0.0021	-0.0011
	(0.0052)	(0.0097)	(0.0249)	(0.0026)	(0.0081)	(0.0140)
Initial Trade Lib.	0.0458	0.3500	-0.6120	0.2020***	0.7890***	0.6090*
	(0.162)	(0.4040)	(0.9080)	(0.0628)	(0.2180)	(0.3640)
Initial Agric. Lib.		0.7340**			0.1830	
		(0.2850)			(0.1610)	
Observations	17,632	4,138	1,479	152,022	46,126	12,798
R-squared	0.147	0.282	0.292	0.739	0.717	0.724

Notes: The dependent variable is the annualized growth rate of product quality. *, **, and *** denote statistical significance at the 10 percent, 5 percent and 1 percent level, respectively. All coefficients and standard errors are multiplied by 100 for presentation purposes.
1/ Includes country and product fixed effects.
2/ Includes country-product and product-time fixed effects.

Table 6. Robustness II: adding financial openness variables

	Manufacturing	Agriculture	Natural Res.
Ln(Initial Quality)	-14.9***	-14.4***	-15.1***
	(0.13)	(0.19)	(0.40)
Ln(Initial GDP p.c.)	0.3400***	0.3540***	-0.1080
	(0.0378)	(0.1030)	(0.1940)
Initial Institutional Quality	0.0049***	0.0059**	0.0036
	(0.0011)	(0.0028)	(0.0051)
Initial Human Capital	0.0107***	0.0040	0.0033
	(0.0021)	(0.0058)	(0.0106)
Initial FDI inflows	0.0087***	-0.0082	0.1270***
	(0.0319)	(0.0079)	(0.0173)
Initial Trade Lib.	0.6870***	1.0300***	0.5530
	(0.0818)	(0.2290)	(0.4240)
Initial Agric. Lib.		-0.0479	
		(0.1740)	
Initial Dom. Financial Lib.	-0.2510**	0.2640	-0.3630
	(0.1020)	(0.2960)	(0.5240)
Initial Ext. Capital Account Lib	-0.1270***	0.1230	-0.2030
	(0.0489)	(0.1430)	(0.2570)
Observations	80,076	25,501	6,802
R-squared	0.858	0.846	0.835

Notes: All equations estimated using observations averaged of 10-year non-overlapping periods and include country-product and product-time fixed effects. The dependent variables is the annualized growth rate of product quality. *, **, and *** denote statistical significance at the 10 percent, 5 percent and 1 percent level, respectively. All coefficients and standard errors are multiplied by 100 for presentation purposes.

Appendix Table A.1. Full sample regressions covering all sectors

Sets of Fixed Effects	Country, Product, and Time	Country and Product-Year	Country-Product and Year	Country-Product and Product-Year
Ln(Initial Quality)	-6.56***	-5.49***	-15.5***	-13.8***
	(0.06)	(0.05)	(0.11)	(0.09)
Ln(Initial GDP p.c.)	0.0050	-0.0800**	0.4490***	0.3220***
	(0.0471)	(0.0399)	(0.0452)	(0.0354)
Initial Institutional Quality	0.0028**	0.0017	0.0068***	0.0058***
	(0.0013)	(0.0011)	(0.0012)	(0.0009)
Initial Human Capital	-0.0015	0.0028	0.0034	0.0064***
	(0.0029)	(0.0024)	(0.0027)	(0.0020)
Initial FDI inflows	0.0076**	0.0088***	0.0105***	0.0108***
	(0.0030)	(0.0029)	(0.0033)	(0.0031)
Initial Trade Lib.	0.4650***	0.4240***	0.6660***	0.5670***
	(0.1040)	(0.0877)	(0.0995)	(0.0768)
Initial Agric. Lib.	0.1000	0.1660**	-0.1080	-0.1090*
	(0.0759)	(0.0646)	(0.0740)	(0.0579)
Observations	112,010	112,010	112,010	112,010
R-squared	0.123	0.545	0.610	0.847

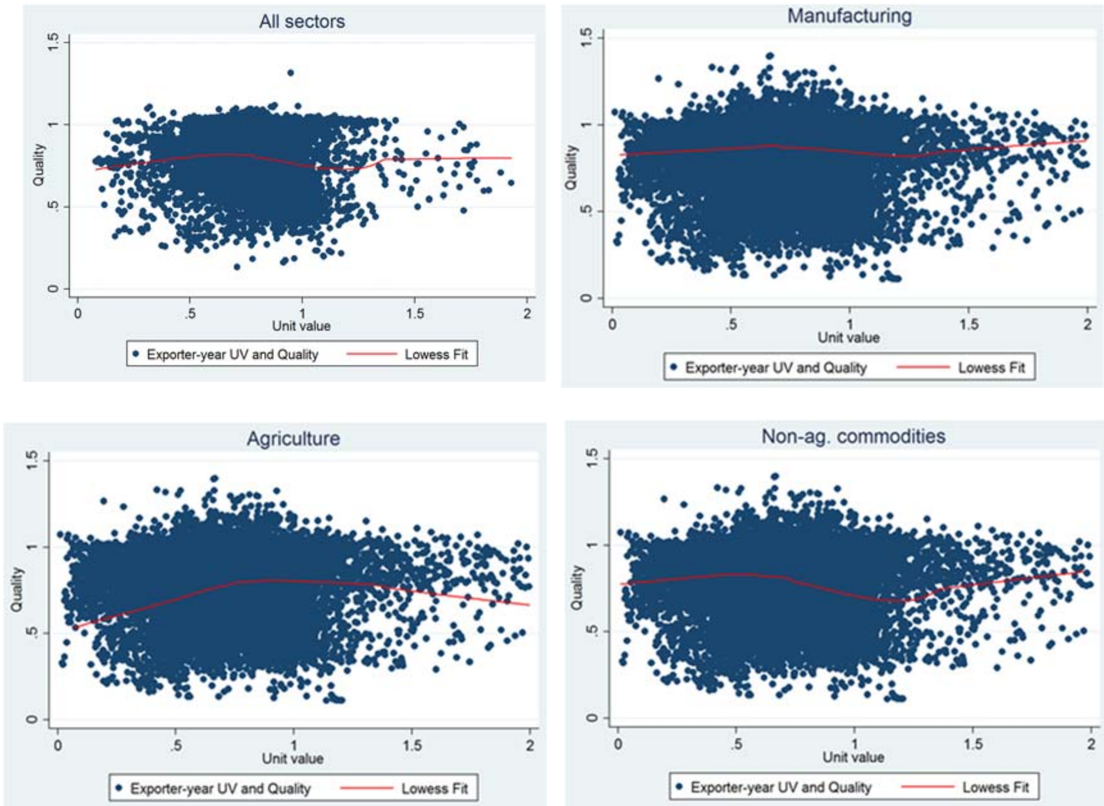
Notes: All equations estimated using observations averaged of 10-year non-overlapping periods. The dependent variables is the annualized growth rate of product quality. *, **, and *** denote statistical significance at the 10 percent, 5 percent and 1 percent level, respectively. All coefficients and standard errors are multiplied by 100 for presentation purposes.

Appendix Table A.2. Intermediate sets of fixed effects

	Country-Product and Year Fixed Effects			Country and Product-Year Fixed Effects		
	Manufacturing	Agriculture	Natural Res.	Manufacturing	Agriculture	Natural Res.
Ln(Initial Quality)	-17.2***	-15.0***	-13.5***	-5.70***	-5.65***	-5.29***
	(0.13)	(0.18)	(0.36)	(0.06)	(0.09)	(0.20)
Ln(Initial GDP p.c.)	0.5080***	0.4990***	0.0116	-0.0649*	-0.1170	-0.2210
	(0.0399)	(0.1070)	(0.1810)	(0.0337)	(0.1000)	(0.1880)
Initial Institutional Quality	0.0061***	0.0092***	0.0142***	0.0091	0.0037	0.0005
	(0.0012)	(0.0028)	(0.0053)	(0.0011)	(0.0027)	(0.0058)
Initial Human Capital	0.0042*	0.0056	-0.0123	0.0017	0.0031	-0.0037
	(0.0025)	(0.0064)	(0.0113)	(0.0021)	(0.0060)	(0.0122)
Initial FDI inflows	0.0072**	0.0148*	-0.0129	0.0072***	0.0057	0.0409**
	(0.0031)	(0.0077)	(0.0129)	(0.0026)	(0.0070)	(0.0164)
Initial Trade Lib.	0.5530***	0.9320***	0.2080	0.1730**	0.5930***	-0.0378
	(0.0884)	(0.2320)	(0.4000)	(0.0741)	(0.2180)	(0.4200)
Initial Agric. Lib.		0.1970			0.3080**	
		(0.1700)			(0.1570)	
Observations	98,746	29,802	8,365	98,746	29,802	8,365
R-squared	0.577	0.634	0.656	0.540	0.510	0.380

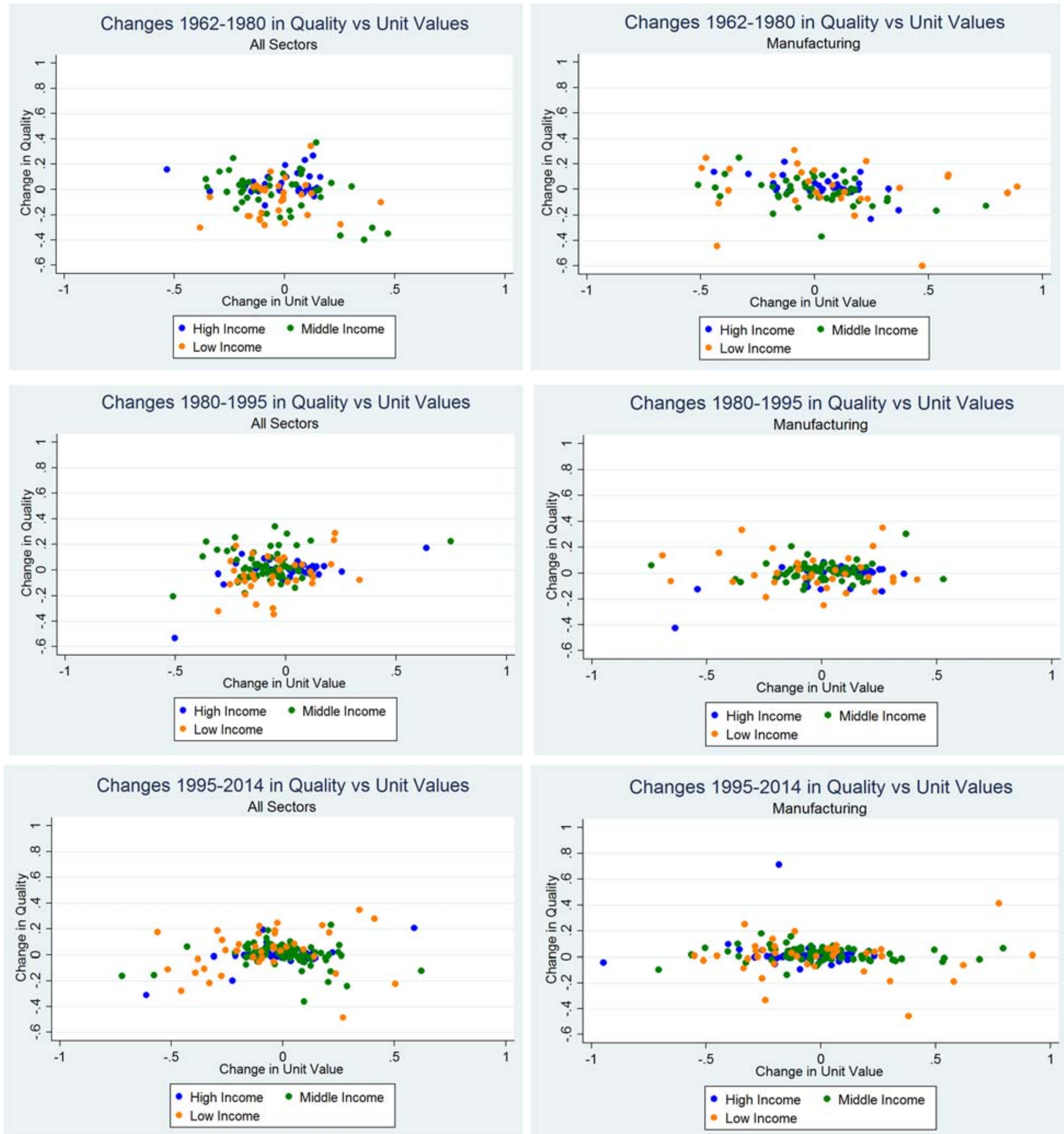
Notes: All equations estimated using observations averaged of 10-year non-overlapping periods. The dependent variables is the annualized growth rate of product quality. *, **, and *** denote statistical significance at the 10 percent, 5 percent and 1 percent level, respectively. All coefficients and standard errors are multiplied by 100 for presentation purposes.

Figure 1. Quality and unit values



Note: Each dot depicts an exporter-year combination. The 90th percentile is set to unity for both unit values and quality observations.

Figure 2. Changes in quality, and changes in unit values



Note: Each dot depicts one exporter.

Figure 3. Quality and unit values for passenger motor car exports (SITC 7321)

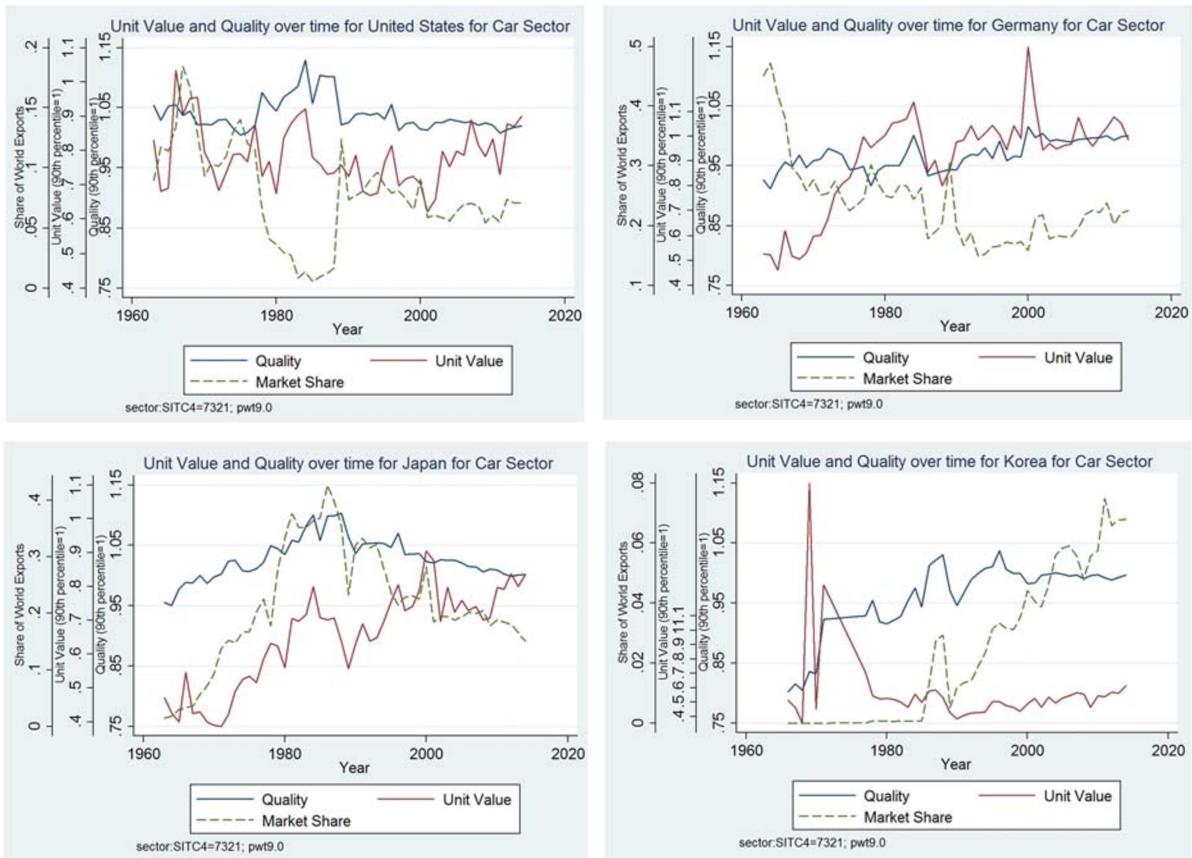


Figure 4. Quality and unit values for apparel exports (SITC 84)

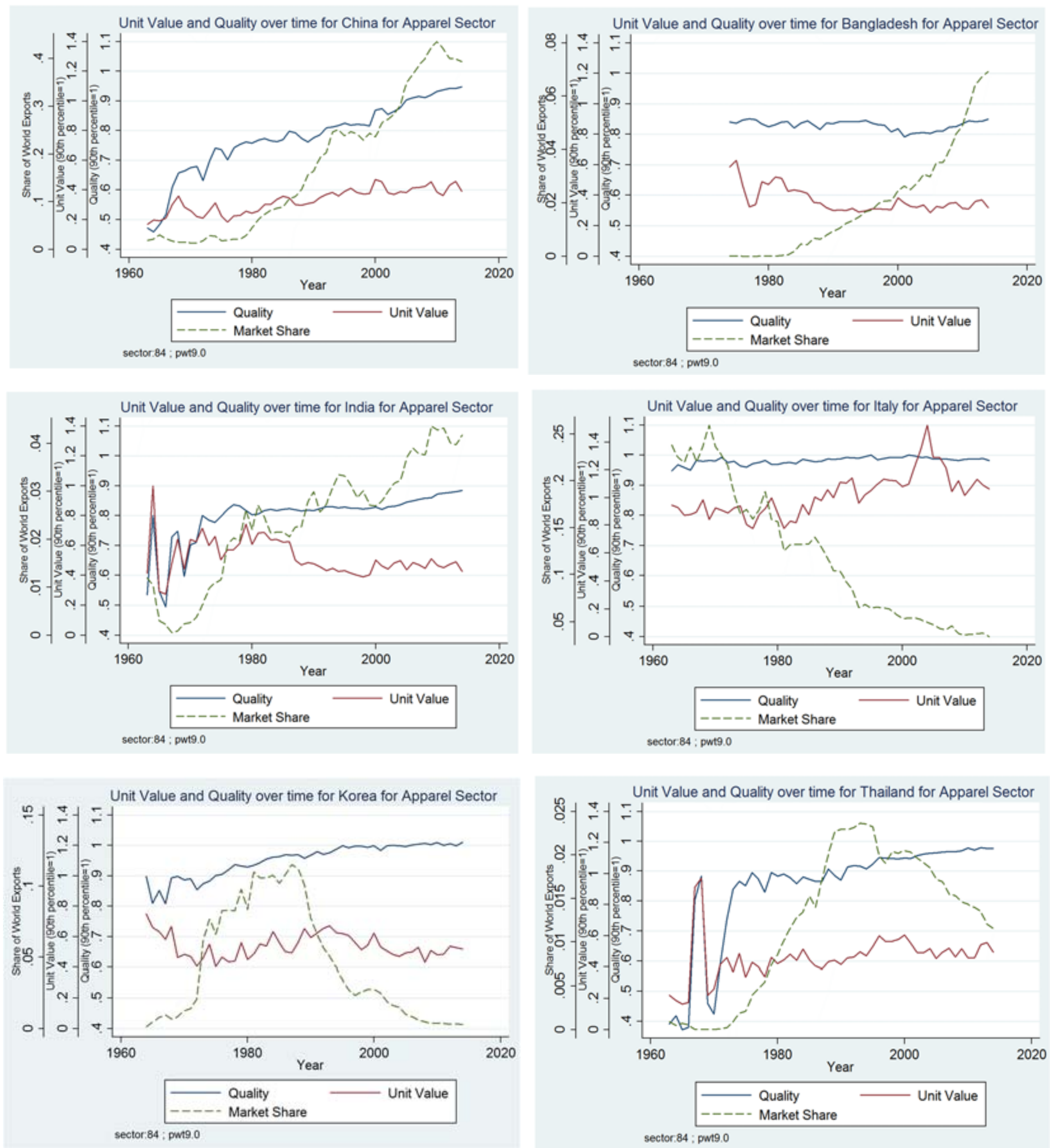


Figure 5. Quality, unit values, and GDP per capita

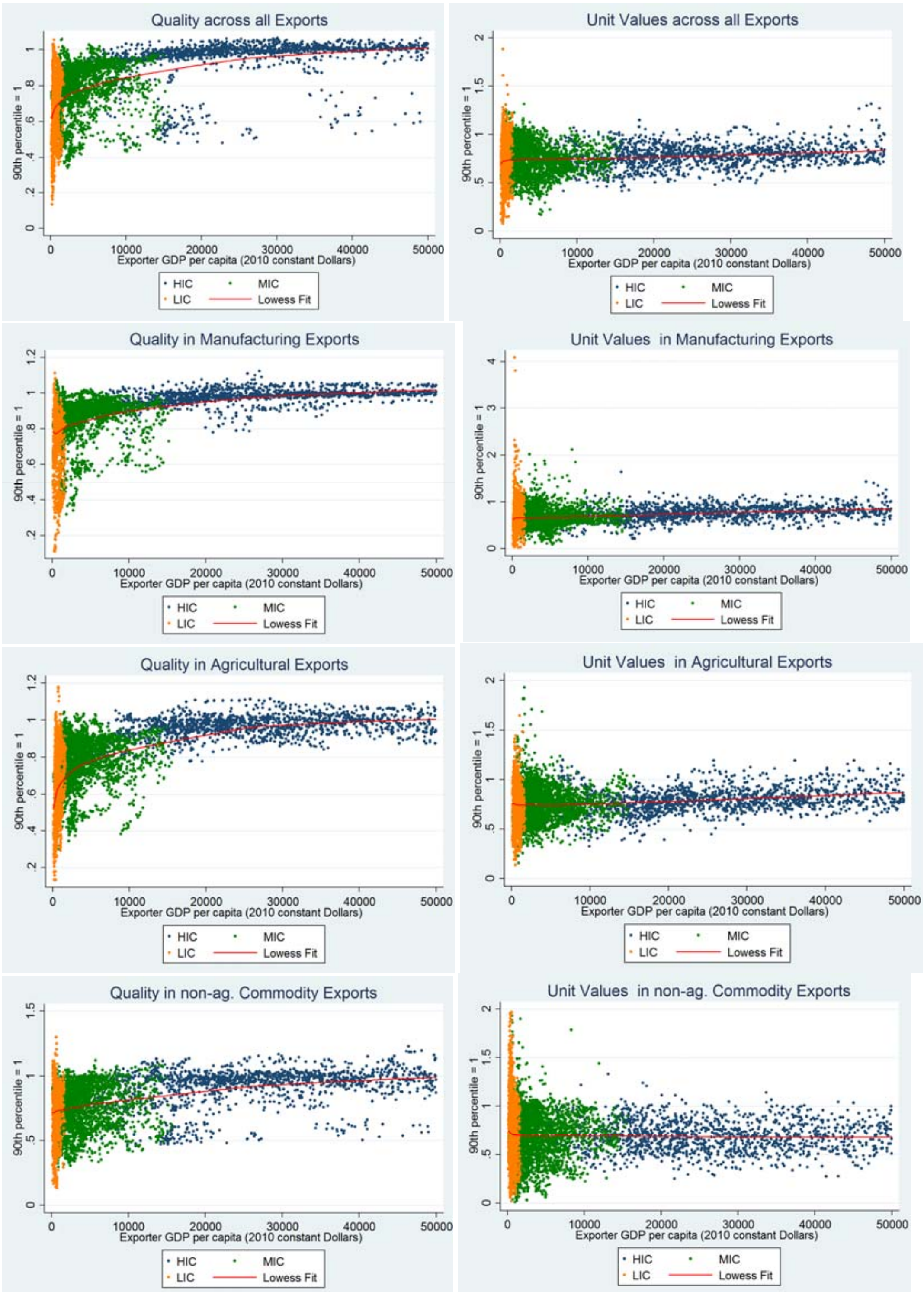


Figure 6. Quality, unit values, and GDP per capita: small states and commodity exporters

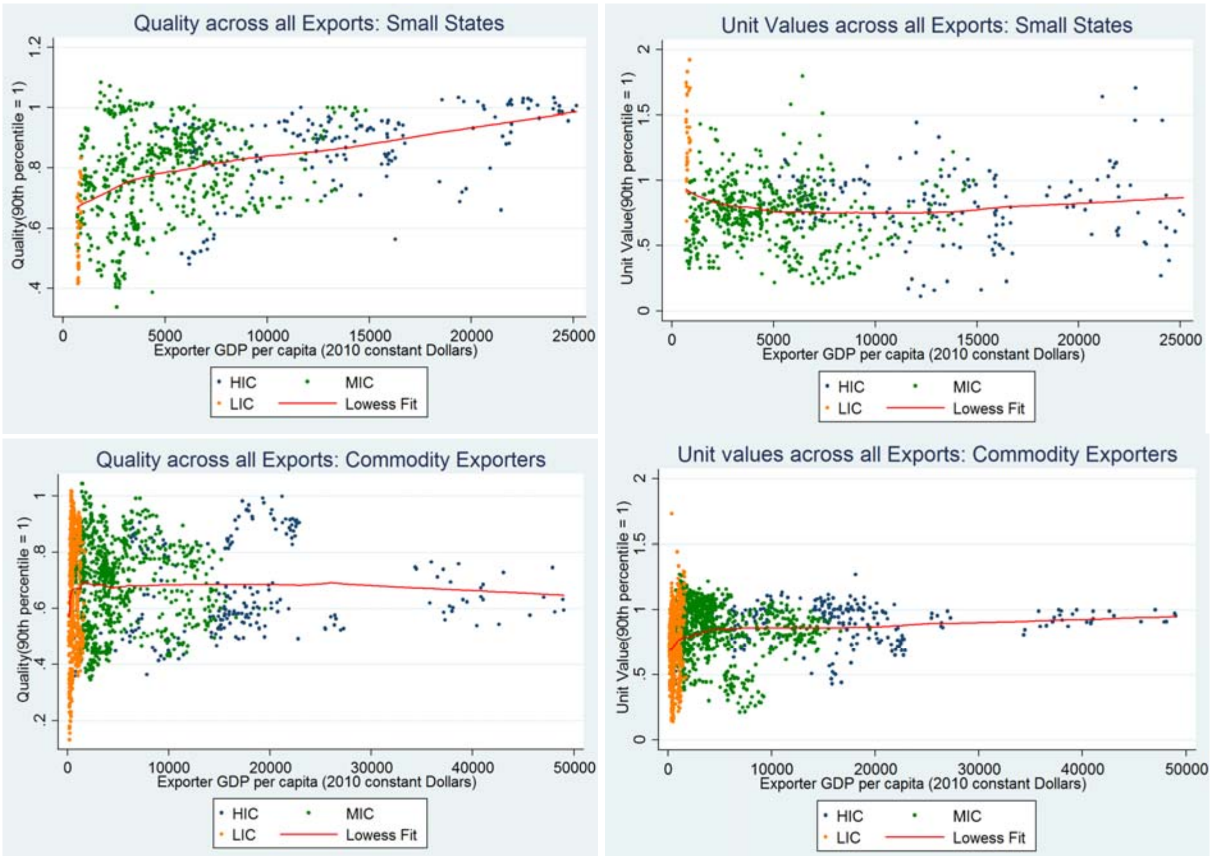


Figure 7. Quality in selected agricultural and manufacturing sectors

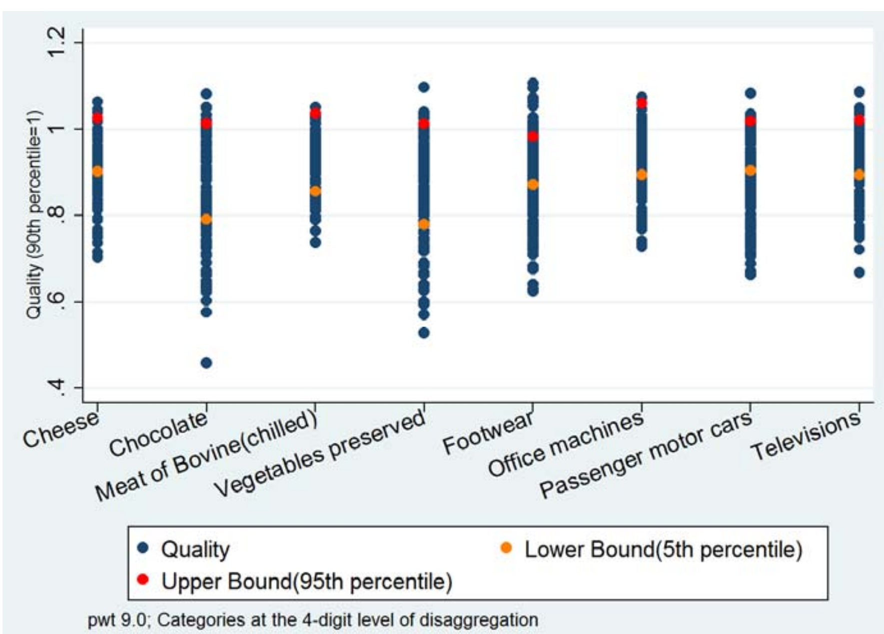


Figure 8. Quality ladders: China, Malaysia, Tanzania, and Vietnam

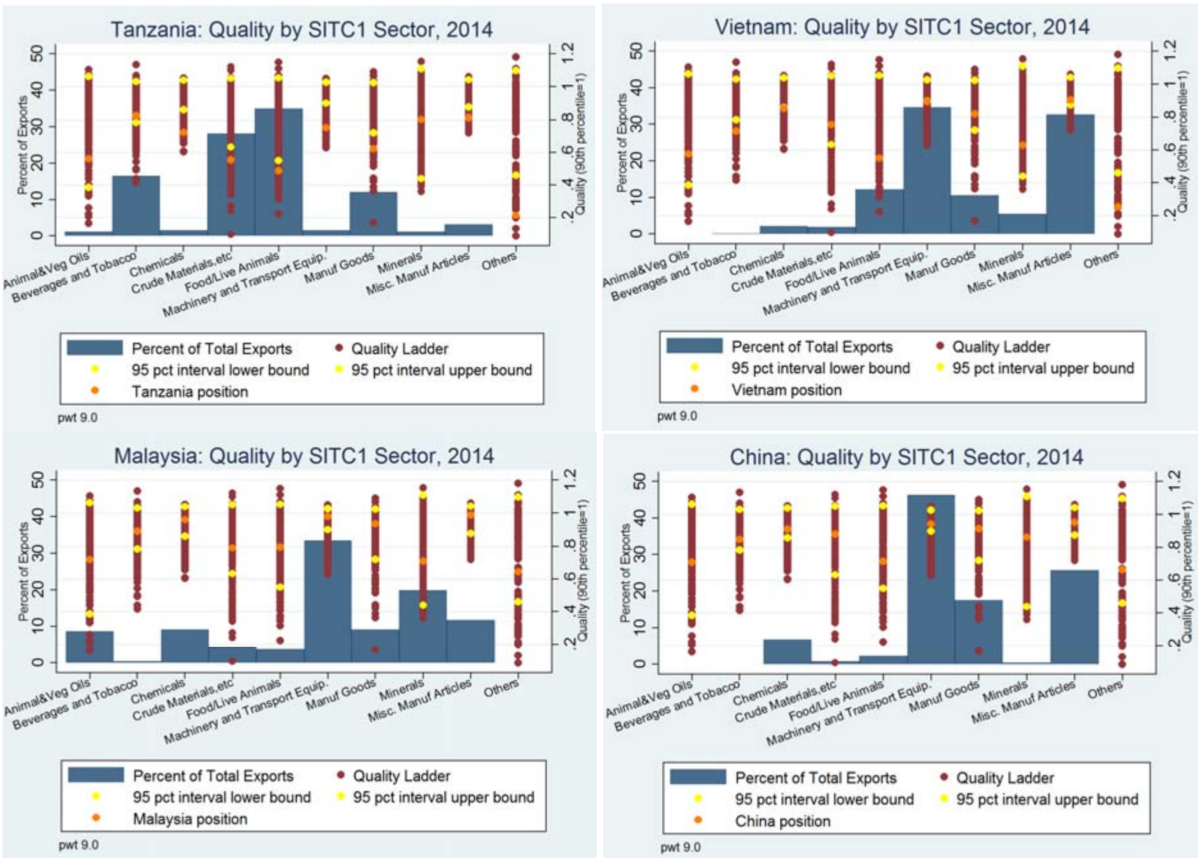


Figure 9. Export quality by income group over time

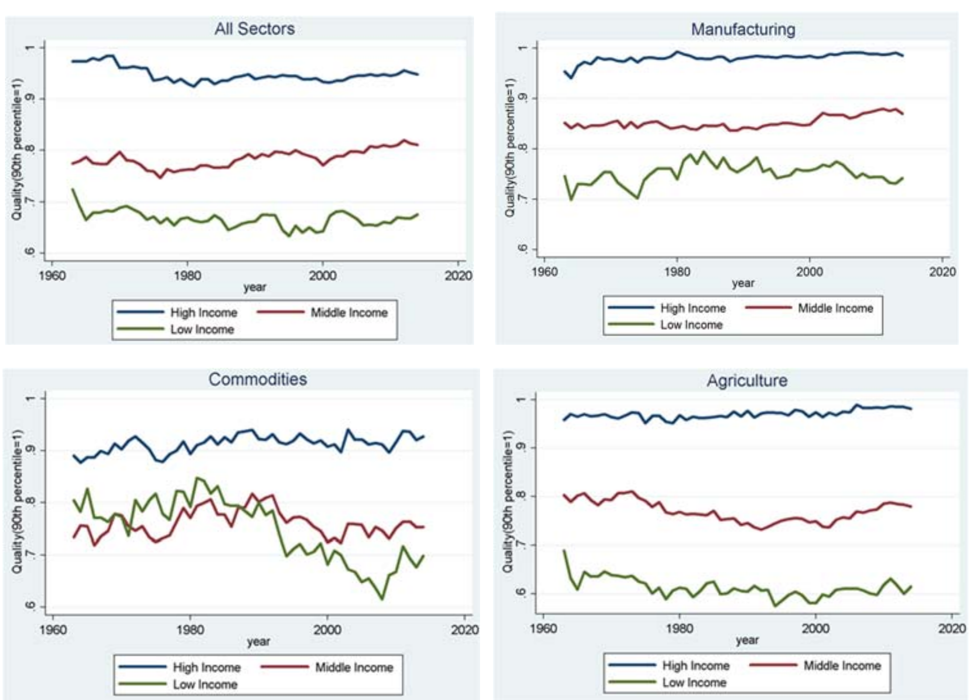


Figure 10. Export quality by region

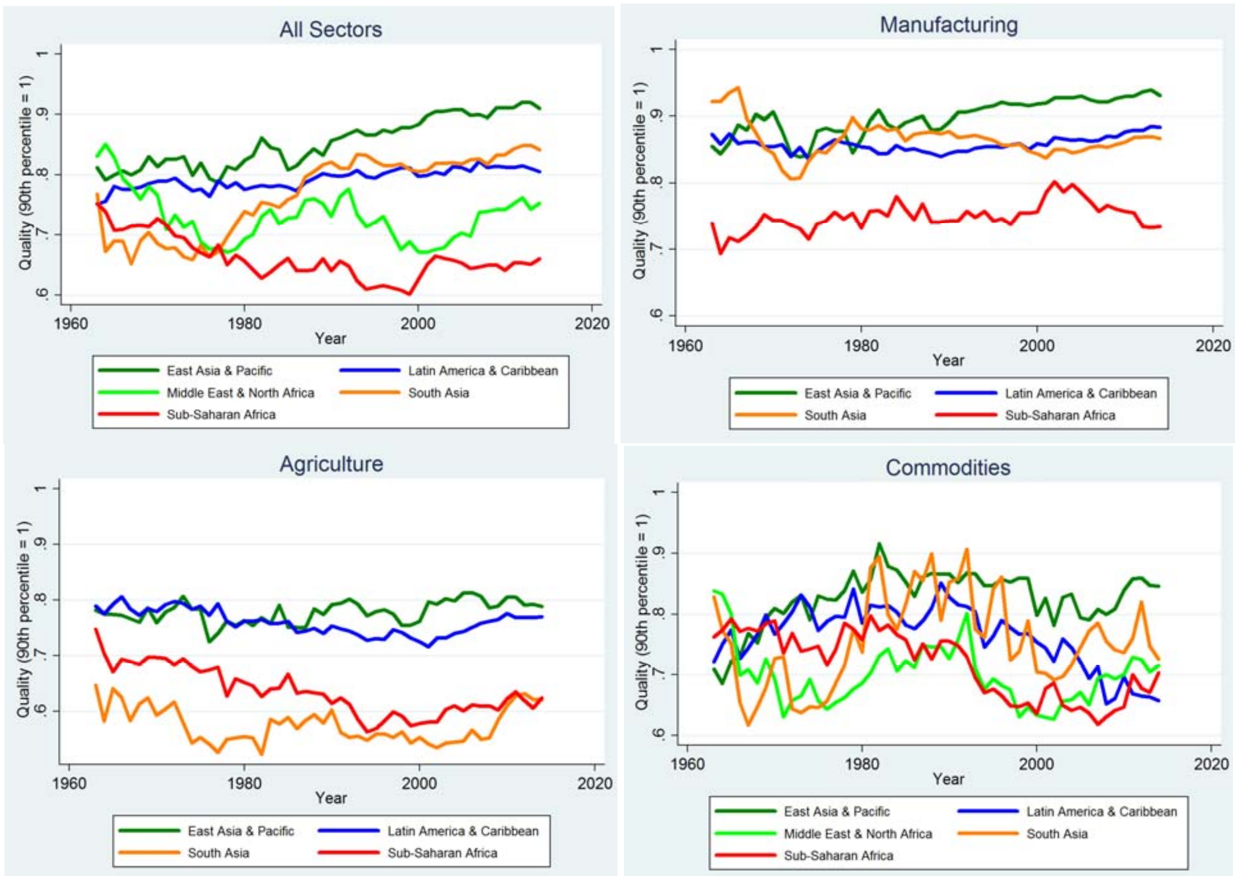


Figure 11. Country-level heterogeneity in quality upgrading in Asia and Africa

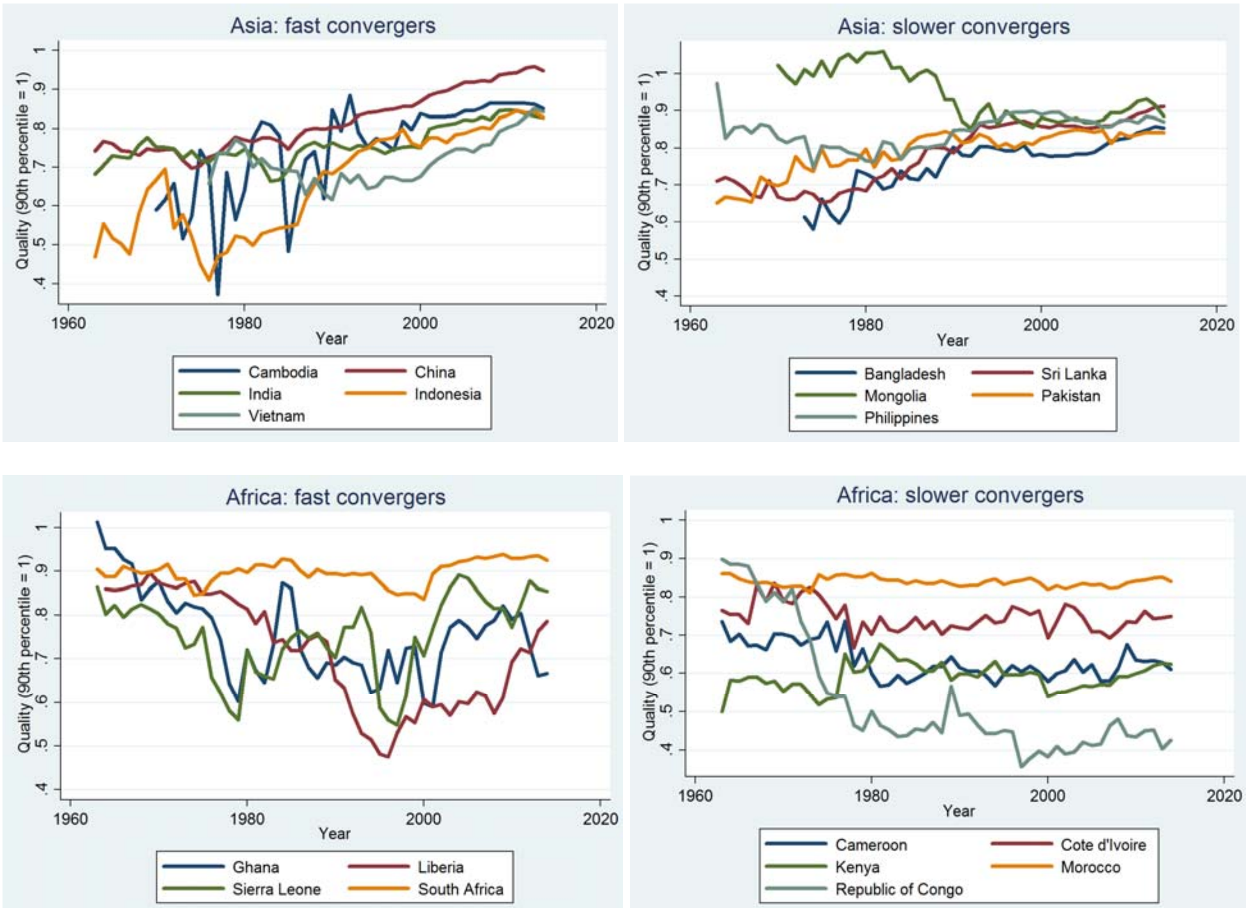


Figure 12. Quality upgrading and destination markets, by country group

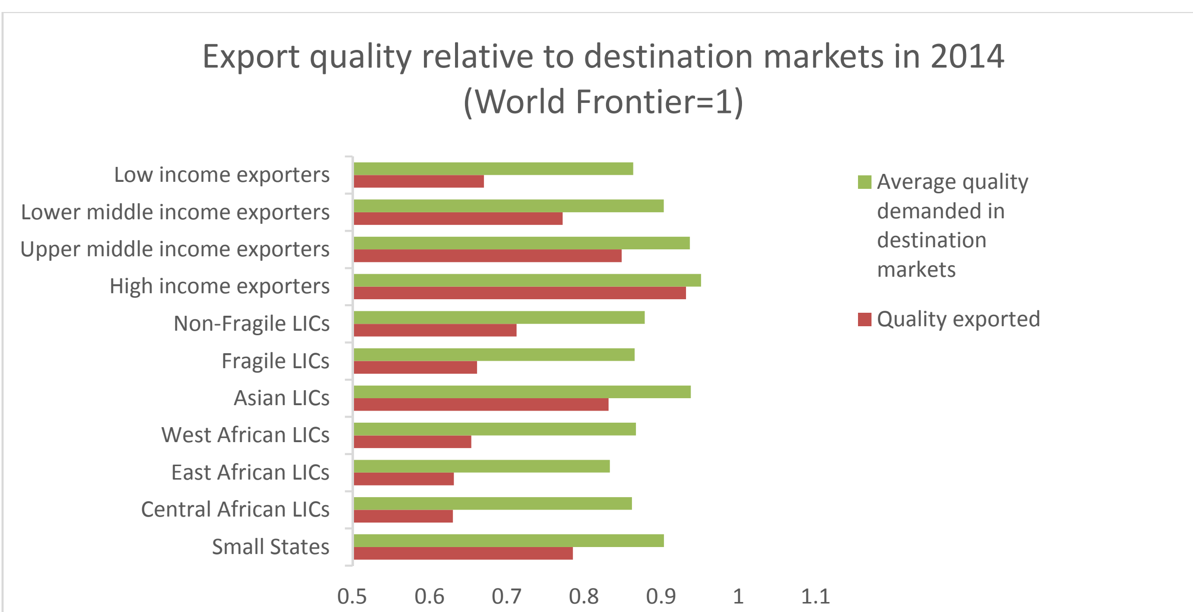


Figure 13. Quality upgrading and destination markets, for fast and slower quality convergers among low-income and lower middle-income countries

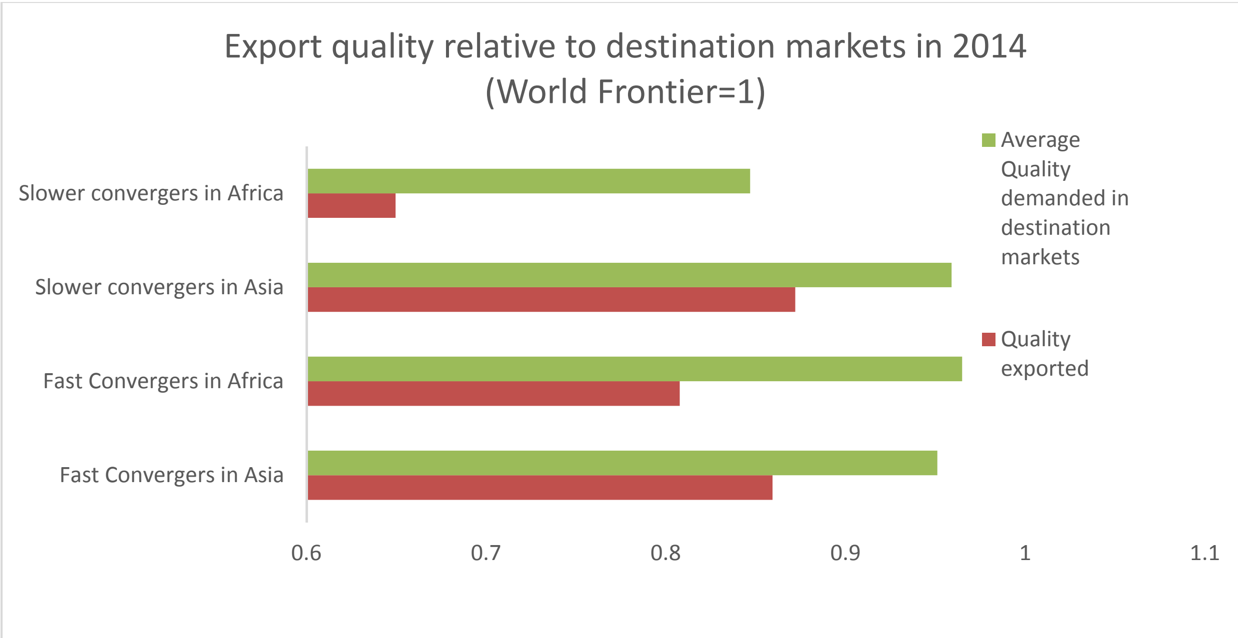


Figure 14. Quality and unit values for passenger motor car imports (SITC 7321)

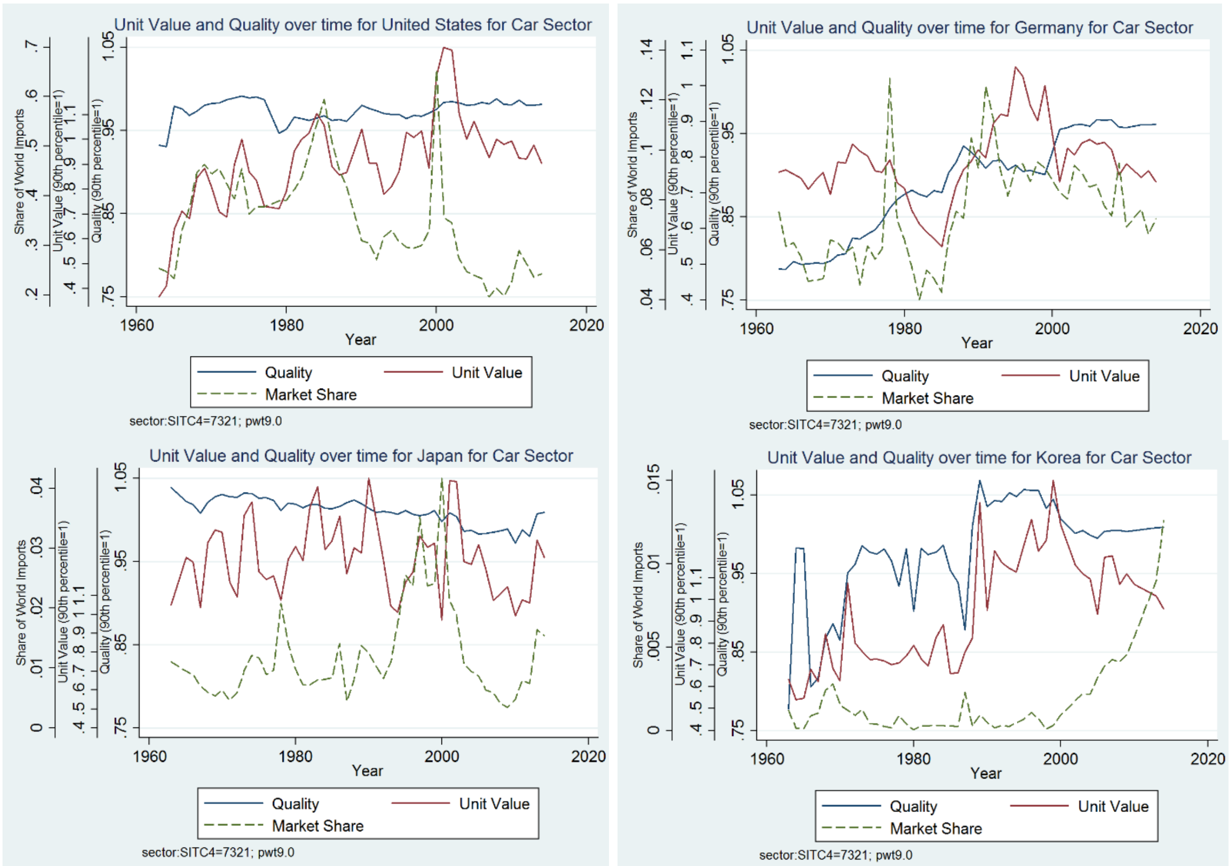


Figure 15. Quality and unit values for apparel imports (SITC 84)

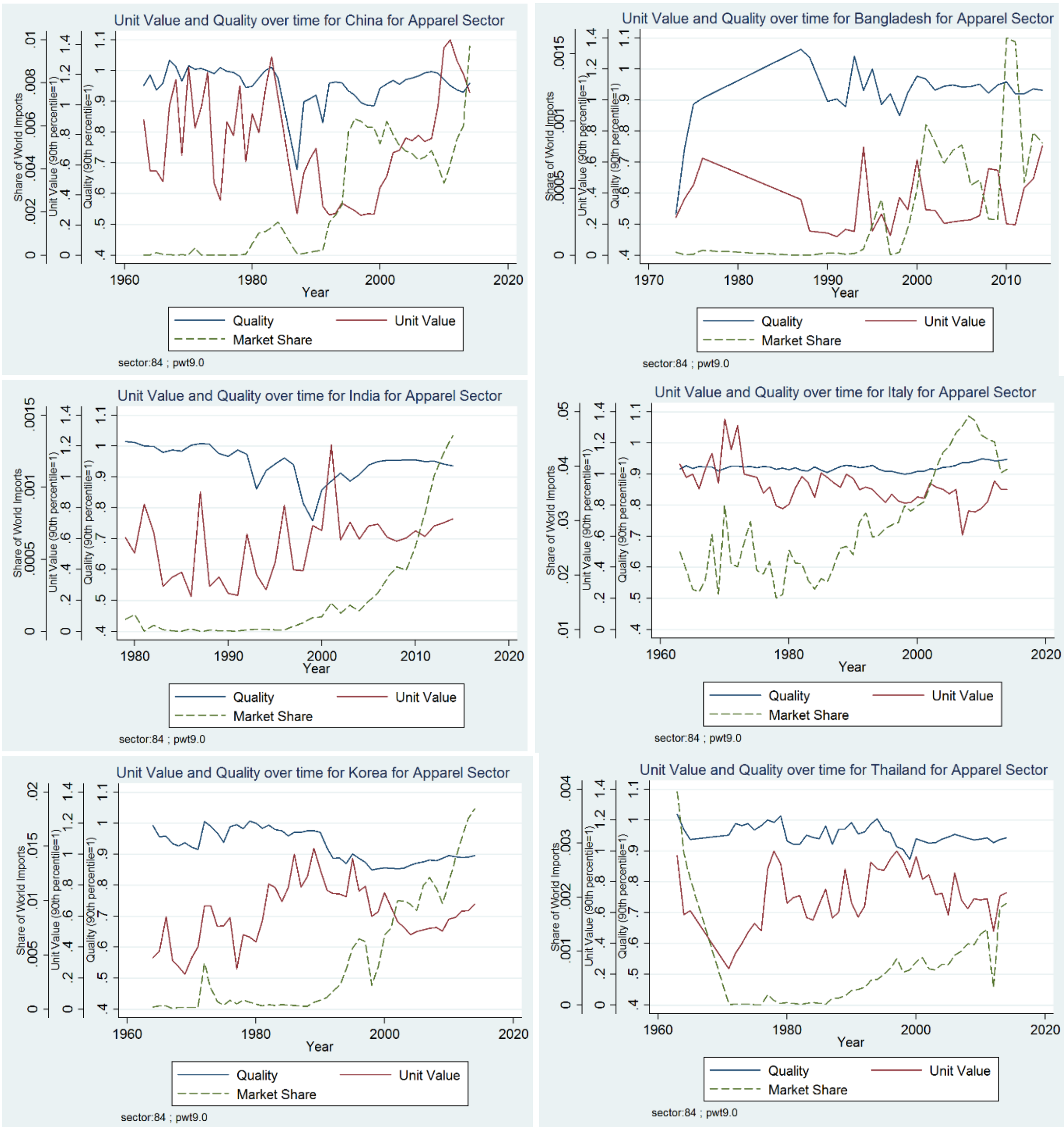


Figure 16. Import quality, unit values, and GDP per capita

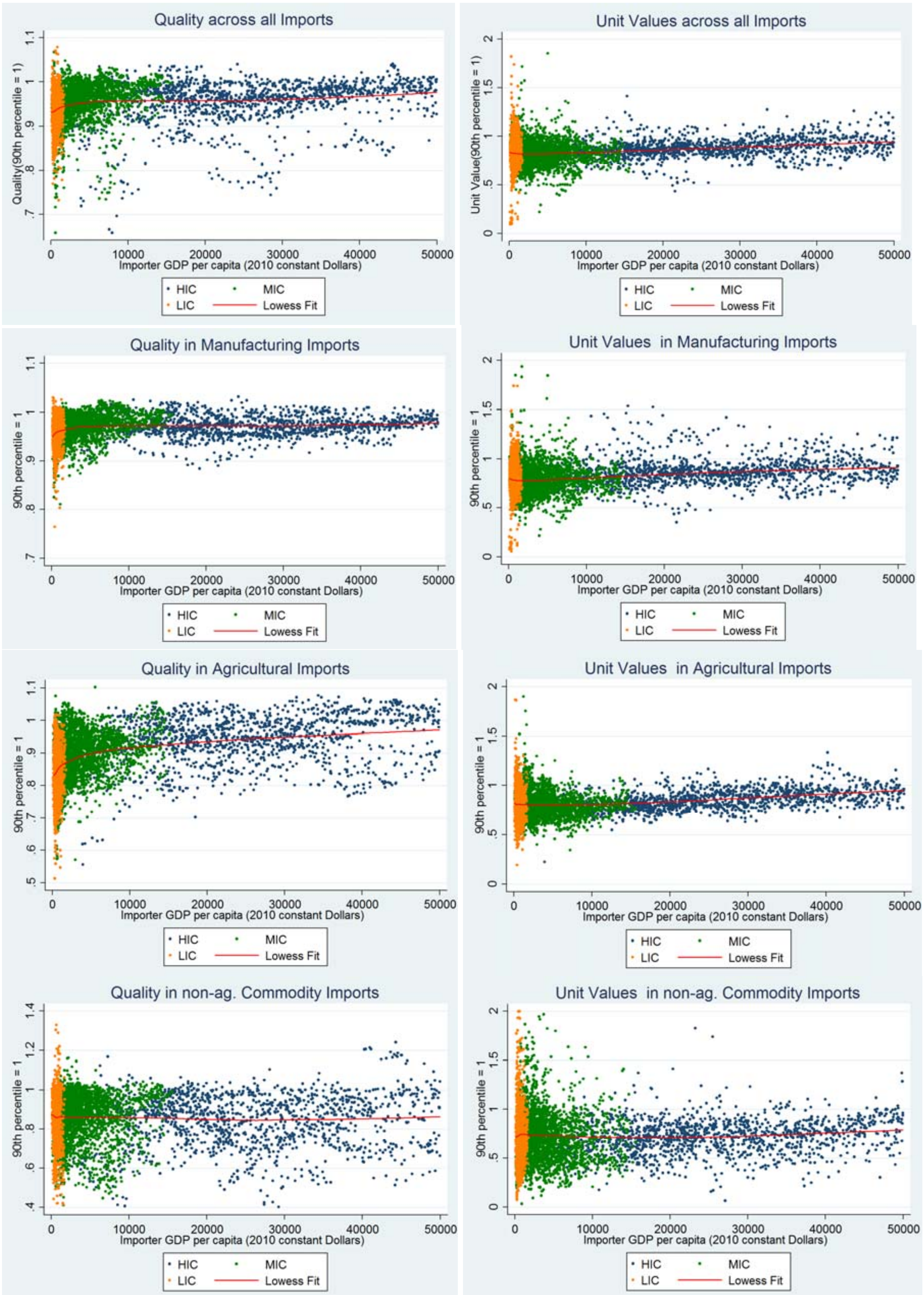


Figure 17. Import quality by income group over time

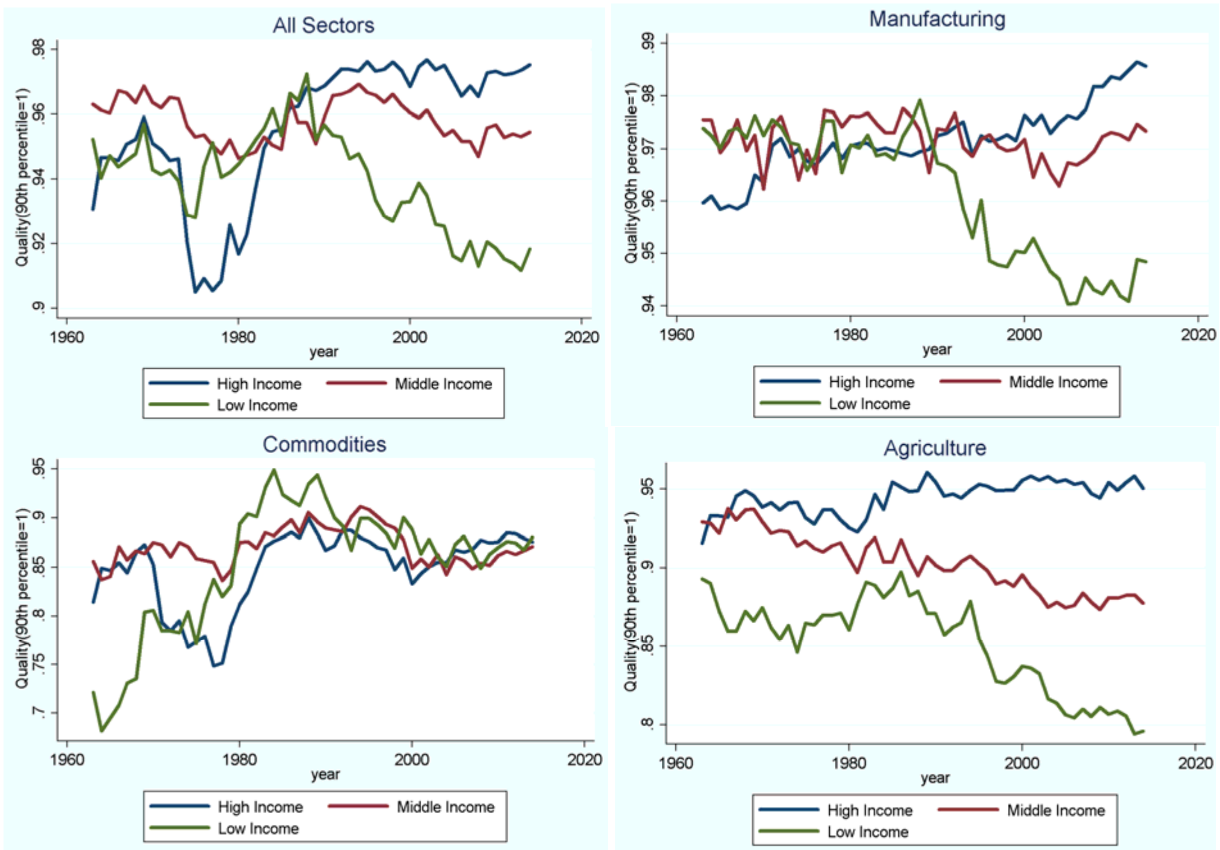


Figure 18. Import quality by region

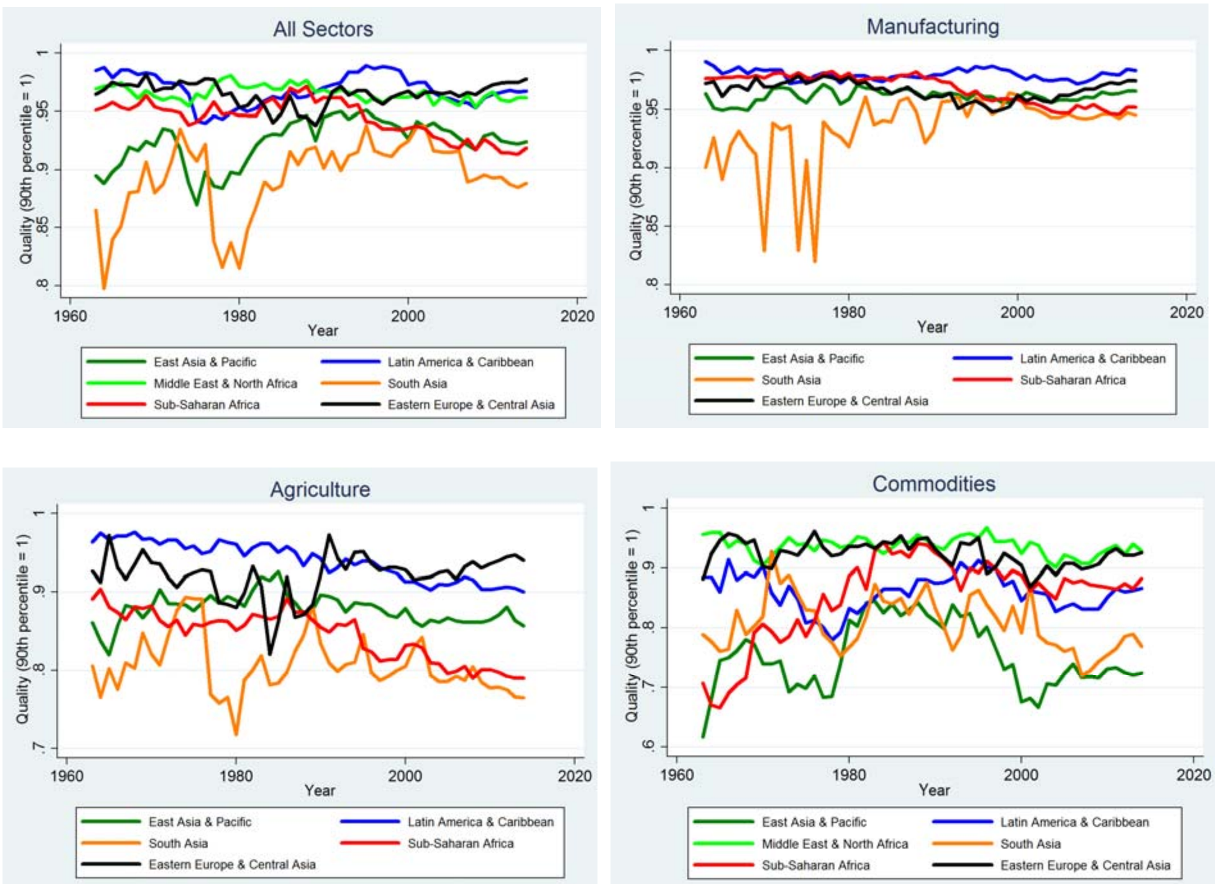


Figure 19. Unconditional quality convergence