

# Diversification, Growth, and Volatility in Asia

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## Abstract

Economic development critically involves diversification and structural transformation—that is, the continued, dynamic reallocation of resources from less productive to more productive sectors and activities. This paper documents that, over an extended period, developing Asia has on average been particularly successful in diversifying its exports, particularly in comparison with Sub-Saharan Africa. Much of the progress has occurred through diversification along the ‘extensive margin,’ that is, through

entry into completely new products. In addition, developing Asia has on average benefited significantly from quality upgrading, helping it capitalize on already existing comparative advantages. Yet, agricultural and natural resources tend to have lower potential for quality upgrading than manufactures. Therefore, for lower-income “frontier” countries, diversification into products with longer “quality ladders” may be a necessary first step before large gains from quality improvement can be reaped.

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# Diversification, Growth, and Volatility in Asia

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## I. INTRODUCTION

Limited diversification in exports and broader economic structure has long been an underlying characteristic of many developing economies. Yet some have shown a remarkable economic transformation, especially over the past two decades. In particular, it has been argued that developing Asia has benefited significantly from diversification. This paper examines the claim with a comprehensive look at the facts, employing newly developed data sets covering diversification in both external trade and domestic production.

The paper focuses on two key questions. First, is diversification crucial to sustaining growth and reducing volatility? Put differently, does concentration in sectors with limited scope for productivity growth and quality upgrading, such as primary commodities, result in less broad-based and sustainable growth? And does lack of diversification increase exposure to adverse external shocks and macroeconomic instability?

Second, what precisely does diversification, in both external trade and the broader domestic economy, involve? How is it linked to broader structural transformation, including the process of quality upgrading? And which countries and regions have been more successful in promoting diversification?

Throughout, our focus is on Asia, and in particular on two groups of countries: “Emerging Asia”, comprising those economies generally classified as emerging markets; and “Frontier Asia”, comprising some economies that are still at lower income levels, but have experienced rapid growth and, in most cases, demonstrated a fair degree of macroeconomic stability over an extended period of time.<sup>2</sup>

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<sup>2</sup> Frontier Asia comprises: Bangladesh, Bhutan, Cambodia, Lao PDR, Maldives, Mongolia, Myanmar, Nepal, Papua New Guinea, and Vietnam. Emerging Asia comprises: China, India, Indonesia, Malaysia, the Philippines, Sri Lanka, and Thailand.

## II. HOW IS DIVERSIFICATION MEASURED?

Measures of economic diversification need to look beyond trade, to capture domestic sector diversification and the underlying dynamic process of structural transformation. *Trade diversification* and *domestic diversification* are in principle interlinked, the former reflecting diversification in the external sector, and the latter capturing diversification in the domestic production process across sectors. An underlying theme of this paper is that focusing on the entire structure of production paints a more comprehensive and illuminating picture. Therefore, the two dimensions of diversification are evaluated simultaneously, filling a gap in the existing literature, which has treated them independently. In addition, the analysis focuses on “diversification spurts,” that is, rapid, sustained, significant spells of diversification.

Trade diversification can be achieved along several dimensions. First, diversification may occur across either products or trading partners. Second, product diversification may occur through the introduction of new product lines (the *extensive* margin), or a more balanced mix of existing exports (*intensive* margin). Finally, product-quality upgrading represents a slightly different notion and is evidenced by higher prices for existing exports. Our main data source for trade is an updated version of the UN–NBER data set, which harmonizes UN COMTRADE bilateral trade flow data at the 4-digit SITC (Rev. 1) level.<sup>3</sup> However, while the existing literature typically focuses on the post-1988 period, this paper uses data extending back to 1962. The extended time dimension turns out to be greatly helpful in examining relationships more comprehensively.

Analysis of domestic diversification in frontier economies required construction of a new data set. This paper examines diversification in sectoral output and the sectoral allocation of labor using data from existing and new sources. Existing data sets include measures of value added for 28 manufacturing sectors, during 1985–2010 (from UNIDO, 2011; 3-digit ISIC classification); and labor employment shares in nine economy-wide sectors, during 1969–2008

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<sup>3</sup> The dataset combines importer- and exporter-reported data from COMTRADE to maximize comprehensiveness, while ensuring internal consistency, using the methodology of Asmundson (forthcoming).

(from ILO, 2011; 1-digit classification). It is well known, however, that both of these data sets are quite limited in their coverage of frontier countries. For this reason, a new data set was constructed, covering 12 economy-wide sectors during 2000–2010, using country data compiled from IMF desk inputs (see below for further discussion).

Appendix I provides greater details on the diversification indices and quality measures employed in this paper. Briefly, diversification is measured using the Theil index, which has the advantage of being decomposable into diversification along the extensive and intensive margins. Lower values of the index indicate *greater* diversification. Quality measures are based on individual products' unit values (that is, trade prices), but with important adjustments for differences in production costs, as well as for selection bias in the composition of international trade. Appendix II sets out a full list of the countries and regions analyzed.

### **III. DIVERSIFICATION, GROWTH, AND VOLATILITY**

We start by examining the evidence on the links between diversification and growth. One result stands out: diversification patterns and growth are clearly related, although the relationship displays much heterogeneity. In particular, greater diversification is on average associated with faster subsequent output growth (Figure 1). The relationship holds both for the sample as a whole, and for Asian countries alone. Adopting a multivariate regression approach, output growth remains significantly associated with both initial diversification and initial product quality measures, even after controlling for a variety of standard growth determinants (Table 1). This conclusion is in line with a large literature, including Singer (1950), Sachs and Warner (1995) on the “natural-resource curse”, and Hausmann and others (2007) on the links between growth and product sophistication.

In a similar vein, diversification spurts (defined as in Papageorgiou and Spatafora, 2012) are associated with sharp subsequent growth accelerations (defined analogously to diversification spurts). This is especially true for non-fragile frontier countries. Conversely, growth accelerations are associated with subsequent increases in diversification among non-fragile frontier countries.

Next, we examine the links between diversification and volatility. Does diversification serve as a buffer against external shocks? Related, are diversification spurts associated with increased macroeconomic stability? The existing literature provides some evidence that countries with more diversified production structures tend to have lower volatility of output, consumption, and investment (Mobarak, 2005; Moore and Walkes, 2010). Further, product diversification can increase the resilience of frontier economies to external shocks (Koren and Tenreyro, 2007).

A key channel is that diversification involves frontier economies shifting resources from sectors where prices are highly volatile and correlated, such as mining and agriculture, to less volatile and correlated sectors, such as manufacturing, resulting in greater stability. And indeed, the data show clearly that output volatility diminishes after diversification spurts (Figure 2).

#### IV. PATTERNS OF DIVERSIFICATION

Having established that diversification is indeed linked with macroeconomic performance, we now examine in greater details patterns of diversification, with a focus on identifying which regions and countries have made greater progress in achieving diversification. Overall, higher income per capita and development are broadly associated with greater **trade diversification** (Figure 3), at least until an economy reaches advanced-economy status (with GDP per capita of \$25,000–\$30,000; see also Cadot and others, 2011). The relationship holds for the sample as a whole. It also holds between and within countries (that is, when the figure is restricted to show the pure cross-sectional or time-series variation); in the latter case, the data set's extended time dimension is critical to confirming the relationship.

At the regional level, Western Europe is the most diversified region. However, Emerging and Frontier Asia have been rapidly catching up (Figure 4). Asia in general shows higher, and more rapidly growing, diversification than Sub-Saharan Africa and MENA countries, although the progress has slowed down after 1995. Increases in diversification have largely occurred along the extensive margin, that is, through entry into completely new products, although there has also been some progress along the intensive margin for Emerging Asia (Figure 5). Also, changes in trade diversification over time have been paralleled by decreases in the relative



importance of agricultural exports, and increases in the relative importance of manufactured exports, especially for Asian countries (Figure 6).

Higher income levels are also associated with increasing diversification across trade partners—at least until advanced-economy status is reached. After 1995, Asia greatly diversified its trade across partners (Figure 7). Frontier economies in general, including in Sub-Saharan Africa, also have made progress in diversifying their exports across partners. The trend is especially clear when considering the extensive margin, with a significant increase in exports to completely new partners. This is related to the ongoing process of globalization and a clear shift in trade away from the European Union and toward Asia, and China in particular (see also Samake and Yang, 2011).

The data also reveal that, within developing countries, greater income per capita is also associated with greater **real-sector diversification**, that is, diversification in the broader domestic economy. During the 2000s, both across all developing countries and within Frontier Asia, analysis of six key sectors shows that there was significant real diversification. In particular, the share of agriculture in output declined significantly. The gap was filled largely by nontradables such as construction, wholesale trade, and transportation, rather than by manufacturing (Figure 8). That said, there is significant cross-country variation, both in the magnitude of the resource shift out of agriculture and in the precise identity of the sectors that have expanded in its place.

## V. PATTERNS OF QUALITY UPGRADING

Economic development is underpinned not just by new products and markets, but also by **quality improvements** to existing products. Producing higher-quality varieties, through the use of more physical- and human-capital intensive production techniques, helps build on existing comparative advantages. It can boost countries' productivity and export revenues.<sup>4</sup> Ongoing work is helping to develop a toolkit to answer key questions, including calculating an

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<sup>4</sup> See Schott (2004) for an early demonstration that product quality varies significantly and systematically across exporters.

economy's export quality and how it has evolved over time, determining the current potential for quality upgrading, and analyzing whether diversification into new products is a prerequisite for further quality upgrading. One robust conclusion is that both Emerging Asia and, more recently, Frontier Asia have on average enjoyed remarkable success in quality upgrading. That said, there remains significant cross-country variation.

Our quality measures are based on individual products' unit values (that is, trade prices). However, these unit values are adjusted to reflect differences in production costs, as well as selection bias in the composition of international trade. Quality estimates at the country level are then constructed as a geometric value-weighted mean of the quality estimates for individual products. For full details, see Appendix I, as well as Henn, Papageorgiou, and Spatafora (forthcoming). Among other benefits, these quality measures smooth much of the artificial volatility often observed in unit values.

The data suggest some clear patterns. Higher incomes per capita are associated with greater export quality at the country level. The relationship holds both across all goods (Figure 9), and (even more clearly) within manufacturing, which has greater scope for differentiation. Quality upgrading is particularly marked as countries evolve from frontier status into middle-income economies.

There is much heterogeneity in quality levels, even when controlling for income per capita. In particular, Emerging Asia has enjoyed immense success in quality upgrading since 1970 (Figure 10), whereas Frontier Asia only began the process in the early 2000s. Sub-Saharan Africa stands out as producing relatively low-quality goods.

Focusing on Asia, some countries have converged or are continuing to converge to the world frontier. In other cases, convergence seems to have slowed since the mid-1990s (Figure 11). Overall, improvements in export quality are associated with growth takeoffs. Hence, Japan converged to the world frontier in the 1970s; the Republic of Korea's convergence occurred between the 1970s and the early 1990s; China started its take-off in the late 1980s, and has since been converging very rapidly; and Vietnam's convergence started in the 1990s. In Malaysia and Thailand, convergence was rapid but appears to have stalled before reaching the

world frontier. India seems to be converging but only slowly. Likewise, Bangladesh's convergence is very slow, particularly given its large catch-up potential.

Crucially, developing countries' potential for quality upgrading does not appear to be limited by low demand for quality in their existing destination markets. Frontier economies do tend to serve markets that import lower-quality products (Figure 12). However, the differences are not substantial enough to act as a constraint on quality upgrading. Indeed, on average, the lower-income the exporter, the greater the gap between its export quality and the average quality of its trade partners' imports. Likewise, in slow-converging countries, 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.

## VI. COUNTRY CASE STUDIES

To obtain robust policy conclusions, it is critical to complement the above cross-country analysis of product diversification and quality upgrading with individual country case studies. To this end, Appendix III provides a more detailed discussion of the experience of Bangladesh, a frontier economy with income per capita well below \$1,000, and Vietnam, a country that has achieved middle-income status. In addition, Pitt et al. (forthcoming) analyze developments in Tanzania, another frontier economy; Angola, the second largest oil exporter in Sub-Saharan Africa and a middle-income country still facing significant physical and human capital needs; and Malaysia, an emerging market whose income per capita has grown 20-fold over the past 40 years.

Overall, these case studies provide some tentative evidence in favor of four main themes. First, analyzing the entire structure of production paints a more comprehensive and illuminating picture than focusing purely on external trade. Structural transformation may well be associated with significant diversification of domestic production, including of nontradables. Examining this may shed light on the underlying mechanisms and barriers to further transformation.

Second, diversification and structural transformation are often underpinned by reforms and policy measures that are general in scope. Macroeconomic stabilization is a clear example. But even microeconomic measures are often broad-based, focusing on improving the quantity and quality of infrastructure or essential business services, or on setting up a welcoming environment for foreign investors. It remains an open issue to what extent industry-focused and narrowly targeted measures have historically helped underpin diversification efforts.

Third, effective policy measures come in “waves” and aim at exploiting the evolving comparative advantages of the economy in changing external conditions. The types of reforms underpinning diversification and structural transformation in the early stages of development are different from those required later on and need to be adapted to the external environment faced by the economy.

Finally, the frequency with which new products are introduced and the rate at which they grow can indicate potential policy-driven bottlenecks. Little entry may indicate that barriers deter firms from exporting or experimenting. If survival rates are low, firms may face more obstacles than expected. If surviving firms cannot expand, they may have inadequate access to finance.

## VII. CONCLUSIONS

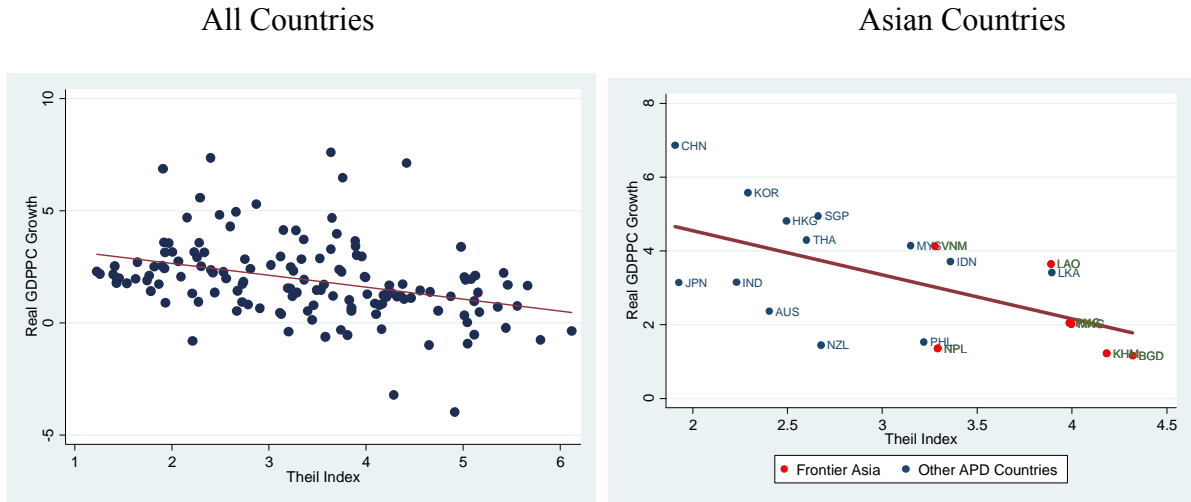
One key message from this paper and related work is that economic development critically involves diversification and structural transformation—that is, the continued, dynamic reallocation of resources from less productive to more productive sectors and activities. This process involves not just external trade, but the broader economy. Success in this transformation process will lead to lower volatility and higher growth.

However, there are major differences across regions and countries in the degree to which they have succeeded in diversifying and transforming their economies. Over an extended period, Asia has on average been particularly successful in diversifying its exports, particularly in comparison with Sub-Saharan Africa. Much of the progress has occurred through diversification along the ‘extensive margin,’ that is, through entry into completely new products.

Structural transformation crucially involves changes not only in the type, but also in the quality of goods produced. Emerging Asia has on average benefited significantly from quality upgrading, helping it capitalize on already existing comparative advantages. Yet, the potential for quality upgrading varies by product. Agricultural and natural resources tend to have lower potential for quality upgrading than manufactures. Therefore, for frontier countries, diversification into products with longer “quality ladders” may be a necessary first step before large gains from quality improvement can be reaped.

Overall, development strategies must promote sustained resource reallocation, and encourage continued quality upgrading. Ongoing work is focused on identifying the specific bottlenecks to structural transformation. In particular, it will analyze in greater detail measures of product quality, and examine what policies are needed to promote diversification and to sustain quality upgrading. That said, case studies of individual countries have already yielded some important lessons. For instance, diversification and structural transformation are often underpinned by reforms and policy measures that are general in scope, rather than industry-focused and narrowly targeted. In addition, the types of reforms underpinning diversification and structural transformation in the early stages of development are different from those required later on.

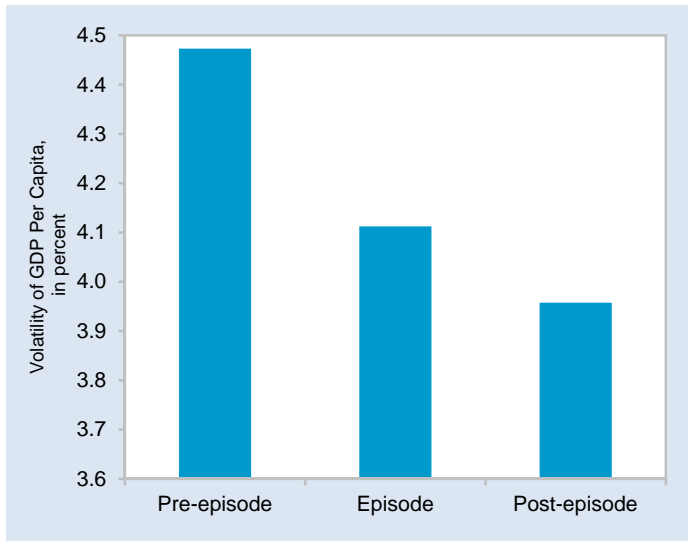
Figure 1. Growth and Export Diversification, 1962–2010



Sources: Penn World Table 7.0, UN COMTRADE, and author calculations.

Note: GDPPC = Gross Domestic Product Per Capita. AZE = Azerbaijan, etc. APD = Asia & Pacific.

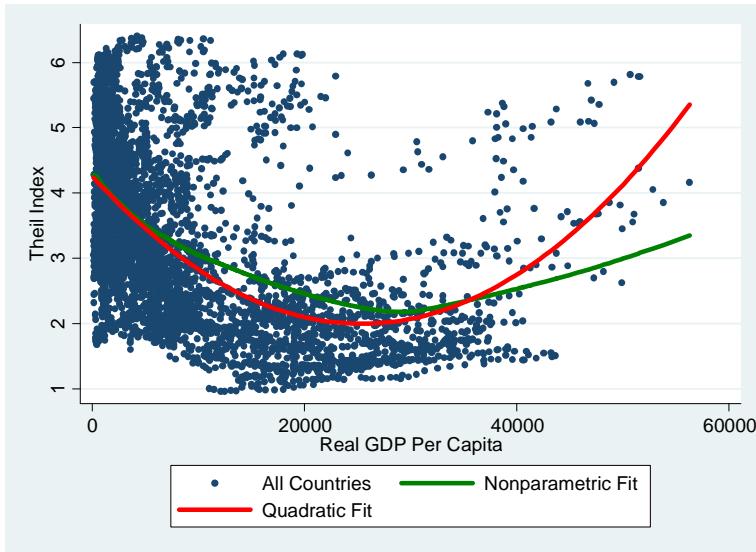
Figure 2. Volatility and Export Diversification



Sources: UN COMTRADE, and author calculations.

Note: Episode indicates diversification spurts. The procedure for identifying spurts is based on Berg et al. (2012).

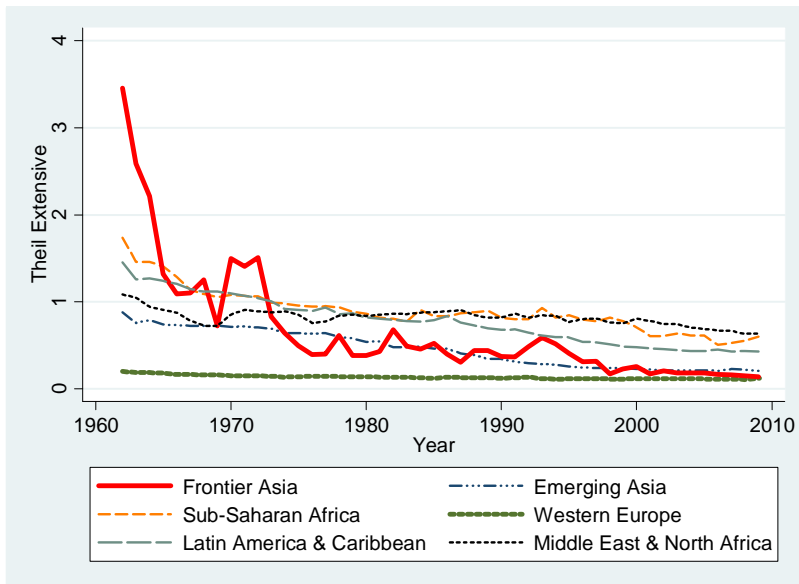
Figure 3. Export Diversification and Real GDP Per Capita



Sources: Penn World Table 7.0, UN COMTRADE, and author calculations.

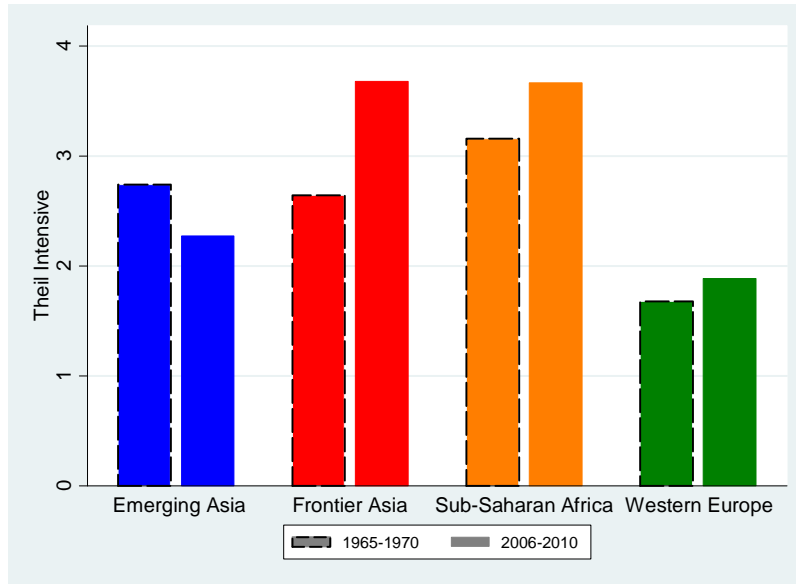
Note: Each observation denotes one country-year combination. Real GDP Per Capita bases on 2000 constant U.S. dollars.

Figure 4. Export diversification by Region, 1960–2010: Extensive Margin



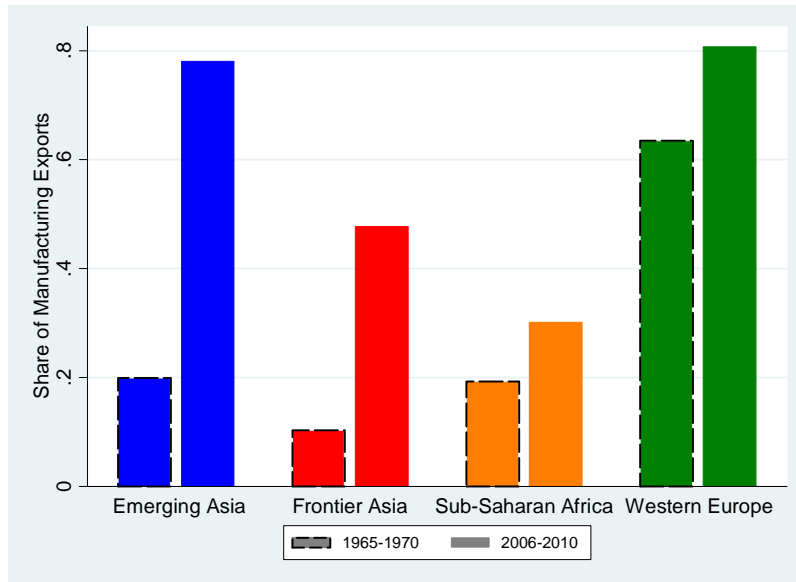
Sources: UN COMTRADE, and author calculations.

Figure 5. Export diversification by Region and Period: Intensive Margin



Sources: UN COMTRADE, and author calculations.

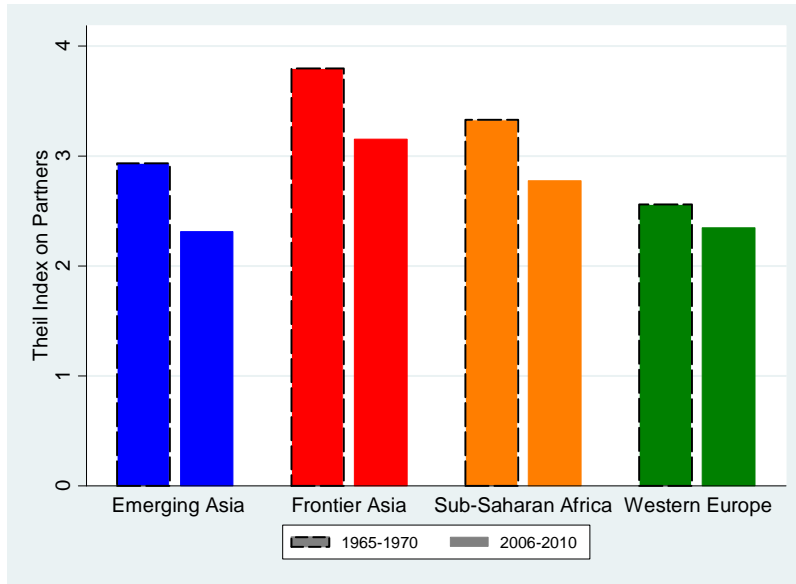
Figure 6. Manufacturing Exports Share, by Region and Period



Sources: UN COMTRADE, and author calculations.

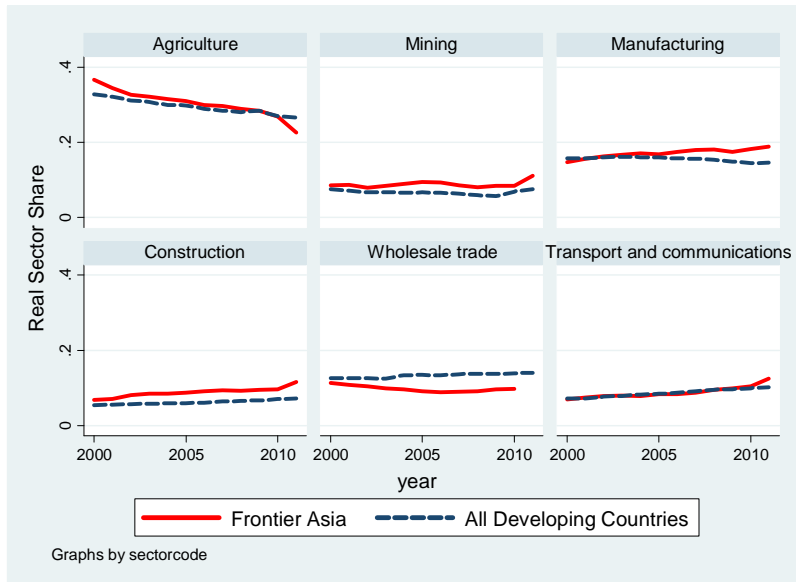


Figure 7. Trade Diversification across Partners over Time



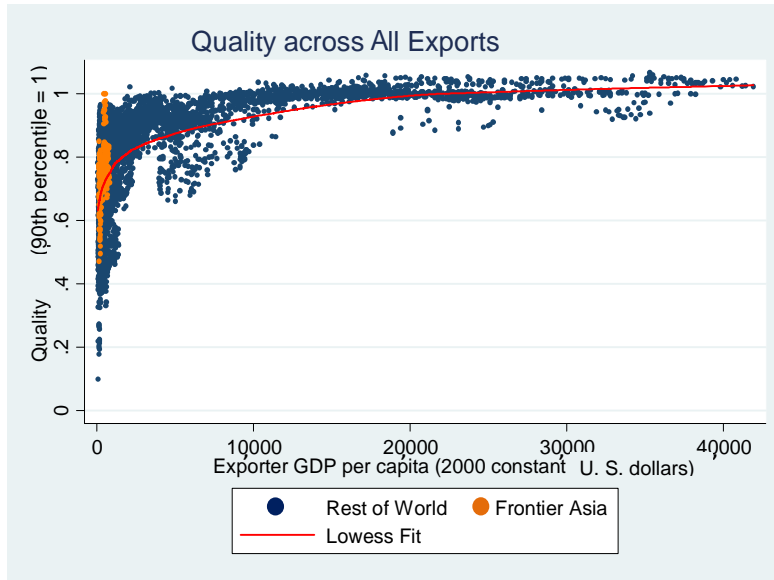
Sources: UN COMTRADE; Author calculations.

Figure 8. Real Sector Share of Frontier Asia, 2000–10



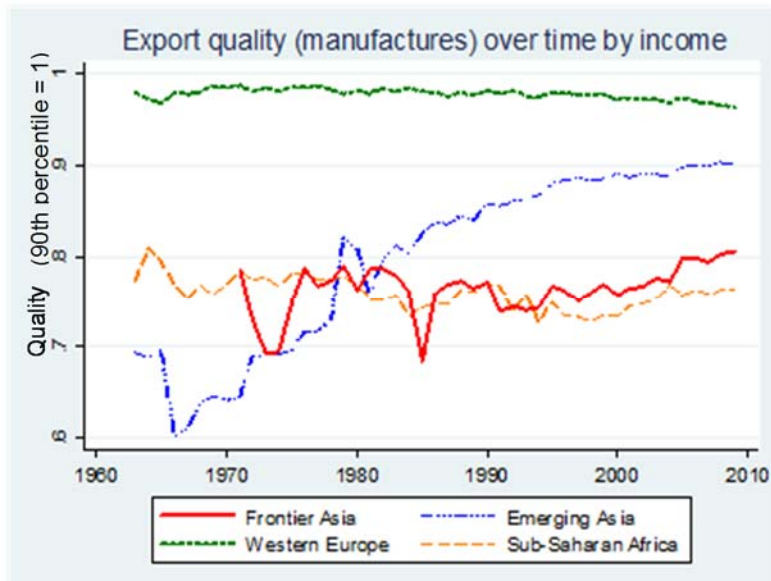
Sources: IMF, and author calculations.

Figure 9. Quality Index and GDP Per Capita, 1960–2010



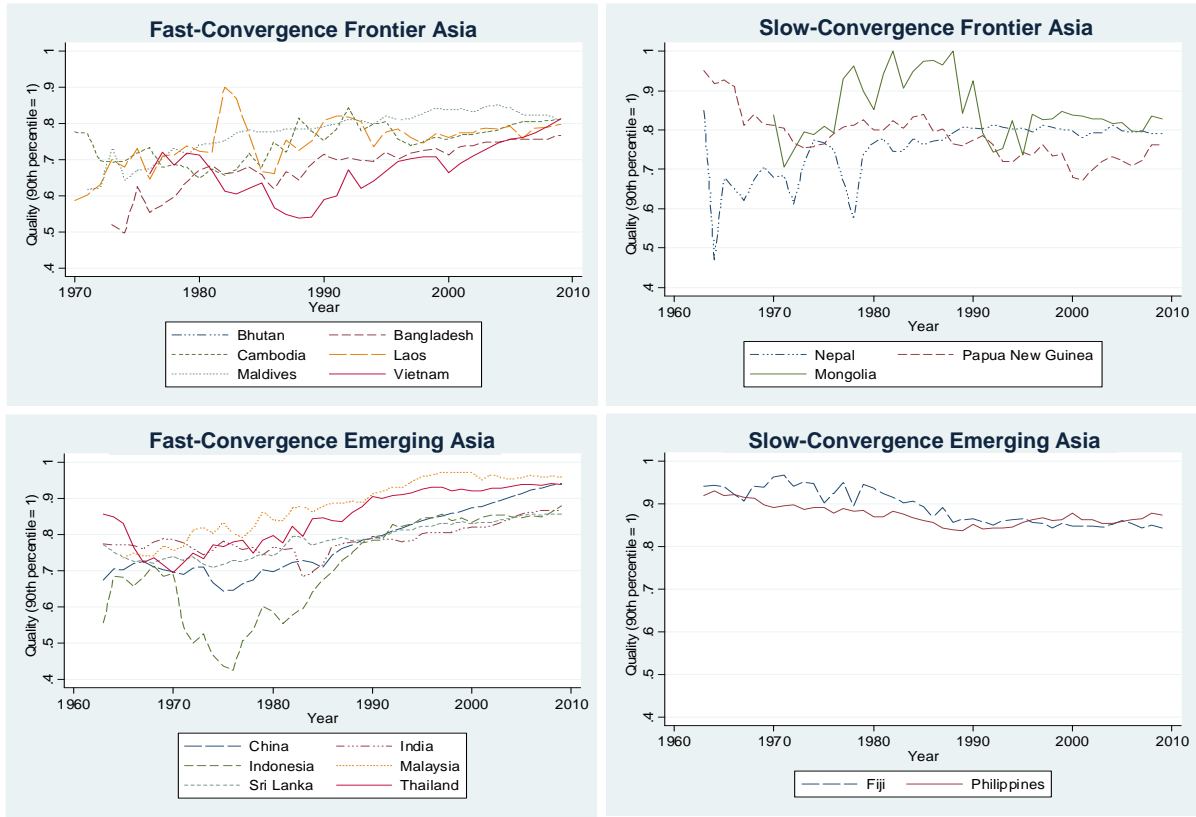
Sources: Penn World Table 7.0, UN COMTRADE, and author calculations.

Figure 10. Manufacturing Quality Index by Region, 1960–2010



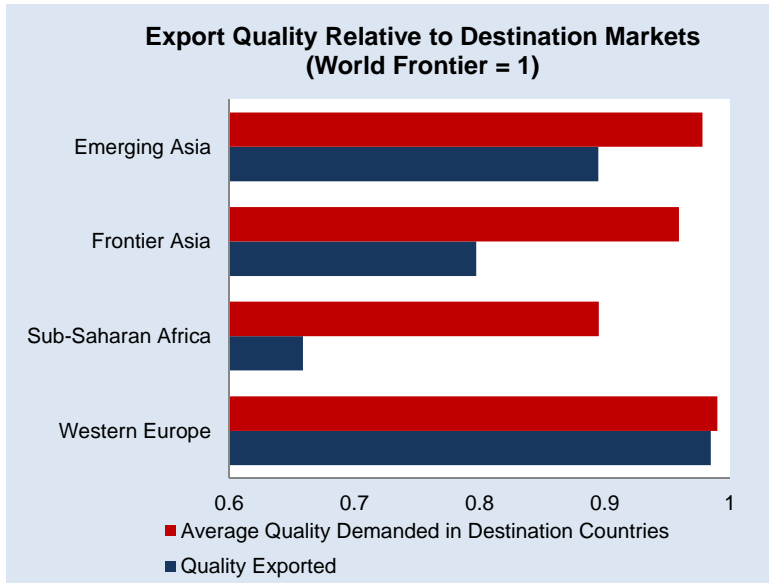
Sources: Penn World Table 7.0, UN COMTRADE, and author calculations.

Figure 11. Quality Convergence of Asian Countries, 1960–2010



Sources: Penn World Table 7.0, UN COMTRADE, and author calculations.

Figure 12. Export Quality by Region, 2009



*Sources:* Penn World Table 7.0, UN COMTRADE, and author calculations.

Table 1. Growth Regressions with Diversification and Quality Indices

Growth Regression, GLS fixed effects								
VARIABLES	All Countries				East Asia		South Asia	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lagged GDP	-5.363*** (0.439)	-6.027*** (0.464)	-5.898*** (0.454)	-5.897*** (0.471)	-5.604*** (1.697)	-4.886*** (1.551)	-3.882 (3.488)	-7.313*** (2.173)
Education	0.124*** (0.023)	0.139*** (0.023)	0.146*** (0.023)	0.137*** (0.023)	0.236** (0.101)	0.217** (0.100)	0.203 (0.125)	0.208* (0.112)
Investment	3.599*** (0.433)	3.523*** (0.429)	3.513*** (0.429)	3.374*** (0.436)	4.520*** (1.428)	4.324*** (1.408)	4.046** (1.626)	4.436*** (1.401)
Population growth	-0.053 (0.229)	-0.194 (0.227)	-0.238 (0.228)	-0.118 (0.227)	0.869 (0.738)	0.670 (0.736)	-1.346 (2.749)	-1.759 (2.248)
Diversification Index	-0.608** (0.279)							
Quality upgrade index		8.761*** (2.124)			13.660* (6.878)			
Quality Index, Agriculture			9.687*** (2.348)			21.036** (8.361)	-8.572 (15.365)	
Quality Index, Manufacture				7.646*** (2.485)				48.638** (18.846)
Constant	35.550*** (3.720)	31.748*** (3.534)	29.948*** (3.614)	31.842*** (3.570)	16.662* (9.267)	6.508 (9.840)	22.728 (19.191)	0.110 (18.537)
Observations	790	789	789	789	75	75	46	46
R-squared	0.234	0.250	0.250	0.241	0.291	0.317	0.295	0.402
Number of countrycode	113	113	113	113	10	10	6	6

Source: Author calculations.

Note: Both country and time fixed effects are used in the estimations. For Asian country groups, the estimated coefficients on the diversification index are not statistically significant. Standard errors in parentheses. \*\*\* denotes  $p < 0.01$ , \*\* denotes  $p < 0.05$ , \* denotes  $p < 0.1$ .

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## APPENDIX I. DEFINITIONS OF MAIN INDICES

### A. Herfindahl Index

As a starting point, we measure diversification using the Herfindahl index. The value of Herfindahl index, for any given country  $i$  and time period  $t$ , equals the sum of squares of export shares (in total exports), where the summation is across all goods  $j$  in the set  $J_{it}$  of categories which the country exports:

$$HFI_{it} = \sum_{j \in J_{it}} (X_{ijt} / \sum_{k \in J_{it}} X_{ikt})^2$$

where  $X_{ijt}$  equals the value of exports by country  $i$  of good  $j$  at time  $t$ . This is an inverse measure of diversification which ranges from maximum of 1 (no diversification: all exports lie in a single category) down to 0 (full diversification: each category contains a negligible fraction of the country's exports).

### B. Theil Index

We calculate the overall, within, and between Theil indices following the definitions and methods used in Cadot et al (2011). We first create dummy variables to define each product as “Traditional,” “New,” or “Non-traded.” Traditional products are goods that were exported at the beginning of the sample, and non-traded goods have zero exports for the entire sample. Thus, for each country and product, the dummy values for traditional and non-traded remain constant across all years of our sample. For each country/year/product group, products classified as “new” must have been non-traded in at least the two previous years and then exported in the two following years. Thus, the dummy values for new products may change over time.

The overall Theil index is a sum of the within and between components. The between Theil index is calculated for each country/year pair as:

$$T_B = \sum_k (N_k/N) (\mu_k/\mu) \ln(\mu_k/\mu)$$

where  $k$  represents each group (traditional, new, and non-traded),  $N_k$  is the total number of products exported in each group.  $\mu_k/\mu$  is the relative mean of exports in each group.



The within Theil index for each country/year pair is:

$$T_w = \sum_k (N_k/N) (\mu_k/\mu) \left\{ (1/N_k) \sum_{i \in I_k} (x_i/\mu_k) \ln(x_i/\mu_k) \right\}$$

### C. Product Quality

Our methodology measures quality based on unit values, but with important adjustments for differences in production costs and for selection bias in the composition of international trade. Henn, Papageorgiou, and Spatafora (forthcoming) provide full details of the methodology. Briefly, we employ a modified version of Hallak (2006), which sidesteps data limitations to achieve maximum country and time coverage.<sup>5</sup> As a first step, for any given product, the trade price (equivalently, unit value)  $p_{mxt}$  is assumed to be determined by the following relationship:

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

where the subscripts  $m$ ,  $x$ , and  $t$  denote, respectively, importer, exporter, and time period. Prices reflect three factors. First, quality  $\theta_{mxt}$ . 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 would expect  $\zeta_2 < 0$  for capital-intensive sectors and  $\zeta_2 > 0$  for labor-intensive sectors.<sup>6</sup> 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.<sup>7</sup>

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<sup>5</sup> 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.”

<sup>6</sup> 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.

<sup>7</sup> 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

Next, we specify a quality-augmented gravity equation. This equation is specified separately for each product, because preference for quality and trade costs may vary across products:

$$\ln(\text{Imports})_{mxt} = \text{ImFE} + \text{ExFE} + \alpha \text{Dist}_{mx} + \beta I_{mxt} + \delta \ln \theta_{mxt} \ln y_{mt} + \varepsilon_{mxt} \quad (2)$$

$\text{ImFE}$  and  $\text{ExFE}$  denote, respectively, importer and exporter fixed effects. Distance is as defined above. The matrix  $I_{mxt}$  is a set of standard trade determinants from the gravity literature.<sup>8</sup> The exporter-specific quality parameter is  $\theta_{mxt}$ , which enters interacted with the importer's income per capita  $y_{mt}$ . If  $\delta > 0$ , then greater income increases the “demand for quality”.

The estimation equation is obtained by substituting observables for the unobservable quality parameter in the gravity equation. Rearranging equation (1) for  $\ln \theta_{mxt}$ , and substituting into (2), yields:

$$\begin{aligned} \ln(\text{Imports})_{mxt} = & \text{ImFE} + \text{ExFE} + \alpha \text{Dist}_{mx} + \beta I_{mxt} + \zeta'_1 \ln p_{mxt} \ln y_{mt} + \\ & \zeta'_2 \ln y_{xt} \ln y_{mt} + \zeta'_3 \ln \text{Dist}_{mx} \ln y_{mt} + \xi'_{mxt} \end{aligned} \quad (3)$$

where  $\zeta'_1 = \frac{\delta}{\zeta_1}$ ,  $\zeta'_2 = -\frac{\delta \zeta_2}{\zeta_1}$ ,  $\zeta'_3 = -\frac{\delta \zeta_3}{\zeta_1}$ , and  $\xi'_{mxt} = -\frac{\delta \zeta'_0 + \delta \xi_{mxt}}{\zeta_1} \ln y_{mt} + \varepsilon_{mxt}$ .

This equation is estimated separately for each of the 851 products in the dataset, yielding 851 sets of coefficients. We obtain estimates by two stage least squares.  $\xi_{mxt}$  is a component of  $p_{xmt}$ , so that the regressor  $\ln p_{xmt} \ln y_{mt}$  is correlated with the disturbance term  $\xi'_{mxt}$ . We therefore use  $\ln p_{xmt-1} \ln y_{mt}$  as an instrument for  $\ln p_{xmt} \ln y_{mt}$ . Where a unit value for the

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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.

<sup>8</sup> 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.

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.<sup>9</sup>

The regression results are used to calculate a comprehensive set of quality estimates. 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:

$$\text{Quality estimate}_{mxt} = \delta \ln \theta_{mxt} = \zeta_1' \ln p_{mxt} + \zeta_2' \ln y_{xt} + \zeta_3' \ln \text{Dist}_{mx} \quad (4)$$

As is standard, quality  $\theta_{mxt}$  and importers' taste for quality  $\delta$  are not separately identified.<sup>10</sup>

The quality estimates are then aggregated into a multi-level database. The estimation yields quality estimates for more than 20 million product-exporter-importer-year combinations. To enable cross-product comparisons, all quality estimates are first normalized by their 90<sup>th</sup> percentile in the relevant product-year combination. The resulting quality values typically range between 0 and 1.2. The quality estimates are then aggregated, using current trade values as weights, to higher-level sectors (SITC 4-, 3-, 2-, and 1-digit, as well as country-level totals).<sup>11</sup> At each aggregation step, the normalization to the 90<sup>th</sup> percentile is repeated. Aggregations are also produced based on the BEC classification, as well as for 3 broad sectors (agriculture, non-agricultural commodities, and manufactures). To allow for easy comparisons with unit values, the latter are also normalized with the 90<sup>th</sup> percentile set equal to unity.

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<sup>9</sup> If unit values are not available in any of the preceding five years, the observation is excluded from the estimation.

<sup>10</sup> The preference for quality parameter  $\delta$  will also vary by sector. Therefore, when we aggregate quality estimates across sectors, the aggregation will necessarily also aggregate across these heterogeneous preference for quality parameters.

<sup>11</sup> Changes in the higher-level (including country-level) quality estimates 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 quite possible for the quality of any given product to be rising sharply, but country-level quality to rise slowly (or indeed decline).

**APPENDIX II. REGION DEFINITIONS**

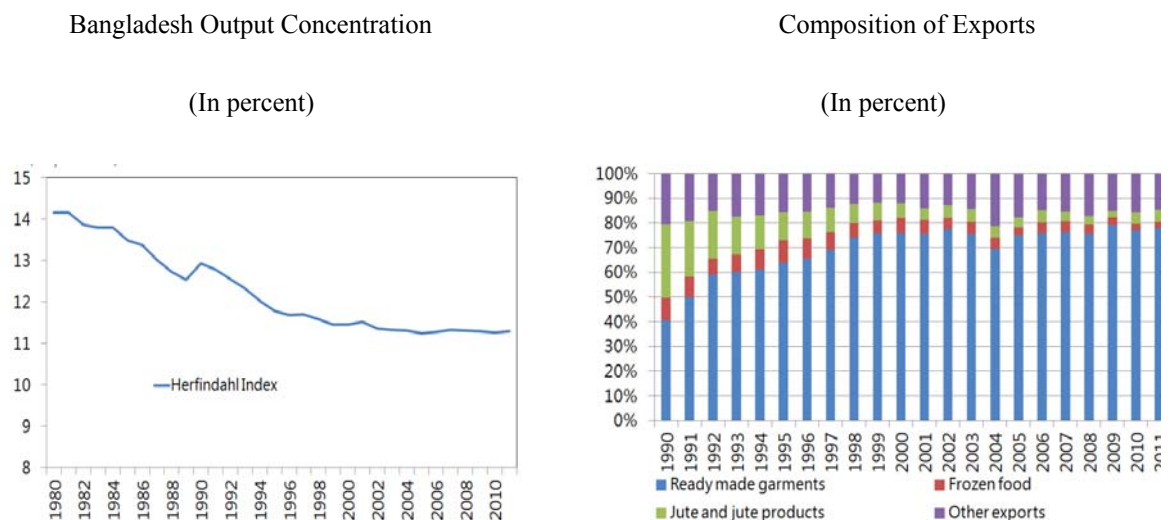
<b>Frontier Asia</b>	<b>Emerging Asia</b>	<b>Sub-Saharan Africa</b>	<b>Western Europe</b>
Bangladesh	Brunei Darussalam	Angola	Austria
Bhutan	China	Benin	Belgium
Cambodia	Fiji	Botswana	Croatia
Lao PDR	India	Burkina Faso	Cyprus
Maldives	Indonesia	Burundi	Denmark
Mongolia	Malaysia	Cameroon	Finland
Myanmar	Marshall Islands	Cape Verde	France
Nepal	Micronesia	Central African Republic	Germany
Papua New Guinea	Philippines	Chad	Greece
Vietnam	Sri Lanka	Comoros	Iceland
	Thailand	Congo, Dem. Rep.	Ireland
	Tuvalu	Congo, Rep.	Israel
		Cote d'Ivoire	Italy
		Equatorial Guinea	Luxembourg
		Eritrea	Malta
		Ethiopia(excludes Eritrea)	Netherlands
		Gabon	Norway
		Gambia, The	Portugal
		Ghana	Slovak Republic
		Guinea	Slovenia
		Guinea-Bissau	Spain
		Kenya	Sweden
		Lesotho	Switzerland
		Liberia	United Kingdom
		Madagascar	
		Malawi	
		Mali	
		Mauritania	
		Mauritius	
		Mozambique	
		Namibia	
		Niger	
		Nigeria	
		Rwanda	
		Senegal	
		Seychelles	
		Sierra Leone	
		South Africa	
		Sudan	
		Swaziland	
		Sao Tome and Principe	
		Tanzania	
		Togo	
		Uganda	
		Zambia	
		Zimbabwe	
		Somalia	

### APPENDIX III. CASE STUDIES

This section uses case studies to illustrate the lessons from structural transformation at different stages of development. Specifically, we focus on two countries: *Bangladesh*, with income per capita well below \$1,000; and *Vietnam*, by now well on its way to emerging market status, and which is representative of countries that are successfully diversifying, or have successfully diversified, their economies.

Bangladesh illustrates that initial diversification success, to be sustained, requires a combination of further reforms. Diversification in Bangladesh was largely triggered by external factors such as the introductions of the multi-fiber agreement (MFA) and the generalized system of preferences in the 1970s. These spurred development of the ready-made garments industry. As a result, Bangladesh shifted rapidly away from traditional agricultural and jute products towards manufacturing (Figure A1). Combined with the rise in output from wholesale and retail trade, this contributed to a steady increase in output diversification. Now, however, with ready-made garments accounting for 80 percent of total exports, Bangladesh's output diversification has seemingly peaked, although as a low cost producer scope remains for further gains through increases in global garment market shares. Attempts to move beyond garments or to increase their quality have been hindered by a lack of supportive reforms. Challenges include poor governance and the high cost of doing business as a result of scarce electricity supplies, severe infrastructure bottlenecks, weak contract enforcement, and expensive credit provision. While such factors did not hinder diversification and inward FDI in the 1990s and early 2000s, they may now be preventing further progress.

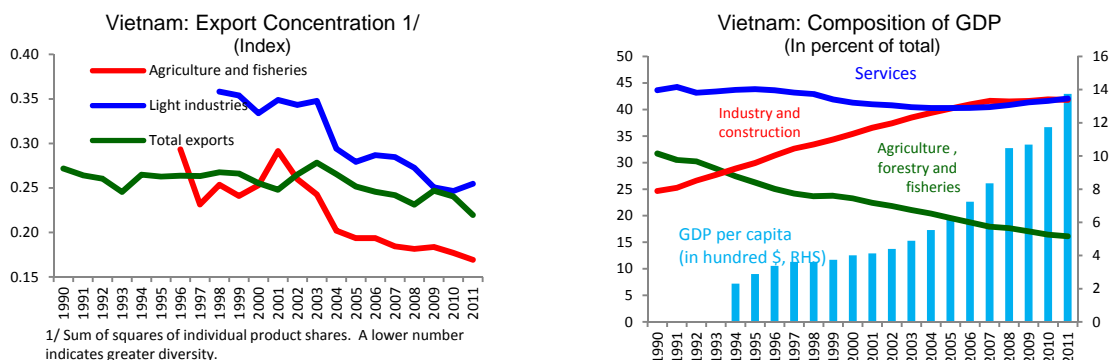
Figure A1. Bangladesh: Concentration of Output and Composition of Exports



Sources: Country authorities and author calculations.

In contrast, Vietnam's experience shows that "waves" of supportive reforms can sustain diversification and structural transformation. The first wave of reforms during the 1980s opened new areas of activity to the private sector by reducing barriers to entry and expansion. Domestic prices, external trade and access to foreign exchange were liberalized; the rationing system largely abolished; subsidies significantly cut back; and inflation reduced. In agriculture, individual land-use rights were recognized, production freed from state-set quotas, and collective assets privatized. As a result, agriculture expanded, rising to almost half of total exports in 1995, and also diversified into cash crops, such as coffee and marine and forestry products (Figure A2). In a second wave of reforms, during the 1990s, liberalization of FDI helped develop other sectors. Initially, FDI was concentrated in the oil sector, but real estate (including hotels), food processing and heavy and light industry gained importance. FDI helped Vietnam integrate into emerging global supply chains, and gradually diversify its output and exports from textiles to footwear and electronics. This product diversification was accompanied by a diversification of trade partners, first from the Commonwealth of Independent States (CIS) to Asia, and then towards Europe and the United States

Figure A2. Vietnam: Diversification of Exports and Composition of GDP



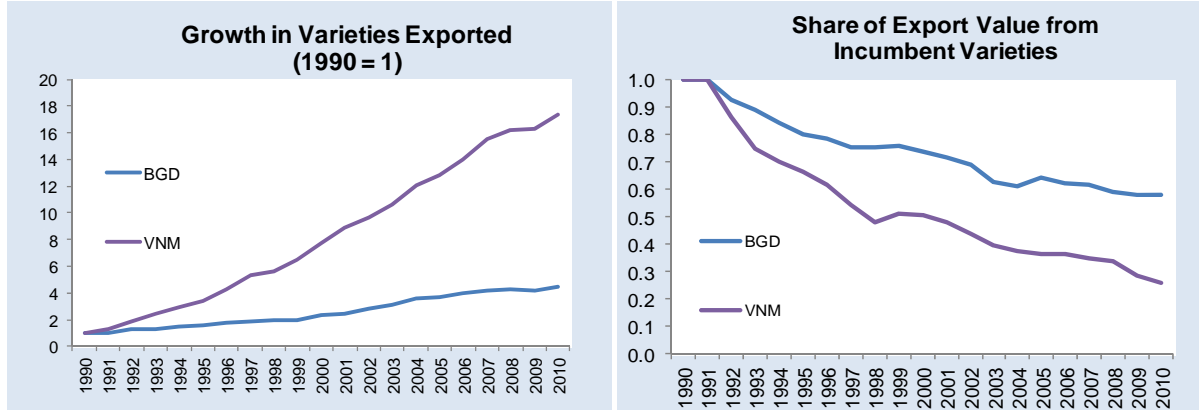
Sources: Country authorities, and author calculations.

Diversification in frontier economies depends crucially on the frequency with which new products are introduced, the likelihood that they will survive, and their growth prospects. Initial trade diversification in frontier economies is mainly driven by entry into new products (the extensive margin). In the above two countries, over 1990–2011, there were significant differences (over time and across countries) in three key measures of the extensive margin: (i) the number of new product varieties introduced in a given year,<sup>12</sup> (ii) the survival rates of new varieties, (iii) and the growth rates of surviving varieties. Over time, such differences can cumulate into large differences in overall exports.

Differences in these measures underline the case studies' different experiences. Vietnam showed significant new entry and reductions over time in the relative importance of incumbent varieties (Figure A3). Vietnam in particular stood out as having a high probability of survival of new varieties. Bangladesh had less experimentation and also less growth in surviving varieties, accounting for its current, unusually high concentration.

<sup>12</sup> Here, a variety is defined as a specific product exported to a specific country as in Asmundson (forthcoming).

Figure A3. Export Experimentation



Sources: UN COMTRADE, and author calculations.

Overall, these case studies provide some tentative evidence in favor of four main themes. First, analyzing the entire structure of production paints a more comprehensive and illuminating picture than focusing purely on external trade. Structural transformation may well be associated with significant diversification of domestic production, including of non-tradable. Analyzing this may shed light on the underlying mechanisms and barriers to further transformation.

Second, diversification and structural transformation are often underpinned by reforms and policy measures that are general in scope. Macroeconomic stabilization is a clear example. But even microeconomic measures are often broad-based, focusing on improving the quantity and quality of infrastructure or essential business services, or on setting up a welcoming environment for foreign investors. It remains an open issue to what extent industry-focused and narrowly targeted measures have historically helped underpin diversification efforts.

Third, effective policy measures come in “waves” and aim at exploiting the evolving comparative advantages of the economy in changing external conditions. The types of reforms underpinning diversification and structural transformation in the early stages of development are different from those required later on and need to be adapted to the external environment faced by the economy.



Finally, the frequency with which new products are introduced, and the rate at which they grow, can indicate potential policy-driven bottlenecks. Little entry may indicate that barriers deter firms from exporting or experimenting. If survival rates are low, firms may face more obstacles than expected. If surviving firms cannot expand, they may have inadequate access to finance. This type of analysis suggests directions for further study.