IMF Working Paper

The Dynamics of Product Quality and International Competitiveness

Stefania Fabrizio, Deniz Igan, and Ashoka Mody

INTERNATIONAL MONETARY FUND

IMF Working Paper

European Department

The Dynamics of Product Quality and International Competitiveness

Prepared by Stefania Fabrizio, Deniz Igan, and Ashoka Mody

April 2007

Abstract

This Working Paper should not be reported as representing the views of the IMF.
The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

Despite the appreciation of the exchange rate, the eight Central and Eastern European countries (the CEE-8) that entered the European Union in May 2004 have achieved a decade of impressive export growth, expanding significantly their shares of world markets. Does this mean that the real exchange rate is irrelevant? If not, what other factors compensated for the appreciation to explain the apparently strong competitiveness of these economies? And will these favorable factors continue to power export growth? This paper places in international context the achievements of the CEE-8 and helps more broadly to identify the determinants of international competitiveness. Building from data at the six-digit level of disaggregation, it shows that the CEE-8 made an impressive shift in product quality and in the technological intensity of exports, and that these shifts associated with the structural transformation were also associated with increased market share. The analysis strongly suggests that, when trading in international markets, countries benefit from higher product quality. However, while the structural transformation achieved was valuable in raising market shares, the easy gains from this process may be over.

Author's E-Mail Address: SFabrizio@imf.org; DIgan@imf.org; AMody@imf.org

Contents   Page

Contents   Page

I. INTRODUCTION

Of the new members entering the European Union (EU) in May 2004, several had achieved a decade of impressive export growth, expanding significantly their shares of world markets. What factors lay behind this performance? This paper places in international context the achievements of the eight Central and Eastern European countries (the CEE-8).[1] Though the timing and pace varied, the gains in market shares are evident for six of these eight countries (Figure 1); only Slovenian and Latvian market shares remained relatively flat. In benchmarking this performance, the goal of the paper is to more broadly help identify the determinants of international competitiveness.

The puzzle is that the market share gains by the CEE-8 were achieved despite the appreciation of real exchange rates (Figure 1). Of course, the bivariate relationship between real exchange rates and evolution of market shares does not control for other developments during this period. Nevertheless, the question does arise: Is the real exchange rate irrelevant? If not, what other factors compensated for the appreciation to explain the apparently strong competitiveness of these economies? And will these favorable factors continue to power export growth?

The key to the puzzle is that a structural transformation was also achieved during this period. This transition from planned economic systems was accompanied by extensive privatization and restructuring, alongside the dismantling of trade barriers and the inflow of foreign direct investment. Forced to compete with international producers, domestically and in foreign markets, firms in the CEE-8 survived by reducing their quality-adjusted prices. This, in turn, required both cost reduction and quality enhancement. Meanwhile, the composition of production shifted toward higher-technology products. This paper documents that transformation. Building from data at the six-digit level of disaggregation, the evidence shows an impressive shift in product quality—measured by the unit value of a country's exports relative to the unit value of world exports— and in the technological intensity of exports (Figure 2). At the same time, while the pace and timing of the shift once again varied across countries, there was also a movement from relatively low-technology products principally to the medium-technology range, and more slowly, to the production and export of high-technology products.

---

[1] The Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, the Slovak Republic, and Slovenia.

Figure 1. CEE-8: Market Share and REER, 1994-2004 1/

☐ World share of exports (2000=100, right scale) ▬ REER (2000=100, left scale)
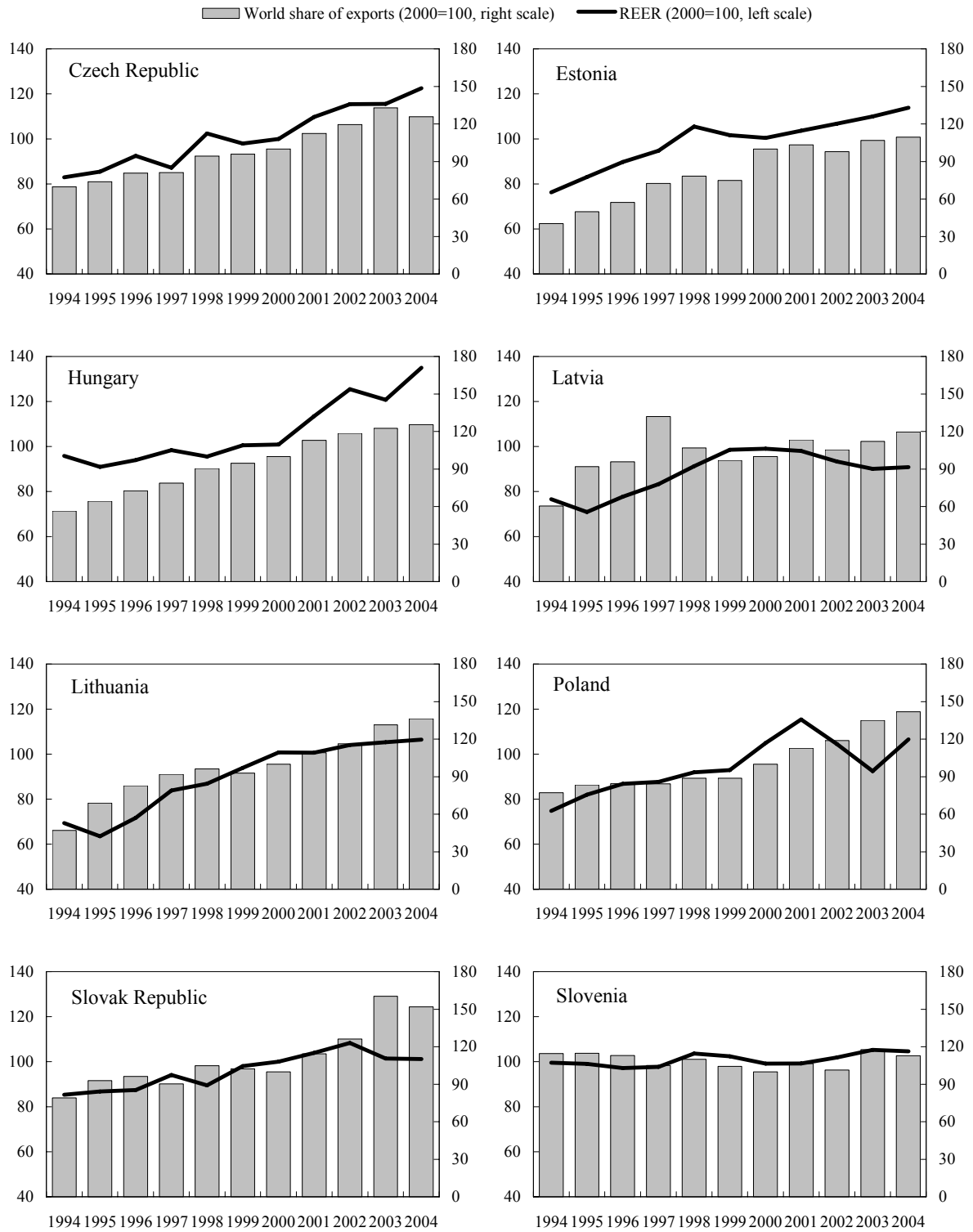
Sources: UN Comtrade database; IMF, International Financial Statistics; and IMF staff calculations.
1/ Market share is the share in percent of a country's manufacturing exports in the global manufacturing trade.

Figure 2. CEE-8: Moving Up the Technology and Quality Ladder, 1994-2004
(Share in percent of country exports)

low-tech   medium-low-tech   medium-high-tech   high-tech   UVR 1/
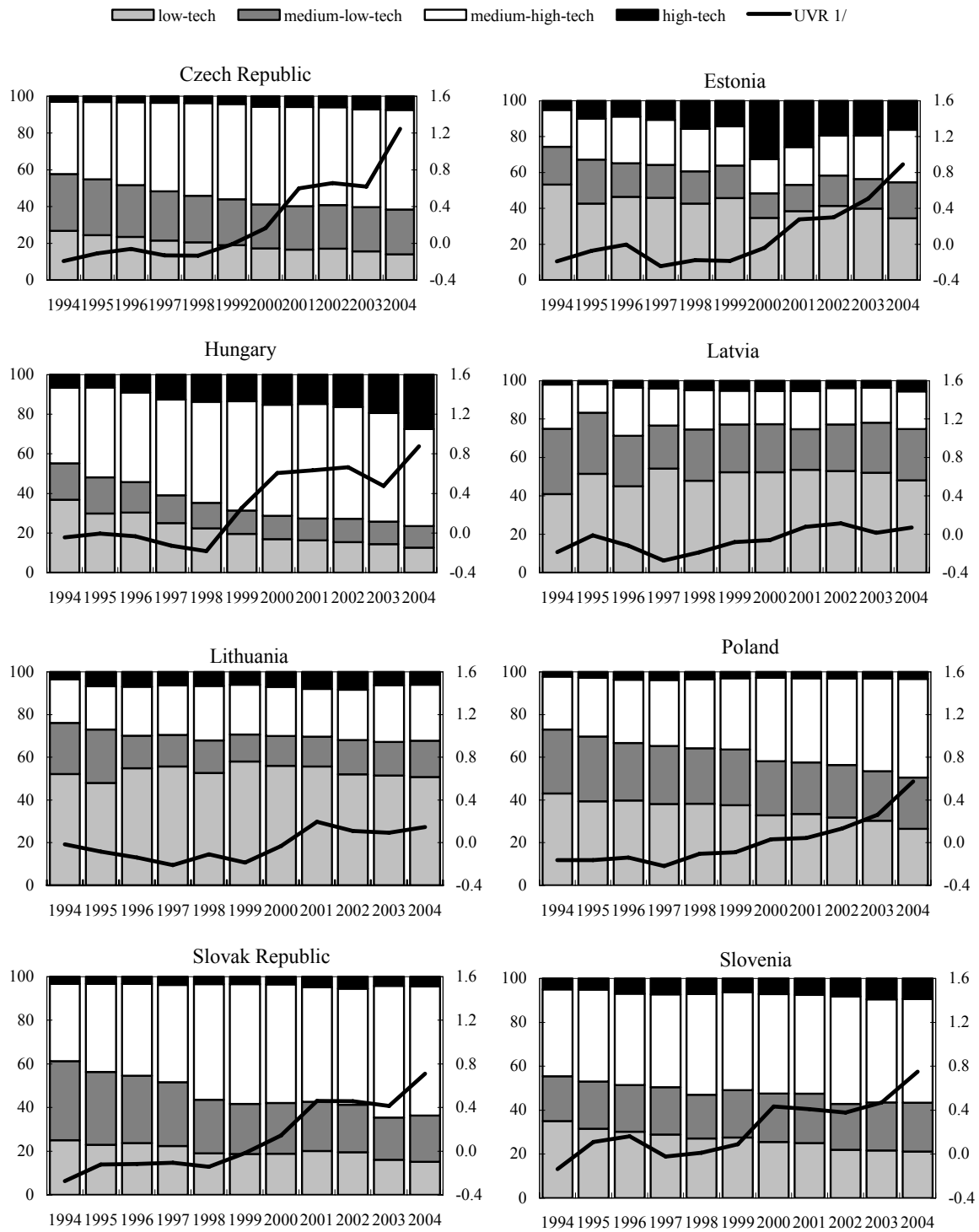
Sources: UN Comtrade; and IMF staff calculations.
1/ UVR is the unit value of a country's exports divided by the unit value of world exports. Expressed in logarithm so that a value of zero means country unit value equals world unit value.

The empirical analysis shows that, in a cross-section of countries, over the period 1994-2004, quality and technology upgrading associated with the structural transformation were, indeed, also associated with increased market share. The analysis strongly suggests that, when trading in international markets, countries benefit from higher product quality. The implication, therefore, is that the observed association for the CEE-8 between improved product quality and increased market share was not accidental but rather the outcome of the apparent value attached to higher-quality products in international markets. The cross-country analysis leads to four specific conclusions of relevance to the CEE-8:

- A small initial market share allows for a catch-up process: coming out of their transition from planned economies, the CEE-8 started with relatively small market shares and took advantage of the catch-up potential.

- Controlling for initial market share, both a higher starting product quality, proxied by the unit value ratio, and an increase in this ratio over time have helped expand market share; however, the evidence also suggests that this process may have diminishing returns.

- Once quality variations are accounted for, real exchange rate appreciation appear to hurt a country's ability to expand its world market share.

- Higher product quality has, as expected, been especially relevant for so-called differentiated products, which are valued for the range and quality of their attributes. Higher product quality of differentiated products from a country appears "twice blessed" in the sense that this quality also helps gain market share in "reference-priced" and "homogenous" products, possibly by enhancing that country's reputation or economies of scale in sourcing and transportation costs.

The message for the CEE-8, therefore, is complimentary but also cautionary. These countries have gone through a catch-up phase during which they have also put to good use their human capital in moving up the technology and quality ladder. These factors have allowed them to maintain the dynamism of their exports despite exchange rate appreciations. However, looking ahead, the task will become harder, for several reasons. First, the market share gains made possible by the particularly small world market shares at the time of transition have been largely achieved. Second, the task of technology and quality upgrading was facilitated by the opportunities for relatively easy gains through privatization and restructuring. A new generation of restructuring and technical progress will require more sophisticated efforts and measures. Finally, there is some evidence that technological upgrading may have diminishing returns. However, it will be necessary to keep pace with technical change in competitor economies to maintain market shares and limit the risk of falling behind. Hence, the pressures for continued productivity gains will only increase over time.

This paper builds on an incipient empirical literature linking product quality and export performance. Dulleck and others (2005) report the improvements in the product quality and technology content of exports from the CEE-8. In their empirical analysis, however, they

focus on assessing whether improved product quality/technology of a particular product is associated with an increasing share of that product in the country's basket of exports. Instead, the question we ask is whether the country's share of world markets (either for all goods or for different baskets of goods) is a function of country product quality. This paper is closest in spirit to that by Hallak (2006), who examines the role of product quality in explaining bilateral trade. However, he asks a narrower question, which is whether richer countries have a greater demand for quality. In other words, his analysis focuses on the direction of trade flows in relation to quality characteristics. Also, he limits his analysis to a cross-section of countries, rather than examining changes over time within countries.[2]

The rest of this paper is organized as follows. In Section B, we discuss the role of product quality in international trade, highlighting the relevant theoretical findings and supporting stylized facts. Section C then presents several bivariate relationships to motivate an empirical framework for analyzing the evolution of market shares. Section D reports the basic regressions results, explaining the changes in market shares for 58 countries (accounting for almost 94 percent of the world trade) over the period 1994 to 2004. Section E reports results that distinguish between differentiated, reference-priced, and homogenous products. Section F concludes.

II. THEORETICAL AND EMPIRICAL BACKGROUND

As countries become richer, their consumers demand not only more of everything (increased quantities) but often the additional demand is expressed predominantly for higher quality products and services. Copeland and Kotwal (1996, p. 1746) make—possibly, somewhat overstate—this point: "...it is the quality and not the quantity of a differentiated good that responds to an income change: richer people buy fancier cars rather than more cars."

For emerging economies, the observation raises a challenge. To increase their exports, they need to supply higher quality products. Absent this ability, there is some risk, Copeland and Kotwal (1996) conclude, that trade between relatively poor and rich nations may break down. Or, as Murphy and Schleifer (1997) have stated starkly, there may be "nothing to sell." They spotlight the example of the inexpensive Yugo and Lada cars. Produced in Eastern Europe, the cars found no buyers in the rich western nations because they did not meet the quality requirements. Instead, buyers purchased more expensive and higher quality cars produced within their own borders or in countries with similar capital and skill endowments.

Copeland and Kotwal (1996) and Murphy and Shleifer (1997) conclude that considerations of product quality reinforce the tendency of rich nations to trade among themselves, consistent with recent empirical investigations. However, the implication also is that the development process is associated with quality upgradation. Hummels and Klenow (2005, p. 704) find that within product categories, "...richer countries export higher quantities at modestly higher prices." This, they infer, implies that rich countries sell higher quality

---

[2] Also, as we discuss below, comparison of product quality across countries is challenging. Instead, we focus on the quality changes in a fixed basket of goods over time within a country.

products. At the same time, Hallak (2006, p. 240) finds that "...rich countries tend to import relatively more from countries that produce higher quality goods" But this does not imply that developing and emerging economies are excluded from selling superior quality products. For many products, consumers in rich nations do buy a significant range of product qualities, creating entry opportunities for emerging economies starting at at the lower end of the quality spectrum (Schott 2004). It is the exploitation of these opportunities by moving up the quality ladder that forms the focus of this paper.

While the focus on product quality emphasizes the demand side, supply considerations are crucial. Raising the quality of production goes hand in hand with raising capital and skill endowments. Romalis (2004) develops the relevant supply side links to export performance. He shows, first, that countries with relatively large capital and skill stocks will tend to have larger shares in world markets of capital- and skill-intensive products. The implication also is that *increases* in capital and skill stocks will lead to *increases* in the share of capital and skill-intensive products. As such, the second, more interesting implication of Romalis (2004), following Ventura (1997), is that these structural shifts in production allow countries to maintain high growth rates without hitting diminishing returns.

Thus, the so-called "miracle" economies of East Asia sustained high rates of growth over more than two decades because the additional capital and skilled labor did not produce more of the same goods (which would have implied diminishing returns) but deployed these accumulations in new products. In turn, these new products were exported to and absorbed by deep international markets.

Pulling together, then, these two literatures on the demand for quality and the structural shift to more advanced production structures, a growth trajectory can be mapped. Emerging economies catch up with richer nations by raising the sophistication of production, the flip-side of which is enhancing the quality of the output that emerges from that production process. On the production end, diminishing returns are avoided by moving into new product areas. On the demand side, the ensuing upgrading of quality opens up new markets. Income convergence, therefore, is accompanied by an increase in share of world trade.

As such, our empirical analysis focuses on the implications of higher quality exports for a country's share of international markets. We do not study explicitly the supply-side. We show that higher quality exports (where quality is measured by higher unit values of exports) are associated with a shift to more "high-technology" production. Given that shift, the question we ask is whether these largely concomitant shifts allow a country to more rapidly increase its presence in world markets. In our focus on world market shares, we differ both from Hallak (2006) who studies the quality (and hence the demand side) of trade but does not draw out the aggregate implications of the demand for quality and from Romalis (2004) who examines the supply side but mainly from the point of view of shifts in export structure as commoving with rapid income growth in the exporting country.

III. EXPLAINING MARKET SHARES: AN EMPIRICAL FRAMEWORK

We begin with the proposition that a large initial market share constrains the subsequent increase in market share. This intuition is based on the presumption that, whereas newer entrants have a significant catch-up possibility, a country's share saturates at some point. To test this intuition, an appropriate measure of market share is needed. To motivate such a measure, Figure 3 plots, for select economies, the share of their GDP in world GDP against the share of their exports in world trade. Figure 3a, for 1994, shows the countries clustered around the 45-degree line; the CEE-8 were already slightly above that line, especially Slovakia and Slovenia. By 2004, these countries had acquired more of a presence in world GDP but especially in world trade. In conducting the analysis, therefore, two measures of market share are possible. First, the simple share of exports in world markets, as shown in Figure 3, can be used. The concern with such a measure is that it also reflects the size of the country and not just its competitive capability. Second, the export share can be normalized by the country's GDP share in world GDP. This latter measure is a metric of how far ahead a country's trading relationships are relative to its production capabilities. A large normalized market share would indicate reduced potential for further inroads into world markets, absent expansion of domestic production capacity. Because this analysis relies primarily on within-country variation over a decade, the change in country size during that period can be quantitatively important in some cases; however, in general, the findings remain similar irrespective of the measure used.

The data do support the expected inverse relationship between initial share and the subsequent increase in market shares. Figure 4a shows this relationship for the simple measure of market share, and Figure 4b for the normalized measure. Countries with smaller shares in 1994 had made, on average, larger gains by 2004, showing the possibility of catch-up. The countries in Eastern Europe benefited from this process. Note also, for example, that the Czech Republic is above the line, implying that its market share gain was due to more than its initial low level of initial market penetration and despite its substantial exchange rate appreciation during this period. Other CEE-8 are in a similar position. This finding prompts us to examine what other factors were at work.[3]

To examine the role of technology and quality upgrading in the evolution of market shares, we constructed measures along two dimensions: quality and technology composition. As noted, based on trade data detailed at the six-digit level according to the Harmonized System (HS), unit value ratios (*UVR*s) are constructed. These are the ratios of a country's export unit values to the global average. For every country in the sample, we fix the basket of goods throughout the period under consideration.[4] By considering an unchanging basket of goods, we eliminate effects arising from greater product variety exported by a country (which may

---

[3] Noteworthy is China's impressive performance. Figure 3a shows that China's absolute gain in market share between 1994 and 2004 was large. However, Figure 3b suggests that China's export expansion was largely commensurate with its catch-up potential and growing economy.

[4] Products are dropped if there are missing values in the construction of the unit values or if there are erratic movements in the unit values.

Figure 3. GDP Share in World GDP versus Export Share in Global Trade, 1994 and 2004
(In purchasing power parity, in percent)
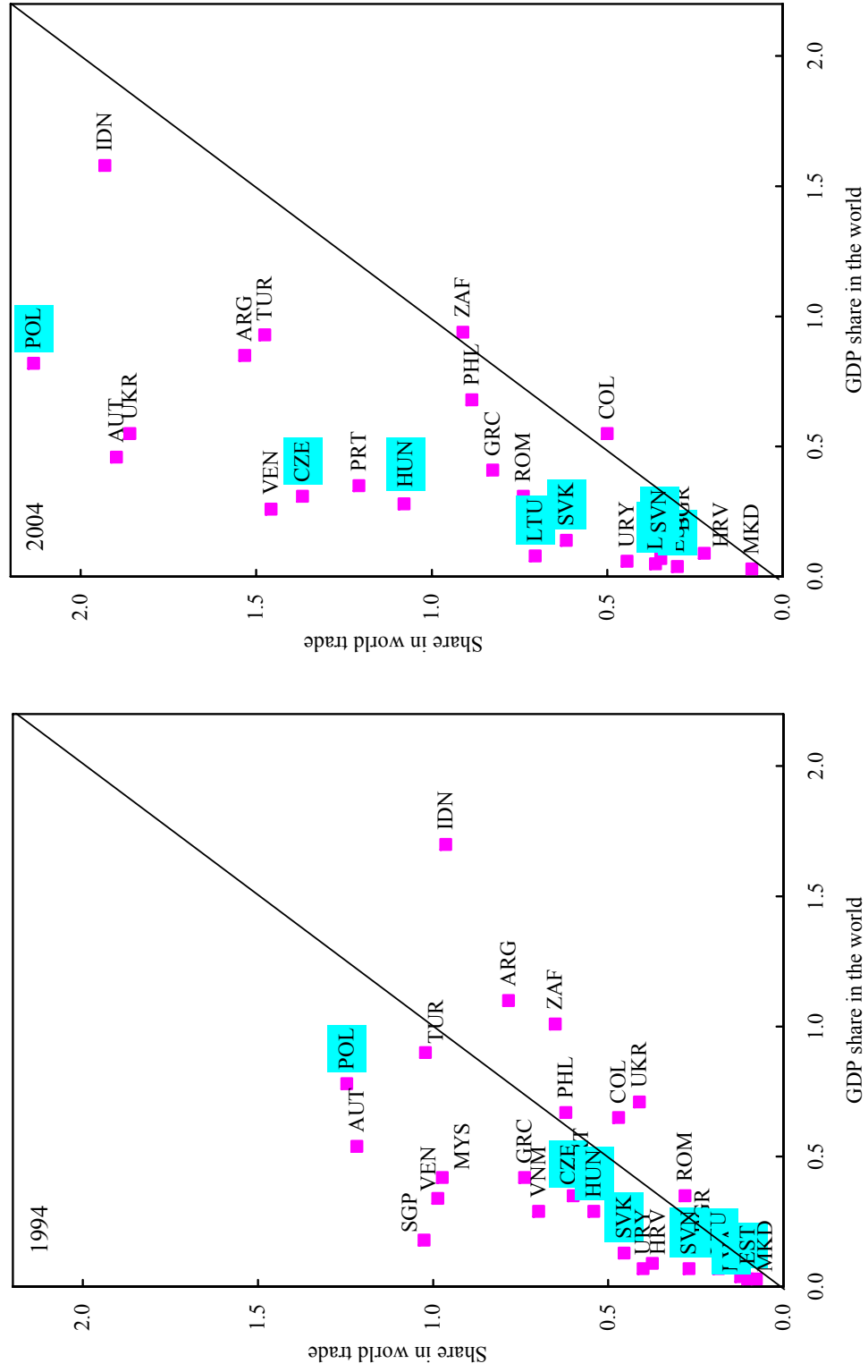
Source: IFS, UN COMTRADE database, and IMF staff calculations.

Figure 4a. Increases in Market Shares Relative to Initial Market Shares, 1994-2004
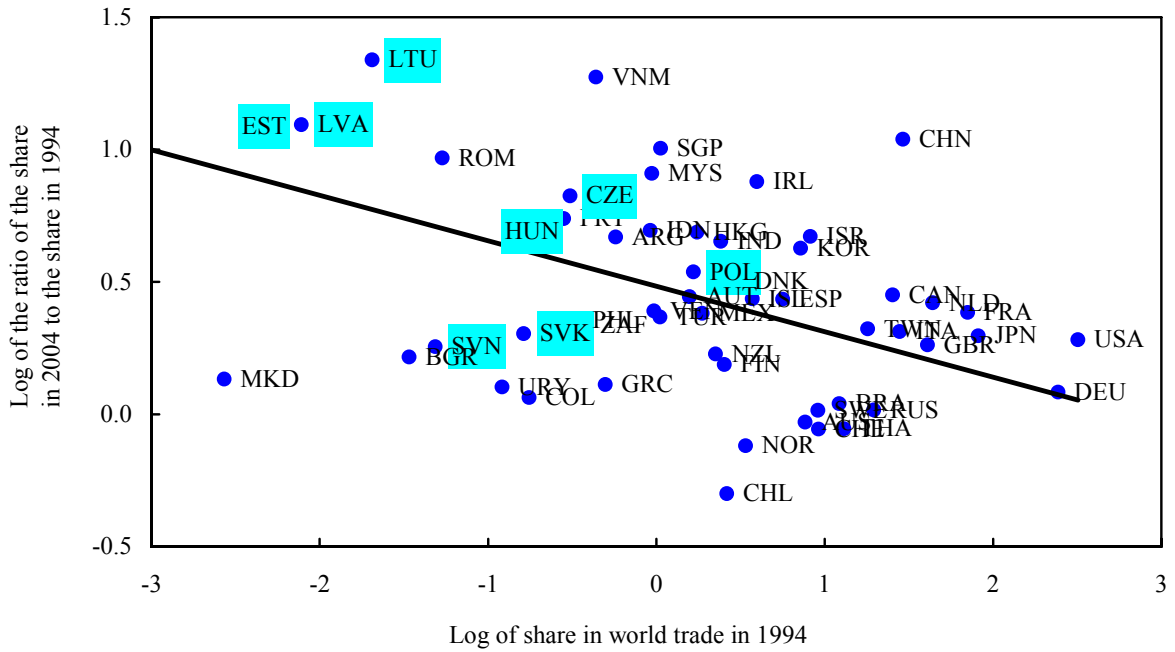
Figure 4b. Increases in Normalized Market Shares Relative to Initial Normalized Market Shares, 1994-2004
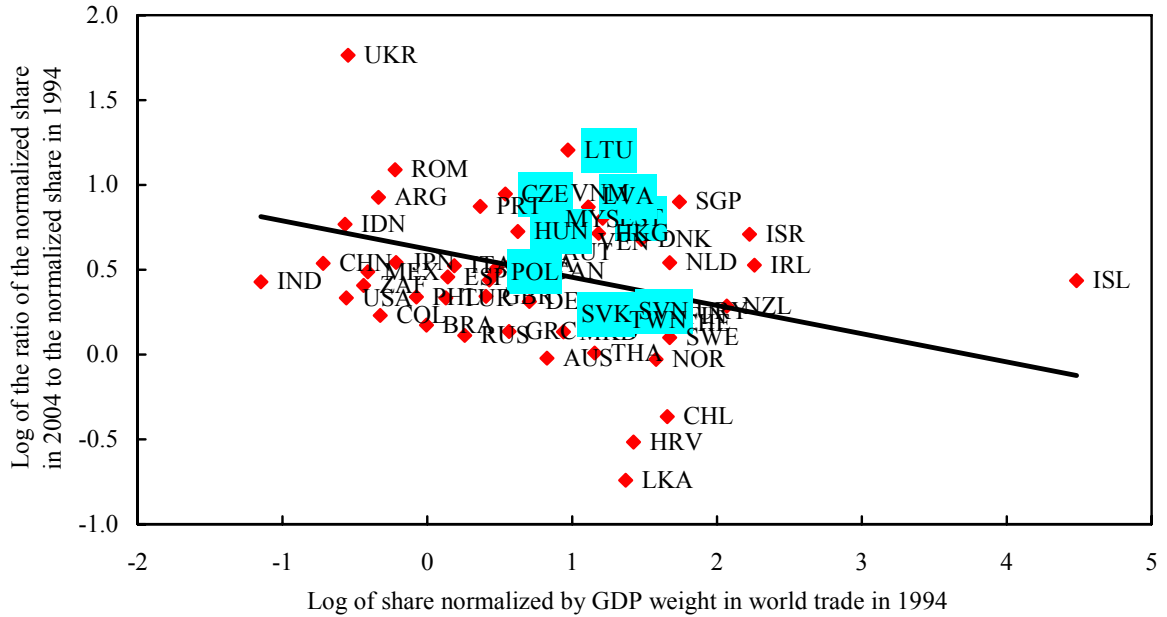
be of value to international buyers) and the shift to products with higher technology content, both of which may allow a country to raise the average prices at which it sells its exports. With these two effects eliminated, and because the analysis focuses on changes over time within a country, the *UVR*, in principle, proxies product quality, on the premise that a higher price reflects higher quality (see Hallak and Schott, 2005). The concern remains that the *UVR* is picking up other influences, especially if local monopolies exist and competition does not arbitrage away differences in quality-adjusted prices. To the

Figure 5. Change in Unit Value Ratio vs Change in High-Tech Share, 1994-2004

extent that is the case and the *UVR* does not measure "quality," the estimates will be biased downward. Hence, a finding that a higher *UVR* helps increase market share would provide a conservative estimate of the effects of quality. There remains the possibility that the UVR is picking up changes in the relative shares of products within the fixed basket of goods. To control for this, using higher R&D intensity as a metric for higher technology, we obtain measures of a country's technology composition (for the fixed basket of goods, the technology composition changes to the extent that shares within that basket evolve).[5] Figure 5 shows that an increase in the high-tech share of a country's export composition is (imperfectly) correlated with its unit value ratios. Among developing countries/emerging markets, East Asia and the CEE-8 were the forerunners in technology and quality upgrading, whereas Latin America lagged (Figure 6).

These considerations lead to the following base empirical specification:
log (*normalized market share$_{i,t+1}$/normalized market share$_{i,t}$*) = f (*log normalized market share$_{i,t}$, log UVR$_{i,t}$, ΔUVR$_{i,t+1}$, ΔREER$_{i,t+1}$*).

Throughout, we use the change in the *normalized market share* as the variable to be explained. *i* refers to a country. *ΔUVR$_{t+1}$* is the log change in *UVR* from period *t* to period *t*+1, and *ΔREER$_{t+1}$* is the log change in the real effective exchange rate (*REER*) from period *t* to period *t*+1. Thus, we examine if the initial *UVR* influences the subsequent evolution of a

---

[5] See the Appendix for details. Using the same R&D metric for all countries does not allow for the possibility that the technology for even a narrowly defined product category may differ across countries. The assumption is that international competition induces countries to adapt or innovate, though in possibly differing ways. In using a common categorization for all countries, we follow, for example, Rajan and Zingales (1998), who apply the U.S. measure of dependence on external finance to all countries.

Figure 6. Change in Unit Value Ratio and High-Tech Share, 1994-2004 1/

■ UVR change　□ High-tech share change

CEE-8
Average UVR change = 0.81
Average high-tech share change = 12 percentage points

Emerging Asia
Average UVR change = 0.82
Average high-tech share change = 21 percentage points

Selected EU-15
Average UVR change = 0.73
Average high-tech share change = 10 percentage points

EU Candidates
Average UVR change = 0.45
Average high-tech share change = 3 percentage points

Latin America
Average UVR change = 0.15
Average high-tech share change = 2 percentage points

Others
Average UVR change = 0.11
Average high-tech share change = 4 percentage points

Sources: UN Comtrade database, and IMF staff calculations.
1/ Average changes in UVR and high-tech shares are unweighted means across each country group. The changes are computed as the log difference for UVR and as the absolute change for high-tech share.

country's market share and allow also for the possibility that the change in the *UVR* helps gain market share over the period considered. Because of the difficulties in measuring the equilibrium value of the exchange rate, especially for developing economies, we consider only the change in *REER*.

Panel regressions with country fixed effects allow analysis of within-country changes in market shares. The period from 1994 to 2004 is divided into three subperiods, 1994–97, 1998–2001, and 2001–04, since annual changes are too noisy to give reliable results. We also ran the regressions for five-year periods with very similar findings. All regressions include country dummies, which are not reported. Since the dependent variable is the change in the market share, which, on average, does not change systematically for all countries in the same direction over time, we do not include time dummies. For 58 countries (covering almost 94 percent of world trade) and the three time periods, we have, in principle, 174 observations. The Appendix lists the countries.

IV. BASE RESULTS

Three factors are found to be significant in determining the evolution of market shares (Table 1). First, as Figure 4 above foreshadowed, the change in market share is inversely related to the starting share. Second, the initial *UVR* is positively associated with the subsequent increase in market share at a high level of statistical significance. Thus, of two countries starting each with a 1 percent share of the world market, the one with a starting unit value at the world average (and, hence, a log *UVR* equal to zero) will see its market share unchanged over the next three-year period (assuming no change in *UVR* and *REER*). A similar country with a starting unit value that is 10 percent above the world average will increase its market share to 1.05 percent. Third, the change in *UVR* over the three-year period is also positively and significantly associated with an increased market share. Once we control for these factors, the direction of the effect of a real exchange rate change is such that an appreciation hurts; however, in this specification, the statistical significance is weak.

Table 1. Base Specification – Dependent Variable: Ratio of End-of-Period Share to Beginning-of-Period Share

	(1)	(2)	(3)	(4)
Initial share	-0.912***	-0.996***	-0.984***	-1.005***
	[7.25]	[8.48]	[8.55]	[8.72]
Initial UVR		0.343***	0.516***	0.516***
		[4.61]	[5.09]	[5.12]
UVR change			0.191**	0.186**
			[2.46]	[2.40]
REER change				-0.287
				[1.50]
Constant	0.811***	0.786***	0.715***	0.735***
	[8.30]	[8.70]	[7.70]	[7.88]
Observations	174	174	174	174
Number of countries	58	58	58	58
R-squared	0.31	0.42	0.45	0.46

Notes: Absolute value of t-statistics in brackets. * significant at 10 percent; ** significant at 5 percent;
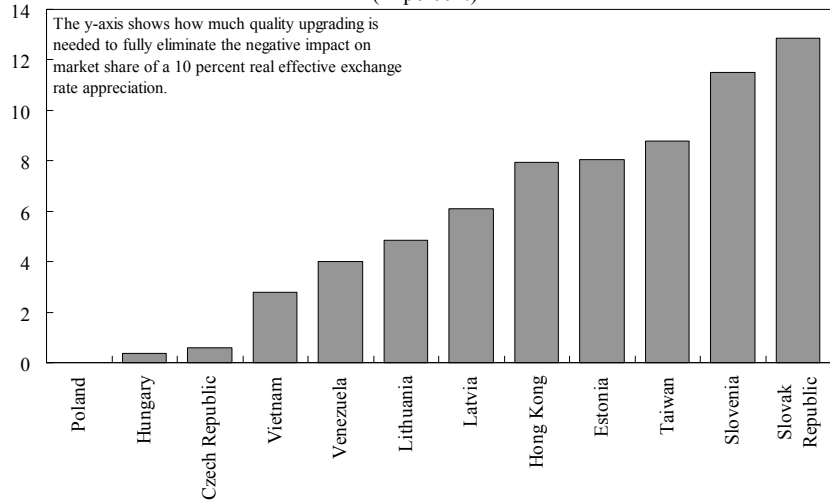*** significant at 1 percent. All variables are in logarithms.

These relationships work differently for developed and developing countries.[6] Not surprisingly, the inertia set by initial market shares is significant in developed countries (Table 2, columns 1 and 2), implying that it is difficult for them to increase their international presence from their well-established world market positions. Because the initial market share is so potent, the effect of other variables is more modest, though the initial *UVR* has a strong bearing for exports from the EU-15. *REER* has the "wrong" sign for developed economies. In contrast, the developing country group is less constrained by its market share history (Table 2, columns 3–5), allowing more space for market share increase through technology and quality upgrading. Also, developing countries are apparently punished more for real exchange rate appreciations. Figure 7 plots how much quality upgrading is required to compensate for a given level of exchange rate appreciation in order to keep a country's market share constant. Using the coefficients in Table 2, column 3, we calculate the *UVR* change that would leave the market share unchanged if a 10 percent *REER* appreciation occurred. Since this calculation takes the initial share and initial *UVR* in 1994 as given for each country, the required rise in *UVR* depends on the actual

Figure 7. UVR Upgrade Requirement to Compensate for 10 percent REER Appreciation (In percent)

The y-axis shows how much quality upgrading is needed to fully eliminate the negative impact on market share of a 10 percent real effective exchange rate appreciation.

initial conditions a country starts with and, therefore, differs across countries. Reflecting the catch-up effect, countries with smaller initial market shares and higher initial quality levels can do less upgrading than those with less advantageous initial conditions and still achieve the same results.

The evidence is mixed on whether the gains from technology and quality upgrading are nonlinear (Table 3). In the rest of the analysis, we focus only on developing countries. In exploring a number of extensions, we first briefly consider if quality variations have nonlinear effects. The square of *UVR* does have a negative sign, indicating that continued *UVR* enhancement brings declining gains, though the coefficient is not significant at the 5 percent level. However, the sum of the evidence, including the observation noted above that such quality enhancements play a limited role for developed economies, suggests that there are limits to gains from this upgrading process. This (and their already large market shares) may explain the smaller gains made recently by East Asian countries (compared with the CEE-8) despite their continued impressive technology and quality upgrading.

---

[6] The term "developing countries" follows the World Bank classification, with the countries highlighted in Appendix Table 1.

Table 2. Differences between Developed and Developing Countries –
Dependent Variable: Ratio of End-of-Period Share to Beginning-of-Period Share

Sample	(1) EU-15	(2) Developed Countries	(3) Developing Countries	(4) EU-8, Emerging Asia, Latin America	(5) EU-8, EU candidates, Emerging Asia, Latin America
Initial share	-1.896***	-1.721***	-0.876***	-1.013***	-0.886***
	[6.11]	[6.75]	[7.14]	[5.57]	[7.04]
Initial UVR	0.259*	0.142	0.529***	0.597***	0.513***
	[1.94]	[0.96]	[4.63]	[5.73]	[4.55]
UVR change	0.056	-0.097	0.288***	0.292***	0.286***
	[0.45]	[0.78]	[3.39]	[3.98]	[3.40]
REER change	2.087***	1.362***	-0.597***	-0.646***	-0.699***
	[4.25]	[3.38]	[2.93]	[3.11]	[2.96]
Constant	2.139***	1.769***	0.538***	0.581***	0.528***
	[5.68]	[6.34]	[6.52]	[4.98]	[6.16]
Observations	42	63	111	81	99
Number of countries	14	21	37	27	33
R-squared	0.84	0.75	0.51	0.57	0.55

Notes: Absolute value of t statistics in brackets. * significant at 10 percent; ** significant at 5 percent;
*** significant at 1 percent. All variables are in logarithms.

Table 3. Non-linearities in the Effects of Quality Upgrading –
Dependent Variable: Ratio of End-of-Period Share to Beginning-of-Period Share

Sample	(1) Developing Countries	(2) Developing Countries	(3) Developing Countries
Initial share	-0.834***	-0.857***	-0.846***
	[6.79]	[6.61]	[6.43]
Initial UVR	0.790***	0.579***	0.633***
	[4.33]	[3.73]	[3.52]
UVR change	0.255***	0.292***	0.329***
	[2.97]	[3.40]	[3.11]
REER change	-0.545***	-0.597***	-0.593***
	[2.69]	[2.92]	[2.88]
Initial UVR, squared	-0.168*		
	[1.82]		
Initial share*Initial UVR		-0.058	-0.126
		[0.48]	[0.76]
Initial share*UVR change			-0.069
			[0.60]
Constant	0.517***	0.527***	0.524***
	[6.31]	[6.16]	[6.06]
Observations	111	111	111
Number of countries	37	37	37
R-squared	0.53	0.51	0.51

Notes: Absolute value of t statistics in brackets. * significant at 10 percent;
** significant at 5 percent; *** significant at 1 percent. All variables are in logarithms.

Finally, two other considerations deserve attention. First, does the quality improvement reflect technical change? In other words, within the fixed basket of goods we consider, does a higher *UVR* primarily reflect the fact that the composition of this fixed basket is moving to higher-tech products with higher unit values? Table 4 shows that taken by itself, a move toward higher technology is associated with an increase in market shares. However, in the "horse race" between *UVR*s and technology shares, *UVR*s win. The implication is that there is some collinearity between improving product quality and technological upgrading, that is, countries experiencing one process also go through the other. However, within the fixed basket of goods, better quality of the individual products is more important than shifts to higher-technology products.[7]

Second, could the apparent influence of *UVR*s be a proxy for the possibility that countries are able to sell products at higher prices to importing countries growing rapidly and, hence, that the gain arises from astute selection of destination rather than from the effort to raise product quality? Table 4 shows that the growth of partner country GDP per capita is important: countries exporting to rapidly growing partners experience more rapid expansion of international market shares.[8] However, this finding does not negate the importance of quality improvements.

We pursue the relative roles of partner country growth and product quality in Table 5. As discussed in Section B, there is a presumption that richer countries have a higher propensity to buy higher product qualities. The first column of Table 5 shows that more rapid partner country growth is mainly relevant when the partner country is a developing economy. In other words, the more rapid growth of developing country buyers helps expand international market shares in a way that growth of industrialized country partners does not. In contrast, quality matters more for selling to industrialized economies. We interact the change in *UVR*s separately with developing and industrialized partner country growth. The results imply that if the developing country partner is not growing, the elasticity of change in market share with respect to change in *UVR* is about 0.66. This elasticity falls to zero if the developing country partner growth is 5 percent a year. In contrast, the elasticity is almost double for zero industrialized country growth and remains high for the observed range of industrialized country growth rates.

---

[7] It may still be the case—and this analysis does not examine the proposition—that a more ambitious change in production structure (elimination of low-tech products and graduation to new high-tech products) is necessary for increasing world market shares.

[8] To calculate the growth rate of trading partners' GDP per capita, we use the GDP per capita (in purchasing power parity terms) of a given country's trading partners in each year. We first take the average of these using the share of each trading partner in that country's exports as weights, and then calculate the annualized growth rate of this trade-weighted average. The alternative is to first calculate the growth rate for each trading partner and then take the trade-weighted average of the growth rates. The values obtained through these two methods are highly correlated, and the regression results are virtually the same.

V. IDENTIFYING QUALITY EFFECTS ACROSS PRODUCT CATEGORIES

Presumably, quality matters more for some products than for others. In his important contribution, Rauch (1999) has identified the degree to which product varieties are differentiated within a product group. He concludes, using supporting evidence, that the degree of differentiation influences the information necessary to trade these products. The more differentiated the product, Rauch finds, the greater the role of informal (ethnic) information networks in successfully conducting international trade in that product. In this section, we examine whether the degree of product differentiation is also consistent with quality variations that allow greater scope for pricing differentials.

Table 4. Does Quality Upgrading Reflect Technology Upgrading? –
Dependent Variable: Ratio of End-of-Period Share to Beginning-of-Period Share

Sample: Developing Countries	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	High and Medium Tech Upgrading			High Tech Upgrading			Impact of Trading Partners' Income
Initial share	-0.877***	-0.821***	-0.843***	-0.879***	-0.841***	-0.864***	-1.131***
	[6.98]	[6.11]	[6.59]	[7.16]	[6.93]	[6.81]	[8.72]
Initial UVR	0.442***			0.383**			0.523***
	[3.63]			[2.15]			[5.27]
UVR change	0.293***			0.221**			0.399***
	[3.37]			[2.12]			[5.07]
REER change	-0.584***	-0.611***	-0.601***	-0.566***	-0.595***	-0.551**	-0.485***
	[2.89]	[2.78]	[2.76]	[2.77]	[2.86]	[2.52]	[2.74]
Initial high and medium tech share	0.188	0.328**	0.282***				
	[1.51]	[2.59]	[3.01]				
High and medium tech share change	-0.011	0.054					
	[0.12]	[0.54]					
Initial high tech share				0.099	0.209***	0.109***	
				[1.46]	[4.58]	[3.58]	
High tech share change				0.051	0.112***		
				[1.08]	[2.84]		
Trading partners' GDP per capita growth							0.148***
							[4.36]
Constant	0.870***	1.178***	1.124***	0.929***	1.400***	1.088***	-0.002
	[4.09]	[5.60]	[6.10]	[3.32]	[7.72]	[7.18]	[0.01]
Observations	111	111	111	109	109	109	108
Number of countries	37	37	37	37	37	37	36
R-squared	0.54	0.44	0.43	0.55	0.52	0.46	0.65

Notes: Absolute value of t statistics in brackets. * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.
All variables are in logarithms.

Table 5. Differences between Developing and Industrial Trading Partners –
Dependent Variable: Ratio of End-of-Period Share to Beginning-of-Period Share

	(1)	(2)	(3)
Initial share	-1.226***	-1.196***	-1.207***
	[11.90]	[11.96]	[12.16]
Initial UVR	0.488***	0.366***	0.372***
	[6.40]	[4.35]	[4.54]
UVR change	0.345***	1.105***	0.627***
	[5.39]	[4.22]	[5.74]
REER change	-0.245*	-0.269*	-0.273*
	[1.70]	[1.92]	[1.96]
Developing trading partners' income growth	0.114***	0.105***	0.117***
	[4.92]	[4.63]	[5.24]
Industrial trading partners' income growth	-0.082	-0.028	-0.061
	[1.15]	[0.40]	[0.89]
UVR change*Developing trading partners' income growth			-0.066***
			[3.13]
UVR change* Industrial trading partners' income growth		-0.211***	
		[2.99]	
Constant	0.571***	0.373*	0.451**
	[2.81]	[1.80]	[2.26]
Observations	171	171	171
Number of countries	57	57	57
R-squared	0.70	0.73	0.73

Notes: Absolute value of t statistics in brackets. * significant at 10 percent; ** significant at 5 percent;
*** significant at 1 percent. All variables are in logarithms.

Following Rauch (1999), we classify goods into three categories, reflecting the differences in their price-setting mechanisms:[9]

- Differentiated products do not have well-defined product standards and are not traded on specialized exchanges. They carry the largest potential for quality variation.

- Reference-priced products are goods that have referable standards with reference prices that are available in specialized publications; however, they are not traded on organized exchanges. Quality variation is possible but less so than for differentiated goods.

- Homogenous products are goods that have clearly defined standards and/or are internationally traded on organized exchanges. Hence, they have well-defined prices and the smallest potential variation in quality.

Table 6 reports the standard deviations of the *UVR*s for the three categories. As expected, differentiated products have the highest standard deviations, followed by reference goods, and then by homogenous goods (which are clustered quite tightly around a single international price). Notice, however, that there is some tendency for homogenous products

---

[9] Appendix Table 3 provides examples of products in each category.

to become more differentiated over time, as the information intensity in trade increases and technological advances help expand the spectrum of product varieties. Figure 8 shows the *UVR*s for all three categories in the CEE-8. The changes in the aggregate country *UVR*s are driven by the changes in the *UVR*s of differentiated products, for which quality differentiation is intuitively expected to be the strongest.

Table 6. Scope of Quality Variation Across Product Groups 1/

Year	Differentiated Goods	Reference-Priced Goods	Homogeneous Goods
1994	0.31	0.31	0.11
1998	0.78	0.44	0.22
2001	0.56	0.43	0.33
Total	0.67	0.41	0.24

1/ The table summarizes the stardard deviation of UVRs.

The analysis in Section C is repeated for these three categories of products (Table 7). Some findings stand out. First, for the differentiated and reference-priced products, their initial *UVR* and the *UVR* change work strongly, but these variables have little influence on the market shares of commodities. This is as we would expect, though the fact that quality levels and changes work at least as strongly for reference-priced goods as for differentiated goods is something of a surprise (Hallak, 2006, obtained a similar result). Second, differentiated goods, however, appear to play a special role, through spillover benefits for reference-priced goods. One interpretation is that the quality of a country's differentiated goods serves as a signal of a country's general ability to develop quality products; as such, a high *UVR* for these goods benefits other exports. In contrast, if the *UVR* of reference-priced goods is higher, the exporting country makes less headway in differentiated goods—as if resources were diverted to the reference-priced goods. Third, the appreciation of the real exchange rate has the expected negative effect. This effect is, surprisingly, most pronounced for differentiated goods, followed by homogenous and reference-priced goods, where for the latter two the statistical significance falls below the conventional levels. Finally, growth of partner GDP helps expand market shares, as above, but mainly for reference-priced and homogenous goods.

VI. CONCLUSIONS

The analysis in this paper helps explain some part of the process through which the CEE-8 gained world market shares over the period 1994–2004. Essentially, they benefited from a catch-up process. Though their normalized export shares (export shares in world markets divided by share of GDP in world GDP) were not small even in 1994, there was scope for expansion, given that these are, with perhaps the exception of Poland, small, open economies. Trade liberalization created the opportunities for expanded trade, and the economic reforms instigated privatization, restructuring, and the expanded use of foreign capital and management skills. These developments allowed a process of quality and technology upgrading. The results of this paper show that such upgrading is consistent with gains in international market share. The results also indicate that, while quality and

Figure 8. CEE-8: UVRs According to Potential Quality Differentiation, 1994-2004 1/

Differentiated — — — Reference ——— Homogeneous ∙∙∙∙ Total
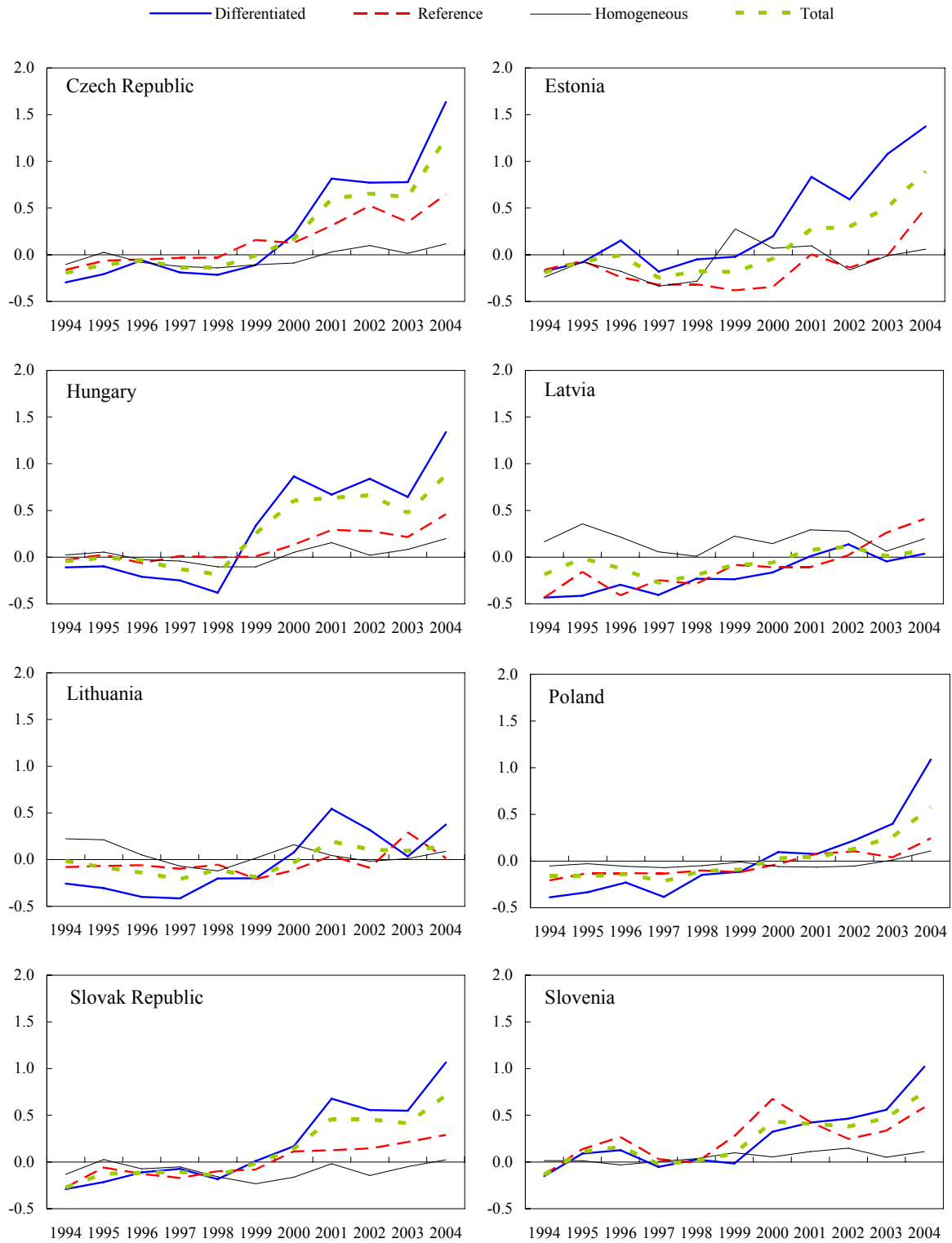
Source: UN Comtrade database; and IMF staff calculations.
1/ UVR is the unit value of a country's exports divided by the unit value of world exports. Expressed in logarithm so that a value of zero means country unit value equals world unit value.

Table 7. Product Groups According to Price-Setting Mechanism –
Dependent Variable: Ratio of End-of-Period Share to Beginning-of-Period Share (Calculated Specifically for Each Product Group)

Sample: Developing Countries	Differentiated Goods		Reference-Priced Goods		Homogeneous Goods	
	(1)	(2)	(3)	(4)	(5)	(6)
Initial share	-1.147***	-1.102***	-1.131***	-1.171***	-0.804***	-0.762***
	[11.28]	[10.71]	[5.63]	[6.09]	[5.85]	[5.61]
Initial UVR of differentiated goods	0.541***	0.589***		0.247***		0.137
	[6.44]	[6.80]		[2.76]		[0.99]
Initial UVR of reference-priced goods		-0.217*	0.717***	0.523**		0.308
		[1.84]	[3.04]	[2.22]		[1.55]
Initial UVR of homogeneous goods					0.173	0.069
					[0.34]	[0.14]
UVR change	0.342***	0.347***	0.483**	0.409**	-0.174	-0.182
	[4.93]	[5.09]	[2.48]	[2.18]	[0.60]	[0.64]
REER change	-0.570***	-0.572***	-0.203	-0.182	-0.51	-0.463
	[2.93]	[2.99]	[0.89]	[0.84]	[1.50]	[1.38]
Trading partners' GDP per capita growth	0.047	0.04	0.262***	0.194***	0.238***	0.195***
	[1.15]	[0.99]	[6.85]	[4.41]	[4.37]	[3.11]
Constant	-0.024	0.009	-0.404**	-0.118	-0.137	-0.05
	[0.12]	[0.05]	[2.03]	[0.54]	[0.50]	[0.17]
Observations	108	108	108	108	108	108
Number of countries	36	36	36	36	36	36
R-squared	0.72	0.74	0.54	0.59	0.50	0.54

Notes: Absolute value of t statistics in brackets. * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent.
All variables are in logarithms.

technology tend to improve together, the primary factor in gaining market share may well be quality improvements. This interpretation is also consistent with the finding that quality improvements in differentiated products help not only the exports of differentiated products but also "spill over" to benefit reference-priced goods. In other words, quality improvements appear related to building country reputation (as suggested by Shapiro, 1983). Reputation building, in turn, is valuable when a country is still not well established in international markets and information about its export quality and delivery capabilities has still to be established. That the catch-up process is associated with such information signaling is also consistent with Rauch's analysis. Finally, though it appears in a simple bivariate comparison that the real effective exchange rate appreciation did not hurt the CEE-8, the multivariate analysis suggests that, if exchange rates had not appreciated, performance could have been even better.

Looking ahead, the task becomes challenging for several reasons. First, the increased market share makes further gains more difficult. Second, there is some evidence of decreasing returns to improved quality. Thus, with reduced prospects of catching up, and continued (and possibly heightened) technological competition, the pressure to maintain market shares will increase. Continued policy efforts to raise productivity will therefore be needed.

To the Fund's evolving analysis of competitiveness, this paper adds some new dimensions. There may be merit in examining not only export shares in the global economy but also the normalized shares to assess how export performance is responding to changes in domestic production capabilities. Second, the role of product quality and technology upgrading could be important in some circumstances, but its importance will need to be assessed in context. In any event, this study demonstrates that a careful harnessing of disaggregated data can provide useful insights into the structural change of a country's export composition. Finally, analyzing exports along the dimensions in which they are differentiated can also have an important bearing on competitiveness. The analysis of competitiveness, therefore, has not become easier!

Appendix

The Appendix reports on the country sample, data sources, industry taxonomies, construction of the *UVR*, and selected products under the Rauch classification of traded goods.

A. The Sample

We started with 119 countries, accounting for approximately 99 percent of world manufacturing trade in the period 1994-2004. We ranked these countries according to their market shares and examined data coverage, both for trade-related variables and the control variables mentioned above. We retained those countries that had the data necessary for this analysis. The final data set covers the period between 1994 and 2004 for 58 countries. In Appendix Table 1, we provide the original list of countries, with the names of those countries included in the final sample in bold and those classified as "developing countries" highlighted. These countries account for 93.5 percent of global trade in manufactured products. For the purpose of this paper, we compute each country's export share as a fraction of the global trade in manufacturing products (Appendix Table 2).

B. Data Sources

The trade data come from the UN Comtrade database and consist of the trade values and quantities of export flows. The export data are at the six-digit product level, according to the Harmonized System (HS) classification, the most disaggregated level available from Comtrade.[10] For each product, an observation consists of the country of origin, time, trade value in dollars, quantity, and units in which the quantity is expressed.

The real effective exchange rate, based on the consumer price index (CPI), is taken from the IMF's *International Financial Statistics* (IFS).

The income level of trading partners is calculated using the GDP per capita from *International Financial Statistics* and the trade weights from *World Economic Outlook* database. To check robustness, both nominal and purchasing power parity (PPP) based measures are used. The results reported here use trading partners' income level in PPP terms, but the results using the alternative measure based on nominal GDP per capita are virtually the same.

---

[10] For the European Union, 8-digit trade data are available from the Eurostat database COMEXT, and, for the United States, 10-digit data are available from the U.S. Census Bureau. The COMTRADE database accounts for a country's exports to the world market.

Appendix Table 1. List of Countries

Albania	Cyprus	**Indonesia**	Myanmar	**South Africa**
Algeria	**Czech Republic**	Iran	Namibia	**Spain**
Angola	Côte d'Ivoire	**Ireland**	**Netherlands**	**Sri Lanka**
Argentina	**Denmark**	**Israel**	**New Zealand**	Sudan
Armenia	Dominican Rep.	**Italy**	Nicaragua	**Sweden**
Australia	Ecuador	Jamaica	Niger	**Switzerland**
Austria	Egypt	**Japan**	Nigeria	Syria
Azerbaijan	El Salvador	Jordan	**Norway**	**Taiwan POC**
Bangladesh	**Estonia**	Kazakhstan	Oman	Tanzania
Belarus	Ethiopia	Kenya	Pakistan	**Thailand**
Belgium	**Finland**	**Korea, Rep. of**	Panama	Togo
Bolivia	**France**	Kuwait	Papua New Guinea	Trinidad and Tobago
Bosnia and Herzegovina	Gabon	**Latvia**	Paraguay	Tunisia
Botswana	Gambia, The	Lebanon	Peru	**Turkey**
Brazil	**Germany**	Libya	**Philippines**	Uganda
Bulgaria	Ghana	**Lithuania**	**Poland**	**Ukraine**
Burkina Faso	**Greece**	**Macedonia**	**Portugal**	UAE
Cameroon	Guatemala	Madagascar	**Romania**	**United Kingdom**
Canada	Guiena	Malawi	**Russia**	**United States**
Chile	Guiena-Bissau	**Malaysia**	Saudi Arabia	**Uruguay**
China	Haiti	Mali	Senegal	**Venezuela**
Colombia	Honduras	**Mexico**	**Serbia and Montenegro**	**Vietnam**
Congo	**Hong Kong SAR**	Moldova	Sierra Leone	Yemen
Congo, Dem. Rep.	**Hungary**	Mongolia	**Singapore**	Zambia
Costa Rica	Iceland	Morocco	**Slovak Republic**	Zimbabwe
Croatia	**India**	Mozambique	**Slovenia**	

Notes: Countries included in the final sample that produced the reported results in the paper are in bold. Countries that are classified as "developing countries" are highlighted.

Appendix Table 2. Country Exports as a Share of World Exports 1/

	1994	1997	2001	2004		1994	1997	2001	2004
Argentina	0.42	0.48	0.46	0.49	Macedonia	1.48	1.11	0.76	0.77
Australia	0.91	0.85	0.79	0.69	Malaysia	1.91	1.96	2.07	1.93
Austria	3.10	2.62	2.71	3.20	Mexico	0.32	0.51	0.61	0.47
Brazil	0.39	0.37	0.36	0.43	Netherlands	3.49	3.75	3.51	3.98
Bulgaria	0.68	1.08	1.09	1.23	New Zealand	1.85	1.74	1.73	1.39
Canada	1.29	1.56	1.43	1.10	Norway	1.81	1.58	1.48	1.52
Chile	1.36	1.22	1.14	1.34	Philippines	0.51	0.55	0.64	0.51
China	0.42	0.39	0.45	0.55	Poland	0.75	0.77	1.02	1.32
Colombia	0.21	0.21	0.29	0.27	Portugal	1.76	1.67	1.54	1.69
Croatia	1.49	0.88	0.88	1.16	Romania	0.53	0.66	1.05	1.26
Czech Republic	1.49	1.79	2.63	3.04	Russia	0.36	0.45	0.51	0.43
Denmark	3.51	2.98	2.92	3.17	Serbia and Montenegro	0.09	0.62	0.58	0.86
Estonia	1.20	2.16	3.08	2.45	Singapore	4.66	4.96	4.24	4.56
Finland	2.75	2.84	2.86	2.80	Slovak Republic	1.66	1.76	2.22	2.95
France	1.99	1.89	1.91	2.01	Slovenia	3.78	3.47	3.51	3.72
Germany	2.44	2.48	2.57	2.99	South Africa	0.53	0.62	0.69	0.62
Greece	0.58	0.55	0.50	0.51	Spain	1.34	1.38	1.37	1.50
Hong Kong SAR	3.55	2.89	2.35	1.99	Sri Lanka	0.87	0.82	0.84	0.70
Hungary	1.22	1.83	2.44	2.81	Sweden	3.84	4.17	3.52	3.72
Iceland	3.91	3.19	3.25	2.73	Switzerland	5.30	4.85	4.37	5.21
India	0.19	0.19	0.18	0.19	Taiwan POC	2.30	1.90	1.91	1.80
Indonesia	0.40	0.40	0.54	0.46	Thailand	1.09	1.06	1.30	1.23
Ireland	4.75	4.16	5.00	6.30	Turkey	0.62	0.58	0.84	1.02
Israel	1.69	1.69	2.04	1.92	Ukraine	0.23	0.57	0.64	0.68
Italy	1.75	1.68	1.61	1.77	United Kingdom	1.44	1.53	1.42	1.27
Japan	0.86	0.90	0.92	0.99	Uruguay	1.43	1.10	0.88	0.77
Korea	1.23	1.29	1.34	1.52	USA	0.55	0.64	0.63	0.48
Latvia	0.61	1.34	1.15	0.97	Venezuela	0.49	0.49	0.40	0.43
Lithuania	0.50	0.98	1.17	1.28	Vietnam	0.41	0.61	0.76	0.87

Sources: UN Comtrade database; and staff calculations.

1/ Shares are computed using the common basket of products for the country and the benchmark (world). Trade values are summed up across products within a country and then divided by the sum of trade values of the same products exported by all countries.

C. Construction of Variables

We construct measures of technology and quality change at the country level using the detailed trade data at the product level. As in similar studies, the sample of products is limited to those of the manufacturing sectors. We use the Classification of Economic Activities in the European Community (NACE). Manufactures of coke products, refined petroleum products, and nuclear fuel are excluded from the analysis.

The technology content of products is based on the taxonomy provided by Hatzichronoglou (1997). Products are classified into four groups: high technology, medium-high technology, medium-low technology, and low technology.[11] This classification is based on a cutoff procedure using R&D intensities in select OECD economies in two-digit International Standard Industrial Classification (ISIC) product categories.

The measure of product quality is the relative unit value of a country's exports with respect to the unit value of all exports to a given market. Referred to as the "unit value ratio (UVR)" and commonly used in the trade literature, this concept of measuring quality by relative unit value has its basis in the idea that consumers would be willing to pay more for the same product if they perceive it to be of better quality.

We first calculate the unit value of each product that a specific country exports by dividing the trade value by the quantity. Then, we calculate the world unit value for the same basket of goods. We then divide the country's unit value for each product in the basket by the world unit value for the corresponding products. Finally, we aggregate these product unit value ratios into a single unit value ratio, using the weights of each product in the overall exports of the country. The reported UVR takes the logarithm of this ratio. Hence, a negative UVR corresponds to a quality lower than world standard.

Four remarks on UVR follow. First, products that fail to appear consistently in a country's export basket are excluded from the UVR calculations. Thus, the UVR measures the changes in the relative quality of the products that the country has been exporting on a continuous basis. Second, the basket of goods on which UVR calculations are based on is the intersection of the set of goods a country exports and the set of goods comprising the world exports. To calculate the UVR, the quantities should be expressed in the same units across the sample of countries. Third, the weights used in aggregating the country's product unit values change as the export composition changes. Hence, the aggregated unit value reflects not only the quality but also the composition of exports. Finally, market shares are calculated using the same basket of goods as for the UVR.

---

[11] The mapping between the Hatzichronoglou (1997) taxonomy and the HS is based on conversion tables from the UN Statistics Division, and in our judgment for a small number of products left out of the conversion tables.

Appendix Table 3. Partial List of Products in Rauch Classification 1/

Differentiated	Reference Priced	Homogenous
Soya sauce	Soya bean flour and meal	Coffee, not roasted or decaffeinated
Vitamins and their derivatives	Tar distilled from coal or lignite	Barley
Beauty, makeup, skin-care	Propane, liquefied	Rice in the husk (paddy or rough)
Artificial waxes	Mercury	Soya beans
Chemical preparations for photography	Sulphates of copper	Crude soya-bean oil
Activated carbon	Methanol (methyl alcohol)	Raw cane sugar, in solid form
Prepared rubber accelerators	Ionones and methylionones	Raw beet sugar, in solid form
Articles of apparel and clothing accessories	Vaccines for human medicine	Cocoa beans, whole or broken, raw
Vulcanized rubber thread and cord	Medicaments of alkaloids or derivatives	Tobacco, not stemmed/stripped
Hygienic or pharmaceutical articles	Fertilizers	Ores and concentrates
Articles of apparel of leather	Cellulose and its chemical derivatives	Lignite, not agglomerated
Wooden frames for paintings and photographs	Plates of polymers of ethylene	Petroleum oils and oils
Parquet panels of wood	Gummed or adhesive paper	Carbon
Textile wall coverings	Woven fabrics of cotton	Aluminium oxide, other than artificial
Articles of gold or silversmith	Woven fabrics of synthetic fibres	Natural rubber latex, in primary form
Flanges, stainless steel	Asphalt or similar material article	Latex of synthetic rubber
Chain, roller, iron or steel	Ferro-alloys	Cotton, not carded or combed
Table knives having fixed blades	Flat-rolled products of stainless steel	Wood in rough form
Carbon or graphite electrodes	Rails, iron or steel	Diamonds unsorted whether worked or not
Electrical insulators	Pipes and tubes, copper-zinc base	Silver in unwrought forms
Rail locomotives	Chain and parts thereof of copper	Gold in unwrought forms, nonmonetary
Automobiles	Plates, sheet, strip and foil, nickel	Platinum, unwrought or in powder form
Aircraft undercarriages and parts	Foil, aluminium	Iron, unrefined
Optical devices, appliances and instruments	Tin bars, rods, profiles and wire	Copper-zinc base alloys, unwrought
Clocks and watches	Molybdenum and articles thereof	Nickel, unwrought, not alloyed
Playing cards	Magnesium and articles thereof	Powders, molybdenum
Ballpoint pens	Nickel-iron electric accumulators	Magnesium

1/ See Rauch (1999).

Appendix Table 4. Taxonomies 1/

Taxonomy	Source	Method	Example
Factor intensity	Peneder (2001)	Statistical cluster analysis, using data on labor and capital use, share of R&D and advertising in total turnover at the NACE 3-digit level	Mainstream: Articles of paper and paperboard Labor-intensive: Wooden containers Capital-intensive: Pulp, paper, and paperboard Marketing-driven: Publishing Technology-driven: Office machinery and computers
Skill intensity	Peneder (2001)	Statistical cluster analysis, using data on employment shares of high, medium and low-skilled labor for selected OECD countries at the ISIC 2-digit level	Low-skill: Basic metal processing Medium-skill/blue-collar: Steam generators Medium-skill/white-collar: Electric motors, generators and transformers High-skill: Machinery for production
Technological intensity	Hatzichronoglou (1997)	Cut-off procedure, using data on R&D intensities for OECD countries at the ISIC 2-digit level	High-tech: Pharmaceuticals Medium-high-tech: Other chemicals Medium-low-tech: Rubber and plastic products Low-tech: Food, beverages, and tobacco
Hi-tech product list (HTP)	Hatzichronoglou (1997)	Cut-off procedure modified with subjective expert opinion, using data on R&D intensities for selected OECD members at the SITC 5-digit level	Includes storage units of digital automatic data processing machines, but excludes other parts of digital automatic data processing machines
Information and Communication Technology (ICT)	OECD	Statistical identification of industries whose products are intended to fulfill the function of information processing and communication including transmission and display, or use electronic processing to detect, measure and/or record	Includes manufacture of insulated wire and cable, but excludes electricity distribution and control apparatus Includes manufacture of industrial process control equipment, but excludes manufacture of medical appliances

1/ These taxonomies are based on product classification systems different from HS. Mapping of classifications is done using the conversion tables from UN Statistics Department.

References

Boldrin, M., and J. A. Scheinkman, 1988, "Learning-by-Doing, International Trade and Growth: A Not," in P.W. Anderson, K. J. Arrow, and D. Pines, eds., The Economy as an Evolving Complex System, Reading, MA: Addison-Wesley, pp. 285–300.

Copeland, B. R. and A. Kotwal, 1996, "Product Quality and the Theory of Comparative Advantage," *European Economic Review*, Vol. 40, pp. 1745-1760.

Dulleck, U., and others, 2005, "Dimensions of Quality Upgrading," *Economics of Transition*, Vol. 13 (No. 1), pp. 51–76.

Flam, H. and E. Helpman, 1987, "Vertical Product Differentiation and North-South Trade," *American Economic Review*, Vol. 77, pp. 810–822.

Grossman, G. M. and E. Helpman, 1991, "Quality Ladders in the Theory of Growth," *Review of Economic Studies*, Volume 58 (No. 1), pp. 43-61.

Hallak, J.C., 2006, "Product Quality and the Direction of Trade," *Journal of International Economics*, Vol. 68 (January), pp. 238-65.

Hallak, J.C. and P. Schott, 2005, "Estimating Cross-Country Differences in Product Quality," Working Paper, University of Michigan, Ann Arbor and Yale University.

Hatzichronoglou, T., 1997, "Revision of the High-Technology Sector and Product Classification," OECD Science, Technology and Industry Working Papers, 1997/2, (Paris: OECD, Directorate for Science, Technology and Industry).

Hummels, D. and P. Klenow, 2005, "The Variety and Quality of a Nation's Exports," *American Economic Review*, Vol. 95, pp. 704–723.

Landesmann, M., 2003, "Structural Features of Economic Integration in an Enlarged Europe: Patterns of Catching-Up and Industrial Specialization," European Commission DG-EcoFin Economic Papers No. 181.

Marimon, R. and F. Zilibotti, 1998, "Actual versus Virtual Employment in Europe: Is Spain Different?," *European Economic Review*, Vol. 42, pp. 123–153.

Murphy, K. and A. Shleifer, 1997, "Quality and Trade," *Journal of Development Economics*, Vol. 53, pp. 1–15.

Rajan, R. and L. Zingales, 1998, "Financial Dependence and Growth," *American Economic Review*, Vol. 88, pp. 559–586.

Rauch, J. E., 1999, "Networks versus Markets in International Trade," *Journal of International Economics*, Vol. 48 (No. 1), pp. 959–73.

Romalis, J., 2004, "Factor Proportions and the Structure of Commodity Trade," *American Economic Review*, Vol. 94 (No. 1), pp. 67-97.

Schott, P., 2004, "Across-Product versus Within-Product Specialization in International Trade," *Quarterly Journal of Economics*, Vol. 119, pp. 647–678.

Shapiro, C., 1983, "Premiums for High Quality Products as Returns to Reputations," *Quarterly Journal of Economics*, Vol. 98 (No. 4), pp. 659–680.

Stokey, N., 1991, "The Volume and Composition of Trade between Rich and Poor Countries," *Review of Economic Studies*, Vol. 58, pp. 63–80.

Ventura, J., 1997, "Growth and Interdependence," *Quarterly Journal of Economics*, Vol. 112 (No. 1), pp. 57-84.