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The Real Exchange Rate in the Long Term

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Abstract

This paper examines the factors that determine the long-term Real Exchange Rate (RER). Is the RER a stationary variable, as predicted by purchasing power parity theory? Or does it depend on long-term factors, particularly relative productivity (as per Samuelson (1964) and Balassa (1964))? We examined the change in the RER during a long period of three decades in a broad panel of countries, and found that the positive correlation between RER appreciation and economic growth (which is a proximate estimation of the change in relative productivity) is derived solely from the poorest countries. A further examination, based on a smaller number of countries and a shorter time frame, did not find a correlation between the RER and two direct indices of relative productivity: 1) relative manufacturing productivity in relation to overall productivity in the economy; and 2) transition from exports of traditional goods to exports of more advanced goods. However, we find a correlation between the RER and demographic variables.

שער החליפין הריאלי בטווח הארוך והבינוני

רוני פריש

תקציר

מחקר זה בוחן את הגורמים הקובעים את שער החליפין הריאלי בטווח הארוך. הוא מתמקד בשאלה אם שער החליפין הריאלי הוא משתנה סטציונרי (קבוע ונעדר מגמת זמן), כפי שמתחייב מהשערת חוק המחיר האחיד, או שהוא תלוי בגורמים ארוכי טווח – ובפרט בפריון היחסי – כפי שטענו בלסה וסמואלסון (Balassa (1964) ו-Samuelson (1964)). בחנו את השינוי בשער החליפין הריאלי במשך תקופה ארוכה – שלושה עשורים – בפנל מדינות רחב, ומצאנו שהמתאם בינו לבין השינוי בתוצר לנפש (קירוב לשינוי בפריון היחסי) נובע מהמדינות העניות בלבד. בחינה נוספת מתייחסת לטווח שנים ולפנל מצומצמים יותר, ולא נמצא בה מתאם בין התפתחות שער החליפין להתפתחותם של שני מדדים ישירים לפריון היחסי: 1) הפריון היחסי של התעשייה ביחס לפריון הכולל במשק, ו-2) העתירות הטכנולוגית של יצוא הסחורות. במבחני קו-אינטגרציה נמצא ששער החליפין הוא משתנה סטציונרי והזעזועים לו מתמידים פחות מהזעזועים לתוצר לנפש. אמדנו נתוני פנל בשיטת Arellano Bond כדי לטפל במתאם הסדרתי הגבוה של שער החליפין ובבעיית האנדוגניות בינו לבין התוצר לנפש, ומצאנו שהמתאם הקיים בין שני המשתנים בנתוני פנל משקף את ההתפתחות בטווח הקצר (מתאם על פני מחזור העסקים) ואין בין השניים מתאם בטווח הארוך .

1. Introduction

This study focuses on the question of whether the Real Exchange rate (RER) depends on long-term factors, particularly relative productivity, as claimed by Balassa (1964) and Samuelson (1964), or whether it follows the Purchasing Power Parity (PPP) theory. The PPP implies that a currency has the same purchasing power at home and in foreign countries; hence, the RER does not depend on productivity or any other variable.

The RER is defined as the ratio between the prices of an identical basket of products in two economies, with the prices measured in the same currency. The price differentials generate an incentive to increase international trade, and that in turn acts to equalize prices, subject to the constraints resulting from transportation costs, customs duties, etc. According to the weak version[1] of the Law of One Price, the price differential is bounded and the prices of an identical basket of products in two economies do not diverge—in other words, the RER is stationary (with no trend). Cross-sectional data, however, show a significant positive correlation between the cost of a basket of products and per capita GDP (GDP_PC): the same basket of products is more expensive in, for example, Japan and South Korea, two wealthy countries, than in Cambodia and Laos, two developing countries. Balassa and Samuelson asserted that the correlation was due to the technological improvements taking place primarily in the production of industrial goods traded between countries (tradable goods). Rapid growth in Japan and South Korea resulted mainly from improved productivity in the tradable sector, and even though this could lead to some decrease in the price of tradable goods, on the whole it made the basket of products more expensive. In particular, the rise in productivity led to a surge in Japanese and South Korean exports, to higher wages in the export sector, and finally led to higher wages for all workers in Japan and South Korea. The wage hikes increased the demand and price of nontradable items, in which productivity did not increase (gardening services, banking services, etc.), and the rise in their prices became dominant in the price level for Japan and South Korea. The Balassa-Samuelson hypothesis posits that a rapid increase in relative productivity—productivity in the tradable sector compared with productivity in the nontradable sector—causes higher prices, and these price hikes are equivalent to appreciation in the RER.

The PPP hypothesis (weak version) has been tested in many studies, and has been verified when long-term data or extensive panel data were used (over many years and countries). For example, Taylor and Taylor (2004) found that the ratios between the price levels in the US and the UK was converged over the course of 200 years. The same study examined the exchange rates in an extensive panel of countries for a shorter period, of 30 years, and reached a similar conclusion: price levels do not diverge over the entire sample period (although the correlation for annual data is weak). However, the Balassa-Samuelson hypothesis has also been confirmed in many studies, although the evidence in its favor is not unequivocal (see Rogoff, 1996). It was found that rapid growth in GDP_PC caused appreciation in the RER (these studies assumed that growth in GDP_PC

[1] According to the strong version, the absolute price levels in two economies, when measured in a single currency, consistently return to their fixed average. According to the weak version, a difference is likely to remain between them—due to the differences in the level of taxation, shipping costs, etc.—and only the ratio between them (when measured in a single currency) consistently returns to its fixed average.

was correlated with growth in relative productivity), and that rapid and prolonged growth in the industrial sector (relative to the other sectors productivity) led to higher price level and appreciation (Ito, et al., 1999).

Countries in Southeast Asia can serve as a test case for the Balassa-Samuelson hypothesis. The rapid growth observed in them until the eve of the 1996 crisis was accompanied by significant appreciation in exchange rates, indicating a long-term connection between rapid growth and real currency appreciation (Ito, et al., 1999). The test we conducted, however, found that this statistical correlation vanishes in the longer term (between 1973 and 2011). It can be argued that the growth process of countries in Southeast Asia is unique and unrepresentative, as it rests on rapid growth in exports, and such growth creates a need to preserve a competitive price level: export prices must be reduced and a depreciated exchange rate maintained (Krugman, 1989). Therefore, we tested the long-term correlation in a much broader group of countries (all the countries for which data on the RER in 1980 are available). However, a similar result was found: over three decades, rapid growth in GDP_PC does not cause exchange rate appreciation, with the exception of countries with very low GDP_PC at the beginning of the period (in 1980).

There are several ways of testing the Balassa-Samuelson hypothesis. The simplest is to test the change in the level of prices in the economy (in terms of PPP) in comparison with the change in GDP_PC over as long a period as possible. We tested this correlation over periods of four decades, and found no correlation between rapid GDP_PC growth and an increase in prices, other than in poor countries – meaning countries in which the starting GDP_PC (in 1980) was less than $1,000 (in 2000's price level). Another way is to estimate the change in the RER over a long period (from 1980 through 2010), compared with the change in GDP_PC over the same period, against a broad set of control variables. We find that over time, rapid growth in GDP_PC is uncorrelated with real appreciation in the exchange rate. As for the other explanatory variables, we found that the most significant of them was the population growth rate over the four decades. Other variables were not found to be convincingly and consistently significant, except for national savings and general government final consumption (which are endogenous variables).

A more correct way to test the Balassa-Samuelson hypothesis is to examine the effect of relative productivity—the tradable-sector productivity relative to the non-tradable sector productivity—on the RER. To do this, Chapter 3 examines two measures of relative productivity. The first measure is the labor productivity of the most tradable sector—manufacturing—divided by the labor productivity of the other sectors in the economy. The second measure examines the transition of the economy's export profile: an upgrade in the export profile—a transition from exports of labor-intensive goods to exports of technology and capital-intensive goods—constitutes evidence of a relatively rapid improvement in the productivity of the tradable sector (Hausmann 2007). We found that the two measures were correlated with the growth rate of GDP_PC—in other words, upgrades in the export profile and rapid growth in manufacturing productivity are correlated with rapid growth in GDP_PC during the same period. We did not find, however, a correlation between improvement in the two indices and the RER: rapid growth in the two indices was not found to be correlated with real appreciation in the exchange rate (over two decades).

2. Review of the Literature

Studies based on long-term data have confirmed the Law of One Price (weak version) hypothesis: Frankel (1986) examined the exchange rate of the dollar against the British pound in 1869–1984; Edison (1987) examined the same exchange rate in 1890–1978; Glen (1992) examined a panel of nine countries in 1900–87, and rejected the random walk hypothesis; Taylor and Taylor (2004) found that the ratios between the price levels in the US and the UK had not diverged over the course of 200 years. Alba and Papell (2007) found that the Law of One Price (weak version) tended to be fulfilled in countries that were relatively open to international trade, had a growth rate similar to that in the United States, low inflation, and little fluctuation in the nominal exchange rate. The Law of One Price is more likely to be fulfilled in European and Latin American countries than in Asian and African countries. Rogoff (1996) highlights that the evidence for long run PPP also indicates that adjustment to the long run PPP was extremely slow; the half-life of exchange rate shock is three to five years: "The PPP puzzle then is this: How can one reconcile the enormous short term volatility of RERs with the extremely slow rate at which shocks appear to damp out?" The shocks faded so slowly that it seemed questionable whether they faded at all. Several papers presented evidence revealing threshold type nonlinearity in RER data: the RER moves as a random walk until it crosses a threshold that generates an incentive to arbitrage in goods. Taylor, Peel and Sarno (2001) find that for modest shocks, the half-life of decay is three years, while for larger shocks the half-life is much shorter. Sarantis (1999) applies smooth transition autoregressive models and rejected linearity for RER of industrial countries, and Zussman (2003) shows nonlinear adjustment speeds for a very wide sample of countries.

Balassa and Samuelson hypothesized that a persistent deviation from the Law of One Price occurs when the ratio of productivity in the tradable sector to productivity in the nontradable sector increases, in comparison with the same productivity ratio in a country's trading partners. This process occurred in Japan in the 1970s and 1980s (Martson 1980), and also took place in other countries in East Asia (Ito, Isard and Symansky 1999). Other empirical studies that support the Balassa-Samuelson hypothesis are: Balassa (1973), David (1973), Marston (1987), Clague (1988), Krajnyak and Zattemeyer (1988), Cipriani (2001), Chudhri and Khan (2004), and Dorin and Rault (2010).[2] However, others, especially the panel studies, rejected it.[3] Tica & Druzic (2006) reviewed all the empirical studies that tested the Balassa-Samuelson hypothesis and were published—a total of 58 articles, summarizing their review as follows: "Results of the

[2] Dorin and Rault (2010) estimated the Balassa-Samuelson hypothesis in the 20 Latin American countries. They used the cointegration method, and found confirmation of the hypothesis.

[3] For example, an estimation using a VAR model found that a permanent increase in productivity in the tradable sector did not cause a permanent currency appreciation in any of the G7 countries: G. Coresti, L. Dedola, and S. Keduce (2006), "Productivity, External Balance, and Exchange Rates: Evidence on the Transmission Mechanism among G7 Countries," NBER.

survey indicate that a growing body of evidence definitely points towards professional rethinking about the significance of the Harrod-Balassa-Samuelson effect."

The specification of the Equilibrium RER (ERER) varies from one study to another, but two variables appear in most of the estimations—relative productivity (tradable versus nontradable) and the terms of trade. For example, Bereau et al. (2012) estimated the RER as a function of three variables: relative productivity, terms of trade, and the ratio of the volume of Net Foreign Assets (NFA) to GDP. The sample included 31 advanced and developing economies and the eurozone, and the sample period was from 1980 to 2007. Ricci et al. (2013), estimated the exchange rate using the three above-mentioned variables, and added to them public consumption (percent of GDP) and restrictions on international trade (rate of customs duties). Yet, Gubler and Sax (2011) found, in contrast to the Balassa-Samuelson hypothesis, that the RER was not correlated with relative productivity, and that terms of trade were the only variable that significantly explained the RER; the sample Gubler and Sax used included OECD countries in 1985–2008.

International trade economists have proposed various explanations to explain the phenomenon of rapid growth in GDP_PC without RER appreciation (in contrast to the Balassa-Samuelson hypothesis). Krugman (1989) asserted that the growth process should be expected to cause real exchange rate <u>depreciation</u>, since different countries specialize in making different goods, and the growth process means an increase in the supply of the output unique to that country. Since an increase in supply is known to cause a drop in price, countries with rapid growth are forced to take action to reduce prices in order to sell a greater quantity on the international market. In the long term, however, the countries with growth diversify their export goods, thereby refraining from lowering the prices of exports, and the Law of One Price is therefore fulfilled in the long term. Devereux (1999) used Balassa's revised model to explain the phenomenon of growth without currency appreciation characteristic of some of the Asian countries with high growth rates: in addition to the tradable and nontradable sectors, the revised model includes a third non-competitive sector with economies of scale, whose task is to distribute the tradable product to the consumer. Economic growth lowers production costs in the distribution sector and the price of tradable products, and growth therefore causes real depreciation. A different explanation reverses the causal direction, claiming that an economic policy that enforces real depreciation accelerates the growth rate (Rodrik 2008). These explanations illustrate the complexity of the link between economic growth and the RER.

3. Findings of Ito et al. (1999)

Ito, et al. (1999) found that some of the countries with particularly rapid growth in 1973–95 had also experienced prolonged real currency appreciation, as predicted by the Balassa-Samuelson hypothesis. This was the case in South Korea, Taiwan, Hong Kong, and Singapore. However, in Thailand, the real exchange rate remained unchanged (in comparison with the US). In China, the currency depreciated, even though its growth rate was second only to that of South Korea, and the cases of India, Malaysia, and Chile also failed to support the Balassa-Samuelson hypothesis. The researchers claimed that this was due to a differential in the composition of growth—currency appreciation occurred in countries whose economic growth was accompanied by a transition from exports of relatively simple goods, such as textiles, to exports of more sophisticated goods, such as machinery. China and India did not progress to production of more sophisticated goods (as of 1995, the end of the sample period), and therefore no currency appreciation took place. Except for China, which was closed to international trade at the beginning of the sample period (1973), a significant positive correlation was found between an increase in GDP_PC and real currency appreciation.[4]

Figure 1 reconstructs the study of Ito, et al. (1999), and includes data for the same years (1973–95) and same countries as in the original paper, except for Papua New Guinea, as the data were unavailable to us.[5] Like the original study, we display the GDP per capita growth rate against the real currency appreciation in 1973–95 and again find a significant positive correlation between a GDP_PC growth rate and RER (except for China). The positive correlation between rapid growth rate and appreciation disappears, however, when the sample is extended for any year after 2003. For example, Figure 2 shows the low correlation in 1973–2011 and in 1973–2005 (before the outbreak of the 2008 global crisis): The rapid growth in Thailand, Malaysia, and Chile did not cause exchange rate appreciation, and the slow growth in Mexico and the Philippines did not cause exchange rate depreciation. South Korea showed the most prominent connection between rapid growth and appreciation.[6]

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[4] The study emphasizes that no support was found for the underlying assumptions of the Balassa-Samuelson hypothesis, according to which economic growth leads to higher prices for nontradable goods, while prices of the tradable goods develop similarly in all countries. For example, a positive correlation was found between the change in the price of a basket of products and the change in the prices of the tradable goods.

[5] The RER of each country is measured in comparison with its trading partners, and the growth rate and exchange rate are calculated in comparison with the corresponding figures in the US.

[6] Extension of the sample was based on figures from the World Bank, except in the cases of Indonesia, South Korea, Thailand, and Hong Kong. Data are missing for these countries, and we therefore used Bruegal's database on a one-time basis in this study.

Figure 1: GDP per Capita Growth Rate against the Real Currency Appreciation in 1973–95

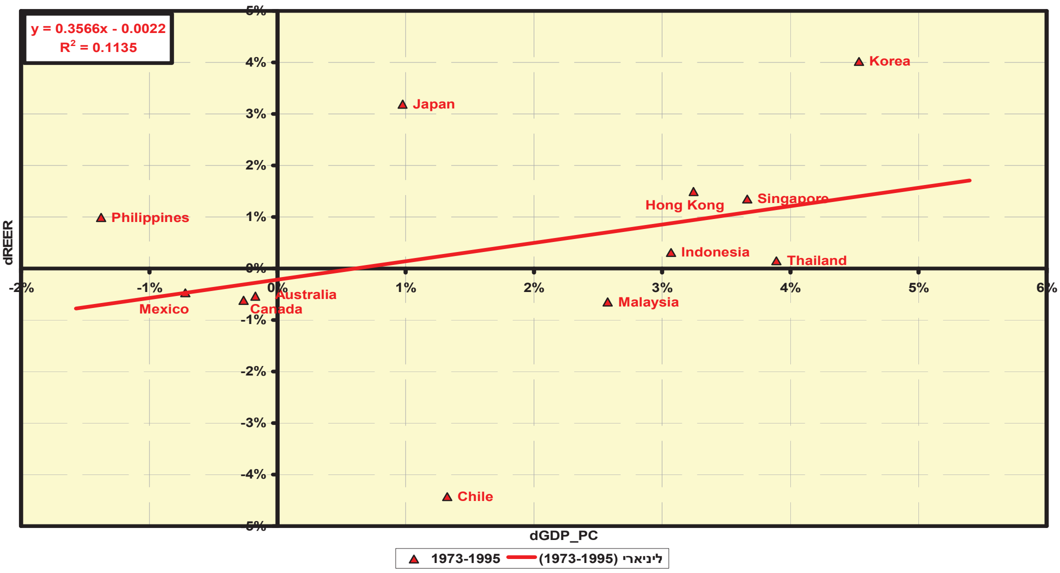
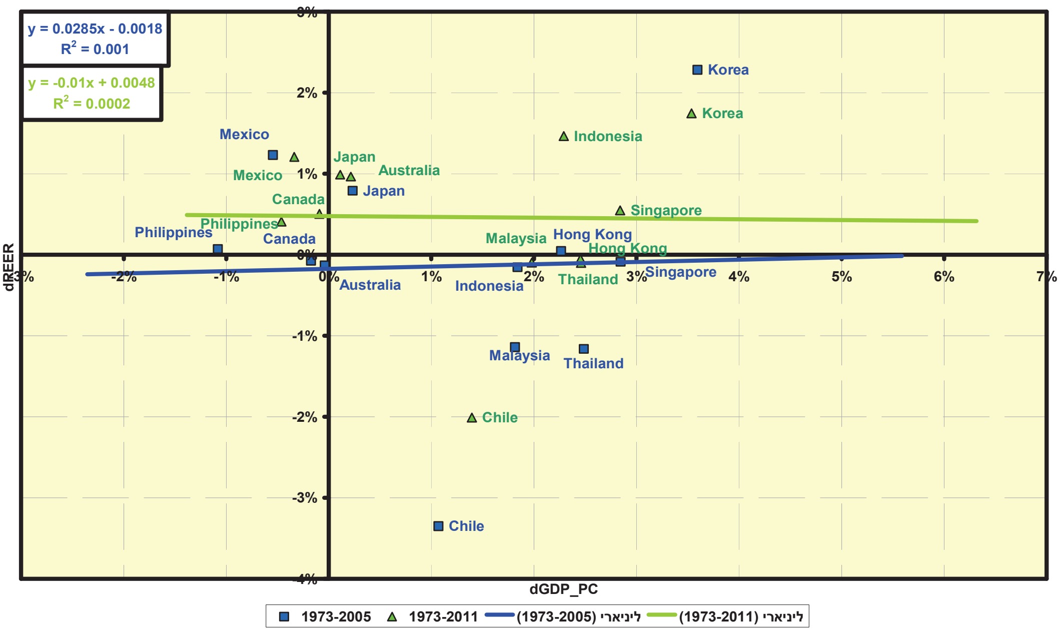


Figure 2: GDP per Capita Growth Rate against the Real Currency Appreciation in 1973–2011



Exports Profile and the Growth Rate

A basic assumption underlying this examination is that a transition from exports of relatively simple and traditional goods to exports of more sophisticated and advanced goods is correlated with an increase in productivity in the tradable sector (according to the hypothesis of Ito, et al. 1999). The export profile indices are based on detailed goods export data by country and 12 industrial sectors, including chemicals, electronics, and textiles, as well as the agricultural sector. A detailed explanation of the classification of industries by their technological level appears in the appendix; here we will merely explain that the classification is based on the assumption that exports of countries with a high GDP_PC are more technology-intensive than exports of countries with a low GDP_PC; hence, the textile industry, whose products are exported mostly by developing countries, is classified as a low-technology industry; while the pharmaceutical industry, which is exported mostly by advanced economies, is classified as a high-technology industry—this measure is based on the Hausmann index method.[7] We assume that countries that upgraded their export profile (replaced exports of low tech products with exports of high tech products) actually upgraded their productivity in the tradable sectors (in comparison with the tradable productivity in the rest of the world).

We first identified the countries that upgraded their export profile, and then examined whether these countries also experienced rapid growth of GDP_PC and real currency appreciation. Due to limited data availability, we tested only 30 countries—for which detailed export data, by sector, were available—from 1992 onward (the data source was the World Trade Organization).[8] Countries that remarkably upgraded their export profile (between 1992 and 2009) included Ireland, Greece, and Turkey,[9] and countries with a downgraded export profile included Japan and Mexico. As expected, a positive and significant correlation was found between an upgraded export profile and the GDP_PC growth rate, and this correlation was still robust after we omitted two outlier observations—China and Zimbabwe (Table 1A).[10] However, no significant correlation was found between an upgraded export profile and a change in prices in PPP terms (Table 1B), nor was a correlation found between an upgraded export profile and a change in the RER.[11] Upgrade in the country export profile is indeed correlated with more rapid growth rate, but that upgrade did not increase the price levels in the economy or cause RER appreciation.

[7] The Hausmann (PRODY) index. See R. Hausmann, Hwang J., and D. Rodrik (2007).

[8] This is a list of countries according to a ranking of the technological intensity of goods exports in 2011: Switzerland, Israel, Japan, Trinidad and Tobago, South Korea, Singapore, Mexico, the US, Canada, Taiwan, Venezuela, Hong Kong, Croatia, Thailand, Malaysia, Jordan, China, Algeria, India, Turkey, Australia, Brazil, Serbia, Argentina, Tunisia, Indonesia, Chile, New Zealand, Zimbabwe, Paraguay, Peru, and Madagascar. See the table in Appendix 2.

[9] We note that Thailand and Indonesia notably upgraded their exports profile, but no exceptional increase in productivity in the manufacturing industry in comparison with the other industries was found.

[10] A positive correlation was also obtained when we added a measure of the level of human capital in the economy—the proportion of primary school graduates in 1990 or in 2000—as an explanatory variable.

[11] This study uses both World Bank RER data and UN RER data.

Table 1A: Effect of Export Technological Intensity Change on GDP Growth
Dependent Variable: Growth in GDP_PC
Explanatory Variable: Upgrading of Technology Intensity in Exports

Sample Period	1992 until 2009		1992 until 2011	
	Regression 1	Regression 2	Regression 3	Regression 4
Change in exports technological intensiveness Index	***4.63 (1.49)	***2.11 (0.77)	***5.75 (1.81)	***2.69 (0.87)
R^2	0.29	0.29	0.31	0.34
Number of countries	31	29	30	28
Countries omitted	--	China and Zimbabwe	--	China and Zimbabwe

Standard error deviations in parentheses. ***P<0.01, **P<0.05,* P<0.1. (P value< Percent level of significance). All the regressions included a constant and GDP_PC in 1992.

Table 1B: Effect of Export Technological Intensity Change on Output Prices (PPP)
Dependent Variable: The Change in Output Prices (PPP)
Explanatory Variable: Upgrading of Technology Intensity of Exports

Sample Period	1992 until 2009		1992 until 2010	
	Regression 1	Regression 2	Regression 3	Regression 4
Change in exports technological intensiveness Index	-0.64 (1.09)	-1.06 (1.15)	-0.11 (1.12)	-0.47 (1.20)
R^2	0.028	0.054	0.022	0.034
Number of countries	31	29	31	29
Countries omitted	--	China and Zimbabwe	--	China and Zimbabwe

Standard error deviations in parentheses. ***P<0.01, **P<0.05,* P<0.1. The explanatory variable - change in exports technological intensiveness Index - is not significant. All the regressions included a constant and GDP_PC_1992 as an additional explanatory variable.

Another test of the Balassa-Samuelson hypothesis examines the change in productivity in the mining and manufacturing industry (whose goods are relatively more tradable), in comparison with the change in productivity in the other sectors (that is, the productivity of the total economy excluding mining and manufacturing industries). We have data for the ratio of industrial output to GDP, and the proportion of those employed in industry for 39 countries (between 1990 and 2009). 22 countries (of 39) increased the productivity of mining and manufacturing industries at a faster pace than the productivity of other sectors. Productivity in the manufacturing industry rose at the fastest rate (compared with the other economic sectors) in South Korea, Singapore, and Malaysia, and in several South American countries, including Peru and Colombia. In Europe, there was a notable increase in Austria and Ireland. Among the countries in which industrial productivity lagged significantly behind the other sectors were Poland, Romania, Brazil, Turkey, and Bulgaria.

In regressions 1 and 3 in Table 2A, it was found that a rapid improvement in industrial productivity (compared with the that of the other sectors) was correlated with a rapid economic growth rate (at a 10 percent level of significance): in countries where industrial productivity grew more rapidly, compared with productivity in the other sectors, GDP_PC grew more rapidly. The positive correlation (at a 10 percent level of significance) remained after three outlier countries were omitted from the sample:

Norway, since natural resources on a large scale were found there; South Korea and Colombia.[12] A positive correlation was also found in a sample for 1990–2009, which enables us to increase the number of countries. After omitting three countries with significant revenue from exports of natural resources—Russia, Norway, and Azerbaijan (regressions 3 and 4), a positive correlation was found. We also omitted Eastern European countries (Regression 5) because of the dramatic changes that took place in their economic regime in the 90's; once again positive correlation was found. However, an increase in the relative productivity of mining and manufacturing over two to three decades (compared with that of the other sectors) did not cause a higher price level in PPP terms or RER appreciation - Table 2B. Regression 3 found negative correlation: rapid growth in productivity correlated with a lower price level. Using real exchange data from the World Bank (or from the UN) yielded similar results to PPP price level.

Table 2A
Effect of the Productivity Differential between Tradable and Nontradable Sectors on the Change in GDP_PC
Dependent Variable: The Change in GDP_PC
Explanatory Variables: The Difference in the Rate of Increase in Productivity between the Mining and Manufacturing Industry and the Other Industries, and the Initial GDP_PC

	1980–2009		1990–2009		
	1	2	3	4	5
Differential between sectors in the rate of productivity growth	*0.605 (0.320)	*0.900 (0.483)	***0.264 (0.108)	*0.219 (0.126)	*0.233 (0.129)
R^2	0.33	0.40	0.43	0.44	0.52
Number of countries	24	21	36	34	30
Countries omitted	--	Norway, Colombia, and South Korea	Norway, Azerbaijan, and Russia	Norway, Azerbaijan, Russia, Colombia, and South Korea	As in Regression 4, and without Eastern European countries

Standard error deviations in parentheses. ***P<0.01, **P<0.05,* P<0.1. All the regressions included a constant and the level of GDP_PC at the beginning of the period (either 1980 or 1990).

All the regressions included the level of GDP_PC in the first year of the sample (either 1980 or 1990) as an additional explanatory variable, and a constant. Countries included in Regression 1: Belgium, Bulgaria, Chile, Colombia, Finland, France, Hungary, Indonesia, Italy, Japan, South Korea, Malaysia, the Netherlands, Norway, the Philippines, Portugal, Singapore, Spain, Sweden, Switzerland, Thailand, the UK, the UK, and Russia. Regression 3 also included Argentina, Austria, Brazil, Costa Rica, Denmark, El Salvador, Mauritius, Mexico, Peru, Poland, Romania, Sri Lanka, and Turkey.

[12] Growth in GDP_PC in South Korea was particularly rapid (an outlier). In Colombia, we find that the growth rate for GDP_PC was lower than in the other countries.

Table 2B
Effect of the Productivity Differential between Tradable and Nontradable Sectors on the Change in Output Prices (PPP)
Dependent Variable: The Change in Output Prices (PPP)
Explanatory Variables: Initial GDP_PC and the Difference in the Rate of Productivity Growth between the Mining and Manufacturing Industries and the other Industries

	1980-2009		1990-2009	
	Regression 1	Regression 2	Regression 3	Regression 4
Differential between sectors in the rate of productivity growth	-0.003 (0.13)	0.015 (0.31)	-0.19 (0.12)	0.016 (0.11)
R^2	0.09	0.07	0.22	0.13
Number of countries	24	21	36	30
Countries omitted	--	South Korea, Norway, and Colombia	Norway and Russia	Norway, South Korea, Colombia, and Eastern European countries

Standard error deviations in parentheses. ***P<0.01, **P<0.05, *P<0.1. All the regressions included a constant and the level of GDP_PC at the beginning of the period (either 1980 or 1990).

The assumption of previous studies, that rapid growth in GDP_PC indicates an increase in the tradable sector productivity relative to the increase in productivity in the nontradable sector, is indeed valid. Rapid growth in GDP_PC is correlated with a rapid increase in productivity in the manufacturing industry, compared with the other industries. Rapid growth in GDP_PC is also correlated with upgrading of the economy's exports profile—technology-intensive exports. Direct measures for relative productivity, however, did not confirm the Balassa-Samuelson hypothesis: a rapid increase in productivity of the manufacturing industry, compared with productivity in other industries,[13] or upgrading the profile of goods exports is not accompanied by RER appreciation.

4. The RER in the Long Term

4.a The Problem Concerning the RER: Cross-Sectional Data versus Panel Data

The strongest correlation between price level and GDP_PC appeared in the Penn World Table (PWT) database. The PWT database enables us to compare prices between countries. According to cross-sectional data for 2010, we conclude that GDP price level (for year 2010) elasticity to GDP_PC_2010 is 0.17 (Table 4, Regression 1), meaning that if `PPP Converted GDP Per Capita, 2010`, in country A is twice as much as country B, then the Price Level of GDP (G-K method, US = 100) of country A will be higher by 17 percent then in country B. The elasticity of 2010 price level to public consumption to GDP_PC_2010 is 0.30 percent, investment prices level elasticity to GDP_PC_2010 is 0.09 percent, and private consumption price level elasticity to GDP_PC_2010 is 0.17 percent.

[13] This is the case except for three countries that rapidly upgraded their trade profile, although the relative increase in their industrial productivity was (relatively) slow: Turkey, Thailand, and Indonesia.

Penn World Table data indicate that output prices are correlated with GDP_PC level. However, prices in 2010 were correlated with GDP_PC in 1970 (Regression 2)—just as they are correlated with the contemporaneous GDP_PC (Regression 1). Furthermore, change in GDP_PC has no robust effect on the change in prices. For example, no significant positive correlation was found between the change in GDP_PC and the change in prices in the period beginning in 1970 and ending in 2010, conditional on GDP_PC in 1970 (Regression 3); a similar result was found in each of the periods ending in 2010 and beginning in each of the years from 1971 to 1989. The contemporaneous correlation between prices and GDP_PC in 2010 becomes non-significant when GDP_PC in 1970 is added (Regression 4), and becomes weaker when the population growth rate in 1970–2010 is added (Regression 5). However, population growth rate has robust effect on the price level, as found by Braude (2010)—rapid population growth in 1970–2010 is correlated with a lower level of prices in 2010 (Regression 6).

Table 4
Effect of GDP_PC and Population Growth on Output Prices
Dependent Variable: (ln) Output Prices in 2010

	1	2	3	4	5	6
GDP_PC in 2010 (level, ln)	***0.172 (0.019)	--	--	0.011 (0.038)	**0.134 (0.025)	--
GDP_PC in 1970 (level, ln)	--	***0.226 (0.021)	***0.225 (0.021)	***0.215 (0.046)	--	***0.192 (0.026)
Population growth, 1970-2010 (1, ln)	--	--	--	--	***-0.111 (0.046)	**-0.089 (0.041)
Change in GDP_PC, 1970-2010	--	--	0.475 (1.544)	--	--	--
R^2	0.40	0.49	0.50	0.49	0.43	0.52
Number of countries	123	123	123	123	121	121

All the regressions included a constant. ***P<0.01, **P<0.05,* P<0.1. The standard deviations are in parentheses. 1. Population growth - annual rate of change. Regression 1 included only countries with data available for their GDP_PC in 1970. Regressions 3 and 6 do not include Bulgaria and Estonia, because the population of these countries decreased between 1970 and 2010.

Source: Penn World Table 7.1 (September 2012)

Table 5 examines the correlation between economic growth and the change in prices, (according to PWT 7.1). No significant correlation was found between change in GDP per capita (in PPP terms) and the change in (PPP) prices between 1980 and 2010 (Regression 1). As the weak version of the Law of One Price and the Balassa-Samuelson hypothesis depend on the existence of international trade, we omit the bottom decile of the closed countries in 1980[14], including China, a country that experienced rapid growth with no notable real appreciation. We found that GDP per capita growth has a positive and statistically significant effect on prices. The positive and robust effect remained after

[14] The countries were ranked by a measure of openness to international trade—according to the ratio of the volume of exports and imports to GDP in 1980; after omitting the bottom decile of the closed countries, a significant connection between growth in GDP_PC and the exchange rate was obtained.

we omitted from the sample countries that are rich in natural resources—Saudi Arabia, Venezuela, Trinidad & Tobago, and Gabon; see Regression 3. The correlation is not significant, however, when we also omit the poor countries—countries where GDP_PC in 1980 is lower than $1,000 in PPP terms (of year 2010); see Regressions 4, 5 and 6. We divide the countries into poor and rich according to their GDP_PC at the beginning of the period (the threshold was half of the GDP_PC in the US in 1980)—there is no significant correlation between GDP_PC growth rate and change in prices in either group (Regression 7 and 8).

Table 5
Effect of GDP_PC Growth Rate on Output Prices level (in PPP)
Dependent Variable: Change in Prices between 1980 and 2010 (compared with US)
Explanatory Variable: GDP_PC Growth During the Same Years (in PPP, compared with US)

(Average annual rate of change)

	Countries included	β (std)	R^2	Number of countries
1	All the countries	0.109 (0.102)	0.009	123
2	Excluding countries closed to international trade[1]	**0.241 (0.121)	0.036	108
3	Excluding countries closed to trade[1] and rich in natural resources[2]	*0.247 (0.135)	0.034	97
4	Excluding poor[3] countries and closed to trade[1]	0.145 (0.117)	0.017	89
5	Excluding poor[3] countries rich in natural resources[2] and closed to trade[1]	0.087 (0.133)	0.006	78
6	Excluding poor[3] countries	0.093 (0.116)	0.007	97
7	GDP_PC higher than 50 percent of US GDP_PC	-0.051 (0.088)	0.013	27
8	GDP_PC lower than 50 percent of US GDP_PC	0.093 (0.116)	0.007	96

All the regressions included a constant. ***P<0.01, **P<0.05,* P<0.1. The standard deviations are in parentheses.
[1] Countries closed to trade—countries in which the ratio of imports and exports to GDP is less than 20 percent (in 1980) - in the bottom decile.
[2] Countries whose ratio of revenues from natural resources to GDP was in the top decile (in 1980 or 1990).
[3] Countries whose GDP_PC in 1980 was less than $1,000 (in PPP terms).
Source: Penn World Table 7.1 (September 2012).

The demographic variables are key factors in explaining output price levels in the long term: rapid population growth is significantly correlated with decreasing price level (see Table 6). Inclusion of this demographic variable wiped out the significant effect of GDP_PC growth rate on the rise in prices (in 1980–2010, 1970–2010, and 1975–2005). In countries in which the population grew rapidly and in countries with a high proportion of children (ages 0–14) in the population at the beginning of the period (1970 or 1980), there was clear currency depreciation during the period. At the same time, these countries grew at a slower pace in terms of GDP_PC.[15] We conducted similar estimations for the exchange rates published by the World Bank and the UN, and obtained similar results: the positive correlation between GDP_PC growth and real currency appreciation is not significant in either a sample without the poor countries (GDP_PC less than $1,000 in 1980 in PPP terms), or when a demographic variable is included, such as the population growth rate during the period or the proportion of children in the population at the beginning of the sample period.

Table 6
Effect of GDP_PC Growth and Population Growth on Development of Output Prices (PPP)
Dependent Variable: Change in Prices (in PPP, compared with the US)
Explanatory Variables: GDP_PC Growth Rate (in PPP, compared with the US) and the Population Growth Rate During the Same Years
(Average of the rates of annual change during the sample period)

Sample Period	1980-2010			1970-2010		1975-2005	
	1	2	3	4	5	6	7
GDP_PC growth rate	**0.241 (0.121)	--	0.048 (0.121)	0.085 (0.098)	0.012 (0.103)	***0.27 (0.097)	0.118 (0.099)
Population growth rate	--	***-0.77 (0.163)	***-0.75 (0.177)	--	**-0.308 (0.154)	--	***-0.66 (0.166)
R^2	0.036	0.175	0.176	0.007	0.043	0.07	0.191
Number of countries	108	108	108	108	108	108	108

Excluding countries closed to trade. All the regressions included a constant. ***P<0.01, **P<0.05,* P<0.1.
The standard deviations are in parentheses.
Source: Penn World Table 7.1

To summarize, there is a notable difference between the contemporaneous estimations in a cross section (for example, 2010) and between estimations testing the change over the course of 30 or 40 years: while the contemporaneous estimations indicate a statistically significant contemporaneous correlation between GDP_PC and prices, in a long time period, no correlation was found between the rates of change in the two variables. This means that the change of prices over time is not consistent with the Balassa-Samuelson hypothesis, while the level of contemporaneous prices is not consistent with the Law of One Price hypothesis (since the output price level is higher in countries with higher GDP_PC).

4.b Estimation of the Connection between a Change in the Exchange Rate and Growth – Multivariate Regression

The previous section (4.a) tested the effect of a narrow list of variables on RER (price level). However, previous papers use numerous variables to explain the RER: fiscal policy variables (ratio of public consumption to GDP, government deficit), current account surplus variables (terms of trade, exports of natural resources, international trade

[15] There is a negative correlation between the population growth rate in 1970–2010 and GDP_PC growth in the same period: when the annual rate of population growth declines by 1 percent, the growth rate in GDP_PC (in fixed prices, PPP prices) accelerates by 0.59 percent (0.14 standard deviation, 1 percent level of significance). The result obtained for 1980–2010 was almost identical.

openness, customs duties), real and financial business cycle variables (unemployment rate, credit to the business sector), etc.[16] Previous studies reported different findings about a wide range of variables with a significant effect on the RER. We attempt to refine a specification that will include all of the variables whose effect on the exchange rate is consistent and reliable.

Table 3 in the Appendix tests the effect of 27 different variables (the X variables) on the RER during a fairly long period—three decades. Each row focuses on 1 of the 27 different, potential explanatory, variables—the description of each variable appears in the right-hand column of Table 3. Each column presents the result of 27 different regressions, one regression for each X variable. Column 1 displays the results of univariate regression—where the X variable is the only explanatory variable. Columns 2–7 display results of a regression with two explanatory variables: the X variable and a demographic variable that was found to be very robust: the proportion of children (up to age 14) in the total population at the beginning of the sample period (usually at year 1980). The dependent variable in Columns 1–7 is the change in the RER from 1980–84 (average) to 2006–10 (average). Column 3 refers to the exchange rate published by the World Bank, and Column 4 to the exchange rate published by the UN[17]. The other columns refer to the rate from two sources – the World Bank serves as the principal source, but when it does not publish continuous data for a given country between 1980 and 2011, we used continuous data from the UN website (if such data were there). The exchange rate figures for each country are always taken from a single source. The UN data made it possible to substantially expand the sample size.

The results indicate that the demographic variables have significant effect on the real exchange rate in the long term: real depreciation occurred in countries in which the proportion of children (0–14) in the total population was high at the beginning of the period and in countries in which the proportion of children in the population increased during the period. Given the proportion of children in the population at the beginning of the period, most of the other 26 variables we tested have no significant effect on the exchange rate in the long term (even though it was found that some of them are statistically significant in univariate regression). The change in the following variables didn't have a statistically significant effect on the change of the RER in the long term:

- The openness to international trade—measured as the sum of exports plus imports to GDP.

[16] See the review of the literature in S. Edwards and A.M. Savastano (1999).

[17] The correlation coefficient between the exchange rate of the UN and that of the World Bank was only 0.78 (1,671 common observations); the regression coefficient (β) between the variables was 0.94, and its standard deviation was 0.02. Both the exchange rate of the World Bank and that of the UN refer to the Consumer Price Index (CPI). The RER of country *i* is the weighted average of its real bilateral exchange rates with the other countries of the world. The weight assigned to each bilateral exchange rate can be determined using various methods, and this is the main source of the differences between the exchange rates published by different entities: the weighting can be determined according to the weight of the trading partner in world trade, according to its weight in trade with country *i*, etc. This study uses both World Bank data and UN data.

- The revenues from natural resources (per GDP).[18]
- The economy's capital stock (per GDP). One measure of the capital stock is the average rate of investment over the 20 previous years.[19] A second measure sums the investments made over the 30 preceding years (for example, the capital stock in 1980 sums the investments in 1960–79, in constant prices[20]); the capital stock is the ratio of total past investments to current GDP.[21]
- The share of investment in GDP.
- The unemployment rate.
- The ratio of the money supply to GDP.
- The share of bank credit to GDP, and the change in the share of credit to the business sector (indications of financial system development).

Changes in public consumption and savings were correlated with a change in the real exchange rate during the period: a rise in the ratio of 'End consumption' to GDP is correlated with RER appreciation, and the estimations yield a positive correlation between a rise in public consumption and RER appreciation (excluding African countries). A rise in the ratio of savings to GDP was significantly correlated with real currency depreciation. This correlation remains significant when various demographic control variables are included, (in addition to the proportion of the 0–14 age group in the population).

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[18] In the few cases in which a significant correlation was found, the increase in revenues from natural resources was correlated with RER depreciation (and not with RER appreciation as expected. Perhaps the increase in the Current Account surplus enables the economy to reduce customs duties).

[19] The average share of investment in GDP in 1960–79 constituted an indication of the capital stock in 1980–84, and the average share of investment in GDP in 1986–2005 constituted an indication of the capital stock in 2006–10.

[20] In order to calculate the capital stock for year T, we summed the investments made in the past after adjusting them to current prices (using PWT data). We adjusted past investments (time t) to the current level of prices according to the rise in the index for investment prices from t until time T. We assumed a 5 percent annual scrap rate (after a decade, for example, an investment loses 40 percent of its original value ((1-0.05)^10)=0.6)).

$$K_T = \sum_{t=1980}^{T} \left\{ Investmet\_current\_price_t \times \frac{price\_level\_of\_investment_T}{price\_level\_of\_investment_t} \times (1-g)^{(T-t)} \right\}$$

[21] This result contradicts the hypothesis of Bhagwati (1984) and Kravis-Lipsey (1983), which claimed that the price differentials between countries were caused by differences in capital intensity per worker: in capital-intensive countries, the marginal output of the workers was higher, and therefore labor-intensive goods were more expensive; nontradable goods are labor-intensive, and therefore are more expensive in capital-intensive countries and cheaper in labor-intensive countries. It therefore follows that an increase in the per-worker capital stock can be expected to cause real currency appreciation. As noted, however, no correlation was found between our estimates of capital stock and the change in the exchange rate (see the bottom row in Appendix Table 3).

The dummy variable for Southeast Asian countries was not significant, even though their growth rate was relatively fast, with a rapid rise in the capital stock. The dummy variable for African countries, countries in which the population grew quickly, indicates a tendency toward currency depreciation during the period. There was a clear trend in Latin American countries toward currency appreciation during the period, and since some of them experienced a currency crisis in the starting period (1980–84), it is possible that currency appreciation during the three decades offset excessive depreciation in 1980–84.

Only three factors had a significant effect on the RER over the long term: the demographic factor, savings (as a share of GDP) and the public consumption as a share of GDP (per GDP). The effect of demographic variables on the exchange rate was first found by Braude (2010). The effect of public consumption on RER is also well known in the literature. An increase in public consumption increases the demand for non-traded goods, hence it could affect their price. The effect of savings on the exchange rate is consistent with the hypothesis that the equilibrium exchange rate is the one that balances the current account in the long term (the current account surplus equals the difference between savings and investment, and an exogenous increase in the ratio of savings to GDP leads to exchange rate appreciation). However, the savings rate is not an exogenous or "fundamental" variable; and except for demographic variables, we did not find any exogenous variables that affect RER through its effect on the saving rate.

Table 7 introduces multivariate regressions which test the correlation between change in the RER from 1980–84 to 2006–10 and GDP_PC growth rate. As explanatory variables, we use two additional variables that were found to be significant in the regressions introduced in Appendix Table 3: the proportion of children (the 0–14 age group) in the population in 1980 and the difference in the ratio of public consumption to GDP (between 2006–10 and 1980–84). Given these two variables, we found negative correlation between the change in GDP_PC and the change in the real exchange rate during the period starting in 1980–84 and ending in 2006–10, (according to World Bank data). Table 7 didn`t support the Balassa-Samuelson hypothesis, as it didn't find significant positive correlation between RER appreciation and rapid growth rate in GDP_PC. However, this paper cannot support the PPP hypothesis either, because there are some factors that affect the RER (and the price level) over the long term; the most notable are the demographic variables.

Table 7
Effect of Selected Variables on the Change in RER
Dependent Variable: Rate of Change in the RER, Average in 2006–10 Compared with the Average in 1980–84, Excluding African Countries

	World Bank and the UN	UN Data	World Bank
GDP_PC growth rate[1]	*-0.058 (0.031)	-0.099 (0.073)	*-0.040 (0.022)
Population growth rate[1]	***-0.013 (0.004)	**-0.113 (0.005)	***-0.018 (0.003)
diff in the ratio of public consumption to GDP[2]	**0.021 (0.008)	**0.021 (0.001)	***0.027 (0.064)
Number of countries	53	43	41
R^2	0.30	0.20	0.62

All the regressions included a constant. ***P<0.01, **P<0.05,* P<0.1. 1. Average rate of change between 1980-1984 and 2006-2010. 2. Difference between the average in 2006-2010 and the average in 1980-1984.

5. Summary

This paper examines the factors that determine the long-term Real Exchange Rate. Is the RER depends on long-term factors, particularly on relative productivity (Samuelson (1964) and Balassa (1964))? Or is it a stationary variable, as predicted by the purchasing power parity theory?

We examined the change in the RER in 128 countries during a period of four decades, and found a positive correlation between economic growth (which is a proximate estimation of the change in relative productivity) and output price level (PPP). However, that positive correlation is derived solely from the countries at the lowest 10th percentile of GDP_PC in 1970. The age composition in 1970 affects both the PPP price level and economic (GDP_PC) growth through the following decades; the positive correlation between price level and economic growth rate was wiped out after controlling for age composition.

A further examination, relating to a much smaller number of countries and a shorter span, did not find a correlation between the RER and two direct indices of relative productivity:

1) Relative manufacturing productivity in relation to overall productivity in the economy.
2) Transition from exports of traditional goods to exports of more advanced goods.

As expected, those two direct indices of relative productivity were both correlated with rapid economic growth.

This paper could not confirm the Balassa-Samuelson hypothesis that a long-term improvement in the productivity of the tradable sector (relative to the nontradable sector) is correlated with RER appreciation. However, it could not confirm the Law of One Price either, since it found a significant correlation between the change in the price level and the age composition in 1970 (/1980). The demographic variables have a significant and consistent effect on the price level: The lower the proportion of children (age 0–14) in the population in the initial year, the greater the increase in price level over the next period.

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Appendix

The index for technological intensity in the per-industry composition of exports of country i (hereafter $index_i$) is calculated as follows:

$$index_i = \sum_j (EXPORTS_{i,j} \times \frac{Z_j}{\sum_j Z_j})$$

Where $EXPORTS_{i,j}$ represents the exports of industry j in country i, and Z_j is the rating for industry j, obtained as follows:

$$Z_j = \sum_i (X_{j,i} \times gdp\_per\_capita_i)$$

Where $X_{j,i}$ is the weight of industry j in the total exports of country i ($Ex_{j,i}$) with respect to the share of j in global exports.

Appendix Table 1: The Ratings of Export Industries (Z_j), 1992-2011

Year	Pharma-ceutical	Vehicles	Chemicals	Machinery and Equipment	Electronics	Office Equipment	Electrical Appliances	Metals	Communications	Agriculture	Food	Textiles	Clothing
1992	1.39	1.30	1.19	1.11	1.09	0.96	0.90	0.90	0.88	0.83	0.79	0.62	0.47
1993	1.39	1.29	1.19	1.10	1.09	0.95	0.90	0.90	0.88	0.82	0.79	0.62	0.47
1994	1.39	1.29	1.19	1.10	1.09	0.95	0.90	0.90	0.88	0.82	0.79	0.62	0.47
1995	1.39	1.29	1.19	1.10	1.08	0.95	0.90	0.89	0.88	0.82	0.79	0.61	0.47
1996	1.39	1.29	1.19	1.10	1.08	0.95	0.90	0.89	0.88	0.82	0.79	0.61	0.47
1997	1.38	1.29	1.19	1.10	1.08	0.95	0.90	0.89	0.88	0.82	0.79	0.61	0.47
1998	1.38	1.28	1.18	1.10	1.08	0.95	0.90	0.89	0.87	0.82	0.78	0.61	0.46
1999	1.37	1.28	1.18	1.09	1.07	0.94	0.89	0.89	0.87	0.81	0.78	0.61	0.46
2000	1.37	1.28	1.17	1.09	1.07	0.94	0.89	0.88	0.87	0.81	0.78	0.61	0.46
2001	1.37	1.28	1.18	1.09	1.07	0.94	0.89	0.89	0.87	0.81	0.78	0.61	0.46
2002	1.37	1.28	1.17	1.09	1.07	0.94	0.89	0.88	0.87	0.81	0.78	0.61	0.46
2003	1.37	1.28	1.17	1.09	1.07	0.94	0.89	0.88	0.87	0.81	0.78	0.61	0.46
2004	1.37	1.27	1.17	1.09	1.07	0.94	0.89	0.88	0.87	0.81	0.78	0.61	0.46
2005	1.37	1.27	1.17	1.09	1.07	0.94	0.89	0.88	0.87	0.81	0.78	0.61	0.46
2006	1.36	1.27	1.17	1.09	1.07	0.94	0.89	0.88	0.87	0.81	0.78	0.61	0.46
2007	1.36	1.27	1.17	1.09	1.07	0.94	0.89	0.88	0.87	0.81	0.78	0.61	0.46
2008	1.37	1.27	1.17	1.09	1.07	0.94	0.89	0.88	0.87	0.81	0.78	0.61	0.46
2009	1.37	1.28	1.18	1.09	1.07	0.94	0.89	0.89	0.87	0.81	0.78	0.61	0.46
2010	1.37	1.27	1.17	1.09	1.07	0.94	0.89	0.88	0.87	0.81	0.78	0.61	0.46
2011	1.37	1.28	1.17	1.09	1.07	0.94	0.89	0.88	0.87	0.81	0.78	0.61	0.46

Appendix Table 2: Technological Intensity of Exports, by Country, 1992 and 2011

Country	tech_by_export_nf_1992	tech_by_export_nf_2011
Switzerland	1.100	1.159
Israel	0.985	1.089
Japan	1.076	1.086
Trinidad and Tobago	0.991	1.070
Korea, Rep.	0.961	1.052
Singapore	0.992	1.036
Mexico	1.037	1.034
United States	1.027	1.029
Canada	1.055	1.026
Taiwan	0.959	1.022
Venezuela, RB	0.965	1.009
Hong Kong	0.888	0.980
Croatia	0.911	0.980
Thailand	0.878	0.974
Malaysia	0.961	0.963
Jordan	1.030	0.957
China	0.814	0.956
Algeria	0.967	0.946
India	0.801	0.938
Turkey	0.762	0.922
Australia	0.898	0.907
Brazil	0.933	0.901
Serbia	0.885	0.900
Argentina	0.854	0.895
Tunisia	0.755	0.881
Indonesia	0.777	0.872
Chile	0.839	0.857
New Zealand	0.848	0.832
Zimbabwe	0.822	0.821
Paraguay	0.820	0.803
Peru	0.796	0.803
Madagascar	0.790	0.733

Appendix Table 3

Dependent Variable: Change in Average RER, 2006–10, Compared with the 1980-1984 Average

Explanatory Variables: A Replaced Explanatory Variable Listed in the Right Column and One Other Explanatory Variable: The Proportion of the 0–14 Age Bracket in the Population in 1980.

Column 1 Displays Results of Regressions with a Replaced Variable only

	1	2	3	4	5	6	7	8	9	10
Exchange Rate Data	Consolidated	Consolidated	World Bank	UN Data	Consolidated	Consolidated	Consolidated	Consolidated	Consolidated	Consolidated
X Variable (in rows)	All the Countries*	All the Countries*	All the Countries*	All the Countries	Except for Africa	Except for Africa and East Asia	Except for Africa and Latin America	All the Countries*	All the Countries*	Except for Poor Countries and Those Closed to Trade
	1980-1984 to 2006-2010	1980-1984 to 2006-2010	1980-1984 to 2006-2010	1980-1984 to 2006-2010	1980-1984 to 2006-2010	1980-1984 to 2006-2010	1980-1984 to 2006-2010	1980-1984 to 2005-2007	1985-1987 to 2005-2007	1980-1984 to 2006-2010
The additional explanatory variables (in addition to X variable)	Single Variable	Proportion of 0-14 age bracket in 1980	Proportion of 0-14 age bracket in 1980	Proportion of 0-14 age bracket in 1980	Proportion of 0-14 age bracket in 1980	Proportion of 0-14 age bracket in 1980	Proportion of 0-14 age bracket in 1980	Proportion of 0-14 age bracket in 1980	Proportion of 0-14 age bracket in 1980	Proportion of 0-14 age bracket in 1980
GDP_PC (rate of change)	-0.0138 (0.036) [76]	-0.045 (0.031) [76]	*-0.0452 (0.0255) [57]	-0.0411 (0.0635) [63]	*-0.0607 (0.032) [53]	-0.0810 (0.173) [41]	*-0.0433 (0.025) [40]	-0.049 (0.035) [76]	-0.0402 (0.066) [77]	-0.060 (0.067) [56]
GDP_PC 15-64 (rate of change)	-0.0063 (0.0420) [76]	-0.0565 (0.0371) [76]	*-0.0564 (0.0300) [57]	-0.0624 (0.0727) [63]	*-0.0721 (0.0386) [53]	-0.0945 (0.192) [41]	-0.0502 (0.0298) [40]	-0.0001 (0.0003) [79]	-0.0002 (0.0004) [80]	-0.0723 (0.0766) [56]
GDP_PC in 1980 (or in 1986) (initial level)	***1.7e-05 (5.0e-06) [75]	-4.6e-05 (8.4e-06) [75]	-8.5e-06 (6.6e-06) [56]	-3.6e-06 (9.4e-06) [62]	-8.3e-06 (8.6e-06) [53]	*-1.8e-05 (1.0e-06) [41]	*-1.1e-05 (6.5e-06) [40]	-3.4e-06 (7.9e-06) [75]	-1.1e-05 (7.9e-06) [76]	-9.8e-06 (9.0e-06) [55]
Weight of public consumption in GDP (difference)	**0.0121 (0.0058) [76]	0.0069 (0.0053) [76]	0.0064 (0.0044) [57]	0.0082 (0.0058) [63]	**0.0196 (0.009) [55]	*0.0186 (0.012) [43]	**0.0210 (0.008) [42]	0.0059 (0.0051) [77]	0.0060 (0.008) [78]	0.0110 (0.0068) [58]
Weight of final consumption in GDP	*0.0083 (0.0044) [76]	**0.0077 (0.0038) [76]	**0.0076 (0.0034) [57]	0.0062 (0.0046) [42]	*0.0093 (0.0049) [55]	0.0054 (0.0061) [43]	0.0073 (0.0044) [42]	**0.0078 (0.0034) [77]	0.0058 (0.0036) [78]	0.0078 (0.0048) [58]
Weight of investment in GDP (difference)	***-0.0109 (0.0039) [80]	*-0.0067 (0.0036) [80]	*-0.0070 (0.0035) [58]	-0.0057 (0.0039) [67]	-0.0074 (0.0049) [56]	-0.0091 (0.0071) [44]	-0.0052 (0.0039) [43]	-0.0047 (0.0034) [80]	-0.0022 (0.0051) [80]	-0.007 (0.005) [60]
Weight of national savings in GDP (difference)	***-0.0173 (0.0039) [79]	***-0.0124 (0.0037) [79]	***-0.0096 (0.0033) [57]	***-0.0125 (0.0044) [66]	***-0.017 (0.0045) [55]	***-0.0167 (0.0053) [43]	***-0.0131 (0.004) [42]	***-0.0129 (0.0035) [79]	***-0.009 (0.0039) [79]	***-0.012 (0.0044) [59]
Current account surplus as percentage of GDP (difference)	-0.041 (0.0036) [80]	-0.0041 (0.0031) [80]	-0.0055 (0.0041) [58]	-0.0035 (0.0034) [67]	-0.0045 (0.0033) [56]	-0.0043 (0.0039) [44]	*-0.0047 (0.0025) [43]	*-0.0051 (0.0028) [80]	**-0.0077 (0.0038) [80]	-0.0043 (0.0032) [60]
Weight of exports in GDP (difference)	0.0023 (0.0021) [77]	0.0006 (0.0019) [77]	0.0013 (0.0022) [58]	0.0008 (0.0020) [64]	0.0005 (0.0020) [55]	0.0043 (0.0038) [43]	0.0010 (0.0016) [42]	0.0003 (0.0018) [78]	-0.0011 (0.002) [79]	0.0013 (0.002) [58]
Weight of imports in GDP (difference)	0.0021 (0.0022) [77]	0.0012 (0.0019) [77]	0.0039 (0.0024) [58]	0.0008 (0.0021) [64]	0.0010 (0.0021) [55]	0.0038 (0.0035) [43]	0.0013 (0.0017) [42]	0.0015 (0.0019) [78]	0.0013 (0.0024) [79]	0.002 (0.002) [58]
Openness to trade – weight of exports and imports in GDP	0.0012 (0.0011) [77]	0.00045 (0.0099) [77]	0.0014 (0.0012) [58]	0.0004 (0.0011) [64]	0.0004 (0.0010) [55]	0.0022 (0.0019) [43]	0.0006 (0.0008) [42]	0.00046 (0.0009) [78]	7.4e-06 (0.0012) [79]	0.0009 (0.001) [58]
Weight of manufacturing in GDP (difference in percentages)	***-0.0163 (0.0036) [68]	**-0.0079 (0.0038) [68]	***-0.0134 (0.0047) [54]	*-0.0077 (0.0041) [56]	**-0.0143 (0.0055) [47]	**-0.0140 (0.0066) [36]	**-0.0159 (0.0070) [36]	**-0.0077 (0.0033) [68]	***-0.015 (0.005) [70]	**-0.011 (0.005) [50]
Unemployment rate (difference)	0.0126 (0.0101) [46]	0.0117 (0.0096) [46]	0.0094 (0.0097) [37]	0.0081 (0.0104) [37]	0.0170 (0.011) [43]	*0.0193 (0.011) [37]	0.0124 (0.009) [32]	0.007 (0.009) [46]	0.0085 (0.009) [48]	0.0127 (0.010) [42]
Weight of revenue from natural resources (difference in percentages)	-0.0067 (0.0046) [79]	-0.0036 (0.0040) [79]	-0.0025 (0.0041) [58]	-0.0048 (0.0043) [66]	-0.0056 (0.0055) [56]	-0.0078 (0.0059) [44]	-0.0017 (0.0048) [43]	-0.0048 (0.0034) [79]	-0.0057 (0.0037) [80]	-0.007 (0.005) [59]
Trade terms (consolidated) (difference)	**0.0011 (0.0005) [65]	0.0006 (0.0005) [65]	0.0001 (0.0007) [47]	0.0008 (0.0005) [54]	0.0005 (0.0006) [44]	-0.0019 (0.0015) [32]	*0.0008 (0.0004) [31]	0.0006 (0.0005) [66]	0.0003 (0.0009) [67]	-0.0000 (0.0011) [46]
Weight of money supply in GDP (change in percentages)	*0.0019 (0.0010) [71]	0.00001 (0.0011) [71]	0.00009 (0.0008) [51]	0.00065 (0.0013) [60]	-0.0006 (0.0011) [48]	0.00008 (0.0012) [37]	-0.00009 (0.0009) [35]	0.00039 (0.0011) [71]	0.0002 (0.001) [72]	-0.0001 (0.0011) [51]
Weight of local bank credit in	***0.0020	0.0003	0.0002	0.0004	-0.0003	-0.0007	0.0001	0.0004	0.0002	0.0002

GDP (change in percentages)	(0.0007) [78]	(0.0008) [78]	(0.0006) [58]	(0.0009) [65]	(0.0008) [55]	(0.0009) [44]	(0.0007) [42]	(0.0008) [78]	(0.001) [79]	(0.0008) [58]
Weight of private sector credit in GDP (change in percentages)	***0.0023 (0.0008) [78]	0.0002 (0.0009) [78]	0.00027 (0.0007) [58]	0.00048 (0.0011) [65]	-0.00002 (0.009) [55]	0.0003 (0.001) [44]	0.0043 (0.0008) [42]	0.0006 (0.0009) [78]	0.0006 (0.0012) [79]	0.0004 (0.0009) [58]
Dummy variable for Latin America	0.0926 (0.1038) [81]	**0.186 (0.0888) [81]	*0.137 (0.0816) [58]	**0.218 (0.109) [68]	0.163 (0.102) [57]	0.075 (0.125) [44]	--	0.140 (0.085) [81]	*0.204 (0.103) [82]	0.163 (0.098) [60]
Dummy variable for East and South Asia	-0.084 (0.104) [81]	-0.084 (0.089) [81]	-0.047 (0.097) [58]	-0.072 (0.069) [68]	-0.149 (0.093) [57]	--	-0.0913 (0.0815) [44]	-0.078 (0.084) [81]	-0.083 (0.103) [82]	-0.215 (0.004) [60]
Dummy variable for Africa	***-0.32 (0.076) [81]	*-0.148 (0.086) [81]	-0.101 (0.085) [58]	-0.153 (0.0967) [68]	--	--	--	-0.124 (0.082) [81]	-0.148 (0.100) [82]	**-0.215 (0.107) [60]
Weight of 15-64 age bracket in the population (difference during the period)	-0.0084 (0.0083) [81]	0.0071 (0.0077) [81]	0.0037 (0.0075) [58]	0.0126 (0.0087) [68]	-0.0032 (0.0127) [57]	0.0018 (0.015) [44]	-0.0035 (0.011) [44]	0.0093 (0.0078) [81]	0.0032 (0.0107) [82]	0.0047 (0.010) [60]
Weight of 64+ age bracket in the population (difference)	***0.069 (0.0160) [81]	*0.0326 (0.0182) [81]	**0.0365 (0.015) [58]	0.0306 (0.019) [68]	0.0255 (0.0197) [57]	0.0385 (0.031) [44]	0.0192 (0.015) [44]	*0.0334 (0.0182) [81]	0.0369 (0.024) [82]	0.025 (0.019) [60]
Change in the weight of the 0-14 age bracket in the population during the period	-0.0062 (0.0079) [81]	-0.0102 (0.0068) [81]	-0.0093 (0.0066) [58]	*-0.0146 (0.0076) [67]	-0.0059 (0.0115) [57]	-0.0108 (0.015) [44]	-0.0054 (0.010) [44]	*-0.0116 (0.0067) [81]	-0.0082 (0.0094) [82]	-0.009 (0.009) [60]
Population increase (rate of change)	***-0.1959 (0.066) [81]	-0.0185 (0.073) [81]	**-0.2866 (0.116) [58]	-0.02613 (0.076) [68]	-0.0136 (0.075) [57]	-0.038 (0.081) [44]	0.0224 (0.059) [44]	-0.0469 (0.102) [81]	-0.225 (0.185) [82]	-0.034 (0.073) [60]
Weight of average investment over the 20 preceding years (difference)	0.0055 (0.0052) [77]	0.0042 (0.0045) [77]	0.0068 (0.0044) [57]	0.0026 (0.0054) [64]	-0.0059 (0.0070) [53]	-0.0014 (0.0106) [41]	0.0003 (0.0059) [40]	0.0049 (0.0042) [77]	0.0037 (0.0065) [78]	0.0039 (0.0061) [57]
Nominal capital stock (difference in percentages of GDP)	0.00008 (0.0008) [41]	-0.00034 (0.00085) [41]	***0.0018 (0.0005) [32]	-0.0003 (0.0010) [37]	-0.00015 (0.009) [37]	--	--	0.00007 (0.0008) [41]	-0.0004 (0.0010) [41]	-0.0002 (0.0009) [35]

Each cell in the table displays the results of a separate regression, and lists the coefficient of the replaced variable and the standard deviation of the replaced variable. The number of countries in the sample appears in the square brackets [].