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Country Size, Growth and Volatility*

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Very preliminary – Please do not quote

Abstract

What are the effects of country size on growth and business cycle volatility? To investigate this question, previously asked by Rose (2006) and Furceri and Karras (2007), we developed an original country-size index with principal component analysis (PCA). Traditional analysis of this topic usually only includes the population. Our methodology enables us to simultaneously consider the countries' population, GDP and arable land. The inclusion of these additional variables allows us to analyse different components of country size and to control for more than a merely demographic effect. Using a panel data set of 163 countries for 1960–2007, we find, contrary to Rose (2006), that country size has a significant and negative impact on economic performance. Our results for output volatility extend the negative and significant relationship found by Furceri and Karras (2007). In addition, we present differentiated results for small and large countries, OECD members, eurozone countries and the so-called BRIC countries. These results are robust for different country and time samples and several control sets.

JEL Codes: E42; F36; F42

Keywords: Country size; Principal component analysis; Economic growth; Business cycle volatility

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Introduction

Does the size of a country influence the pace and volatility of its growth? The existence of a so-called "scale effect" on economic growth is a recurring question in economics. The answers to this question seem to be determined by the economic context and phenomena of the time. The impressive development of small East Asian economies in the 1970s and 1980s was hailed by the motto "small is beautiful" and fuelled a new branch of literature documenting these economic miracles. The latest fad in the field of economic growth describes the success of the BRICs (Brazil, Russia, India and China), i.e., a new type of rapidly growing juggernauts in the world economy. Regarding the relationship between country size and volatility: small and very open economies seem to have a greater sensitivity to abrupt business cycle fluctuations, such as those that follow changes in terms of trade or capital movements. These countries cannot rely on a large domestic market to even out economic turbulence.

Before we delve into the theoretical and empirical literature related to our paper, let us first define "country size". One way of understanding the size of a country that is often used in economics is to consider that, in the world economy, small countries are price takers, whereas large ones are price makers. As Salvatore (2001) notes, however, this definition does not always hold; some small countries may be price makers if there is a limited number of suppliers. Ivory Coast and Ghana, for example, affect the price of cocoa. In addition, country size includes several dimensions: political, economic, geographic and demographic. The political dimension, although obviously important, is difficult to quantify. GDP is easily quantifiable and makes rankings based on economic size straightforward, but in regressions analysing growth determinants, it causes endogeneity problems. The geographic dimension of country size bears the least clear-cut relationship to the other variables, as a large population may densely occupy a small territory and vice versa. Such cases include the Netherlands on one side and Russia or Australia on the other. Population provides the easiest proxy for country size and has been widely used as such. Several authors, including (Kuznets (1960), Demas (1965), Salvatore (2001) and Lloyd and Sundrum (1982)), use arbitrary demographic limits to define small and large countries.

A branch of the literature that is relevant for this paper focuses on the effect of country size on economic performance. It examines whether country size has a clear-cut effect on economic growth and development, and it evaluates the costs and benefits associated with population. Mill (1844)'s reciprocal demand theory has already hinted at the larger gains made by small countries in international trade. These gains are proportional both to the unsatisfied internal demand in autarcy and to the external demand addressed to them. Robinson (1960) conducted a detailed analysis of the "economic consequences of the size of nations", suggesting that the adaptive capacities of small economies can overcome the narrowness of their domestic markets. In a neoclassical growth framework, like that used by Solow (1956), country size has no effect on growth. In an endogenous growth model, like that described by Aghion and Howitt (1998)), a larger country size means a large endowment and scale effects drive economic growth. The argument is straightforward; the larger the country, the larger its workforce and resources—especially in terms of human capital and R&D—to be engaged in industries with increasing returns to scale. This also implies a larger domestic market to sustain growth and that the aggregate, although not necessarily the per capita, catch-up will be quicker. The high growth rates displayed by China and other BRICs in the 2000s empirically demonstrate the existence of a "scale effect" for growth in a liberalised economic context. Conversely, Kuznets (1960) and Lloyd and Sundrum (1982) underlined that the concentration of output in a few industries and commodities, and the limited scope of national industries and agricultural markets, suppressed growth in small economies. However, Katzenstein (1985) and Schiff (1996) confirmed that "small nations obtain greater gains per unit of international trade than do large nations"(Lloyd (1968)) and also highlighted that small countries reap greater benefits from preferential trade agreements and greater integration of international markets. Nevertheless, Rose (2006), searching for this "scale effect", found no relationship between country size and growth, only confirming the higher degree of openness of small countries, which had also been documented by Rodrik (1998) and Alesina, Spolaore, and Wacziarg (2005). The multiplication of the number of independent countries from 51 in 1945 to 195 today in 2010, notwithstanding the political reasons behind state creation, suggests that small countries may be more viable in a globalised world economy with liberalised international trade. Easterly and Kraay (1999) focused on the income advantage of smaller states and found that their greater openness induced both higher growth and higher volatility. Baldwin (2003) strengthened the claim that openness to trade and growth are positively linked by stressing the role of a stable monetary framework in the relationship. On a more societal and institutional note, Robinson (1960) emphasised the higher degree of homogeneity in small countries and the better ability of their institutions to compromise. Conversely Rodrik (1998) showed that because of scale effects and the larger resources at their disposal, large countries are more efficient in the provision of public goods. Milner and Weyman-Jones (2003) also empirically documented that smallness was a hurdle for efficient economic development in developing countries over the 1980-1989 period.

A second issue addressed by the literature is whether country size and business cycle volatility are linked. Two papers find a clear inverse relationship between country size and volatility: Furceri and Karras (2007), and, focusing only on the OECD countries, Furceri and Karras (2008). These papers confirm the intuitive notion that larger countries exhibit greater growth rate inertia. From a theoretical viewpoint, the inverse relationship between country size and output volatility can be modelled: in the work of Imbs (2007), the larger number of sectors present in the economies of large countries accounts for the lesser volatility of output. The higher sensitivity to external shocks and greater volatility of small countries is a consequence of their more specialised economies. Indeed, large domestic markets mean that the covariance between world and domestic growth is higher, whereas small, specialised economies are more likely to face both idiosyncratic and common shocks. Using a real business cycle (RBC) model and Monte Carlo simulations, Crucini (1997) found that even after controlling for market structures and development levels (in terms of investment, savings, trade, and consumption), small economies experience more output volatility than large ones. This phenomenon may also be linked to the relationship between openness and inflation; Romer (1993) found evidence for a higher trade-off between output and inflation in small and more open countries, as the real depreciation effect hinders monetary stabilisation. Furthering the argument made by Katzenstein (1985) that small states in world markets aim achieve "domestic compensation", Furceri and Poplawski (2008) suggest an inverse relationship between country size and the volatility of government consumption. They suggest that this is a consequence of higher exposure to external shocks. Similarly, Rodrik (1998) argues that government plays an income-stabilising role in the face of global uncertainties. This behaviour, called "exposure mitigation", explains why more open economies tend to have larger governments. Finally, it may be asked whether volatility hurts growth in the long run; Aghion and Banerjee (2005), Ramey and Ramey (1995), and Hnatkovska and Loayza (2004) all contend that it does.

Our contribution to the literature is twofold. First, we develop an original measure of country size: a multidimensional index of size generated using principal component analysis (PCA) that includes population, GDP and arable land. The use of this indicator enables us to avoid the shortcomings of either a purely demographic measure or one based on GDP rankings. This *PCA Size index* captures the underlying patterns between three important components of country size: population, GDP and arable land. We thus provide a richer analysis of the effects of country size on economic performance and business cycle volatility. To make our work more easily comparable with previous studies, we also conduct our analysis using population as a proxy for country size. We also use this as a robustness test for our results. Our second contribution is that we empirically investigate the effect of country size on medium-term growth and its volatility for 163 countries over 1960–2007. We rely on a multivariate panel regression analysis to assess the direct and indirect effects of country size on economic performance. Indirect effects can be caused by volatility. In our analysis, we also isolate the scale or country-size effect from those of several economic variables, especially that of trade openness. Our empirical findings suggest that over 1960–2007, for the whole panel, there is a negative relationship between economic performance and size (contradicting Rose (2006)). This relationship is even more apparent for certain groups (small countries, OECD and BRICs). We also show that there is a negative relationship between country size and volatility independent of trade openness, extending Furceri and Karras's results, especially for small countries. A complementary finding of our analysis is that trade is a strong positive determinant of GDP growth but not of its volatility. Our results are robust to the inclusion of several control sets, country size specifications and detrending methods.

The remainder of this paper is organised as follows. Section 2 presents our empirical methodology, the construction of our country-size index, volatility measures and estimation strategy. In Sections 3 and 4, we detail our results for the impact of country size on growth and growth volatility, respectively, before concluding in section 5.

1 Empirical Methodology

1.1 Data

Our data set includes the 163 countries for which the relevant yearly data series, i.e., GDP, population and arable land, were available and comes from the World Bank[1] (listed in Table A-1 in the Appendix) for the 1960–2007 period[2]. Our computation

[1]Our panel included 177 countries, but the data on the GDP, population and arable land to compute our PCA size index and Jalan's size index were only available for 163 countries. We included the additional 14 countries in the regressions with population as a proxy for country size to test for the robustness of our results across size indicators.

[2]For the sake of precision, there are 195 sovereign states in the world, 192 of which are United Nations members. The 2009 CIA World Factbook lists 245 entities, including 195 "politically organized into a sovereign state with a definite territory" and 54 dependencies and areas of special sovereignty affiliated

of output volatility measures required a complete data set over the 1960–2007 time span, hence the exclusion of countries with interrupted GDP series (Fiji, Kuwait, Libya, Myanmar and Somalia). We interpret our results bearing in mind this possible "survivor bias"; however, the list of countries in our panel is comparable to those of our main references Rose (2006) and Furceri and Karras (2007)[3]. We rely on yearly data and decade averages of volatility indicators because we believe that country size, though evolving over time, is a structural and durable component of an economy. Our focus is therefore on the medium- to long-term effect of country size on growth and volatility, not on short-term or seasonal volatility.

Turning to the data, our left-hand-side variable is either the GDP growth rate (%) or a measure of output volatility computed using GDP levels ($ 2000 constant)[4]. Explanatory variables include three possible measures of country size, detailed below, among which population (millions) is measured in logarithm, as we believe its effect is not linear but proportional. Right-hand-side economic variables are trade openness, measured by the ratio of the sum of the values of exports and imports divided by GDP; inflation (%); and the real interest rate (%). Descriptive statistics of our dataset are in Table A-3 in the Appendix.

1.2 An Original Index of Country Size

Our main contribution lies in the country size index we developed using PCA. First, however, for the purpose of comparability with other studies and robustness, we use the log of population as a proxy for country size in our estimation procedure. Second, we use the country size index developed by Jalan (1982). We run our analysis using his measure because we wish to demonstrate that country size encompasses more than just demographic dimensions. Jalan's index is a weighted average of demographic (population), territorial (arable land) and economic (GDP) sizes. Each component is

with another country.

[3]Rose (2006) lists 208 "countries" but refers to them as "populations" because of the inclusion of a number of micro states and islands. The data set used by Furceri and Karras (2007) include 167 countries.

[4]The rationale for considering the GDP per capita as one of the components of the size effect or as the dependent variable is moot. Indeed, in the first case, GDP per capita determines the economic development of a country, not its size. In the second case, normalising GDP with respect to size would make our analysis meaningless. As we focus on the impact of the population level on the growth rate of a country, there is no reason why a 1% increase in the population of a small versus a large country should introduce a bias in the relationship considered. Moreover, introducing GDP per capita as a dependent variable would endogenise country size and lead to spurious econometric results, as both sides of our equation would include the effect of size.

measured against the largest value of the sample in a given year. Indeed, country size should be understood in relative terms as countries are categorised as small or large only in comparison with others. *Jalan's size index* is computed as follows:

$$Size\ Index_{it} = \frac{100}{3}\left(\frac{Population_{it}}{Max\ Population_t} + \frac{Arable\ Land_{it}}{Max\ Arable\ Land_t} + \frac{GDP_{it}}{Max\ GDP_t}\right)$$

This index, therefore, takes values in $[0;100]$. Assessing country size this way is sometimes problematic, as Jalan's size index allows for linear compensation across size dimensions; for instance, a country with a very large territory but small population and economy may qualify as large, even when it would intuitively never be described as such.

Third, we overcome the linearity problem by relying on our own country size index. We use PCA to account for the demographic, economic and geographical dimensions of country size. PCA can be interpreted as a fixed effects factor analysis, as it enables us to identify patterns in the data and emphasise their common trends. We take the three country-size variables in log because we assume they are linked proportionally (not linearly) and that they are not originally expressed in commensurable units. Whereas PCA, as a linear transformation of the data, does not require the compliance of the data with a given statistical model, the high correlation of our variables as shown in Table 1 makes resorting to PCA sensible[5]. PCA performs an eigen

Table 1: Correlation table of our three variables of interest for the size

Variable	Population, log	GDP, log	Arable land, log
Population, log	1		
GDP, log	0.77	1	
Arable land, log	0.81	0.54	1

decomposition of the correlation matrix. We chose to retain only the first component, the only one that has an eigenvalue over one. This unit-length linear combination of the variables contains maximal variance, i.e., 83% of the common variance, as detailed in Table 2, minimising information loss. Thus, the *PCA Size index* we compute allows us to operate a practical data reduction of three variables into one. The index is generated for each country in a given year, has a mean of zero, and is expressed in terms of the contributions of population, GDP, and arable land to country size. This also makes

[5] Additionally, the Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy of 0.72 for the GDP component, 0.59 for population, 0.66 for arable land and 0.64 overall make our PCA size index statistically acceptable given the degree of commonality found in the data.

subsequent interpretation simpler; our *PCA Size index* captures the internal structure linking the three variables. If one of the variables departs from the overall pattern linking it to the other two, it will be assigned a lower weight. The loadings (see the component column in Table 2) that relate the observed data to the components in the eigenvectors are roughly equal so that the three components of our PCA index have a similar role in capturing country size. Data to carry out such a construction were available for 163 countries.

Table 2: Detailing our principal component analysis

Principal Component Analysis					
	Component	Eigenvalue	Difference	Proportion	Cumulative
	Comp1	2.493	2.100	0.831	0.831
	Comp2	0.393	0.279	0.131	0.962
	Comp3	0.114	0.000	0.038	1.000
Principal components (eigenvectors) – Scoring coefficients					
	Variable	Comp1	Unexplained		
	Lgdp	0.550	0.247		
	Lpop	0.609	0.076		
	Lar_land	0.572	0.184		
	Number of obs	163	Number of comp.	1	Trace = 3
	Rotation:(unrotated = principal)		ρ = 0.831		

We consider a country to be large if its *PCA Size index* scores in the top 10 %, the others are considered small. For simplicity, we do not include a medium-sized category. In this study, a country was considered large if the $PCASizeIndex > 1.9853$ (corresponding to the 90% percentile of the sample), and small if the $PCASizeIndex \leq 1.9853$. To get a better sense of what PCA scores capture, we summed up the qualifying thresholds for large countries according to population, GDP and arable land in Table 3.

Table 3: Summary Stats Size Indexes

Thresholds for Large Countries		
Index PCA	1.9853	Quantile 90%
Equivalent to	Population	49.22 millions
	GDP	315.96 billion $
	Arable Land	576.94 th. km^2

In our sample, 17 countries qualify as large and are listed in Table A-2 in the Appendix. An increase of one PCA unit corresponds, on average, either to an area wider of 244,000 km^2 (equivalent to the UK's area), a GDP greater of $151 billion (equivalent to Finland's GDP) or a population that has 31 million people (equivalent to Morocco's population) more.

1.3 Measuring Volatility

Following Furceri and Karras (2007), we compute the cyclical component of the business cycle volatility from the log of real GDP ($ 2000 constant, so as to neutralise inflation and exchange rate fluctuations) using the following techniques:

- (i) simple standard deviation (SD) of the GDP growth rate (decade averages), which yields the most volatile series;
- (ii) standard deviation of the cyclical component of the Hodrick-Prescott (HP) filter (highpass filter) applied to GDP in levels with a smoothing parameter set at 6.25 (as argued by Ravn and Uhlig (2002)) for annual data;
- (iii) standard deviation of the cyclical component of the Baxter-King (BP) filter (lowpass filter), which approximates a moving average of infinite order and drops data at both ends of the series with cut-offs at 2 and 8. The lead-lag length of the filter is set to 3.

1.4 Estimation Strategy

To properly estimate our model (see equation 1), we first checked for common statistical issues of panel data econometrics. Hausman tests run over the whole sample, and on different country groupings (small, large, OECD, eurozone), indicated that the individual effects and our explanatory variables were systematically related, so that the fixed effects (FE, also called *within*) estimator was the most appropriate choice. As noted by Durlauf, Johnson, and Temple (2005), the FE estimator, which allows for varying intercept terms across countries, deals efficiently with unobserved heterogeneity, as time-invariant omitted variables do not bias the regression results[6]. This proves especially important when we use hard-to-measure or -quantify variables, such as political situation and institutions. An FE estimator controls for different national effects of unobserved variables, as long as they remain stable over time. The appropriateness

[6] Indeed, the within-estimator eliminates panel heterogeneity by demeaning variables and performing OLS on the generated data. This linear FE estimator is consistent, even when controls are correlated with the fixed effects.

of our FE estimation was also confirmed by an F-test for the significance of fixed effects. Running a Wald test for group-wise heteroscedasticity confirmed its presence in both data sets. Likewise, the Wooldridge test for autocorrelation in panel data indicated a first order correlation. In addition, following Drazen (2000), country size was not assumed to be an important source of endogeneity and so the IV estimator was not retained[7].

Heeding the results of these tests, we selected the FE estimator because it addresses all the statistical issues of our sample, including links between individual effects and regressors, heteroscedasticity and auto-correlation. We employed robust standard errors clustered at the country level because clustering at the panel data level produces consistent estimates of standard errors even in the presence of autocorrelation.

We estimate bivariate and multivariate models with a set of economic controls. *Controls or* Z_{it} are economic variables that we believe are of importance in distinguishing country-size effects from other economic effects, including trade openness, the real interest rates and the inflation rates. Indeed, we want to isolate possible trade and price competitiveness effects from a country-size effect on growth and volatility. In summary, we estimate the following regression model:

$$Y_{it} = \beta_0 + \beta_1 SIZE_{it} + \beta_2 Z_{it} + \beta_3 U_i + \epsilon_{it} \quad (1)$$

where

- Y_{it} stands for either GDP growth or a measure of output volatility (according to whether we are testing the relationship between country size and economic performance or volatility);
- $SIZE_{it}$ is a measure of country size (either our PCA size index, Jalan's index or population)
- Z_{it} is a set of economic variables (trade openness, real interest rate, inflation; all are expressed as percentages);
- U_i is the fixed- or country-effects term;
- and ϵ_{it} is the error term.

For each of our three estimations with the three size measures used, we run:

[7] The Dickey-Fuller test indicated the absence of panel unit root, so that cointegration was not necessary.

- a bivariate regression;
- a regression adding variable set Z_i;

for a total of six regressions for our FE estimations. The correlation structure of the variables is displayed in Table 4. The strong negative correlation between country size indicators, especially population and PCA size index, and trade openness confirms our intuition that small countries are more open than large ones.

Table 4: Correlation structure of variables

Variable	GDP growth	PCA size index	Jalan's size index	Population	Trade openess	Real interest rate	Inflation
GDP growth	1						
PCA size index	-0.04	1					
Jalan's size index	0.02	0.56	1				
Population, Log	-0.01	0.95	0.51	1			
Trade openness	0.13	-0.56	-0.33	-0.55	1		
Real interest rate, %	0.1	-0.04	-0.03	-0.05	-0.01	1	
Inflation, %	-0.08	0.02	-0.01	0.02	-0.02	-0.3	1

GDP growth is not significantly correlated to any of the economic variables we use as controls, so multicolinearity problems should not weaken the validity of our findings.

2 Country Size and Growth

2.1 Preliminary Analysis

Before we detail our statistical results, we would like to adumbrate an intuition for the relationship between country size (as measured by our PCA size index) and GDP growth for different groups with the scatter plots in Figure 1, 2, 3, and 4. When all countries of our data set are taken together (Figure 1), the flatness of the regression line indicates no clear relationship between country size and GDP growth. This somewhat blunt result of sample averages is to be qualified when we consider different country groups. For high-income countries (Figure 2), particularly in the eurozone (Figure 4), the bivariate plots show a negative correlation between how large a country is and by how much it grows. However, the level of economic development is not the sole driver of this inverse relationship, as low-income countries (Figure 3) do not display a marked positive or negative correlation.

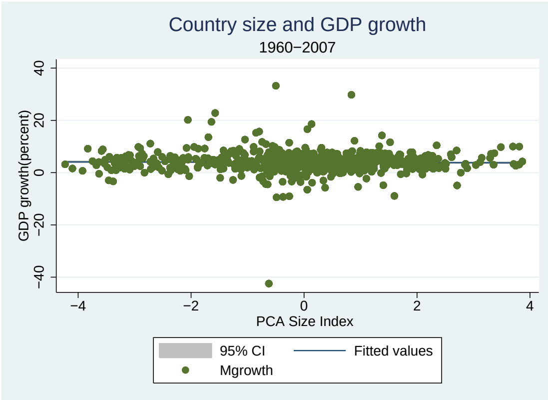

Figure 1: Country size and growth

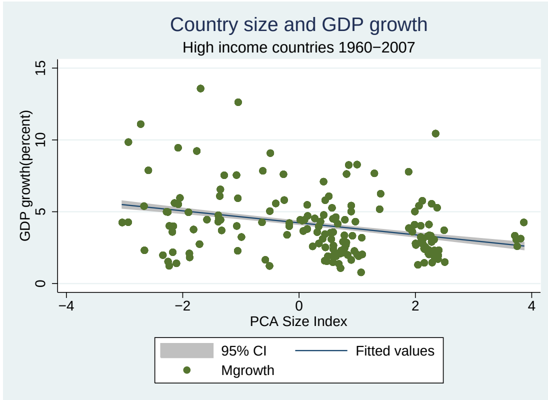

Figure 2: Country size and GDP growth in high income countries

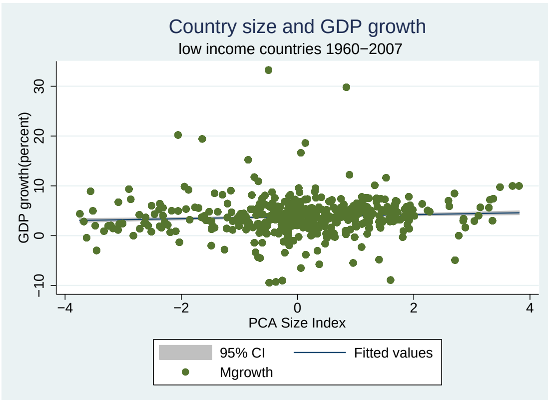

Figure 3: Country size and growth in low income countries

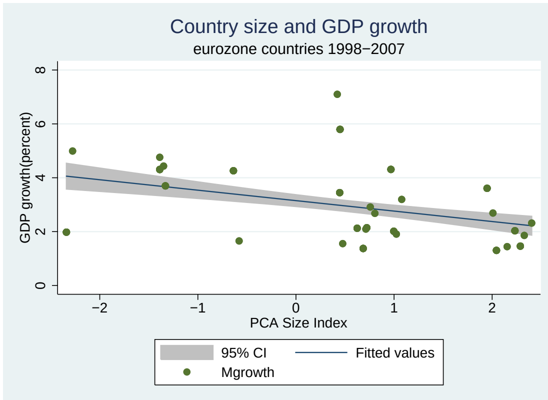

Figure 4: Country size and GDP growth in the eurozone

2.2 Estimation Results

Table 5 displays the results of our FE regressions. Keeping in mind that our estimator controls for all stable national characteristics, both the PCA size index and population have negative and significant coefficients for all countries of the sample over the 1960–2007 period. Because the PCA size index captures changes in population, GDP and arable land, the negative sign of its coefficients shows the impact of these three variables in determining the pace of growth. As a reminder, each additional unit in the PCA corresponds on average to either an area increase of 244,000 km^2, an increase in GDP of \$151 billion or a population increase of 31 million. Because the coefficients measure semi-elasticities, we can compute precise quantitative effects using the values of the standard deviations (see Table A-3 in the Appendix). For instance, a 1% increase in population results in a -2.6%[8] change in the GDP growth rate over the whole period. The effect from Jalan's size index is comparatively small and not significant, confirming that the relationship between country size and growth is proportional and not linear. Following the values of the t-statistics, our results are more precise when economic controls are included in the regression, confirming their relevance in our analysis of a size effect on growth. The negative relationship between growth and country size is indeed robust to the inclusion of economic variables. This means that we can identify a country-size effect on growth independent of the fact that small countries are, on average, more open. It is also worth noting that the impact of trade on long-term GDP growth is very large and significant; 0.1 additional standard deviation of trade increases growth by 3.8%, confirming the vast body of literature on the benefits of trade that we quoted previously.

Table 5: Country Size and GDP Growth – All countries, 1960–2007

Fixed Effects with correction for heteroscedasticity (cluster)						
	bivariate	controls	bivariate	controls	bivariate	controls
PCA Size index	-3.447***	-4.738*				
	[-6.01]	[-1.87]				
Jalan's Size index			0.494	0.346		
			[1.46]	[0.92]		
Population, log					-1.896***	-2.586***
					[-4.46]	[-3.09]
Trade Openness		5.297***		4.990***		5.456***
		[3.33]		[3.01]		[3.61]
Real Interest Rate, %		0.047***		0.044***		0.049***
		[3.15]		[2.95]		[3.11]
Inflation, %		-0.001		-0.001		-0.001
		[-0.89]		[-0.96]		[-0.95]
Constant	3.938***	0.190	3.583***	-0.601	7.061***	3.926**
	[809.67]	[0.13]	[16.00]	[-0.43]	[10.11]	[2.07]
N	6566	3237	6566	3237	6638	3273
R^2 within	0.012	0.047	0.000	0.041	0.007	0.047

t-statistics in brackets. * p<0.1, ** p<0.05, *** p $<$ 0.01. Data source: World Bank.

For small countries, the results shown in Table 6 are similar. All country-size indicators concur first on the negative relationship between country size and growth and second on the positive impact of trade openness on the latter. Among large countries (listed in Table A-2 in the Appendix), there is no clear-cut effect of size on performance.

[8]The effect on GDP growth of an increase by 1 standard deviation of a dependent variable is computed as such: $\sigma_d epvar * coeff_d epvar / \sigma_g dpgrowth$.

Table 6: Country Size and GDP Growth – Small countries, 1960–2007

Fixed Effects with correction for heteroscedasticity (cluster)						
	bivariate	controls	bivariate	controls	bivariate	controls
PCA Size index	-3.467***	-4.604*				
	[-6.01]	[-1.68]				
Jalan's Size index			-1.901	-9.644*		
			[-0.74]	[-1.74]		
Population, log					-1.864***	-2.465***
					[-4.27]	[-2.90]
Trade Openness		5.533***		5.381***		5.758***
		[3.39]		[3.17]		[3.48]
Real Interest Rate, %		0.053***		0.051***		0.056***
		[3.66]		[3.51]		[3.68]
Inflation, %		-0.001		-0.001		-0.001
		[-0.79]		[-0.86]		[-0.82]
Constant	2.957***	-2.030*	4.352***	1.124	6.385***	2.192
	[18.56]	[-1.64]	[7.35]	[0.69]	[11.04]	[1.19]
N	5903	2815	5903	2815	5903	2815
R^2 within	0.012	0.053	0.000	0.050	0.007	0.054

t-statistics in brackets. * p<0.1, ** p<0.05, *** $p < 0.01$. Data source: World Bank.

Table 7 displays the results of our FE estimation for OECD countries. The relationship between our PCA index and GDP growth is negative and significant but this is somewhat less the case when economic controls are included. When country size is proxied by population, its relationship with GDP growth is negative and significant over the 1960–2007 time span. Indeed, among OECD countries with comparable development levels, heterogeneity in terms of population is much larger than in terms of GDP. The negative scale effect on growth seen here is most likely demographic. The impact of trade is not as strong as in previous cases, possibly because most of the OECD countries were already industrialised economies at the start of the period and did not use trade as a strategy to kick-start their economic take-off but rather as a tool for the continuation of their development. Economic performance appears to be better determined by cyclical factors, as indicated by the significance of the inflation and interest rates. More precisely, inflation seems to have a detrimental effect on growth, confirming the importance of macroeconomic stability for growth. The real interest rate also has a negative effect on growth, underlining the importance of the ease of obtaining credit for growth.

In the eurozone, since its creation (1999-2007), our estimates in Table 8 are somewhat puzzling. While we highlight a strong negative and significant relationship between population and GDP growth and a large positive impact of trade, turning to

Table 7: Country Size and GDP Growth – OECD countries, 1960–2007

Fixed Effects with correction for heteroscedasticity (cluster)						
	bivariate	controls	bivariate	controls	bivariate	controls
PCA Size index	-5.271***	-4.077				
	[-3.30]	[-1.00]				
Jalan's Size index			0.687*	0.282		
			[1.97]	[1.06]		
Population, log					-5.441***	-12.59**
					[-4.45]	[-2.87]
Trade Openness		1.465		1.377		4.436***
		[0.88]		[0.78]		[2.99]
Real Interest Rate, %		-0.105**		-0.129***		-0.074**
		[-2.52]		[-3.61]		[-2.30]
Inflation, %		-0.118***		-0.125***		-0.141***
		[-3.14]		[-3.09]		[-3.93]
Constant	9.627***	8.922	2.454***	3.115*	17.62***	36.25***
	[5.24]	[1.55]	[4.39]	[1.85]	[5.57]	[3.10]
N	1302	786	1302	786	1302	786
R^2 within	0.044	0.116	0.005	0.110	0.052	0.202

t-statistics in brackets. * p<0.1, ** p<0.05, *** $p < 0.01$. Data source: World Bank.

our PCA and Jalan's indexes, coefficients are still significant but positive. It seems that European integration through the single market and the monetary union has largely benefited its least populous Member States. The effects of our three size dimensions (population, GDP and arable surface area) thus seem strongly differentiated in the eurozone: that of population considered alone is negative, whereas the effects of the level of national GDP and arable land are positive[9]. A possible explanation why arable land and GDP have been propitious to growth is that some countries like Spain, Ireland and, to a lesser extent, Finland have engaged in rapid economic catch-up processes over this period, with considerable territorial effects (shift from agricultural and industrial to new services and real estate activities) and GDP gains.

We have previously evoked the so-called BRIC (Brazil, Russia, India and China) phenomenon of rapidly-growing, large, emerging economies. Table 9 shows that trade (without distinction between manufactured goods or natural resources) spurred their growth. For these four countries, size is again negatively associated with growth. Besides the economic factors that we control for, these countries also benefit from an infrastructure boom[10] and a higher attractiveness of foreign investment compared to

[9] We ran regressions for these variables separately.

[10] As reported by *The Economist*, investment in infrastructures represented 6% of GDP in the BRICs in 2008, double the figure usually found in developed economies.

Table 8: Country Size and GDP Growth – Eurozone countries, 1999–2007

Fixed Effects with correction for heteroscedasticity (cluster)						
	bivariate	controls	bivariate	controls	bivariate	controls
PCA Size index	4.931*	14.28***				
	[1.84]	[7.23]				
Jalan's size index			0.132	11.22**		
			[0.06]	[2.59]		
Population, log					-14.67**	-44.53***
					[-2.49]	[-5.41]
Trade Openness		6.493***		7.789***		5.221**
		[5.24]		[3.69]		[2.49]
Real Interest Rate, %		-0.099		-0.032		-0.104
		[-1.04]		[-0.28]		[-1.00]
Inflation, %		-0.270*		-0.132		-0.222
		[-1.75]		[-0.93]		[-1.50]
Constant	0.444	-11.65***	3.031**	-12.11***	32.74**	95.36***
	[0.31]	[-7.66]	[2.42]	[-3.16]	[2.75]	[4.88]
N	134	75	134	75	134	75
R^2 within	0.024	0.328	0.000	0.232	0.063	0.366

t-statistics in brackets. * p<0.1, ** p<0.05, *** $p < 0.01$. Data source: World Bank.

countries with comparable development level but smaller domestic markets and less political clout.

We have highlighted the existence of an inverse relationship between country size and economic performance for all countries in our panel, small countries, OECD and eurozone countries. Our results are robust to different measures of country size, and those based on population are also compatible with Bloom, Canning, and Sevilla's theory of a "demographic dividend". This dividend stems from lower fertility rates coupled with relatively high mortality, increasing the ratio of workforce to total population. According to Bloom, Canning, and Sevilla (2003) this accounted for a third of East Asian growth in 1965-1990. Whereas our focus in this paper is not on demographic dynamics, an important question we now address is that of country size and output volatility.

Table 9: Country Size and GDP Growth – BRICs, 1980–2007

Fixed Effects with correction for heteroscedasticity (cluster)						
	bivariate	controls	bivariate	controls	bivariate	controls
PCA Size index	-6.592	-7.847*				
	[-0.62]	[-5.30]				
Jalan's size index			-0.763	-2.691***		
			[-0.60]	[-32.75]		
Population, log					2.323	-2.193*
					[1.10]	[-4.15]
Trade Openness		12.23**		15.41**		10.05*
		[6.72]		[11.12]		[3.49]
Real Interest Rate, %		-0.112**		-0.106**		-0.128**
		[-6.62]		[-7.17]		[-5.92]
Inflation, %		-0.00822		-0.0138		-0.00511
		[-1.15]		[-2.48]		[-0.51]
Constant	25.95	28.58*	10.2	21.34***	-8.922	18.19*
	[0.77]	[5.58]	[1.22]	[24.96]	[-0.70]	[5.30]
N	102	72	102	72	102	72
R^2 within	0.0238	0.51	0.00555	0.557	0.00445	0.493

t-statistics in brackets. * $p<0.1$, ** $p<0.05$, *** $p < 0.01$. Data source: World Bank.

3 Country Size and Growth Volatility

3.1 Preliminary Analysis

Considering the relationship between country size and output volatility, scatter plots of sample averages excluding outliers[11] in Figures 5, 6, 7 and 8 highlight an even stronger negative correlation. This holds for the whole sample (Figure 5) and is more acute after 1980 (Figure 6), reflecting more turbulent development in the world economy. Small countries (Figure 7) and eurozone members (Figure 8) illustrate the negative bivariate relationship, in accordance with Furceri and Karras's results.

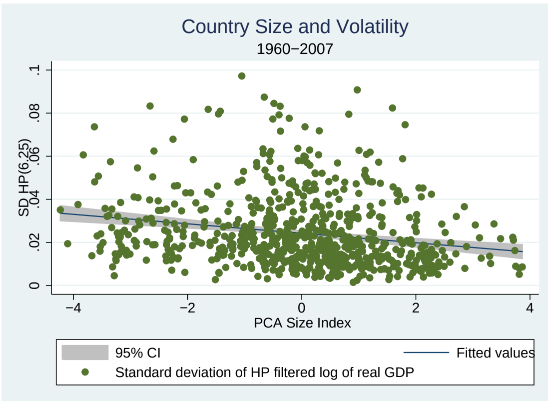

Figure 5: Country size and volatility

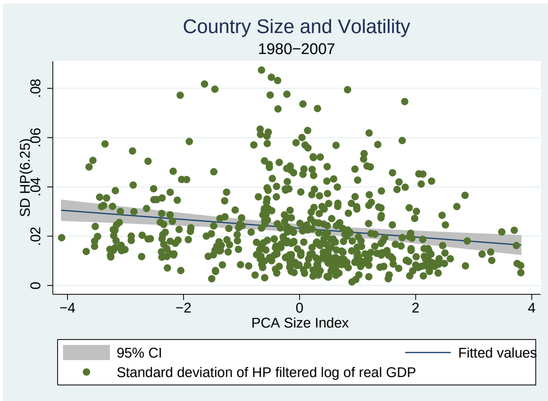

Figure 6: Country size and volatility after 1980

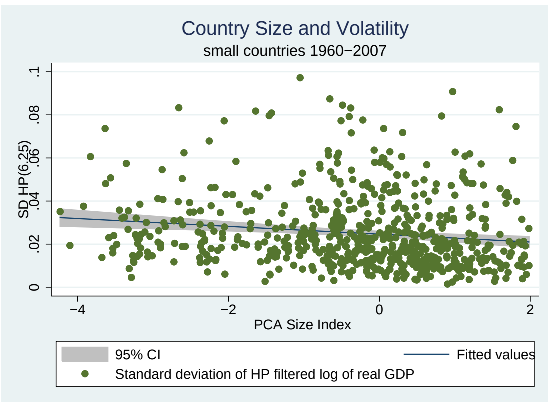

Figure 7: Country size and growth in small countries

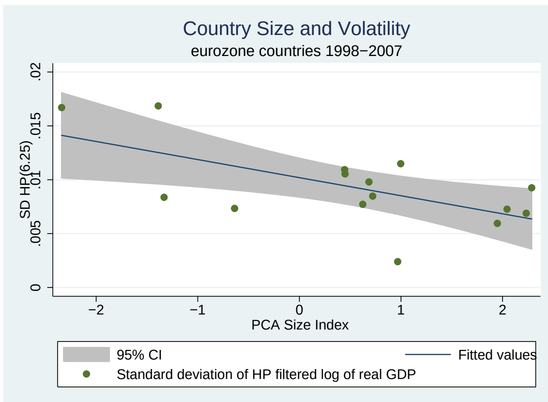

Figure 8: Country size and volatility in the eurozone

[11] Observations were excluded when the standard deviation of the HP 6.25 cyclical component exceeded 0.1.

3.2 Estimation Results

We now focus on the relationship between our size indexes and growth volatility and still rely on the fixed effects estimation robust to heteroscedasticity (with clustering of errors at the country level). We use the HP filter measures of volatility as our benchmark specification. According to the results reported in Table 10, estimated coefficients for the PCA size index and population are negative and significant for all countries, with a tenfold decrease in magnitude in comparison with effects on GDP growth. Small countries are statistically more prone to volatile growth rates than large ones. Strikingly, the coefficient for trade openness is never significant. The trade channel is therefore not the main driver of output volatility. Following Easterly, Islam, and Stiglitz (2000), financial exposure and capital movements may be a more important source of macroeconomic volatility.

Table 10: Country Size and HP Volatility – All countries, 1960–2007

Fixed Effects with correction for heteroscedasticity (cluster)						
	bivariate	controls	bivariate	controls	bivariate	controls
PCA Size index	-0.017***	-0.020**				
	[-3.17]	[-2.01]				
Jalan's Size index			-0.005	-0.002		
			[-1.30]	[-1.70]		
Population, log					-0.012***	-0.020***
					[-2.98]	[-3.08]
Trade Openness		0.001		-0.003		0.004
		[0.03]		[-0.27]		[0.34]
Real Interest Rate, %		-0.001		-0.001*		-0.001
		[-1.45]		[-1.67]		[-1.16]
Inflation, %		0.000		0.000		0.000
		[1.54]		[1.38]		[1.42]
Constant	0.026***	0.029***	0.030***	0.031***	0.046***	0.058***
	[154.95]	[3.74]	[11.82]	[4.05]	[7.32]	[6.00]
N	733	447	733	447	743	452
R^2 within	0.024	0.056	0.001	0.046	0.031	0.072

t-statistics in brackets. * p<0.1, ** p<0.05, *** p<0.01. Data source: World Bank.

For small countries, the results in Table 11 are very similar to those for the whole sample. Quantitatively, a 1 unit PCA (or 1% population) decrease in size brings on average about 0.02% more growth volatility, confirming the vulnerability to cyclical fluctuations.

In the eurozone (see Table 12), country size seems to have a more stabilising effect on output as the negative and significant coefficients generated by the PCA size

Table 11: Country Size and HP Volatility – Small countries, 1960–2007

Fixed Effects with correction for heteroscedasticity (cluster)						
	bivariate	controls	bivariate	controls	bivariate	controls
PCA Size index	-0.017***	-0.021**				
	[-3.09]	[-1.96]				
Jalan's Size index index			-0.048**	-0.043		
			[-2.02]	[-1.52]		
Population, log					-0.015***	-0.020
					[-3.92]	[-3.02]
Trade Openness		0.001		-0.001		0.006
		[0.09]		[-0.12]		[0.47]
Real Interest Rate, %		-0.001		-0.001*		-0.001
		[-1.51]		[-1.70]		[-1.22]
Inflation, %		0.000		0.000		0.000
		[1.34]		[1.16]		[1.25]
Constant	0.023***	0.023**	0.040***	0.039***	0.048***	0.052***
	[13.24]	[2.27]	[7.17]	[4.49]	[9.52]	[5.61]
N	662	393	662	393	662	393
R^2 within	0.024	0.059	0.004	0.051	0.042	0.076

t-statistics in brackets. * p<0.1, ** p<0.05, *** p<0.01. Data source: World Bank.

index and population are about twice as large as those found for the whole sample (between -0.05 versus -0.02 for all countries). Indeed, as the level of trade and investment integration is very high, large countries have a greater influence on their counterparts. Trade openness is now significant and slightly negative in accounting for output volatility. In the context of the single market, trade seems to play an anchoring role for business cycles, rather than acting as a source of volatility.[12] We now check the robustness of our results obtained with the HP filter by testing the country-size effect on volatility with simple differencing or standard deviation (SD) and the Baxter-King detrending method (BK). Using SD detrending, the coefficients are larger, as expected, and confirm a strong negative and significant relationship between country size and business cycle volatility (see Table 13). Table 14 shows that BK detrending yields similar results. In both cases, the insignificance of trade in accounting for volatility is confirmed, supporting the assumption that the higher volatility of small countries is driven by other factors.

The negative scale effect, or stabilising role, of a large country size on output volatility that we highlight holds independently of the economic variables we control for. Other factors we do not include in this analysis, such as market size, the distance to trade partners or diversification of production, may also play a role. The small-

[12] For BRICs, our estimations do not put forward any size effect on output volatility.

Table 12: Country Size and HP Volatility – Eurozone countries, 1999–2007

Fixed Effects with correction for heteroscedasticity (cluster)						
	bivariate	controls	bivariate	controls	bivariate	controls
PCA Size index	0.03	-0.048***				
	[1.35]	[-2.89]				
Jalan's Size index			0.004	-0.014**		
			[1.52]	[-2.00]		
Population, log					-0.047**	0.034
					[-2.54]	[1.09]
Trade Openness		-0.028***		-0.021**		-0.024**
		[-3.84]		[-2.07]		[-2.08]
Real Interest Rate, %		0.001***		0.001***		0.001***
		[5.28]		[4.90]		[7.03]
Inflation, %		0.001**		0.001**		0.001
		[2.36]		[2.27]		[1.19]
Constant	-0.005	0.065***	0.009***	0.038***	0.105***	-0.043
	[-0.41]	[4.39]	[4.93]	[2.64]	[2.86]	[-0.71]
N	30	26	30	26	30	26
R^2 within	0.069	0.815	0.002	0.746	0.143	0.747

t-statistics in brackets. * p<0.1, ** p<0.05, *** p<0.01. Data source: World Bank.

Table 13: Country Size and SD Volatility – All countries, 1960–2007

Fixed Effects with correction for heteroscedasticity (cluster)						
	bivariate	controls	bivariate	controls	bivariate	controls
PCA Size index	-3.547***	-3.087*				
	[-3.52]	[-1.82]				
Jalan's Size index			-0.715	-0.283*		
			[-1.32]	[-1.75]		
Population, log					-2.383***	-2.634***
					[-3.12]	[-2.62]
Trade Openness		-1.174		-1.660		-0.769
		[-0.87]		[-1.23]		[-0.60]
Real Interest Rate, %		-0.029		-0.04*		-0.019
		[-1.28]		[-1.72]		[-0.82]
Inflation, %		0.002		0.001		0.001
		[1.13]		[0.97]		[1.00]
Constant	4.128***	5.329***	4.713***	5.662***	8.085***	9.334***
	[115.36]	[4.95]	[13.55]	[5.12]	[6.68]	[5.14]
N	729	446	729	446	739	451
R^2 within	0.047	0.052	0.001	0.037	0.056	0.069

t-statistics in brackets. * p<0.1, ** p<0.05, *** p<0.01. Data source: World Bank.

Table 14: Country Size and BK Volatility – All countries, 1960–2007

Fixed Effects with correction for heteroscedasticity (cluster)						
	bivariate	controls	bivariate	controls	bivariate	controls
PCA Size index	-0.016**	-0.015				
	[-2.59]	[-1.49]				
Jalan's Size index			-0.005	-0.003**		
			[-1.41]	[-2.06]		
Population, log					-0.010**	-0.014**
					[-2.53]	[-2.24]
Trade Openness		-0.008		-0.01		-0.004
		[-1.11]		[-1.52]		[-0.67]
Real Interest Rate, %		-0.001		-0.001		-0.001
		[-1.24]		[-1.58]		[-0.83]
Inflation, %		0.000		0.000		0.000
		[1.77]		[1.62]		[1.64]
Constant	0.025***	0.032***	0.028***	0.034***	0.042***	0.053***
	[1835.38]	[6.18]	[12.93]	[6.39]	[6.38]	[5.16]
N	712	442	712	442	722	447
R^2 within	0.031	0.050	0.002	0.041	0.032	0.065

t-statistics in brackets. * p<0.1, ** p<0.05, *** p<0.01. Data source: World Bank.

ness and insignificance of the coefficients generated by trade openness indicate that a higher openness to trade does not necessarily mean more vulnerability to external shocks. Notwithstanding our varying results for estimation specifications, we have put forward an inverse relationship between country size and business cycle volatility. More often than not we can dismiss trade openness as a source of vulnerability to international economic fluctuations as it does not seem to induce greater output volatility.

Conclusion

What is the effect of country size on economic performance and business cycle volatility? To answer this question, we used PCA to develop an original country-size index that includes not only the demographical component of country size as in other papers on the topic but also the GDP and surface area. We thus capture a more complete size effect that goes beyond population.

Our empirical analyses of the interactions between country size and economic performance go against Rose's results. Using a panel of 163 countries with yearly data for the 1969-2007 time span, we found a negative relationship between country size and growth for all countries and within certain groups, i.e., small countries, OECD and even the BRICs.

We confirm the negative relationship between country size and growth volatility described by Furceri and Karras (2007). These results are statistically significant and robust to several specifications of country size and output volatility. The estimations for the PCA size index that we introduced support our assumption that, when accounting for growth and its volatility, there is more to a country than its population figures. Moreover, we corroborate that trade openness is conducive to long-term growth, but find no evidence that it increases growth volatility. These findings implicitly support that industrial specialisation and financial exposure are stronger factors for growth volatility.

Furthering the analysis of country size and economic performance may require looking into less quantifiable factors such as institutions and policies. For instance, Fatas and Mihov (2009) showed that fiscal policy with less discretion reduces volatility and enhances growth. The eurozone, in which we highlighted strong negative relationships between country size, economic performance and volatility, showcases the peculiar interactions at play with country size in the context of a monetary union.

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Table A-1: List of countries

List of countries			
Albania	Eritrea	Mali	Suriname
Algeria	Estonia	Malta	Swaziland
Angola	Ethiopia	Marshall Islands	Sweden
Antigua and Barbuda	Finland	Mauritania	Switzerland
Argentina	France	Mauritius	Syrian Arab Republic
Armenia	French Polynesia	Mexico	Tajikistan
Australia	Gabon	Micronesia, Fed. Sts.	Tanzania
Austria	Gambia, The	Moldova	Thailand
Azerbaijan	Georgia	Mongolia	Togo
Bahamas, The	Germany	Morocco	Tonga
Bahrain	Ghana	Mozambique	Trinidad and Tobago
Bangladesh	Greece	Namibia	Tunisia
Barbados	Grenada	Nepal	Turkey
Belarus	Guatemala	Netherlands	Turkmenistan
Belgium	Guinea	New Caledonia	Uganda
Belize	Guinea-Bissau	New Zealand	Ukraine
Benin	Guyana	Nicaragua	United Arab Emirates
Bhutan	Haiti	Niger	United Kingdom
Bolivia	Honduras	Nigeria	United States
Bosnia and Herzegovina	Hong Kong, China	Norway	Uruguay
Botswana	Hungary	Oman	Uzbekistan
Brazil	Iceland	Pakistan	Vanuatu
Bulgaria	India	Palau	Venezuela, RB
Burkina Faso	Indonesia	Panama	Vietnam
Burundi	Iran, Islamic Rep.	Papua New Guinea	Yemen, Rep.
Cambodia	Iraq	Paraguay	Zambia
Cameroon	Ireland	Peru	Zimbabwe
Canada	Israel	Philippines	
Cape Verde	Italy	Poland	
Central African Republic	Jamaica	Portugal	
Chad	Japan	Puerto Rico	
Chile	Jordan	Romania	
China	Kazakhstan	Russian Federation	
Colombia	Kenya	Rwanda	
Comoros	Kiribati	Samoa	
Congo, Dem. Rep.	Korea, Rep.	Saudi Arabia	
Congo, Rep.	Kyrgyz Republic	Senegal	
Costa Rica	Lao PDR	Seychelles	
Cote d'Ivoire	Latvia	Sierra Leone	
Croatia	Lebanon	Singapore	
Cyprus	Lesotho	Slovak Republic	
Czech Republic	Liberia	Slovenia	
Denmark	Lithuania	Solomon Islands	
Djibouti	Luxembourg	South Africa	
Dominica	Macao, China	Spain	
Dominican Republic	Macedonia, FYR	Sri Lanka	
Ecuador	Madagascar	St. Kitts and Nevis	
Egypt, Arab Rep.	Malawi	St. Lucia	
El Salvador	Malaysia	St. Vincent and the Grenadines	
Equatorial Guinea	Maldives	Sudan	

Table A-2: Large Countries

Large Countries		
Argentina	Germany	Russian Federation
Australia	India	Spain
Brazil	Indonesia	Turkey
Canada	Italy	United Kingdom
China	Japan	United States
France	Mexico	

Table A-3: Summary Statistics

Summary Statistics					
All Countries					
Variable	**Nb. Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Lpop	8424	1.441	2.021	-4.200	7.185
indexLpcar	6645	0.000	1.551	-4.368	3.905
indexjar	6645	0.656	1.850	0.000	18.951
gdp_growth (%)	6654	3.937	6.385	-51.03	106.28
trade_op (%)	6325	0.751	0.462	0.053	4.625
real_ir (%)	3725	6.241	19.620	-98.15	789.80
inflation_cp (%)	5583	34.44	410.04	-17.64	23773.13
Large countries					
Variable	**Nb. Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Lpop	665	4.555	1.148	2.350	7.185
indexLpcar	665	2.543	0.549	1.985	3.905
indexjar	665	4.490	4.136	0.916	18.951
gdp_growth (%)	663	3.863	4.131	-27.10	19.40
trade_op (%)	637	0.346	0.176	0.053	1.106
real_ir (%)	454	5.759	9.819	-24.60	78.73
inflation_cp (%)	594	46.366	248.44	-7.63	3079.81
Small countries					
Variable	**Nb. Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Lpop	5980	1.316	1.777	-3.927	5.090
indexLpcar	5980	-0.283	1.357	-4.368	1.985
indexjar	5980	0.230	0.294	0.000	1.710
gdp_growth (%)	5903	3.914	6.529	-51.03	106.28
trade_op (%)	5404	0.779	0.429	0.063	4.625
real_ir (%)	3233	6.329	20.726	-98.15	789.80
inflation_cp (%)	4679	33.89	438.21	-17.64	23773.13
OECD					
Variable	**Nb. Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Lpop	1440	2.596	1.518	-1.737	5.709
indexLpcar	1310	1.152	1.133	-1.933	3.905
indexjar	1310	1.598	3.060	0.018	18.95
gdp_growth (%)	1302	3.555	3.029	-14.570	18.710
trade_op (%)	1253	0.659	0.407	0.093	3.266
real_ir (%)	820	4.414	4.166	-19.490	16.75
inflation_cp (%)	1285	9.024	21.110	-0.900	555.38
Eurozone, post 1999					
Variable	**Nb. Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Lpop	135	1.998	1.688	-0.947	4.413
indexLpcar	134	0.541	1.344	-2.403	2.384
indexjar	134	0.606	0.763	0.006	2.639
gdp_growth (%)	134	3.111	1.976	-1.610	10.720
trade_op (%)	113	1.093	0.640	0.440	3.266
real_ir (%)	86	3.765	2.668	-2.650	11.640
inflation_cp (%)	135	2.592	1.335	0.190	8.880
BRICs, post 2000					
Variable	**Nb. Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Lpop	32	6.080	1.012	4.953	7.185
indexLpcar	32	3.145	0.470	2.563	3.837
indexjar	32	6.497	3.905	2.634	12.772
gdp_growth (%)	32	6.903	2.943	1.270	11.900
trade_op (%)	31	0.439	0.159	0.217	0.720
real_ir (%)	32	12.600	19.380	-9.630	47.680
inflation_cp (%)	32	6.918	5.599	-0.770	21.460