Country size, economic performance and volatility

Olfa Alouini, Paul Hubert

COUNTRY SIZE, ECONOMIC PERFORMANCE AND VOLATILITY[1]

Olfa Alouini
European Commission, DG ECFIN
Paul Hubert
Sciences Po, OFCE

What are the relationships between country size, economic growth and business cycle volatility? To investigate this question, we developed an original country-size index with principal component analysis. Traditional analysis usually equates country size with population. Our methodology enables to simultaneously consider several factors constitutive of country size: population, GDP and arable land. These additional variables allow us to capture different components of the country size and to control for more than a 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 correlation with 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.

Keywords: PCA, GDP growth, Business cycle volatility.

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 fast development of small East Asian economies in the 1970s and 1980s was hailed by the

1. We thank for their help and comments Michael Burda and the participants of the OFCE Seminar where a previous version of this paper was presented. This research project benefited from funding from the European Union Seventh Framework Programme (FP7/2007–2013) under grant agreement No. 266800 (FESSUD). This paper presents the authors' personal views and does not reflect the views of the European Commission.

motto “small is beautiful” and fueled a new branch of literature documenting these economic miracles. More recently, much was carried out on the BRICs (Brazil, Russia, India and China), i.e. a new type of rapidly growing juggernauts in the world economy. Different aspects of country size may affect growth positively or negatively as shown by Alesina, Spolaore, and Wacziarg (2005): a large land area is prone to provide more natural resources but may prove difficult and costly to manage for public services and transportation means. A large population provides a labour force and a wide domestic market with scale economies but may incur larger administrative costs if heterogeneous. A high GDP may be associated with slower growth rates as income and development levels are already high, but also with better infrastructure, greater human capital and so a higher growth potential. In this paper, we aim to test whether we can point out a relationship between size and GDP growth at the cross-country level.

The relationship between country size and volatility is more clearcut. Intuitively, small and very open economies should be more sensitive to output fluctuations, incurred, by changes in terms of trade or in capital flows for instance. These countries cannot rely on a large domestic market to even out economic turbulences. Our second research question is whether we can confirm empirically that GDP growth volatility and the size of a country are negatively related.

Let us first define “country size”. One way of understanding this concept is to consider that, in the world economy, small countries are usually price takers, whereas large ones are price makers. Country size also includes several dimensions: political, economic, geographic and demographic. The political dimension of country size, including the weight and power of countries in international institutions, is obviously important, but difficult to quantify. GDP is easily quantifiable and makes rankings based on economic size straightforward, but in regression analysis, it causes endogeneity problems. The geographic dimension of country size bears the least clearcut relationship to the other variables, as a large population may densely occupy a small territory and vice versa. Population provides the easiest proxy for country size and has been widely used with adhoc thresholds to differentiate between small and large countries (see Kuznets, 1960; Demas, 1965; Salvatore, 2001 and Lloyd and Sundrum, 1982).

Relying on population as a proxy for size, Rose (2006) finds no relationship between country size and growth, and confirms the higher openness of small countries, documented by Rodrik (1998) and Alesina, Spolaore, and Wacziarg (2005). The multiplication of the number of countries from 51 in 1945 to 195 today, notwithstanding the political reasons behind state creation, suggests that small countries may be more viable in a globalised world economy. Trade openness is certainly one of the links between country size and output volatility, for which Furceri and Karras (2007) find a clear inverse relationship.

Our contribution is to 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. This *PCA Size index* captures the underlying patterns between three important components of country size. The interactions of each of these variables on growth are presumably complex and not exclusively related to size. This index enables us to avoid the shortcomings of either a purely demographic measure or one based on GDP, and not to include them individually in our regressions. By construction, it captures the common variation of the three size components and so increases the likelihood that we focus on the size factor and do not pick up "parasite" effects so as to provide a broader analysis of these relationships. To make our work more easily comparable with previous studies and for robustness purposes, we also conduct our analysis using population as a proxy for country size.

We proceed to the empirical investigation of the relationship between country size and short-term growth and its volatility for 163 countries over 1960-2007. We rely on a multivariate panel regression analysis to assess the effects of country size on economic performance and its volatility. In our analysis, we also isolate the scale or country-size effect from the effect 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 more marked for certain groups (small countries, OECD and BRICs) and opposite for eurozone countries, underlying the specificities of the European integration. We then show that there is a negative relationship between country size and business cycle 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 rest of this paper is organised as follows. Section 1 sums up theoretical considerations. Section 2 presents our country-size index and estimation strategy. Sections 3 and 4 provide estimates of the effects of country size on growth and on volatility respectively, before concluding.

1. The framework

What may account for the effect of country size on GDP growth and output volatility? Country size encompasses a number of dimensions such that associated costs and benefits are diverse as shown by Alesina, Spolaore, and Wacziarg (2005). A large area may provide more natural resources but also incur larger transportation and management costs. A large population may swell the ranks of human capital but also the food and administration needs for instance, explaining fertility control policies in developing economies. A large GDP hints at the fact that a country may be close to its steady-state and will thus witness a slower pace of growth, or the other way around, that it possesses a capital or technology-intensive industrial base capable of generating endogenous growth.

In Solow's (1956) growth framework, country size—usually captured by population or endowment—has no effect on growth. Supposing increasing returns to scale as Rodrik (1998), or in an endogenous growth model as Aghion and Howitt (1998), large countries are more efficient because of their larger endowments and potential for scale economies. High growth rates displayed by the BRICs in the 2000s suggest the existence of a “scale effect” for growth. Eichengreen, Hausmann, and Panizza (2003) noted that very large countries may be the only emerging economies able to escape from the “original sin”, by being able to borrow their own currency on international markets. Conversely, Kuznets (1960), Lloyd and Sundrum (1982) and Milner and Weyman-Jones (2003) underlined that limited endowments and diversification in small economies hampered their growth.

The question of the link between country size and growth volatility is related to trade openness and whether small economies tend to benefit more from trade. Mill's (1844) reciprocal demand theory hinted at the larger gains of small countries in international trade.

Katzenstein (1985) and Schiff (1996) confirmed that "small nations obtain greater gains (...) than do large nations" (Lloyd, 1968) and highlighted that small countries reap greater benefits from preferential trade agreements and the integration of international markets. Alesina, Spolaore, and Wacziarg (2005) show that small countries benefit more, in relative terms, from openness to trade than do large countries. Export-led growth increases the productivity of the tradable sector, fuelling smaller economies' GDP growth.

Beyond trade openness, the relative internal efficiency of small and large countries may also account for the observed gap in growth rates. Robinson (1960) suggested that the adaptive capacities of small economies and their higher homogeneity can help overcome the narrowness of their domestic markets. Because of diseconomies of scale in managing larger territories and more administrative entities, larger countries will have a higher proportion of slower-growing regions than smaller countries.

Overall, the intuition that large countries will have more inertia, and smaller ones sharper fluctuations, is well substantiated. Imbs (2007) explains the inverse relationship between country size and output volatility by the larger number of sectors present in large countries, which accounts for the lower output volatility. Easterly and Kraay (1999) found that the greater openness of smaller economies and the fact that they are more specialised induce both higher growth and higher volatility. Using a real business cycle (RBC) model, Crucini (1997) found that after controlling for market structures and development levels (for investment, savings, trade, and consumption), small economies experience higher output volatility than large ones. This result may also be linked to the relationship between openness and inflation. Romer (1993) found a higher trade-off between output and inflation in small and open countries, as the real depreciation effect hinders monetary stabilisation. Furceri and Poplawski (2008) highlight an inverse relationship between country size and the volatility of government consumption, while Rodrik (1998) argues that governments play an income-stabilising role. Finally, Aghion and Banerjee (2005) and Ramey and Ramey (1995) suggest that volatility hurts growth in the long run.

2. Empirical methodology

2.1. Data

Our data set includes the 163 countries for which the relevant annual data series, i.e. GDP, population and arable land, were available for the 1960–2007 period.[2] Our computation 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, our list of countries is comparable to those of Rose (2006) and Furceri and Karras (2007).[3]

Our explained variable is either the real GDP growth rate (%) or a measure of output volatility computed using real GDP levels (constant 2000 Billions US$, World Bank code: NY.GDP.MKTP.KD).[4] Explanatory variables include three possible measures of country size among which population (millions, SP.POP.TOTL) is measured in logarithm to test for a proportional (and not linear) correlation. Standard economic variables are included as controls: trade openness, measured by the ratio of the sum of exports and imports divided by GDP (NE.TRD.GNFS.ZS); CPI inflation (%, FP.CPI.TOTL.ZG); and the real interest rate (%, FR.INR.RINR). Descriptive statistics of our dataset are in Table A-3 in the Appendix.

2.2. An original index of country Size

Our contribution lies in the country size index we developed using PCA. While Alesina, Spolaore, and Wacziarg (2005) take alternatively population and GDP as a proxy for country size, we want to pinpoint a more global "size effect", not just a population or GDP effect. *The PCA Size* index captures the underlying pattern between three important

2. Our data source is the World Bank Database: http://data.worldbank.org/. Our panel included 177 countries, but the data on GDP, population and arable land to compute our *PCA size index* and *Jalan's size index* were only available for 163 countries (see Table A-1 in the Appendix). 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.

3. Rose (2006) lists 208 "countries" 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. Our focus is to explain the effect of size on the pace of growth of countries not on their wealth or on the income level of their inhabitants. Thus, taking GDP per capita—normalising GDP by demographic size—as a dependent variable would endogenise country size, as both sides of our equation would include the effect of size. By the same token, GDP per capita is a proxy for the wealth of a country, not its size, and so does not qualify as an appropriate component for our *PCA size index*.

components of country size: population, GDP and arable land (computed as Agricultural land—in % of surface area, AG.LND.AGRI.ZS—times Surface area, in 1000km2, AG.SRF.TOTL.K2). This should be a more complete indicator of country size and so avoid the shortcomings of either a purely demographic measure or one based on GDP. The interactions of each of these variables on growth are presumably complex and not exclusively related to size. By construction, it captures the common variation of the three demographic, economic and geographical dimensions of country size and so increases the likelihood that we focus on the overall size factor and do not pick up "parasite" effects.

Table 1. Correlation table of the three size variables

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

PCA can be interpreted as a fixed effects factor analysis, as it enables us to identify common trends in the data. 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] 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. The index is gene-rated 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 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

5. 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.

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 was available for 163 countries.

Table 2. Detailing our principal component analysis

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.49	2.10	0.83	0.83
Comp2	0.39	0.28	0.13	0.96
Comp3	0.11	0.00	0.04	1.00
Principal components (eigenvectors) – Scoring coefficients				
Variable	Comp1	Unexplained		
GDP	0.55	0.28		
Population	0.61	0.08		
Arable land	0.57	0.18		
Number of obs	163	Number of comp.	1	Trace=3

For comparability with other studies and robustness, we test the log of population as a proxy for country size. We also use the country size index developed by Jalan (1982). We run our analysis using his measure to substantiate the claim 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 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* takes values in [0; 100] and is computed as follows.

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

Jalan's size index allows for linear compensation across size dimensions, and 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. We overcome the linearity problem by relying on our *PCA size index*.[6]

For subgroups analysis, we consider a country to be large if its *PCA Size index* is in the top 10% of the distribution, the others being considered small. For simplicity, we do not include a medium-sized category. 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. Thresholds for the large countries group

Index PCA	1.98	Quantile 90%
Equivalent to	Population	49.2 million
	GDP	315.9 billion $
	Arable Land	576.9 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 by 244,000 km^2 (equivalent to the UK's area), a GDP greater by $151 billion (equivalent to Finland's GDP) or a population that has 31 million more people (equivalent to Morocco's population).

Following Furceri and Karras (2007), we compute the cyclical component of the output volatility from the log of real GDP ($2000 constant, so as to neutralise inflation and exchange rate fluctuations) using: (i) 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; and (ii) simple standard deviation (SD) of the GDP growth rate (decade averages), which yields the most volatile series.

2.3. Estimation strategy

We first check for common statistical issues of panel data. Hausman tests indicate that the individual effects and our explanatory variables are systematically related, so that the fixed effects (FE, also called *within*) estimator is the most appropriate choice. As noted by Durlauf, Johnson, and Temple (2005), the FE estimator, which allows for

6. The major difference between our PCA index and Jalan's is that the second one considers the three underlying size variables in levels and not logs, which gives less weight to very big countries. Jalan's recomputed measure with logged variables has a correlation of 0.98 with our PCA index (compared to 0.56 with the original Jalan's index, see Table 4). Consequently, there is a similar correlation coefficient between our PCA index and a simple average of all 3 underlying logged size variables. This can be inferred from the proximity of the three parameters in Table 2. Although the outcome of these different ways of encompassing the three dimensions of size are similar, the rationale for using PCA to compute a multidimensional index is sounder as it captures the common denominator of all three variables and discards the outlying idiosyncratic dimensions.

varying intercept terms across countries, deals efficiently with unobserved heterogeneity, as time-invariant omitted variables do not bias the results.[7] This proves important when we use hard-to-measure variables, such as political situation and institutions. An FE estimator has the advantage of controlling for different national effects of stable unobserved variables. The FE estimator is confirmed by an F-test for the significance of fixed effects. A Wald test for group-wise heteroscedasticity confirms its presence in the data. Likewise, the Wooldridge test for autocorrelation in panel data indicates a first order correlation. Finally, country size is assumed not to be an important source of endogeneity and so the IV estimator is not used.[8] The FE estimator addresses all the statistical issues of our sample, including links between individual effects and regressors, heteroscedasticity and auto-correlation, and we employ robust standard errors clustered at the country level.

Table 4. Correlation structure of variables

Variable	GDP growth	PCA size index	Jalan's size index	Pop.	Trade openness	Real Int. Rate	Inf.
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 Int. 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

We estimate bivariate and multivariate models with a set of economic controls. are economic variables that are important in distinguishing country-size effects from other economic effects, including trade openness, the real interest rate and the inflation rate. We want to isolate possible trade and price competitiveness effects from a country-size effect on growth and volatility. Furthermore, a theoretical justification for including inflation and interest rates as controls comes from the new-Keynesian IS curve, in which output growth is determined by these two variables. We aim at isolating the effects of expected inflation

7. 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.
8. The Dickey-Fuller test indicated the absence of panel unit root, so that co-integration was not necessary.

(proxied here by inflation) and the interest rate on GDP growth from those of country size. We estimate the following regression model:

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

where Y_{it} stands for either GDP growth or a measure of output 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 percentage), U_i represents country fixed-effects and ε_{it} is the error term.[9]

For each of the three size measures used, we run a bivariate regression and a regression adding variable set Z_i for our benchmark FE estimations. The correlation structure of the variables is displayed in Table 4. The strong negative correlation between country size indicators and trade openness confirms our intuition that small countries are more open than large ones.

3. Country size and growth

3.1. 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. The estimation is performed with a correction for heteroscedasticity as standard errors are clustered at the country level, so they are robust to outliers.

Because the coefficients measure semi-elasticities, we can compute precise quantitative correlations using the values of the standard deviations (see Table 13 in the Appendix). For instance, a one-standard-deviation increase in population lowers the growth rate on impact by 2.6%.[10] The coefficient on *Jalan's size index* is not significant, suggesting that the definition of country size is not linear. Based on 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, and the negative correlation

9. Additional control variables (investment, exchange rate regime, GDP/capita) have been tested. Their inclusion does not affect qualitatively the relationship between country size and our outcome variables. These results are available from the authors upon request.

10. The effect on GDP growth of a one-standard-deviation increase in one of the *PCA size index* variables is computed as such: $\sigma_{PCA} * \text{coef}_{PCA} / \sigma_{gdpgrowth}$.

between growth and country size is robust to their inclusion. 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 worth noting that the coefficient of trade on GDP growth is very large and significant; a one-standard-deviation increase in trade increases growth by 38%, confirming the main result of the literature on the benefits of trade.

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 (which represent 90% of our sample), the results are similar. All country-size indicators concur first on the negative conditional correlation between country size and growth and second on the positive relationship between trade openness and growth. Among large countries, there is no clear-cut relationship between size and performance.

For OECD countries (i.e. small and large rich countries), the link between our PCA index and GDP growth is negative and significant but less so when economic controls are included.[11] When country size

11. Detailed estimates for small and OECD countries are available from the authors upon request.

is proxied by population, its relationship with GDP growth is negative and significant over the 1960–2007 time span. 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 correlation between growth and 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 launch 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 is negatively associated with growth. The real interest rate has a negative correlation with growth underlining the importance of credit for growth.

Table 6. 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.

Estimates in Table 6 for the eurozone countries tell another story. While we find a strong negative correlation between population and GDP growth and a large positive coefficient on trade, coefficients on PCA and Jalan's indexes are positive. Even with a possible small sample bias (1999–2007), 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) are thus strongly differentiated in the eurozone: that of population considered alone is negative, whereas the effects of the level of national GDP and arable land seem to be positive. Both effects might be specific to the eurozone and the construction of the European Union (EU). A possible explanation why arable land has been propitious to growth is that countries like Spain, Ireland and, to a lesser extent Finland, have benefited from EU structural funds, and have engaged in rapid economic catch-up processes over this period with considerable territorial effects (shift from agriculture and industry to new services and real estate activities). Another explanation for the positive effect of national GDP refers to the positive externality of being big within the institutional framework of the eurozone and European Union. Monetary policy, EU policies or the allocation of EU funds are more focused or better designed for big members than small members. For instance, there has been more tolerance for the non-respect of the 3% deficit rule of the Stability and Growth Pact (SGP) for big countries than small ones.

We have previously mentioned the so-called BRICs (Brazil, Russia, India and China) with rapidly-growing, large, emerging economies. For these four countries, size is again negatively associated with growth.[12] Moreover, trade (without distinction between manufactured goods and natural resources) is positively associated with their growth. Besides the economic factors that we control for, these countries also benefit from an infrastructure boom and a higher attractiveness of foreign investment compared to countries with comparable development level but smaller domestic markets and less political clout.

3.2. Discussion

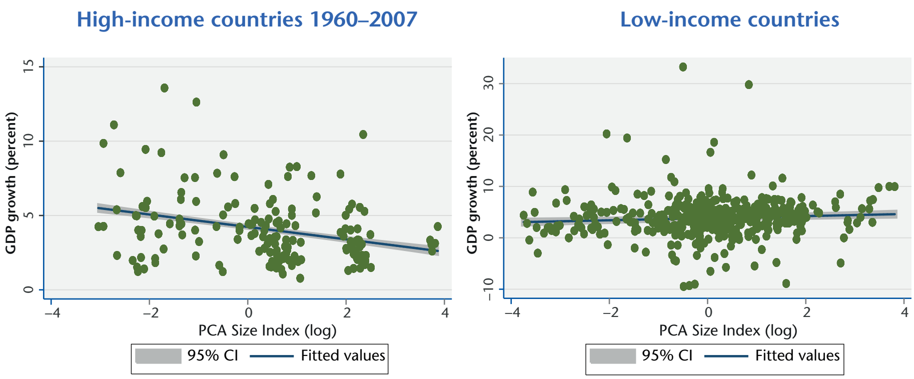
According to our results, the relationship between GDP growth and country size appears negative and robust to different measures of country size and to different subgroups: all countries, small ones, OECD ones and BRICs. The negative effects of size thus seem to outweigh the positive ones. The eurozone displays the opposite outcome and this might be due to its specific institutional framework and peculiar integration mechanisms (and a potential small sample bias).

12. Detailed estimates are available from the authors upon request.

Our results are at odds with both classical and endogenous growth theories. Indeed, the size effects might simply be an artifact of the Solow growth model. Both the PCA and Jalan's indexes contain contemporaneous GDP, and the growth literature (Barro and Sala-i-Martin, 2003) predicts that conditional GDP per capita growth of countries with higher GDP per capita is lower (the so-called β convergence). Since the log of GDP per capita equals the log of GDP minus the log of population, this implies that the dependence of GDP per capita growth on log GDP should also be negative *ceteris paribus*. The Solow model also predicts that higher population growth rates lower GDP growth rates per capita, so if larger countries have higher population growth on average in the sample, then the sign of the coefficient on population in a reduced form regression should be negative too.

An illustration of this intuition for explaining the relationship between country size (as measured by our *PCA size index*) and GDP growth could arise from Figure 1. For high-income countries, the bivariate plot shows a negative correlation between country size and growth. Conversely, low-income countries do not display a marked positive or negative correlation, so a first hint is that the level of economic development might be a driver of this inverse relationship.

Figure 1. Country size and GDP growth



However, this line of reasoning is based on the assumptions that country size is correlated positively first with population growth rates, and second with GDP per capita. Table 7 reports evidence of the opposite and therefore supports that the empirical evidence provided is not an artifact of the Solow growth model. Furthermore, a comparison of previous estimates with regressions from Table 8 with GDP per capita growth as a dependent variable shows that country size has a significant negative correlation with GDP per capita growth, though the correlation between country size and population growth is negligible.

Table 7. Cross-correlation table

Variable	PCA size index	Population	Pop. growth	GDP/capita	GDP/capita growth
PCA size index	1				
Population	0.96	1			
Pop. growth	-0.03	-0.05	1		
GDP/capita	0.17	0.02	-0.21	1	
GDP/capita growth	0.002	-0.003	-0.07	0.05	1

Table 8. Robustness tests

FE with correction for heteroscedasticity (cluster)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	GDP growth			GDP/c. growth		10y growth	
PCA size index	-6.66***		-6.21***	-0.06***		-6.94***	
	[-3.29]		[-2.87]	[-3.18]		[-4.87]	
Population, log		-3.74***			-0.02***		-1.87**
		[-3.94]			[-2.86]		[-2.35]
Dummy GDP/c.			1.68				
			[1.02]				
Interaction term			-0.1				
			[-0.75]				
GDP/capita	2.17**	2.36**	1.80*	0.02**	0.02**	1.20	0.92
	[1.99]	[2.02]	[1.93]	[2.37]	[2.26]	[1.40]	[1.08]
Trade Openness	4.44***	4.69***	4.41***	0.04***	0.04***	2.16***	2.22***
	[3.09]	[3.52]	[3.18]	[3.54]	[3.86]	[2.77]	[3.11]
Real Interest Rate, %	0.05***	0.05***	0.05***	0.01***	0.01***	0.02**	0.02*
	[3.13]	[3.16]	[3.05]	[3.17]	[3.07]	[2.01]	[1.94]
Inflation, %	-0.0	-0.0	-0.0	-0.0	-0.0	-0.01*	-0.01*
	[-0.94]	[-1.02]	[-0.95]	[-1.08]	[-1.15]	[-1.80]	[-1.88]
Constant	-15.44*	-11.48	-13.48*	-0.18**	-0.15*	-6.18	-1.87
	[-1.77]	[-1.31]	[-1.82]	[-2.37]	[-1.93]	[-0.98]	[-0.31]
N	3237	3273	3237	3237	3273	3237	3273
R^2 within	0.06	0.06	0.06	0.06	0.06	0.07	0.04

t-statistics in brackets. * p<0.1, ** p<0.05, *** p< 0.01. Data source: World Bank. We excluded the Jalan index which was not significant in baseline estimates (see Table 5). In column 3, the dummy equals 1 when GDP/capita is above the sample median and 0 otherwise. The interaction term is between the PCA size index and this dummy. In columns 6 and 7, the dependent variable is the average of GDP growth over 10 years.

This suggests that the country size effect previously detailed is indeed on *GDP growth*. As an additional robustness test for the convergence issue, we assess whether the inclusion of the level of GDP per capita as an explanatory variable affects the effect of country size on GDP growth. In addition, we also introduce an interaction term between country size and a dummy capturing above and below median GDP/capita. We find that neither the introduction of GDP per capita nor the interaction term modify the effect of country size on economic growth. We finally provide estimates of the effect of country size on the 10-year average of GDP growth rates and this strongly confirms the main result that country size has a negative effect on GDP growth.

One could also claim that we do not put forward a large country advantage for scale-intensive growth because of the lower prevalence of industries with increasing returns to scale documented by Antweiler and Trefler (2002). We could further argue that the costs associated with large size—transport, transaction, heterogeneity—or conversely, the benefits of small size—homogeneity, density, higher efficiency and adaptability—prevail in accounting for the effect of country size on GDP growth. The coefficient borne by trade openness is always positive, and all the more for smaller countries. This is in line with theories explaining export-led growth of smaller economies in a free-trade environment, which has been the most successful paradigm for emerging economies. Finally, comparing PCA and population coefficients suggests that population may be more negatively associated with growth than are GDP and land area.

4. Country size and growth volatility

We now focus on the relationship between size and growth volatility and still rely on the FE 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 9 for all countries, estimated coefficients for the *PCA size index* and population are negative and significant, with a tenfold decrease in magnitude in comparison with effects on GDP growth. Small countries are statistically more prone than large ones to exhibit volatile growth rates. The coefficient for trade openness is never significant, contradicting the expectation that it should be correlated with output volatility. Following Stiglitz (2000), financial exposure and capital movements may be a more important source of output volatility.

Table 9. 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 are again very similar to those for the whole sample. Quantitatively, a decrease of 1 unit PCA (or 1% population) brings on average about 0.02% more growth volatility, confirming the vulnerability to cyclical fluctuations. In the eurozone, country size seems to have a more stabilising effect on output, as the negative and significant coefficients generated by the *PCA size index* and population are about twice as large as those found for the whole sample (between versus for all countries).[13] As the level of trade and investment integration is very high, large countries which experience less volatility may have a greater influence on their counterparts and decrease their volatility. In addition, once again the eurozone is

13. Detailed estimates for small and eurozone countries are available from the authors upon request. For BRICs and OECD countries, we find no evidence of a significant relationship between size and output volatility.

particular as trade openness is now significant and 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.

We check the robustness of our results obtained with the HP filter by testing the country-size effect on volatility with standard deviation (SD). The coefficients are larger and confirm a strong negative and significant conditional correlation between country size and business cycle volatility (Table 10). The insignificance of trade in accounting for volatility is also confirmed.

Table 10. 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

Overall, we find a negative conditional correlation between country size and output volatility. Other factors implicitly included, such as market size (through GDP), or not included in this analysis such as the diversification of production or financial linkages, may explain why country size is negatively associated with business cycle volatility. Several theoretical considerations can explain the negative correlation between country size and business cycle volatility. Besides the theories mentioned in Section 1, the intuitive notion that larger countries exhibit greater growth rate inertia can be accounted for by Hicks' aggregation theorem: returns to scale in a country's production are a weighted average (according to relative GDP shares) of returns in heterogeneous regional productions. This implies a higher volatility in smaller collections of regions or countries. In contrast, a complementary finding is that trade openness does not appear to be a source of vulnerability to international economic fluctuations, as it is not associated with greater output volatility. Thus, the higher sensitivity to external shocks and greater volatility of small countries most likely stems from their higher degree of specialisation. The insignificance of the coefficient on trade indicates that a higher trade openness does not necessarily mean more vulnerability to external shocks.

5. Conclusion

We use PCA to develop an original country-size index that includes not only the demographic component of country size but also the GDP and arable land. We thus capture a more complete size effect that goes beyond population. We find, contrary to Rose (2006), a significant negative conditional correlation between country size and GDP growth for all countries. The relationship is even more marked for certain groups such as small countries, OECD countries and the BRICs. For eurozone countries, interpreting the relationship proves more complex, as the demographic component of country size is negatively correlated with GDP growth, but our size index displays a positive and significant coefficient. We suspect peculiar effects of European integration to be at play.

We confirm the negative conditional correlation 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. 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.

References

Aghion, P., and A. Banerjee (eds.). 2005. *Volatility and Growth*, Clarendon Lectures in Economics. Oxford University Press, USA.

Aghion, P., and P. Howitt. 1998. *Endogenous Growth Theory*. MIT Press: Cambridge, 1.

Alesina, A., E. Spolaore, and R. Wacziarg. 2005. "Trade, Growth and the Size of Countries." in *Handbook of Economic Growth*, ed. by P. Aghion, and S. Durlauf, *Handbook of Economic Growth*, 1 (23): 1499–1542. Elsevier.

Antweiler, W., and D. Trefler. 2002. "Increasing Returns and All That: A View from Trade." *American Economic Review*, 92(1), 93–119.

Baldwin, R. E. 2003. "Openness and Growth: What's the Empirical Relationship?" NBER Working Papers 9578, National Bureau of Economic Research, Inc.

Barro, R. J., and X. Sala-i-Martin. 2003. *Economic Growth, 2nd Edition, MIT Press Books*. The MIT Press, 1.

Crucini, M. J. 1997. "Country Size and Economic Fluctuations." *Review of International Economics*, Wiley Blackwell, 5(2): 204–220.

Demas, W. G. 1965. *The economics of development in small countries : with special reference to the Caribbean / by William G. Demas*. Published for the Centre by McGill University Press, Montreal.

Durlauf, S. N., P. A. Johnson, and J. R. Temple. 2005. "Growth Econometrics." in *Handbook of Economic Growth*, ed. by P. Aghion, and S. Durlauf, *Handbook of Economic Growth*, 1(8): 555–677. Elsevier.

Easterly, W., R. Islam, and J. E. Stiglitz. 2000. "Explaining Growth Volatility." Macroeconomic paradigms for less developed countries, The World Bank.

Easterly, W., and A. Kraay. 1999. "Small states, small problems?" Policy research working paper series, The World Bank.

Eichengreen, B., R. Hausmann, and U. Panizza. 2003. "Currency Mismatches, Debt Intolerance and Original Sin: Why They Are Not the Same and Why it Matters." NBER working papers, National Bureau of Economic Research, Inc.

Furceri, D., and G. Karras. 2007. "Country size and business cycle volatility: Scale really matters." *Journal of the Japanese and International Economies*, 21(4): 424–434.

Furceri, D., and M. Poplawski. 2008. "Government Consumption Volatility and Country Size." Working papers 2008-17, CEPII Research Center.

Imbs, J. 2007. "Growth and volatility." *Journal of Monetary Economics*, 54(7): 1848–1862.

Jalan, B. 1982. "Classification of Economies by Size." in *Problems and Policies in Small Economies*, ed. by B. Jalan, Commonwealth Secretariat and Croom Helm, London, 17–38.

Katzenstein, P. J. 1985. *Small States in World Markets: Industrial Policy in Europe*. Cornell University Press, Ithaca.

Kuznets, S. 1960. "Economic Growth of Small Nations." in Robinson, 14–32.

Lloyd, P. J. 1968. *International Trade Problems of Small Nations*. Duke University Press, Durham.

Lloyd, P. J., and R. M. Sundrum. 1982. "Characteristics of Small Economies." in *Problems and Policies in Small Economies*, ed. by B. Jalan, Commonwealth Secretariat and Croom Helm, London, 17–38.

Mill, J. S. 1844. *Essays on Some Unsettled Questions of Political Economy*. Longmans, London.

Milner, C., and T. Weyman-Jones. 2003. "Relative National Efficiency and Country Size: Evidence for Developing Countries." *Review of Development Economics*, 7(1): 1–14.

Ramey, G., and V. A. Ramey. 1995. "Cross-Country Evidence on the Link between Volatility and Growth." *American Economic Review*, 85(5): 1138–1151.

Ravn, M. O., and H. Uhlig. 2002. "On adjusting the Hodrick-Prescott filter for the frequency of observations." *The Review of Economics and Statistics*, 84(2): 371–375.

Robinson, E. A. G. 1960. *Economic consequences of the size of nations: proceedings of a conference held by the International Economic Association*. Macmillan, London.

Rodrik, D. 1998. "Why Do More Open Economies Have Bigger Governments?" *Journal of Political Economy*, 106(5): 997–1032.

APPENDIX

Table A-1. List of countries

Albania	Eritrea	Mali	Suriname
Algeria	Estonia	Malta	Swaziland
Angola	Ethiopia	Marshall Islands	Sweden
Antigua & 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 & 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 & Herzegovina	Hong Kong	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	
Côte 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.KittsandNevis	
Egypt, Arab Rep.	Malawi	St.Lucia	
El Salvador	Malaysia	St. Vincent & the Grenadines	
Equatorial Guinea	Maldives	Sudan	

Table A-2. 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

All Countries

Variable	Nb. Obs.	Mean	Std. Dev.	Min	Max
Population	8424	1.441	2.021	-4.200	7.185
PCA size index	6645	0.000	1.551	-4.368	3.905
Jalan's size index	6645	0.656	1.850	0.000	18.951
GDP growth (%)	6654	3.937	6.385	-51.03	106.28
Trade Openness (%)	6325	0.751	0.462	0.053	4.625
Real Interest Rate (%)	3725	6.241	19.620	-98.15	789.80
Inflation (%)	5583	34.44	410.04	-17.64	23773.13

Large countries

Variable	Nb. Obs.	Mean	Std. Dev.	Min	Max
Population	665	4.555	1.148	2.350	7.185
PCA size index	665	2.543	0.549	1.985	3.905
Jalan's size index	665	4.490	4.136	0.916	18.951
GDP growth (%)	663	3.863	4.131	-27.10	19.40
Trade Openness (%)	637	0.346	0.176	0.053	1.106
Real Interest Rate (%)	454	5.759	9.819	-24.60	78.73
Inflation (%)	594	46.366	248.44	-7.63	3079.81

Small countries

Variable	Nb. Obs.	Mean	Std. Dev.	Min	Max
Population	5980	1.316	1.777	-3.927	5.090
PCA size index	5980	-0.283	1.357	-4.368	1.985
Jalan's size index	5980	0.230	0.294	0.000	1.710
GDP growth (%)	5903	3.914	6.529	-51.03	106.28
Trade Openness (%)	5404	0.779	0.429	0.063	4.625
Real Interest Rate (%)	3233	6.329	20.726	-98.15	789.80
Inflation (%)	4679	33.89	438.21	-17.64	23773.13

Table A-3(more). Summary statistics

OECD

Variable	Nb. Obs.	Mean	Std. Dev.	Min	Max
Population	1440	2.596	1.518	-1.737	5.709
PCA size index	1310	1.152	1.133	-1.933	3.905
Jalan's size index	1310	1.598	3.060	0.018	18.95
GDP growth (%)	1302	3.555	3.029	-14.570	18.710
Trade Openness (%)	1253	0.659	0.407	0.093	3.266
Real Interest Rate (%)	820	4.414	4.166	-19.490	16.75
Inflation (%)	1285	9.024	21.110	-0.900	555.38

Eurozone, post 1999

Variable	Nb. Obs.	Mean	Std. Dev.	Min	Max
Population	135	1.998	1.688	-0.947	4.413
PCA size index	134	0.541	1.344	-2.403	2.384
Jalan's size index	134	0.606	0.763	0.006	2.639
GDP growth (%)	134	3.111	1.976	-1.610	10.720
Trade Openness (%)	113	1.093	0.640	0.440	3.266
Real Interest Rate (%)	86	3.765	2.668	-2.650	11.640
Inflation (%)	135	2.592	1.335	0.190	8.880

BRICs, post 2000

Variable	Nb. Obs.	Mean	Std. Dev.	Min	Max
Population	32	6.080	1.012	4.953	7.185
PCA size index	32	3.145	0.470	2.563	3.837
Jalan's size index	32	6.497	3.905	2.634	12.772
GDP growth (%)	32	6.903	2.943	1.270	11.900
Trade Openness (%)	31	0.439	0.159	0.217	0.720
Real Interest Rate (%)	32	12.600	19.380	-9.630	47.680
Inflation (%)	32	6.918	5.599	-0.770	21.460