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Growth Volatility and the Structure of the Economy

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Abstract

The aim of the paper is twofold: i) to propose a methodology to compute the growth rate volatility of an economy, and ii) to investigate the relationship between growth volatility and economic development through the lenses of the structural characteristics of an economy. We study a large cross-section of countries in the period 1970-2009, controlling for the stability of the estimates in two subperiods: 1970:1989 (Period I) and 1990:2009 (Period II). Our main findings are: i) the degree of trade openness has a destabilizing effect, while the degree of financial openness has not a significant effect; ii) the size of the public sector displays a U-shaped relationship with growth volatility, but only in Period II; iii) the level of financial development has a negative effect on growth volatility, but only in Period I. Therefore, the dominant policy orientations in the recent decades contained emphasis on potential sources of instability, e.g. on the increase in openness and on the reduction of the size of the public sector.

Classificazione JEL: O11, O40, C14, C21.

Keywords: growth volatility, economic development, economic structure, nonparametric methods.

Contents

I. Introduction

The volatility of the growth rate of economies has attracted the interest of many researchers, with the emerging stylized fact in the literature that poor countries display a much higher degree of volatility than rich countries (see, e. g., Pritchett (2000) and Durlauf *et al.* (2005), p. 575). Some authors have, moreover, argued that there exists a causal relationship going from high growth volatility to low long-run growth (see the pioneering paper by Ramey and Ramey (1995)). In addition to these pieces of evidence, in recent years developed countries have experienced an abrupt end of the period of the so-called "Great Moderation", i.e. a period characterized by a remarkable reduction of growth volatility started in the 80s' (see, e.g., Stock and Watson (2002) on the US).

The aim of the paper is twofold: 1) to propose a methodology to compute the growth rate volatility of per capita GDP (*GRV* henceforth), which preserves both the time-series and cross-section dimensions, a feature typically overlooked in the literature with the notable exception of Pritchett (2000); and 2) to investigate the relationship between *GRV* and economic development through the lenses of the *structural characteristics* of an economy, that is: i) the *size* of the economy; ii) the degree of *trade and financial openness*; iii) the *size of the public sector*; iv) the level of *financial development*; v) the *composition of GDP*. This paper considers a large cross-section of countries in the period 1970-2009, controlling for the stability of the estimates in two subperiods: 1970:1989 (Period I) and 1990:2009 (Period II). When possible, we use different measures for each structural characteristics. Our findings can be summarized as follow.

i) The size of the economy exerts a stabilizing role at low levels in terms of both total GDP and total population. This finding, however, differs across the two subperiods: in particular, only in Period II total GDP has a significant effect. In the literature the size of an economy is expected to be negatively related to growth volatility because: "individual" volatility (of, e.g., firms, sectors, etc.) should be smoothed out by averaging across an increasing number of units (Canning *et al.* (1998), Scheinkman and Woodford (1994)), and large countries can provide regional "insurance" by fiscal transfers (Alesina and Spolaore (2003), p. 4). The density of population has an inverted U-shaped effect, in contrast with the expected destabilizing effect suggested by Collier (2007).

ii) The degree of trade openness, measured by imports plus exports on GDP, has a destabilizing effect, while the degree of financial openness, measured by the net flow of foreign direct investment on GDP, has not a significant effect. The concentration of exports by trade partner, a novel measure introduced to further qualify the degree of trade openness, has a positive effect effect on *GRV* but only at low levels. In general, the degree of trade and financial openness has an ambiguous effect on volatility because it allows to smooth internal shocks through trade and financial interactions with other countries but, at the same time, it exposes a country to external shocks (see, e. g., Easterly *et al.* (2000) and Di Giovanni and Levchenko (2009)). Malik and Temple (2009), p. 166, moreover, argue that the vulnerability to external shocks is higher when trade is concentrated in few goods.

iii) The size of the public sector, measured by Government consumption on GDP, has a statistically significant effect only in Period II, displaying a U-shaped relationship with GRV, with a minimum around 20 % of GDP. This value should represent the optimal size of a Government aiming at minimizing growth volatility. A large public sector should indeed reduce volatility as it can act as an automatic stabilizer (see, e.g. Galí (1994) and Fatás and Mihov (2001)). Rodrick (1998) discusses a possible positive relationship between openness and the size of government, arguing that more open economies choose large public sectors to counterbalance the increased instability due to their higher degree of openness.

iv) The level of financial development, measured by the stock of domestic credit to private sector on GDP, has a negative effect on GRV, but only in Period I. Our measure of financial development, however, may not be fully adequate to capture the actual level of financial development in more recent years. In principle, financial development can have an ambiguous effect on growth volatility because, as argued by Easterly *et al.* (2000), p. 202: " developed financial systems offer opportunities for stabilization, [but] they may also imply higher leverage of firms and thus more risk and less stability ... As the financial system grows relative to GDP, the increase in risk becomes becomes more important and acts to reduce stability."

v) The composition of GDP, measured by the rents from natural resources on GDP, has a positive effect on GRV but only at high levels and in Period II. There exist many contributions discussing how different sectors display different levels of volatility; for example, Fiaschi and Lavezzi (2005) show that a higher share of agricultural GDP is associated to higher volatility, and Koren and Tenreyro (2007), p. 262, show that sectors can be ranked in terms of their volatility: agriculture, mining and quarrying have high volatility, manufactures have intermediate volatility and services have low volatility. The presence of some sectors with high rents from metals, oil, etc., moreover, can increase volatility as they favour the onset of social conflicts and civil wars (see, e.g., Collier (2007)).

Among the controls, those with explanatory power on GRV are: the quality of the institutions, measured by constraint on executives (we find a negative effect, but only in Period I, see Acemoglu *et al.* (2003) for a similar finding); a measure of the fertility of soil (positive effect at low/medium levels, but only in Period II, see Malik and Temple (2009)); the mean distance to the nearest coastline or sea-navigable river (positive effect, but only in Period II, see, again, Malik and Temple (2009)). Measures of aggregate volatility, as the volatility of world prices of food, or minerals, ores and metals, are statistically significant only in the whole period, suggesting that a change of regime of volatility occurred between Period I and II, while within each period aggregate shocks played a marginal role.

The paper is organized as follows. Section II. discusses the methodology for the computation of growth volatility; Section III. contains the description of the database and the results from the empirical analysis; Section IV. concludes.

II. The Estimation of Growth Volatility

In this section we propose a methodology for the estimation of GRV which exploits both its cross-sectional and time-series dimensions.[1] Then we apply this methodology to the growth rate of per capita GDP of a large sample of countries, discussing the main characteristics of the estimated growth volatilities.[2]

II.A. The Methodology

Following Barro and Sala-i-Martin (1998), p. 37, consider the log-linear approximation around the steady state of the growth rate of per capita income of country j at time t:

$$\tilde{\gamma}_{jt} \approx -\beta \left(\log \tilde{y}_{jt} - \log \tilde{y}_j^{SS} \right), \tag{1}$$

where $\tilde{\gamma}_{jt}$ is the growth rate of per capita income in efficiency units, that is normalized with respect to the growth rate of exogenous technological progress γ_A, i.e. $\tilde{\gamma}_{jt} = \gamma_{jt} - \gamma_A$, where γ_{jt} is the growth rate of per capita income; $\beta > 0$ measures the speed of convergence to steady state, $\tilde{y}_t^j$ is per capita income in efficiency units, and $\tilde{y}_j^{SS}$ is the steady- state level of per capita income in efficiency units of country j. From Eq. (1), taking $\tilde{\gamma}_{jt} \approx \log \tilde{y}_{jt}/\tilde{y}_{j,t-1}$, we obtain:

$$\tilde{\gamma}_{jt} \approx \left(\frac{1}{1+\beta} \right) \tilde{\gamma}_{jt-1}, \tag{2}$$

and, therefore, in terms of the growth rate of per capita income:

$$\gamma_{jt} \approx \left(\frac{\beta}{1+\beta} \right) \gamma_A + \left(\frac{1}{1+\beta} \right) \gamma_{jt-1}. \tag{3}$$

Adding a stochastic term to Eq. (3) we obtain a representation of the dynamics of the growth rate as an $AR(1)$ process:

$$\gamma_{jt} \approx \left(\frac{\beta}{1+\beta} \right) \gamma_A + \left(\frac{1}{1+\beta} \right) \gamma_{j,t-1} + \epsilon_{jt}, \tag{4}$$

where ϵ_{jt} is assumed to be normally distributed with zero mean and standard deviation σ_{jt}^{ϵ}. Writing Eq. (4) in the standard AR(1) form, i.e.:

$$\gamma_{jt} = \mu_j + \phi_1 \gamma_{j,t-1} + \epsilon_{jt}, \tag{5}$$

[1]This is in line with the remark of Galí (2002), p. 224 which, with respect to the US experience, observes: "SW [Stock and Watson (2002)] paper ... studies the phenomenon of changes in the business cycle from a time-series perspective. But measures of macroeconomic volatility appear to vary across countries no less than they vary over time. Can we learn anything from the cross-country evidence regarding the sources of the observed changes (*over time*) in the U.S. business cycle?" (emphasis added).

[2]Data of per capita GDP are from the Penn World Table 7.0. We used the growth rate of PPP Converted GDP Chain Per Capita (PWT code: grgdpch).

we derive the standard deviation of the growth rate γ_{jt} (see, e. g., Hamilton (1994), p. 53):

$$\sigma^{\gamma}_{jt} = \frac{\sigma^{\epsilon}_{jt}}{\sqrt{1-\phi_1^2}}. \tag{6}$$

The unbiased estimator of σ^{ϵ}_{jt} is proportional to the estimated absolute value of residuals from the estimation of Eq. (5) (see McConnell and Perez-Quiros (2000), p. 1466, and Stock and Watson (2002), pp. 207-208), that is:

$$\hat{\sigma}^{\epsilon}_{jt} = \sqrt{\frac{\pi}{2}}|\hat{\epsilon}_{jt}|. \tag{7}$$

Taking as measure of GRV the standard deviation of the growth rate, from Eqq. (6) and (7) we have that:

$$G\hat{R}V_{jt} = \hat{\sigma}^{\gamma}_{jt} = \frac{\sqrt{\frac{\pi}{2}}|\hat{\epsilon}_{jt}|}{\sqrt{1-\hat{\phi}_1^2}}. \tag{8}$$

This method of computation of GRV can be easily extended to higher-order AR models,[3] which correspond to the case where the log-linear approximation in Eq. (1) includes other terms with lagged values of (normalized) per capita income.[4] In the empirical analysis we select the order of AR for each country in our sample (among which the AR of order 0, i. e. the case of growth rate processes which can be represented by their means plus a random error) by a small-sample version of the Akaike Information Criterion (AIC), indicated as AIC_c (see Burnham and Anderson (2004), p. 66). The list of the selected order of ARs for the 69 countries of the sample used in the analysis is reported in Appendix A.

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[3] For an $AR(3)$, the maximum lag considered in the empirical analysis, we have (see Hamilton (1994), pp. 58-59):

$$GRV_{jt} = \frac{\sigma^{\epsilon}_{jt}}{\sqrt{1-\rho_1\phi_1^2-\rho_2\phi_2^2-\rho_3\phi_3^2}},$$

where:

$$\begin{aligned}\rho_1 &= \tfrac{\phi_1+\phi_2\phi_3}{1-\phi_2-\phi_3(\phi_1+\phi_3)};\\ \rho_2 &= \tfrac{\phi_1(\phi_1+\phi_3)+\phi_2(1-\phi_2)}{1-\phi_2-\phi_3(\phi_1+\phi_3)}, \text{ and}\\ \rho_3 &= \phi_1\rho_2+\phi_2\rho_1+\phi_3.\end{aligned}$$

[4] For an $AR(3)$, we have:

$$\tilde{\gamma}_{jt} \approx -\beta_0\left(\log\tilde{y}_{jt}-\log\tilde{y}_j^{SS}\right)-\beta_1\left(\log\tilde{y}_{j,t-1}-\log\tilde{y}_j^{SS}\right)-\beta_2\left(\log\tilde{y}_{j,t-2}-\log\tilde{y}_j^{SS}\right)-\beta_3\left(\log\tilde{y}_{j,t-3}-\log\tilde{y}_j^{SS}\right),$$

from which:

$$\gamma_{jt} \approx \left(\frac{\beta_0+\beta_1+\beta_2+\beta_3}{1+\beta_0}\right)\gamma_A + \left(\frac{1}{1+\beta_0}\right)\left[\left(1-\beta_1\right)\gamma_{j,t-1}+\beta_2\gamma_{j,t-2}+\beta_3\gamma_{j,t-3}\right].$$

Country j's GRV can be decomposed in aggregate shocks, i. e. shocks affecting all countries in the same period,[5] and country-specific (idiosyncratic) shocks deriving from country-specific characteristics, i.e.:

$$\epsilon_{jt} = \lambda_t + u_{jt}, \tag{9}$$

where λ_t is an aggregate shock, normally and independently distributed with zero mean and standard deviation σ_t^λ, and u_{jt} is a country-specific normally distributed random shock with zero mean and standard deviation σ_{jt}^u. Therefore:

$$\sigma_{jt}^\epsilon = \sqrt{\left(\sigma_t^\lambda\right)^2 + \left(\sigma_{jt}^u\right)^2}. \tag{10}$$

The standard deviation of the country-specific shock can be expressed as:

$$\sigma_{jt}^u = \sigma^u(\mathbf{Z}_{jt}), \tag{11}$$

where the vector $\mathbf{Z}_{jt}$ contains the country-specific variables, such as size of the economy, trade and financial openness, etc.

Hence, we rewrite Eq. (8) in the light of Eqq. (10) and (11) as:

$$G\hat{R}V_{jt} = \sqrt{\frac{\left(\hat{\sigma}_t^\lambda\right)^2 + \left(\hat{\sigma}_{jt}^u\right)^2}{1 - \hat{\phi}_1^2}} = f(\mathbf{X}_t, \mathbf{Z}_{jt}), \tag{12}$$

where $\mathbf{X}_t$ is a vector of variables capturing the effect of global shocks on GRV. Eq. (12) represents the structure of our baseline econometric model when the order of the AR process is 1.[6] Specifically, in the empirical analysis the aggregate shocks will be captured by time dummies and by the volatility of world prices of broad categories of goods, such as food and metals, while the impact of country-specific variables will be estimated by a semiparametric specification.

This approach has important advantages with respect to the methods commonly used in the literature, deriving from the exploitation of *both* the cross-sectional and the time-series dimensions of GRV. The most popular methodology consists in calculating GRV by the standard deviation of the time series of country j's growth rates of per capita or per worker GDP (see, e.g., Easterly *et al.* (2000), Di Giovanni and Levchenko (2009), Malik and Temple (2009)). The main drawback of this method is that many variables potentially included in $\mathbf{Z}$ in Eq. (12) are likely to vary over time. In other words, this approach omits the possible changes of within-country volatility in time which, following our representation, may depend of the variation in time of the elements of $\mathbf{Z}$.

Differently, Canning *et al.* (1998) pool the residuals from a panel estimation of the following model:[7]

$$g_{jt} = \gamma_j + \lambda_t + u_{jt}, \tag{13}$$

[5] "[T]he price of a major input in production, such as steel, ... may affect the productivity of sectors that are steel-intensive. More generally, technology- and price-shocks that affect a sector or a group of sectors across countries will fall in this category." (Koren and Tenreyro (2007), p. 248).

[6] We adjust the denominator of Eq. (12) according to the order of the AR process (see Footnote 3).

[7] A similar method to compute volatility is followed also by Koren and Tenreyro (2007), p. 252, and Acemoglu and Zilibotti (1997), p. 714.

partition them into different classes on the basis of the level of total GDP, and calculate the standard deviation within each class. This amounts to assume that **Z** in Eq. (12) includes only total GDP, and that the effect of global shocks can be captured by a time dummy. A similar procedure is also followed by Acemoglu and Zilibotti (1997), p. 715, who partition the residuals in classes defined on the basis of per capita GDP.

Finally, papers such as Head (1995) apply the Hodrick-Prescott filter to countries' growth rates, and then compute *GRV* as the standard deviation of growth rate residuals with respect to the smoothed series. This amounts to assume that growth rates follow a (possibly nonlinear) autoregressive stochastic process as in our methodology but, also in this case, the time-series dimension of *GRV* is completely lost.

II.B. A Look at The Estimated Growth Volatilities

Figure 1 reports the sample average *GRV* for the period 1970:2009 for each year and the relative five-year averages, for our sample of 69 countries (*GRV* is reported in percentage points).[8]

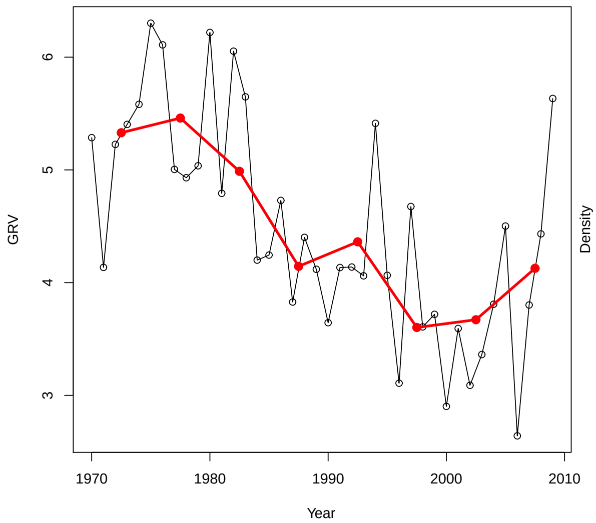

Figure 1: Sample average *GRV* in the period 1970-2009: annual and five-year averages.

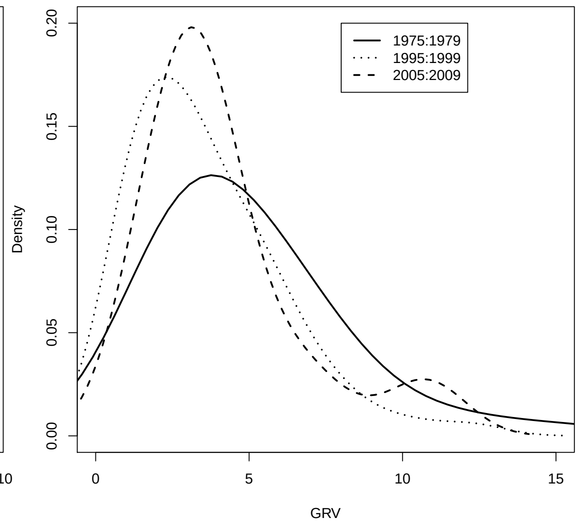

Figure 2: Cross-section distribution of five-year *GRV* for the periods 1975:1979, 1995:1999, and 2005:2009.

We notice a clear downward trend from 1970 to 2000, a period in which the sample average *GRV* almost halves. This piece of evidence is consistent with the literature on the "Great Moderation" in the growth pattern of developed countries (see, e. g., Stock and Watson (2002) and McConnell and Perez-Quiros

[8]All computations are performed with R. Datasets and codes are available on authors'website (http://www-dse.ec.unipi.it/persone/docenti/fiaschi/WorkingPapers.html).

(2000) for the US). After 2000, however, the trend reverted and *GRV* reaches a peak in 2009, the last year that we consider in our analysis.

Figure 2 shows that significant differences also emerge from the dynamics of the cross-country distributions of five-year averages of *GRV*. The distribution with the highest average *GRV* is that of the period 1975:1979, characterized by the oil shocks. This distribution displays a peak at a value not very different from the values of the peaks of the other two distributions, but it has a very broad shape, highlighting that a remarkable number of countries experimented very large shocks. The distribution of 1995:1999, corresponding to the lowest average volatility appears, on the contrary, very concentrated around its peak, with a negligible mass in the top tail. Finally, the distribution of 2005:2009 displays two peaks, suggesting the existence of two distinct clusters of countries in terms of growth volatilities.

Table 1 reports the transition matrix across five classes of *GRV*, defined in order to contain the same number of observations in each class.

	Range of *GRV*	I	II	III	IV	V
I	$[0 : 1)$	0.51	0.22	0.19	0.04	0.04
II	$[1 : 2.2)$	0.29	0.25	0.22	0.16	0.09
III	$[2.2 : 3.8)$	0.18	0.23	0.30	0.22	0.07
IV	$[3.8 : 6.7)$	0.06	0.18	0.25	0.28	0.24
V	$[6.7 : \infty)$	0.03	0.13	0.11	0.27	0.45

Table 1: Transition matrix for *GRV* 1970-2009 with five-year averages

GRV appears characterized by persistence, especially in the extreme classes I and V, where the probability to remain in the same *GRV* class is equal to 0.51 and 0.45, respectively.[9] This suggests the presence of two clusters of countries, one with a persistent low volatility, as opposed to another with high volatility. Figures 3-6, presenting the dynamics of *GRV* for selected individual countries, confirm this intuition.

[9] Also notice that the off-diagonal elements are relatively high.

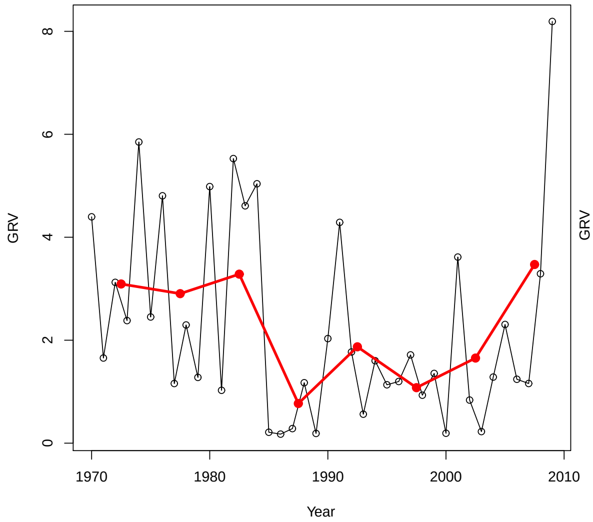

Figure 3: Growth volatility 1970-2009: USA

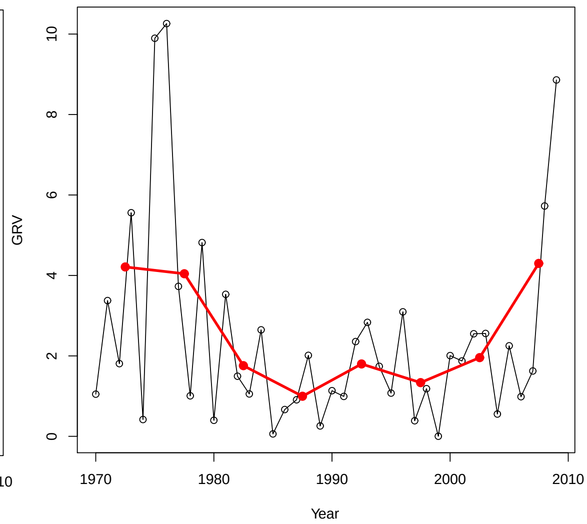

Figure 4: Growth volatility 1970-2009: Italy

In particular, GRV of US and Italy follows a similar U-shaped pattern over time within approximately the same interval, ranging from about 4 in the 1970s to about 1 in the period 1985:2000 for five-year averages (see Figures 3 and 4). Argentina (5), instead, shows a moderate and persistent level of GRV around 6 points from 1980. Finally, Nigeria (6) displays on average a very high GRV of about 10, with wide fluctuations.

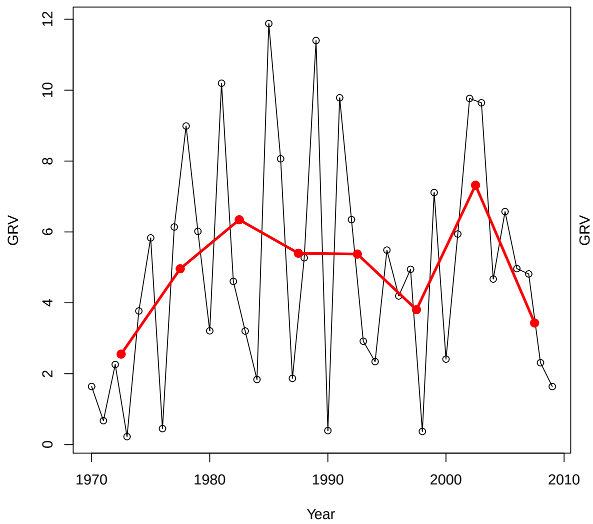

Figure 5: Growth volatility 1970-2009: Argentina

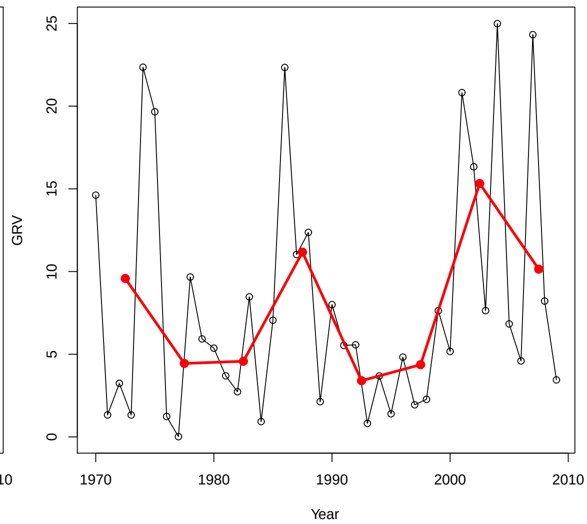

Figure 6: Growth volatility 1970-2009: Nigeria

Overall, these pieces of evidence suggest that GRV is changing in time within each country, as well as in terms of its distribution dynamics across countries, providing support to our methodological approach. In the next section we study the determinants of GRV.

III. Empirical Analysis

In this section we test the explanatory power of the structural characteristics of an economy as possible determinants of GRV. In particular, following the literature, we consider: i) the size of the economy; 2) the degree of trade and financial openness; iii) the size of the public sector; iv) the composition of output. In addition, we control for institutional/cultural characteristics, and geography. The possible presence of aggregate shocks is controlled by time dummies (see, e. g., Koren and Tenreyro (2007), p. 248 or Canning *et al.* (1998), p. 336), and by the volatility of the world prices of food, agricultural products, and metals.

III.A. The Dataset

Table 2 contains the list of variables used in the analysis, their sources, and the relevant references.

The selection of the variables was dictated by the choice to have a balanced panel with a relatively high number of observations for each country, in order to keep track of the within-country dynamics of GRV. This choice prevented us from considering, for example, alternative measures of output composition, such as the share of agriculture (see Fiaschi and Lavezzi (2005)), manufacturing and services on GDP; of exports (i.e. the export concentration index used by Malik and Temple (2009)); of institutions (i.e. the settlers' mortality rate used by Acemoglu *et al.* (2001)) etc., because this would imply a substantial reduction in the number of observations, especially in the time-series dimension.

Considering five-year averages of yearly observations to reduce measurement errors and the effect of cyclical components,[10] we obtain a sample of 69 countries for the period 1970-2009 (the total number of observations is therefore 69 x 8 = 552).[11]

Figures 7 - 15 present the estimates of the univariate relationships between some selected variables and GRV.[12] We also show the estimation of the univariate relationship between GRV and per capita GDP. As noted, a typical stylized fact is that GRV decreases with the level of development, and per capita GDP is the common proxy for development (see, e.g., Fiaschi and Lavezzi (2005), Acemoglu

[10] Given that the variables that we use are relatively stable in time, to enlarge as much as possible the sample the data for a five-year average was calculated also in the limiting case when only an observation out of five was available. In addition, we assume that variables available for one year are representative of the values for the whole period.

[11] The country list is reported in Appendix A

[12] Each figure contains the result of a nonparametric estimation and its 95% confidence band made by the package "sm" in *R*. In particular, we run a Nadaraya-Watson kernel regression, using the *Generalized Cross Validation* as method of selection of the bandwidth (see Bowman and Azzalini (2010)).

Variable	Code	Description and Source	References
Size of the economy	TOTGDP	Total GDP. PPP Converted GDP Per Capita (Chain series, 2005 constant prices). PWT 7.0	Canning *et al.* (1998), Scheinkman and Woodford (1994), Alesina and Spolaore (2003)
	POP	Population. PWT 7.0	
	DENSITYPOP	Population per km^2. PWT 7.0 and `http://www.cid.harvard.edu`	Collier (2007)
Trade and financial openness	OPENNESS	Exports + Imports as % of GDP. PWT 7.0	Easterly *et al.* (2000), Di Giovanni and Levchenko (2009)
	EXPCONCTRADEPARTNER	Herfindhal index of concentration of exports by trade partner. Correlates of War Project (`http://www.correlatesofwar.org`).	Malik and Temple (2009)
	NETFDI	Net flow of foreign direct investments as share of GDP. UNCTAD	
Size of public sector	GOVSHARE	Government Consumption Share of PPP Converted GDP Per Capita at 2005 constant prices. PWT 7.0	Fatás and Mihov (2001) Galí (1994), Rodrick (1998)
Size of financial sector	CREDIT	Domestic credit to private sector (% of GDP). WDI 2011	Easterly *et al.* (2000)
Output composition	NATRESOURCESRENTS	Total natural resources rents (% of GDP). WDI 2011	Acemoglu and Zilibotti (1997), Fiaschi and Lavezzi (2005), Koren and Tenreyro (2007)
Geography	SOILSUITMEDIUM	Percentage of each soil type that is moderately suitable for six rainfed crops in 1995. `http://www.cid.harvard.edu`	Malik and Temple (2009)
	AVDISTANCECOSTLINERIVER	Mean distance to nearest coast line or sea-navigable river. `http://www.cid.harvard.edu`	
Institutions and culture	CONSTRONEXECUTIVE	Executive constraint. 1: unlimited authority, 7: executive Parity or Subordination. POLITY IV	Acemoglu *et al.* (2003), Glaeser *et al.* (2004)
	ETHNOLINGDIVERSITY	Ethnolinguistic diversity (1960). Collier and Hoeffler (2004)	Malik and Temple (2009), Collier (2007), Hegre and Sambanis (2006)
	ETHNICDOMINANCE	Ethnic dominance measure (dummy) (1964). Dummy=1 if the largest ethnic group constitutes 45% − 90% of the population. Collier and Hoeffler (2004)	
Aggregate shocks	VOLFOODPRICE	Estimated volatility of food price at world level (estimated using the same methodology for GRV). UNCTAD	
	VOLAGRIPRICE	Estimated volatility of agriculture raw materials price at world level (estimated using the same methodology for GRV). UNCTAD	
	VOLMETALPRICE	Estimated volatility of minerals, ores and metals price at world level (estimated using the same methodology for GRV). UNCTAD	
	VOLOILPRICE	Estimated volatility of oil price at world level (estimated using the same methodology for GRV). UNCTAD	

Table 2: List of variables used in the analysis

and Zilibotti (1997) and Koren and Tenreyro (2007)). In the multivariate analysis, however, we do not include per capita GDP among the regressors because it does not add significant information to the analysis once we control in the regression for the structural characteristics of an economy.[13]

PERCAPITAGDP, TOTGDP, CREDIT, CONSTRONEXECUTIVE, display a clear negative relationship with *GRV*. On the contrary, NATRESOURCERENTS, OPENNESS, AVDISTANCECOAST, SOILSUITMEDIUM and VOLFOODPRICE, seem to have a substantially positive relation (with the presence of nonlinearities, in particular for VOLFOODPRICE). GOVSHARE, instead, displays a U-shaped relationship, although the increasing part of the relation corresponds to few observations with very high values of Government consumption. Also, ETHNOLINGDIVERSITY displays a U-shaped relationship. Finally, *GRV* and VOLMETALSPRICE exhibit an inverted U-shaped relationship, but the negative part seems to be due to the observations of one period only (the one with the highest price volatility).

The literature on growth volatility largely agrees with the estimated relationships between *GRV* and, respectively, PERCAPITAGDP, TOTGDP, CONSTEXECUTIVE, NATRESOURCERENTS, AVDISTANCECOAST (see, e.g., Koren and Tenreyro (2007) and Malik and Temple (2009)). The main novelty is in the existence of a clear relationship also between *GRV* and CREDIT, GOVSHARE, and OPENNESS, issues still debated in the literature (see, e.g., Galí (1994), Easterly *et al.* (2000), and Fatás and Mihov (2001)). So far, to the best of our knowledge the relationship between *GRV* and ETHNOLINGDIVERSITY and SOILSUITMEDIUM has been analysed only by Malik and Temple (2009), who find a negative impact for both.[14] The evidence for VOLFOODPRICE and VOLMETALSPRICE, variables so far neglected in the literature, suggests that also aggregate shocks may play a role in the explanation of *GRV*. In the next section we test whether these relationships survive in a multivariate analysis.

[13]For example, Fiaschi and Lavezzi (2005) show that per capita GDP loses its explanatory power when the size of the economy, openness and output composition are taken into account. Moreover, here per capita GDP is highly correlated with CREDIT and CONSTRONEXECUTIVE (the correlation coefficients are, respectively, 0.74 and 0.80).

[14]Ethnic diversity and the presence of a not very large ethnic majority (ETHNICDOMINANCE) should be positively associated to rebellion and social conflicts, and therefore to instability (Collier (2007)).

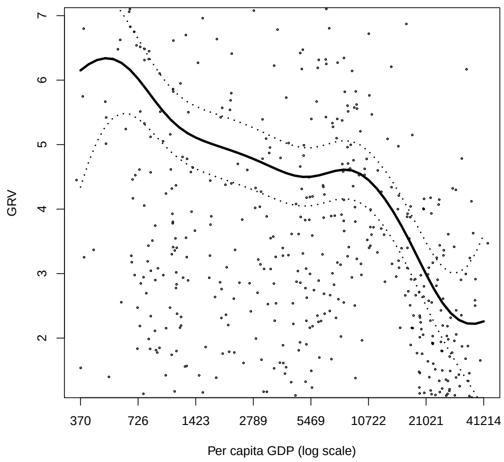

Figure 7: Nonparametric regression of *GRV* on per capita GDP

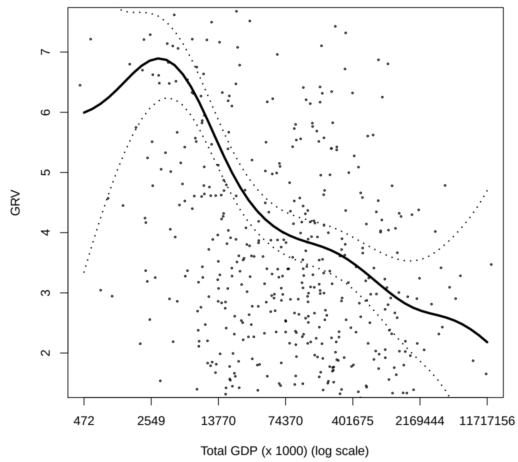

Figure 8: Nonparametric regression of *GRV* on TOTGDP

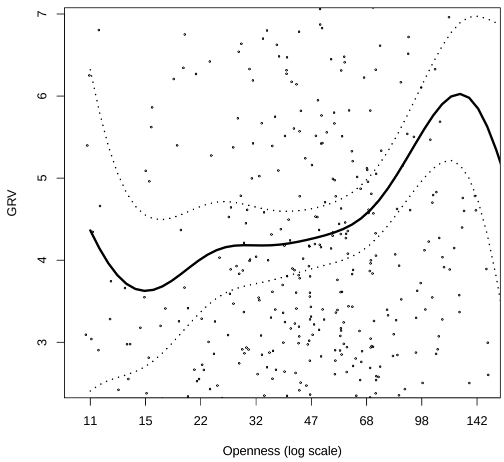

Figure 9: Nonparametric regression of *GRV* on OPENNESS

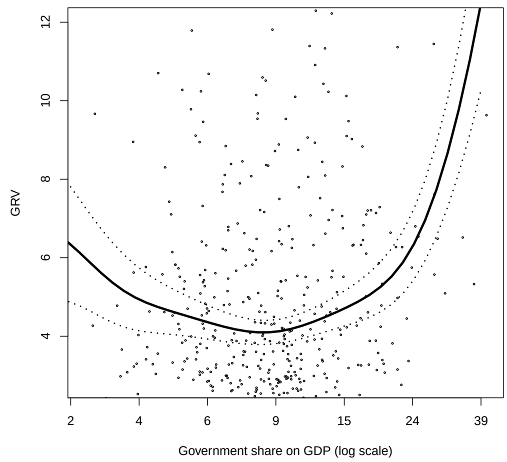

Figure 10: Nonparametric regression of *GRV* on GOVSHARE

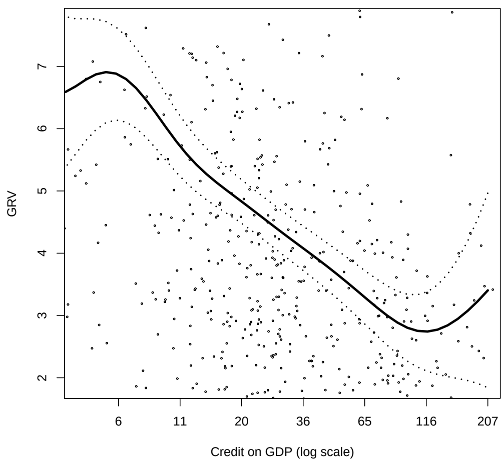

Figure 11: Nonparametric regression of *GRV* on CREDIT

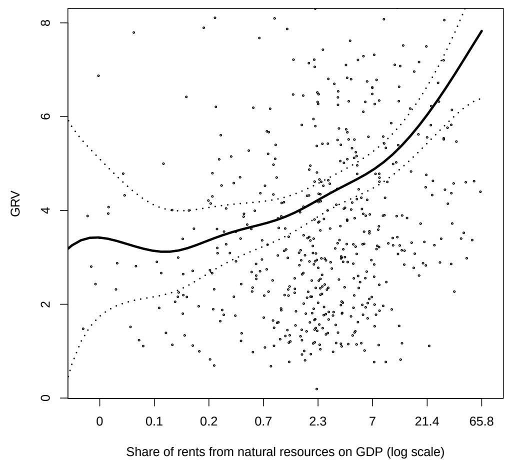

Figure 12: Nonparametric regression of *GRV* on NATRESOURCERENTS

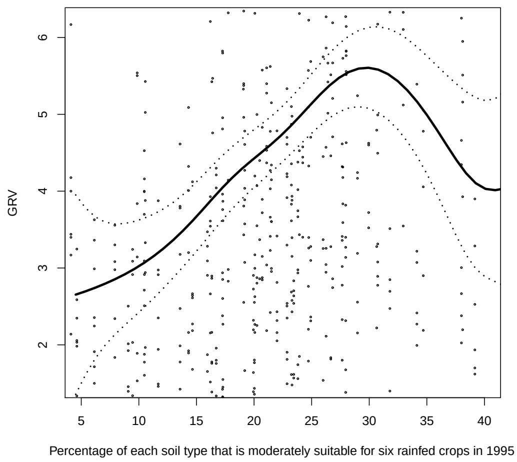

Figure 13: Nonparametric regression of *GRV* on SOILSUITMEDIUM

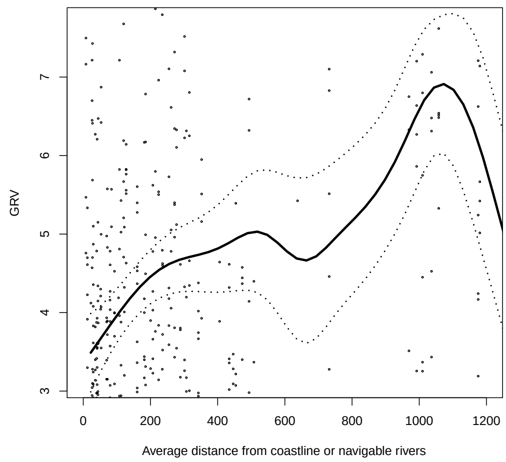

Figure 14: Nonparametric regression of *GRV* on AVDISTANCECOAST

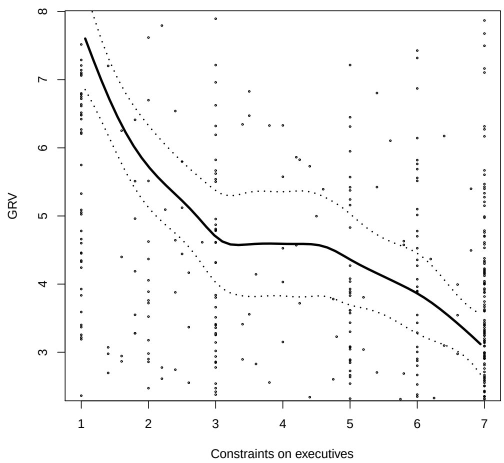

Figure 15: Nonparametric regression of *GRV* on CONSTEXECUTIVE

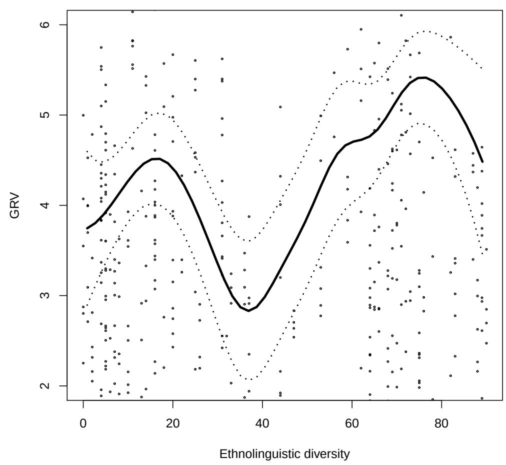

Figure 16: Nonparametric regression of *GRV* on ETHNOLINGUISTICDIVERSITY

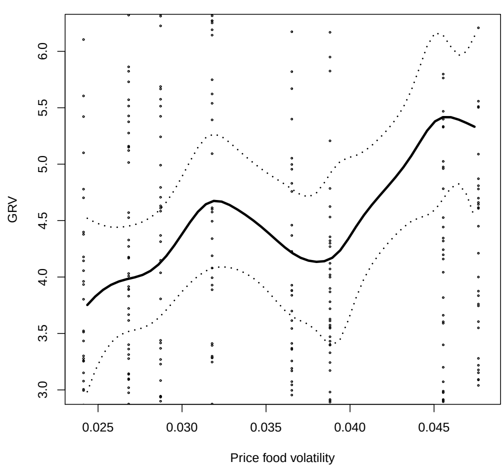

Figure 17: Nonparametric regression of *GRV* on VOLFOODPRICE

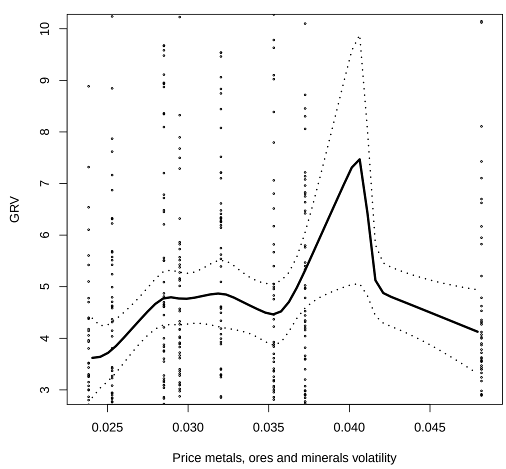

Figure 18: Nonparametric regression of *GRV* on VOLMETALSPRICE

III.B. GAM Estimation

We estimate the relationships between *GRV* and the variables reported in Table 2 by nonparametric methods. In particular, we estimate the following *generalized additive model* (GAM) (see Wood (2006)) based on Eq. (12):

$$\begin{aligned} GRV_{jt} = \beta_0 &+ f_1(\mathbf{Size\ of\ the\ economy}_{jt}) + \\ &+ f_2(\mathbf{Trade\ and\ financial\ openness}_{jt}) + f_3(\mathbf{Size\ of\ public\ sector}_{jt}) + \\ &+ f_4(\mathbf{Size\ of\ financial\ sector}_{jt}) + f_5(\mathbf{Output\ composition}_{jt}) + \\ &+ \mathbf{Controls}_{jt} + \mathbf{Aggregate\ shocks}_t + \xi_{jt}, \end{aligned} \tag{14}$$

where i and t index, respectively, countries and periods; the functions $f_j(\cdot)$, with $j = 1, ..., 5$, are smooth functions of the explanatory variables; **Controls** is a vector including controls for institutional and cultural factors, and geography; aggregate shocks refer to the effect of variables that may affect *GRV* in different countries in the same period, and ξ is a normally distributed random variable with zero mean and standard deviation σ^{ξ}.

Table 3 contains the results from the estimation of different specifications of Eq. (14). For any estimated term, we report either the *estimated degrees of freedom* (*EDF*)[15] or, when the *EDF* of the term are equal to one, the estimated linear coefficient in square brackets.[16] The goodness of fit is measured by the *Generalized Cross Validation* (*GCV*) score (see Wood (2006), p. 132). For each model it is also reported the proportion of deviance explained, a measure comparable to R^2 for linear models (see Wood (2006), p. 84). Each model in Table 3 represents the preferred specification, which is obtained by recursively eliminating the least significant terms until the lowest level of the *GCV* score is reached.[17]

Model I only includes the five explanatory variables on the structure of the economy. All the variables but POP are present in the preferred specification, and their impacts appear nonlinear (in Table 3 the values of *EDF* range from 1.92 for OPENNESS to 8.02 for CREDIT).[18]

Model II adds to Model I the controls for institutional, cultural, and geographical characteristics. In the preferred specification, TOTGDP and NATRESOURCESRENTS are not included. OPENNESS has, instead, a highly significant impact, as shown in Figure 19 (see Di Giovanni and Levchenko (2009) for a similar result): countries more open to world trade display a higher level of *GRV*. As for the magnitude of the effect, we find that a country with OPENNESS of about 100 has *GRV* higher of about 1.5 percentage points than a country with a level of OPENNESS of about 50.

Government consumption does not seem to statistically affect *GRV* at low levels (see Figure 20). At medium levels (around 20 percentage points of GDP),

[15]The *EDF* reflect the nonlinear impact of the variable on *GRV*.

[16]See Wood (2006), pp. 170-172, for more details.

[17]NETFDI and ETHNICDOMINANCE are never statistically significant and therefore do not appear in Table 3.

[18]For lack of space we do not report figures with the impact of the individual variables. These effects are very similar to those reported below for the other models.

Model	I	II	III	IV
Time dummies	YES	YES	YES	NO
Constant	5.0423 (0.000)	7.2702 (0.000)	1.4508 (0.000)	5.1985 (0.000)
log(TOTGDP)	4.996 (0.0005)	-	-	-
log(OPENNESS)	1.916 (0.0000)	1.894 (0.0000)	1.894 (0.0000)	2.244 (0.0001)
log(GOVSHARE)	6.708 (0.0000)	6.600 (0.0035)	6.600 (0.0035)	6.312 (.0023)
log(CREDIT)	8.020 (0.0002)	[−0.5770] (0.0085)	[−0.5770] (0.0085)	[−0.5392] (0.0120)
log(NATRESOURCESRENTS)	2.884 (0.0212)	-	-	-
log(POP)	-	7.191 (0.0005)	7.191 (0.0005)	6.952 (0.0010)
log(DENSITYPOP)	8.239 (0.0000)	7.090 (0.0000)	7.090 (0.0000)	7.475 (0.0000)
log(EXPCONCTRADEPARTNER)	3.498 (0.2159)	3.405 (0.1035)	3.405 (0.1035)	3.494 (0.1035)
CONSTRONEXECUTIVE	-	2.602 (0.0043)	2.602 (0.0043)	2.704 (0.0009)
ETHNOLINGDIVERSITY	-	[−0.0103] (0.0754)	[−0.0103] (0.0754)	-
SOILSUITMEDIUM	-	2.927 (0.0021)	2.927 (0.0021)	2.941 (0.0026)
AVDISTANCECOSTLINERIVER	-	3.655 (0.0022)	3.655 (0.0022)	3.871 (0.0117)
VOLMETALPRICE	-	-	[0.7393] (0.0006)	-
VOLFOODPRICE	-	-	[0.7793] (0.0000)	[0.3057] (0.0543)
GCV score	8.1433	7.8434	7.8434	7.7893
Deviance explained	39.3%	41.8%	41.8%	40.8%
Number of obs.	552	552	552	552

Table 3: Estimation of Eq. (14). Dependent variable is GRV. EDF or estimated linear coefficients (in square brackets) of the preferred specifications (p-values in parenthesis)

however, it exerts a slightly negative influence as expected (see, e.g., Fatás and Mihov (2001)), which becomes strongly positive around a value of 30 percentage points.[19] We conjecture that very high levels of GOVSHARE are indicators of bad macroeconomic policy, whose consequences could also be higher instability (see Collier (2007)). The analysis suggests that there exits an optimal size of Government consumption that may act as economic stabilizer of about 20; in terms of policy this finding should be compared with the possible negative effect on the average growth rate (Barro (1991)).

The size of credit on GDP has a statistically significant and negative (linear) effect. As to the magnitude, the average increase in CREDIT from 25.15 in 1970 to 69.93 in 2000 has reduced the overall volatility on average of 0.59 percentage points. This evidence contrasts with the nonlinear effect found by Easterly *et al.* (2000), p. 202.

Low-population countries appear subject to higher GRV (see Figure 21). The impact of POP, however, already vanishes for countries with more than 3 millions of inhabitants (in 2009 the only countries with less than 3 millions inhabitants are Gabon, Gambia, Jamaica, and Trinidad and Tobago). This finding supports the existence of a size-effect on GRV, by which an increasing size of the country in terms of population reduces volatility. The surprising result, however, is that the minimum size after which the effect vanishes is very low (see Alesina and Spolaore (2003) for a thorough discussion of the possible relevance of the size of population for countries' volatility).

Figure 22 highlights that the density of population has a nonlinear relationship with GRV. At low/medium values, population density decreases volatility, while in the intermediate range (around 0.015, i.e. 15 inhabitants per squared km) the positive effect on GRV is the highest. The expected result was a positive relationship, on the assumption that a high population density puts pressure on available resources, so favouring social conflict and instability (see Collier (2007)). Indeed, in 2009 this holds for some low-medium income countries from South-America (Argentina, Brazil, Chile, Peru, and Uruguay) and Sub-Saharan Africa (Republic of Congo, Mali, Niger, and Zambia), belonging to the intermediate range of population density (between 0.01 and 0.025).[20] However, it remains to be explained how the increase in population density leads to a decrease in GRV at higher population density levels.

Figure 23 gives only partial support to the expected positive relationship between the EXPCONCTRADEPARTNER and GRV (in particular, in the range 0 - 0.2). At medium levels (approximately around 0.2), concentration of trade has a statistically significant and positive impact on GRV while, on the contrary, at low and high levels it does not appear to exert any significant effect.

The measure for the quality of institutions, CONSTRONEXECUTIVE, has the expected negative effect (see Acemoglu *et al.* (2003)), but its effect is statis-

[19] A value found for Gambia, Nicaragua and Rwanda.

[20] In this range we also find Finland, New Zealand, and Sweden, even though their population density strongly depends on geography.

tically significant only at low/medium levels (see Figure 24).

ETHNOLINGDIVERSITY has a negative and moderately significant (linear) impact like in Malik and Temple (2009), pp. 172 and 176, who, however, find a positive impact when this variable is interacted with a dummy for war.[21] This evidence contrasts also with the idea discussed in Alesina and Spolaore (2003) that more fractionalized societies are more subject to instability.

The fertility of soil has a statistically significant and increasing impact on volatility in the low/medium range, while it is not significant at higher levels (see Figure 25). This contrasts with Malik and Temple (2009), p. 176, who find that the fertility of soil has a negative effect on volatility. We conjecture that high fertility favours the increase in the share of output from agriculture which, as shown by Fiaschi and Lavezzi (2005), has an enhancing-volatility effect. The correlation between SOILSUITMEDIUM and the average value of the share of agriculture on GDP for the available observations in WDI 2011 is indeed positive, and equal to 0.37. As noticed, unfortunately, lack of data prevents us to use the agricultural share on GDP in the present analysis.

Finally, as expected, AVDISTANCECOSTLINERIVER has a positive effect on volatility, a result consistent with Malik and Temple (2009), who argue that distance from the sea coast or a river is associated to high concentration in terms of exported goods, which in turns exposes the country to volatility of terms of trade and therefore causes output volatility.[22]

Model III adds to Model II two measures of aggregate shocks calculated on the price of food and metals, minerals and ores: VOLFOODPRICE and VOLMETALPRICE respectively.[23] In the preferred specification both variables have a positive and statistically significant coefficient, capturing a large part of the explanation that in Model II was imputed to the intercept.

Finally, in order to evaluate the robustness of our estimates to time effects, and the explanatory power of VOLFOODPRICE and VOLMETALPRICE we estimate Model IV derived from Model III by removing the time dummies. ETHNOLINGDIVERSITY and VOLMETALPRICE are dropped in the preferred specification, but the estimates of the other regressors are unchanged.[24]

[21] Malik and Temple (2009) actually consider ethnic fractionalization. In this paper we use ethnolinguistic diversity because Hegre and Sambanis (2006) show that it is significantly related to the onset of civil wars.

[22] In the analysis we could utilize neither the export concentration index from UNCTAD, as noted, nor the terms of trade volatility index from WDI 2011, both used by Malik and Temple (2009), because this would imply a sharp reduction of the number of available observations.

[23] VOLFOODPRICE and VOLAGRIPRICE have a correlation coefficient equal to 0.91. Although, the price of agricultural products can have an effect on the volatility of countries with large agricultural sectors, VOLFOODPRICE produces a slightly better fit. Results, not reported here, show that also VOLAGRIPRICE has a positive and significant effect on volatility. VOLOILPRICE is neglected in the analysis, instead, because its inclusion did not lead to an improvement in the estimates.

[24] The figures of the estimates are available upon request.

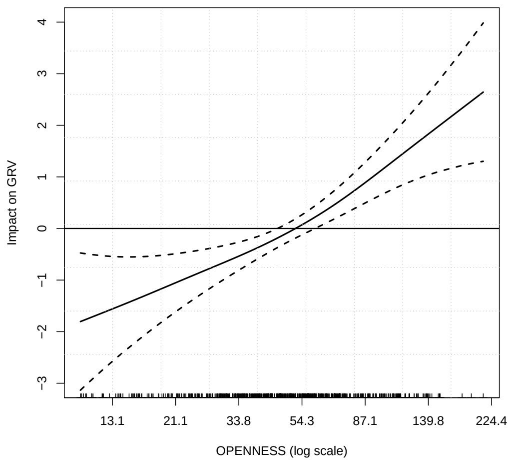

Figure 19: Estimated impact of OPENNESS on GRV in Models II and III. Period 1970:2009

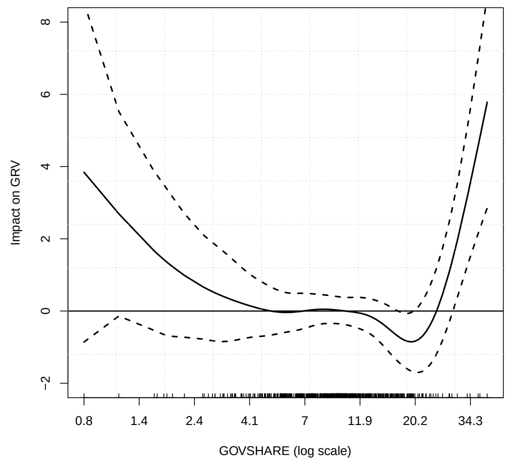

Figure 20: Estimated impact of GOVSHARE on GRV in Models II and III. Period 1970:2009

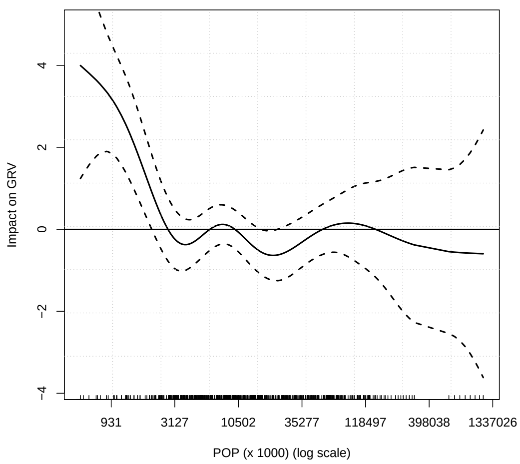

Figure 21: Estimated impact of POP on GRV in Models II and III. Period 1970:2009

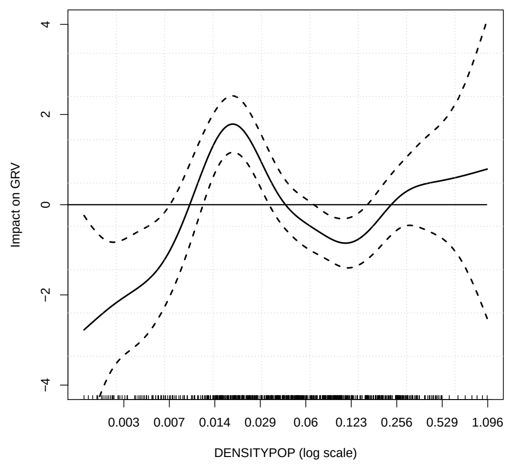

Figure 22: Estimated impact of DENSITYPOP on GRV in Models II and III. Period 1970:2009

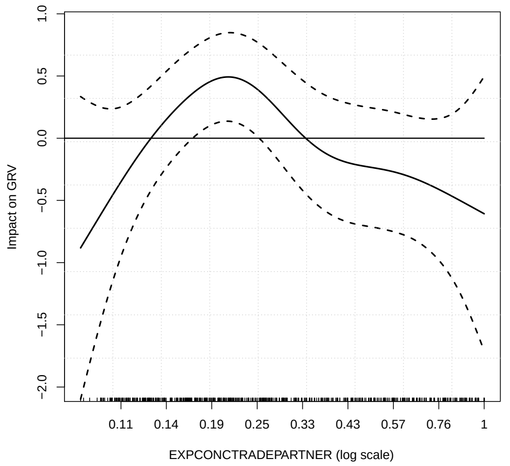

Figure 23: Estimated impact of EXPCONCTRADEPARTNER on GRV in Models II and III. Period 1970:2009

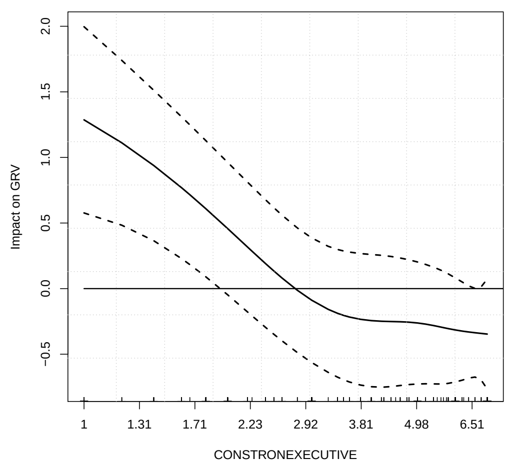

Figure 24: Estimated impact of CONSTRONEXECUTIVE on GRV in Models II and III. Period 1970:2009

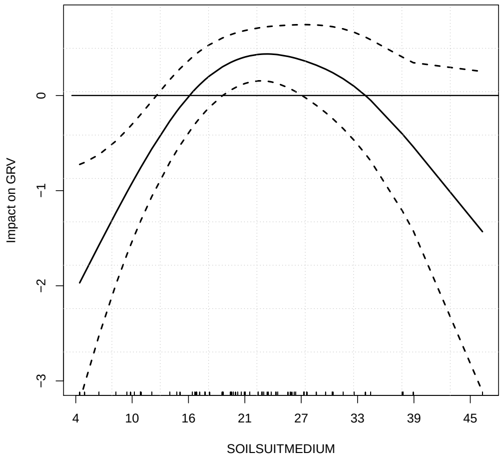

Figure 25: Estimated impact of SOILSUITMEDIUM on GRV in Models II and III. Period 1970:2009

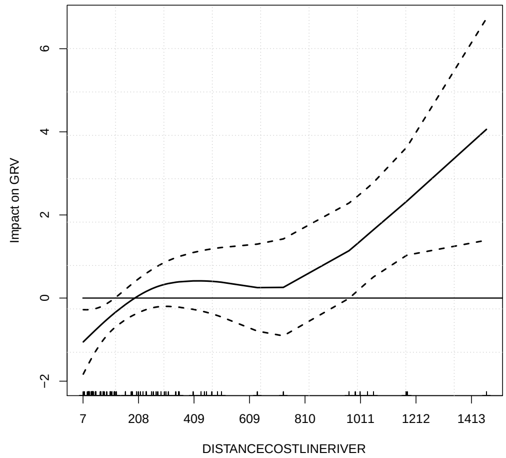

Figure 26: Estimated impact of AVDISTANCECOSTLINERIVER on GRV in Models II and III. Period 1970:2009

III.B.i. On the Stability of the Estimates

Figures 1 and 2 suggest that aggregate behaviour of GRV underwent relevant changes in time. For this reason we control for the robustness of the estimates by considering two twenty-year subperiods: 1970:1989 (Period I) and 1990:2009 (Period II). In Table 4 we report the results of the estimation of Model III in the whole period and in the two subperiods.[25]

The goodness of fit in Period II is remarkably higher with respect to both the entire period, and to Period I (the deviance explained is 61.5% against 41.8% and 42.2% respectively). Period I, as we showed, was characterized by higher turbulence and by phenomena of extreme volatility (see Figure 2).

TOTGDP, absent in the preferred specification for the whole period, has a positive, significant and linear impact in Period I. In Period II, instead, it has a statistically significant positive impact at low levels, negative in an intermediate range, and becomes nonsignificant afterwards (see Figure 33). This suggests the possible existence of an optimal size of the economy in terms of total GDP for the minimization of volatility.

OPENNESS has a positive effect in both periods, even though in Period II its significance is lower (see Table 4 and Figure 27). In addition, the magnitude of the effect is substantially lower in Period II: for example, increasing OPENNESS from 50 to 75 in Period I implies an increase in GRV of about 1 percentage point, while the same increase in Period II is associated to an increase of 0.32 percentage points only.

GOVSHARE is not present in the best specification in Period I, while in

[25]We choose Model III because it contains all the variables of interest. Comparison of the remaining models does not add significant differences to the results presented.

Model	**III**	**III**	**III**
Period	**1970:2009**	**1970:1989**	**1990:2009**
Time dummies	YES	YES	YES
Constant	1.4508 (0.000)	-0.6145 (0.8767)	1.0798 (0.5613)
log(TOTGDP)	-	[0.4945] (0.0520)	6.123 (0.0010)
log(OPENNESS)	1.894 (0.0000)	1.923 (0.0000)	[0.7860] (0.0746)
log(GOVSHARE)	6.600 (0.0035)	-	8.752 (0.0000)
log(CREDIT)	[-0.5770] (0.0085)	[-0.9803] (0.0034)	-
log(NATRESOURCESRENTS)	-	-	3.115 (0.0100)
log(POP)	7.191 (0.0005)	2.052 (0.1115)	-
log(DENSITYPOP)	7.090 (0.0000)	3.475 (0.0018)	8.007 (0.0000)
log(EXPCONCTRADEPARTNER)	3.405 (0.1035)	2.915 (0.0793)	[0.3848] (0.1134)
NETFDI	-	2.080 (0.0505)	4.601 (0.1709)
CONSTRONEXECUTIVE	2.602 (0.0043)	2.751 (0.0000)	-
ETHNOLINGDIVERSITY	[-0.0103] (0.0754)	-	-
SOILSUITMEDIUM	2.927 (0.0021)	-	2.864 (0.0030)
AVDISTANCECOSTLINERIVER	3.655 (0.0022)	-	[0.0023] (0.0011)
VOLMETALPRICE	[0.7393] (0.0006)	-	-
VOLFOODPRICE	[0.7793] (0.0000)	-	-
GCV score	7.8434	8.1799	5.3462
Deviance explained	41.8%	42.2%	61.5%
Number of obs.	552	276	276

Table 4: Estimation of Eq. (14). Dependent variable is GRV. EDF or estimated linear coefficients (reported in squared brackets) of the best specifications of Model III (p-values in parenthesis)

Period II it is highly statistically significant. Figure 34 shows that there exists an optimal size of Government consumption, which minimizes GRV, as in the analysis of the whole period; in particular, in the range 15-23 the magnitude of the negative effect on GRV appears sizeable (around -2 percentage points).

The stabilizing effect of CREDIT found for the whole period holds only for Period I. We conjecture that the absence of a significant effect in Period II may depend on a higher degree of "financialization" of the economy, which qualitatively changed what "the amount of credit" measures. In particular, anecdotal evidence hints at an increasing use of financial resources not for smoothing the effects of the business cycle, but for pure financial operations. A more detailed analysis of this aspect remains for future research.

In Period II NATRESOURCESRENTS has the expected positive impact on GRV, at least after a threshold, as shown in Figure 35. However, NATRESOURCESRENTS is not present in the preferred specification in Period I. It worth to remark that in Period II NATRESOURCESRENTS results highly correlated to the share of primary goods (ores and metals, agricultural raw materials, food and fuel) on total merchandise exports (the correlation coefficient is equal to 0.69), suggesting that a part of explanation of the positive impact could be attributed to the composition of exports (see also Malik and Temple (2009), p. 166).[26]

The estimated effect of POP in Period I resembles the one for the whole period, but its statistical significance is very low. POP is instead absent in the best specification of Period II where, however, the size of the economy is proxied by TOTGDP. The estimate of DENSITYPOP appears significant in both periods, with substantially the same shape (see Figures 29 and 36).

In Period I EXPCONCTRADEPARTNER has the expected positive relationship at low and medium levels of concentration; subsequently the effect becomes nonsignificant (see Figure 30). Differently, in Period II the estimated impact is positive and linear, albeit with poor statistical significance. The magnitude of the impact on GRV is lower in Period II in the range 0-0.25, where the relationship is significant (an increase from 0.11 to 0.25 of concentration in Period I implies a 1.5 percentage points increase in GRV, against a value of 0.32 points in Period II).

[26]The lack of data for the whole period prevented us from using the composition of exports in the analysis.

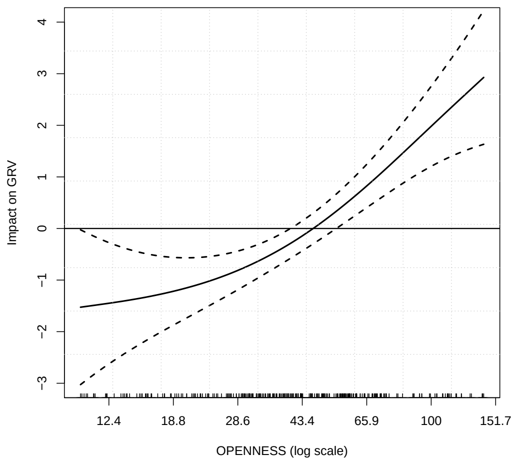

Figure 27: Estimated impact of OPENNESS on GRV in Model II. Period 1970:1989.

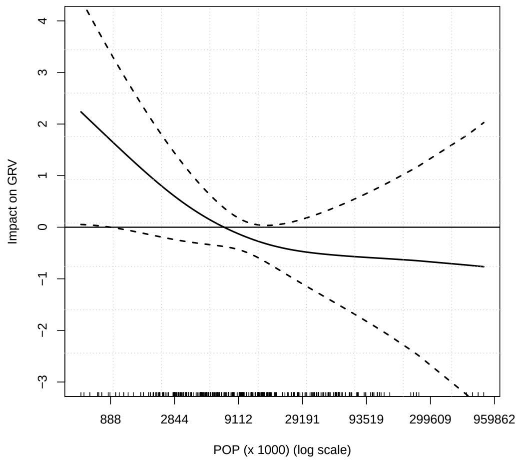

Figure 28: Estimated impact of POP on GRV in Model II. Period 1970:1989.

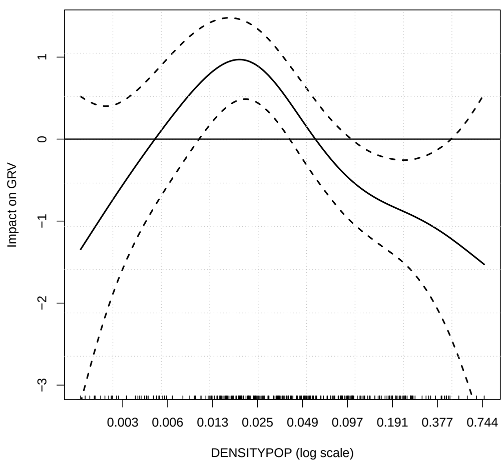

Figure 29: Estimated impact of DENSITYPOP on GRV in Model II. Period 1970:1989.

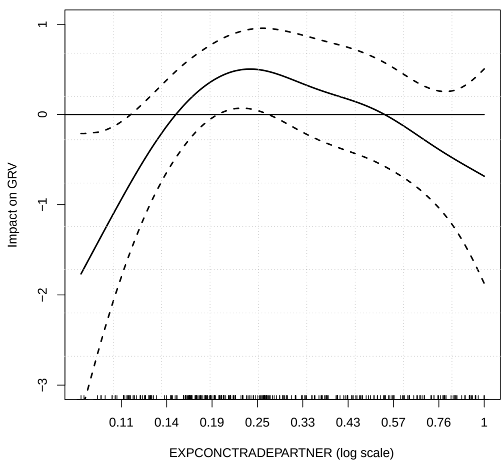

Figure 30: Estimated impact of EXPCONCTRADEPARTNER on GRV in Model II. Period 1970:1989.

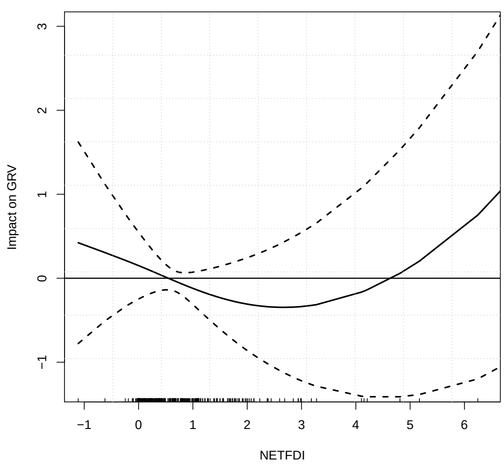

Figure 31: Estimated impact of NETFDI on GRV in Model II. Period 1970:1989.

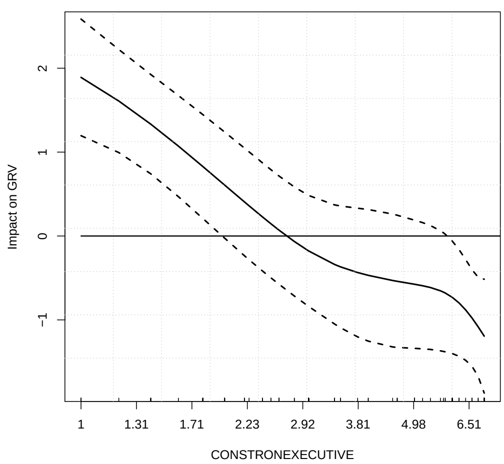

Figure 32: Estimated impact of CONSTRONEXECUTIVE on GRV in Model II. Period 1970:1989.

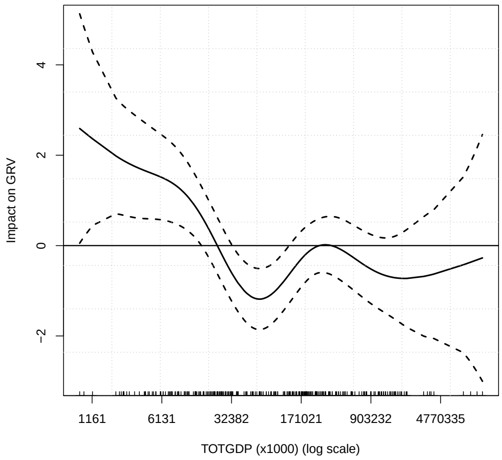

Figure 33: Estimated impact of TOTGDP on GRV in Model II. Period 1990:2008.

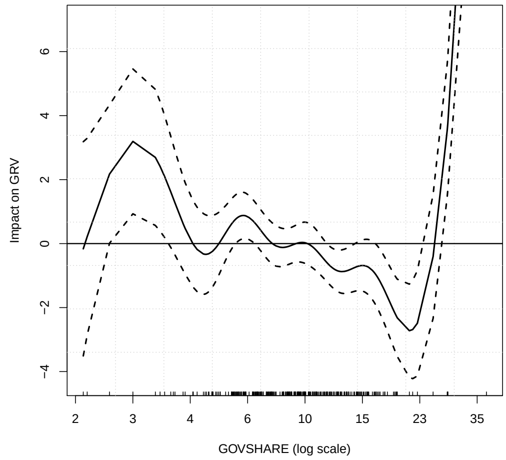

Figure 34: Estimated impact of GOVSHARE on GRV in Model II. Period 1990:2008.

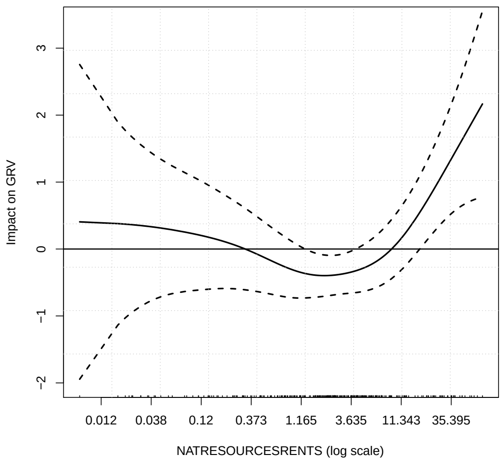

Figure 35: Estimated impact of NATRESOURCESRENTS on GRV in Model II. Period 1990:2008.

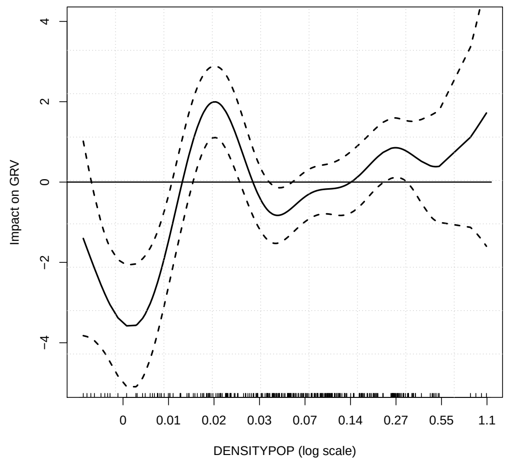

Figure 36: Estimated impact of DENSITYPOP on GRV in Model II. Period 1990:2008.

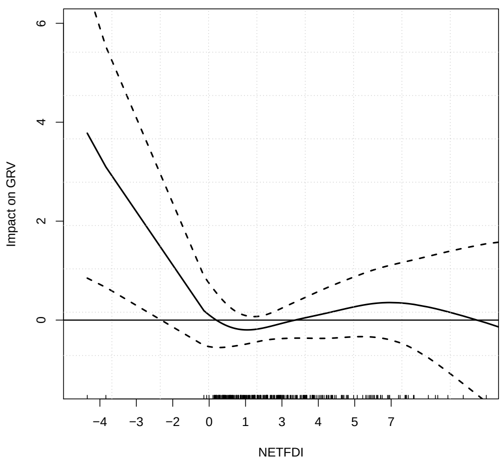

Figure 37: Estimated impact of NETFDI on GRV in Model II. Period 1990:2008.

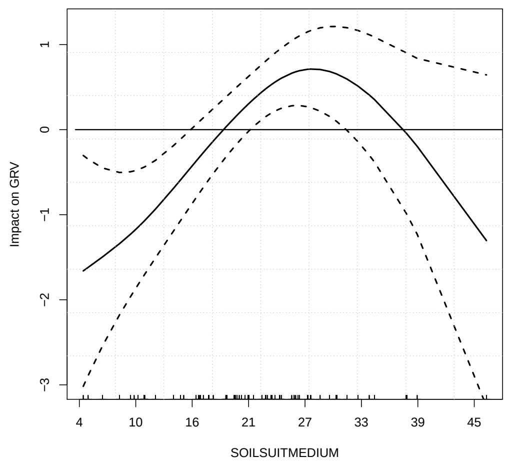

Figure 38: Estimated impact of SOILSUITMEDIUM on GRV in Model II. Period 1990:2008.

NETFDI is in the preferred specification in both Period I and Period II. However, even though the relationship is similar in the two periods (in particular, for the decreasing part at low levels, see Figures 31 and 37), the estimate is very imprecise, preventing us from drawing conclusions on the effect of this variable on GRV.

CONSTRONEXECUTIVE has a clear negative effect on GRV in Period I, while it is not in the preferred specification in Period II. ETHNOLINGDIVERSITY is not significant in the two subperiods; the effect of SOILSUITMEDIUM is negative at low levels and positive at medium levels, and then non statistically significant (see Figure 38), as in the estimate for the whole period; AVDISTANCECOSTLINERIVER has a positive, linear, and significant effect in Period II, but not in Period I.

Finally, the indicators of aggregate shocks, VOLMETALPRICE and VOLFOODPRICE are not statistically significant in the two superiods, pointing out that the explanatory power we found for the whole period was due to the difference in volatility between the two subperiods.

IV. Concluding Remarks

In this paper we have analysed the role of the structural characteristics of an economy in the explanation of growth volatility in the period 1970:2009. We first proposed a novel methodology to measure growth volatility, which allows to preserve the time-series and cross-country dimensions of the phenomenon, controlling for the stability of the estimates in two subperiods: 1970:1989 and 1990:2009.

These results provide insights on the onset of the "Great Moderation", in particular through the change in output composition and the development of the financial sector, and on its end, in particular through the increase in openness and the reduction of the size of the public sector. Therefore, we submit that the dominant policy orientations in the recent decades contained emphasis on potential sources of instability.

Two issues, finally, should be remarked. First, the comparison between the estimates of the two subperiods highlights how the effect on volatility of the integration of economy in the world markets has remarkably changed over time: besides the *amount* of trade, the *structure* of trade has gained importance, suggesting the need for a closer investigation of the latter aspect. Second, the amount of credit has a significant stabilizing effect in the first period, but not in the second. This finding indicates that, to fully evaluate the role of the financial sector, more specific measures are needed, reflecting not only the *quantity* of credit, but also the very different *quality* of the uses of the financial resources available in the economy.

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A List of Countries and selected *AR* order

Country code	Country Name	*AR* order selected by AIC_c
ARG	Argentina	1
AUS	Australia	0
AUT	Austria	0
BDI	Burundi	0
BEN	Benin	1
BFA	Burkina Faso	1
BGD	Bangladesh	0
BOL	Bolivia	0
BRA	Brazil	1
CAF	Central African Republic	0
CAN	Canada	1
CHL	Chile	1
CMR	Cameroon	3
COG	Congo, Rep.	1
COL	Colombia	0
CRI	Costa Rica	2
DNK	Denmark	0
DOM	Dominican Republic	0
ECU	Ecuador	1
EGY	Egypt, Arab Rep.	0
ESP	Spain	1
FIN	Finland	2
FRA	France	1
GAB	Gabon	1
GBR	United Kingdom	2
GHA	Ghana	3
GMB	Gambia, The	0
GRC	Greece	3
GTM	Guatemala	2
HND	Honduras	0
IND	India	0
IRL	Ireland	2
IRN	Iran, Islamic Rep.	1
ISR	Israel	2
ITA	Italy	1
JAM	Jamaica	1
JOR	Jordan	0
JPN	Japan	1
KEN	Kenya	0
KOR	Korea, Rep.	0
LKA	Sri Lanka	0

Country code	Country Name	AR order selected by AIC_c
MEX	Mexico	1
MLI	Mali	0
MYS	Malaysia	0
NER	Niger	0
NGA	Nigeria	1
NIC	Nicaragua	0
NLD	Netherlands	1
NPL	Nepal	1
NZL	New Zealand	0
PAK	Pakistan	0
PER	Peru	2
PHL	Philippines	0
PRT	Portugal	1
RWA	Rwanda	2
SEN	Senegal	0
SLV	El Salvador	1
SWE	Sweden	2
SYR	Syrian Arab Republic	1
TGO	Togo	1
THA	Thailand	1
TTO	Trinidad and Tobago	2
TUR	Turkey	0
UGA	Uganda	1
URY	Uruguay	2
USA	United States	1
VEN	Venezuela, RB	0
ZAF	South Africa	1
ZMB	Zambia	1

Table 5: List of Countries and selected AR order by AIC_c