Growth and volatility reconsidered: reconciling opposite views

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Abstract

Many contributions in the recent literature have investigated over the relationship between growth and its volatility, without getting a clear and unambiguous answer. Besides reassessing the well-known effect of output volatility on growth as benchmark analysis, this study aims at looking into the "black box" of the business cycle volatility by disentangling the impacts of volatility of GDP major components - i.e. private consumption, private investment and government expenditure - on growth, simultaneously considered. Our empirical analysis unveils a remarkably robust and strong negative correlation of consumption volatility with mean growth, and a positive one with volatility of investment and of public expenditure. If these findings shed some additional light on the (still controversial) relationship between economic fluctuations and growth, they also make it possible to compare the relative impact of each component, with possibly relevant policy implications. Importantly, this might reconcile opposite views about the issue, in that different empirical results might originate from the relative importance across empirical studies of the various components of volatility.

Keywords: growth and volatility, panel data estimation, GMM
JEL Classifications: C23, E32, N10, O40

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1 Introduction

Among the issues economists largely debated upon over the recent decades, the relationship between the volatility of business cycle and output growth deserves a particular attention. Nonetheless, for a long time, long-run growth and business cycle were conceived of as independent phenomena to be analyzed by means of separated tools. This view was strongly supported by Lucas (1987) who claimed that the trade-off between growth and business cycle fluctuations was pretty inexistent. Then, the Real Business Cycle (RBC) paradigm (Kydland and Prescott, 1982) pointed to the exogenous stochastic process driving the technological progress as the common root of both trend growth and cyclical fluctuations. However, it was only after that the endogenous technological progress hypothesis was introduced into the RBC framework (King and Rebelo, 1986; Stadler, 1990) that the idea of a causal relationship between the instability of the business cycle and growth gained theoretical support, thus prompting the subsequent empirical literature on volatility and growth. [1]

This paper is meant to contribute to that stream of literature which aimed at verifying both the existence of a statistically significant causal relationship between output volatility and growth and the sign of that relationship. Although no unambiguous evidence has been obtained on this topic - also due to differences across studies with respect to the computation of volatility, sample selections, and estimation methodologies - the largest consensus suggests that volatility is detrimental for growth. It is worth mentioning the seminal work by Ramey and Ramey (1995) which proved the existence of a negative robust relationship between output volatility and average growth whereby volatility was built as a measure of forecast uncertainty. However, despite their findings were subsequently confirmed by an extensive literature (see e.g. Martin and Rogers, 1997; Hnatkovska and Loayaza, 2005; Kose *et al.*, 2005; Imbs, 2007), other relevant empirical studies pointed at a positive impact of output variability on growth (Kormendi and Meguire, 1985; Grier and Tullock, 1989; Caporale and Mc Kiernan, 1996) and, in general an inconclusive evidence comes out of the theoretical debate.[2]

To our knowledge, most contributions to the previous literature have mainly aimed at empirically investigating the impact of the volatility of single macroeconomic variables on growth, as in the case of, for example, fiscal volatility (Afonso and Furceri, 2010; Fatàs and Mihov, 2011), investment share of GDP, real exchange rate volatility (Schnabl, 2008; Aghion *et al.,* 2009) or inflation (Judson and Orphanides, 1999; Al-Marhubi, 2000). Notwithstanding the relevance of the results attained so far, it is still quite difficult to make a comparison among the different kind of volatities in order to identify the one relatively most detrimental to growth. The only attempt to fill this gap is Furceri (2010), that comparatively evaluates the impact of the volatility of investment, government and exchange rate, simultaneously considered, onto long-term growth.

In a similar spirit, our purpose is to go beyond the traditional analysis of the relationship between business cycle volatility and growth, as we are confident that the impact of the former on the latter might

[1] See Aghion and Saint-Paul (1998) for a very interesting analysis of the theoretical evolution on this issue and Gaggl and Steindl (2007) for a literature review on growth and cycle.

[2] From the theoretical point of view the *neo-schumpeterian* view and the *arrovian* approach attain opposite conclusions on the issue. The former considers "*recessions as opportunities*" (Schumpeter, 1942) because the opportunity cost of efficiency-enhancing activities is lower than in normal times, thus prompting optimizing firms towards engaging in those activities. (See e.g. Davis and Haltiwanger, 1989; Bean, 1990; Caballero and Hammour, 1993; Aghion and Saint Paul,1998). Therefore, downturns drive positive effects not only on output growth, but also on productivity growth that turns out to be counter-cyclical. By contrast, according to the arrovian approach, as long as production is dominated by external learning (Arrow, 1962) or *learning-by-doing*, economic booms stimulate productivity enhancement whereas economic downturns negatively affect both the short-term and the long-term growth. As a consequence, productivity growth follows a procyclical path. (See e.g. Shleifer, 1986; Martin and Rogers, 1997; Blackburn and Pelloni, 2004).

depend on the channels through which it is transmitted. Hence, besides reassessing the well-known effect of output volatility on growth as benchmark analysis, this study aims at looking into the "black box" of the business cycle volatility by simultaneously verifying the statistical relevance of the volatility of some of the main components of GDP - private consumption (C), private investment (I) and government expenditure (G) - for growth[3] We believe that disentangling the impacts of GDP main components volatility on growth might not only unveil additional aspects of the (still controversial) relationship between economic fluctuations and growth, but also make it possible to compare the relative impact of each component, with possibly relevant policy implications.

Indeed, there exist several theoretical arguments which suggest how volatility in consumption, private investment and government expenditure can interact with growth. Concerning consumption and investment volatility, the literature on risk and optimal decisions predicts that *ceteris paribus* a higher degree of risk and volatility implies a higher economic growth rate, on average, because higher profitable investments are associated with more volatility, via a higher degree of technology specialization and a smaller degree of risks diversification (Black, 1987). However, as agents are assumed to be risk averse, the ultimate impact of risk on growth crucially depends on the degree of markets completeness: if they were complete, agents could hedge against risks and pursue higher rate-of-return investment plans; if markets were incomplete, this would not be possible and a trade-off would emerge between volatility and growth. Hence, risk averse agents would invest in both high and low expected return sectors in order to ensure a larger diversification of their risk, thereby reducing economic volatility but also economic growth. On the other hand, to the extent that risk aversion and insurance market incompleteness induce agents to increase precautionary savings leading to higher capital accumulation rates (Mirman, 1971), risk and volatility can be beneficial to growth. Concerning fiscal policy volatility, theory predicts ambivalent outcomes in terms of its impact on growth: if government expenditure comes in the form of automatic stabilizers[4] which offset the negative effects of business cycle shocks, one can clearly expects a beneficial effect of more volatility to investment and growth; by contrast, if a balance discipline must be respected and thus government expenditure tends to follow the business cycle, rather than constrasting it, volatility of fiscal policy risks to exacerbate the negative effect of adverse shocks to the economy.

A large number of econometric procedures has been implemented throughout the literature to evaluate the relationship between growth and volatility. Although a pure time-series approach was followed by, for example, Caporale and McKiernan (1996) and Grier and Perry (2000), several cross-country regressions (Ramey and Ramey, 1995; Lenskin *et al.,* 1999; Martin and Rogers, 2000) and panel data estimations (Hnatkovska and Loayaza, 2005; Kose *et al.*, 2005; Rafferty, 2005; Imbs, 2007; Edwards, 2007) have been performed to the same purpose. Here we resort to a panel data investigation but, unlike most recent panel data exercises, we do not average our variables over intervals of time. Indeed, computing volatility as the standard deviation of non-overlapping time spans leaves no choice but averaging the whole sample over the same time periods. We will rather follow a "rolling windows" approach to build our volatility measure, which yields time-varying variables, enabling us to preserve the original time dimension of our data set. In other words, GDP growth at time t will be regressed upon measures of volatility computed on the window t-s, t, where s is the width of the window. The underlying idea is that growth at time t is influenced by volatility (of the relevant macro variables) perceived over a window of s years (we will use a $s = 5$ year interval). This seems more natural than supposing that the average rate of growth of GDP, over a period of s years, is influenced by volatility computed over the same spell of time.

Our paper is organized as follows. Section 2 presents our dataset, some preliminary evidence emerging

[3] We skip net exports for reasons which will become clearer in the sequel.

[4] Among others, see Sachs and Sala-i-Martin (1991), Asdrubali *et al.* (1996), Afonso and Furceri (2010).

from the data and the methodology employed for the estimation. Section 3 describes our empirical results while some concluding remarks are drawn in section 4.

2 Data, Models and Methodology

We use data from Heston *et al.* (2010) and from the Barro-Lee data set (2010), both consisting of annual observations.[5] Our regression analysis focuses on a sample of 25 OECD countries and is performed over the time horizon 1978-2007.[6] However, for the sake of robustness, we also test our models considering a subgroup of the main sample which does not comprise those countries (namely, Iceland, Korea, Luxembourg and Mexico) characterized by an excessive degree of volatility in (at least) a couple of GDP components (see Table A in Data Appendix). Hence, our cross-country dimension is equal to $N = 25$ in the benchmark sample and $N = 21$ for the restricted sample, while our time dimension is equal to $T = 30$.

Before turning to the empirical models specification and discussing the econometric strategy, we present some evidence based on some basic preliminary analysis of our data. In what follows we focus on a subsample of 19 OECD countries[7] over the period 1978-2007 and present the simple cross-country correlation between average output growth rate and, respectively, the standard deviation of output, consumption, investment and government consumption growth rates. What Figures 1 - 3 - 5 - 7 clearly show is that growth positively correlates with the standard deviations of either GDP and GDP components. However, as simple correlation is likely to hide spurious linkages between variables, we also provide the (more robust) partial correlation measure in Figures 2 - 4 - 6 - 8, whose Y-axis display the residuals of a cross-country population weighted estimation in which average growth is regressed against the volatilities of all variables so far mentioned (i.e. GDP, C, I and G) except the one whose standard deviation is displayed on the X-axis. Partial correlation confirms the evidence of the positive linkage assessed by simple correlation only in the case of output and government consumption volatility. On the other hand, the sign of the relationship between consumption and investment volatilities to growth is reverted as a clear negative relationship emerges between their standard deviations and the correspondent regressions residuals. It should be noted, however, that partial correlations do not account for the effect of additional explanatory variables, which will be used in our regression analyses.

[5] An exception is the schooling variable, which is only available on five-years intervals in the World's Bank data release. We applied a polynomial interpolation method to those series in order to get annual observations to be employed in our model.

[6] Our main sample consists of 25 countries out of the whole OECD group of 34 countries. We retain those countries that joined the OECD before the 90's in order to preserve a certain degree of homogeneity in terms of technology, development and quality of data. For the same reason, we do not include Turkey, whose data quality is graded "C" in the Heston *et al.* (2010) data quality scale which range from A (best quality) to D (worst quality).

[7] Compared to our 21 countries restricted sample, we additionally get rid of Ireland and Switzerland which present outlier values in, respectively, the government and consumption volatility series.

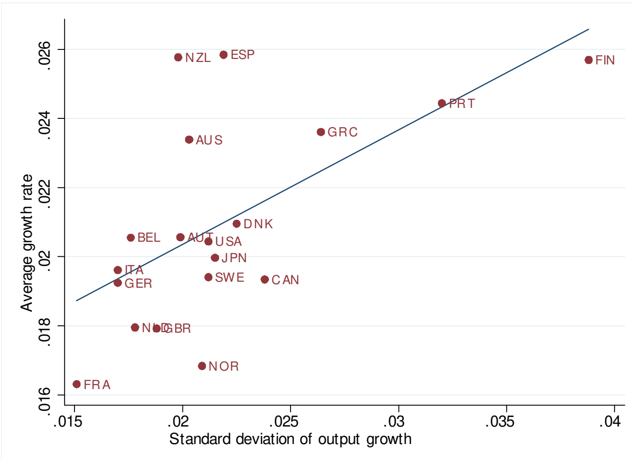

Fig.1 - Simple correlation of growth and output volatility

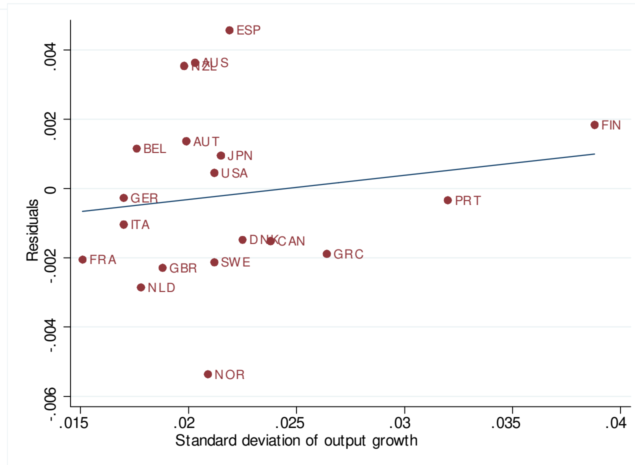

Fig.2 - Partial correlation of growth and output volatility. (Controlling for the volatility of C, G and I)

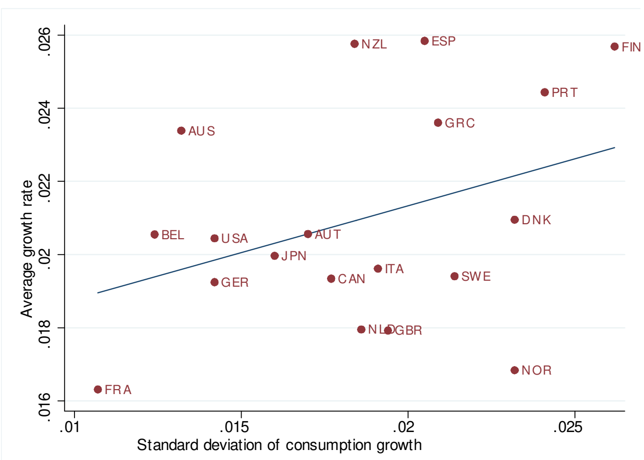

Fig.3 - Simple correlation of growth and consumption volatility

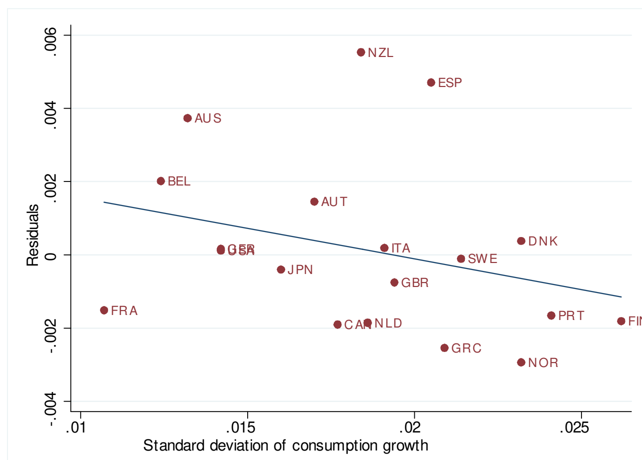

Fig. 4 - Partial correlation of growth and consumption volatility. (Controlling for the volatility of Y, I, and G)

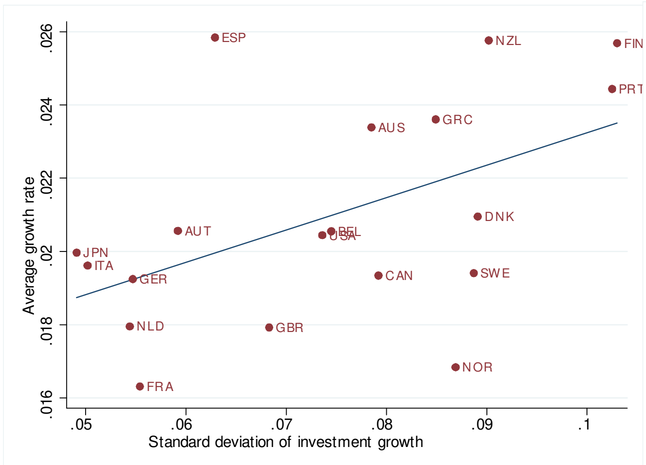

Fig. 5 - Simple correlation of growth and investment volatility

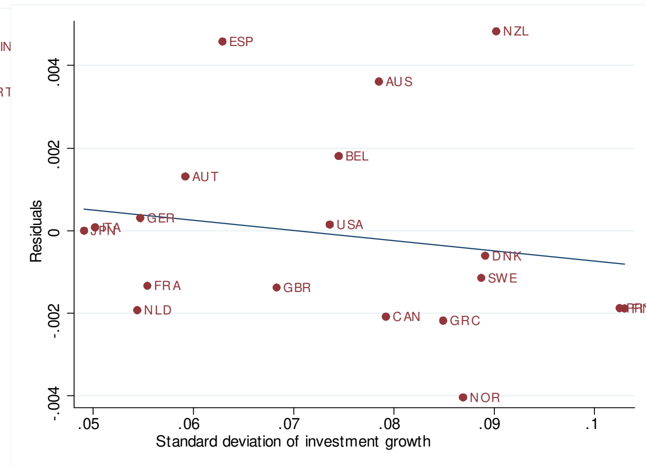

Fig. 6 - Partial correlation of growth and investment volatility. (Controlling for the volatility of C, G and I)

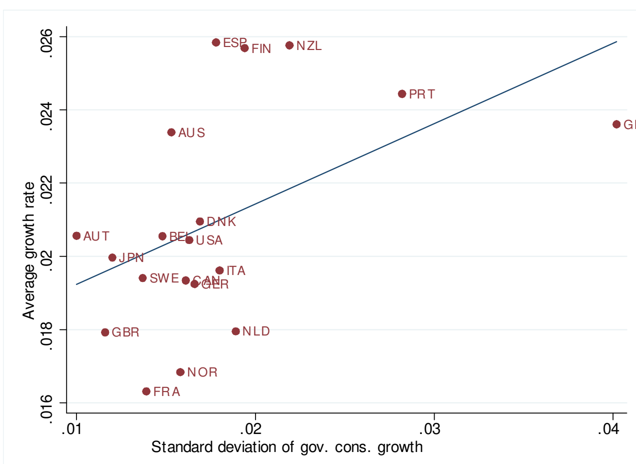

Fig. 7 - Simple correlation of growth and government consumption volatility

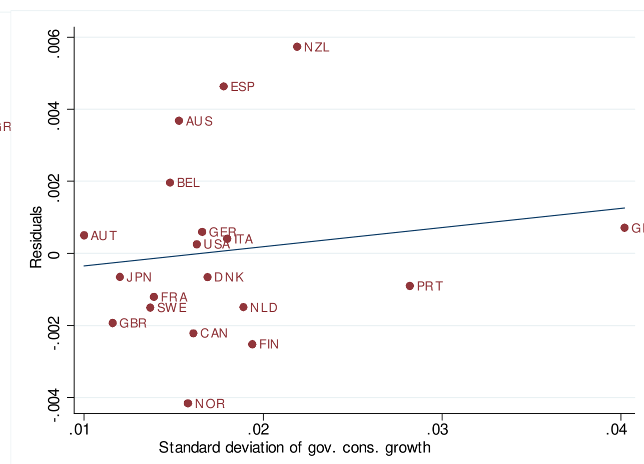

Fig. 8 - Partial correlation of growth and government consumption. (Controlled for volatility of Y, C and G).

2.1 Growth and volatility: a static regression analysis

We start estimating a benchmark model, in the spirit of Ramey and Ramey (1995), where we regress GDP growth against the volatility of output growth along with a set of conditioning variables now standard in the growth regression literature - documented by Levine and Renelt (1992) to be relevant in the context of growth cross-country regressions - and where country and time specific constants are also considered:

$$
\begin{aligned}
g_{it} &= \alpha_{i.} + \tau_{.t} + \beta\sigma^{y}_{it} + \theta' X_{it} + \varepsilon_{it} \\
\varepsilon_{it} &\sim N(0, \sigma^2_{\varepsilon}) \qquad\qquad i = 1, ..., N \quad t = 1, ..., T
\end{aligned}
\tag{1}
$$

where g_{it} is the annual growth rate of per capita GDP of country i at time t; $\alpha_{i.}$ and $\tau_{.t}$ represent, respectively, a country and a time specific fixed effect, σ^{y}_{it} is our measure of output growth volatility and the vector X_{it} includes a set of control variables, namely (i) the annual log-level of investment share of GDP, (ii) the log-level of GDP per capita on the first year of the rolling window over which the corresponding observation of volatility is computed (see below), (iii) a measure for the initial human capital given by the log-percentage of population aged over 25 years who attained a degree of secondary school and (iv) the annual growth rate of population.[8] Finally, ε_{it} is a standard error term.

The peculiarity of our model is that our measure of volatility is time-varying, whereas previous panel studies on volatility and growth, such as, for example, Kose *et al.* (2005) and Rafferty (2005) have measured volatility as the standard deviation over 5 / 10 yearly observations along with averaged observations over the same span for the rest of the variables, which implies a sharp shortening of the time dimension of their panel dataset. By contrast, our measure of volatility is computed as the standard deviation of a five-year rolling window of observations whose terminal year is contemporaneous to the dependent variable g_{it} (thus, 1974-1978 is the first rolling window, 2003-2007 is the last one). Our dependent variable, on the other hand, is not computed as a mean over a rolling window, but rather as a simple growth rate. This is relevant also in statistic terms, as our results should not be affected by serial correlation problems. The aim of this regression is to verify the existence of a causal relationship between the growth rate of GDP at time t and the volatility occurring over the previous interval, from $t-5$ to t.

The next step will be checking whether this global relationship is driven by some specific components, or whether all of them exert the same influence upon growth. To see this, we start from the fundamental accounting identity:

$$GDP_t = C_t + I_t + G_t + NX_t. \tag{2.1}$$

By dividing both members by GDP_{t-1} we get:

$$\frac{GDP_t}{GDP_{t-1}} = \frac{C_t}{GDP_{t-1}} + \frac{I_t}{GDP_{t-1}} + \frac{G_t}{GDP_{t-1}} + \frac{NX_t}{GDP_{t-1}}. \tag{2.2}$$

which can also be written as:

$$\frac{GDP_t}{GDP_{t-1}} = \frac{C_t}{C_{t-1}} s^{C}_{t-1} + \frac{I_t}{I_{t-1}} s^{I}_{t-1} + \frac{G_t}{G_{t-1}} s^{G}_{t-1} + \frac{NX_t}{NX_{t-1}} s^{NX}_{t-1}. \tag{2.3}$$

where $s^{C}_{t-1}, s^{I}_{t-1}, s^{G}_{t-1}, s^{NX}_{t-1}$ represent the GDP shares of consumption, investments, public expenditure and net exports, respectively. In what follows we will assume that those shares are approximately constant, for the (relatively short) spell of time over which volatilities are computed (the time subscript will thus be omitted). Under this assumption, elementary statistics yields:

[8] A detailed description of the series is provided in the Data Appendix.

$$Var(\frac{GDP_t}{GDP_{t-1}}) = (s^C)^2 Var(\frac{C_t}{C_{t-1}}) + (s^I)^2 Var(\frac{I_t}{I_{t-1}}) + (s^G)^2 Var(\frac{G_t}{G_{t-1}}) + (s^{NX})^2 Var(\frac{NX_t}{NX_{t-1}}) + \\ +2\left[s^C s^I Cov(\frac{C_t}{C_{t-1}}, \frac{I_t}{I_{t-1}}) + s^C s^G Cov(\frac{C_t}{C_{t-1}}, \frac{G_t}{G_{t-1}}) + s^C s^{NX} Cov(\frac{C_t}{C_{t-1}}, \frac{NX_t}{NX_{t-1}})\right] \\ +2\left[s^I s^G Cov(\frac{I_t}{I_{t-1}}, \frac{G_t}{G_{t-1}}) + s^I s^{NX} Cov(\frac{I_t}{I_{t-1}}, \frac{NX_t}{NX_{t-1}}) + s^G s^{NX} Cov(\frac{G_t}{G_{t-1}}, \frac{NX_t}{NX_{t-1}})\right] \tag{2.4}$$

Equation 2.4 shows that the variance of GDP growth can be decomposed into the sum of variances of its various components, multiplied by the square of the corresponding shares, plus the covariances between the components. In the following empirical analysis we are going to consider only the first three components of overall volatility as expressed by equation 2.4 - namely, the volatility of private consumption, investment and government consumption - as we decided to focus on the internal sources of volatility and as the variance of net exports is extremely large. In so doing, we are capturing a sizeable portion of the variance of GDP less net exports (around 70%, rising to about 100% if we also take covariances into account, which implies that the impact of the variability of shares is negligible). On the other hand, the share of the first three components of overall GDP volatility over the GDP comprehensive of the trade balance component is slightly larger than one (about 1.11 in some computations), mainly due to the effects of covariances of the three components with net exports.

Hence, estimation of Model 3 aims at detecting whether volatility of consumption, investment and government expenditure influence mean growth in the same direction, or rather some of them are detrimental and some beneficial to growth. In order to do that, we simply augment Model 1 by consumption (σ^c_{it}), investment (σ^i_{it}) and government expenditure (σ^g_{it}) volatility as separate control regressors, as in the following:

$$g_{it} = \alpha_{i.} + \tau_{.t} + \gamma\sigma^c_{it} + \delta\sigma^i_{it} + \epsilon\sigma^g_{it} + \theta^{'} X_{it} + \varepsilon_{it}. \tag{3}$$

Finally, our last empirical specification (Model 4) also includes a measure of overall volatility of GDP growth which will possibly capture the effects of net exports growth volatility, and of all interactions between the various components, and possibly a size effect:

$$g_{it} = \alpha_{i.} + \tau_{.t} + \beta\sigma^y_{it} + \gamma\sigma^c_{it} + \delta\sigma^i_{it} + \epsilon\sigma^g_{it} + \theta^{'} X_{it} + \varepsilon_{it} \tag{4}$$

Turning to the econometric methodology, as our sample of OECD countries more likely represents the universe of countries (at least in terms of economic relevance) than a random sample from a larger universe of countries, we opt for a fixed-effects model specification. Therefore, we assume that the fixed country-specific ($\alpha_{i.}$) and a fixed period-specific terms ($\tau_{.t}$), respectively for each country and period, are deterministic, and that ε_{it} is a standard random component.[9] We account for the presence of both country and time effects, respectively, by applying a "Within-group" transformation (subtracting the mean of each variable over time per country from itself) on all variables and by including time specific dummies. Then we perform a robust least square (LS) estimation, which represents our benchmark estimation.

[9] An appropriate Hausman test of the fixed effects model *vs.* random effects model was performed over all the model specifications, supporting our intuitive argument in favour of the former.

However, since growth equations are likely to be affected by reverse causality issues, we check for endogeneity of the regressors.[10] Test results show both the investment growth volatility and the investment share of GDP to be endogenous with respect to GDP growth, thus implying inconsistency of the LS estimates. The lack of independence between the distribution of the regressors and of the error term call for an Instrumental Variables (IV) approach. Concerning the choice of the instruments, we take advantage of the panel dimension of our data, by using the lagged values of the endogenous variables as predeterminates, with respect to contemporaneous growth. A second concern is that a plain Two-Step Least Square (2SLS) IV estimator, though providing consistent coefficient estimates, implies a loss of efficiency and the inconsistency of standard errors estimates in the presence of heteroskedasticity, which might possibly affect the testing procedures and results in our models.[11] The issue of inefficiency can be tackled by means of the Generalized Method of Moments (GMM), which allows for an efficient estimation in the presence of heteroskedasticity, by resorting to linear orthogonality conditions.[12] Our estimates of models (1), (3) and (4) are thus derived by a two-step efficient GMM estimator, where each variable found to be endogenous - namely, investment volatility and investment GDP share - is instrumented, respectively, by its second lag and its second and third lag. [13] Finally, it is worthwhile noticing that, besides being efficient, our estimation results are also both heteroskedasticity- and autocorrelation-consistent because of the Newey-West specification employed for the estimation of the long-run GMM covariance matrix.[14]

2.2 Growth and volatility: a dynamic panel approach

Even though current growth rates are not likely to affect our measures of volatility (which is computed over the preceding 5-annual observations window), our results might be biased to the extent that persistent innovations to growth affect future growth rates, as also argued e.g. in Fatàs and Mihov (2011). Therefore, we re-estimate our models (1), (3) and (4) including the lagged output growth rates as an additional regressor, as in a dynamic panel estimation framework:

$$g_{it} = \alpha_{i.} + \tau_{.t} + \rho g_{it-1} + \beta\sigma^y_{it} + \theta' X_{it} + \varepsilon_{it} \tag{5}$$

$$g_{it} = \alpha_{i.} + \tau_{.t} + \rho g_{it-1} + \beta\sigma^y_{it} + \gamma\sigma^c_{it} + \delta\sigma^i_{it} + \epsilon\sigma^g_{it} + \theta' X_{it} + \varepsilon_{it} \tag{6}$$

$$g_{it} = \alpha_{i.} + \tau_{.t} + \rho g_{it-1} + \gamma\sigma^c_{it} + \delta\sigma^i_{it} + \epsilon\sigma^g_{it} + \theta' X_{it} + \varepsilon_{it} \tag{7}$$

where all the previous notation holds.

[10] The endogeneity test performed is defined as the difference of two Sargan-Hansen statistics: one for the equation with the smaller set of instruments (where the suspect regressor(s) are treated as endogenous) and one for the equation (with the larger set of instruments) where the suspect regressors are treated as exogenous. See Baum *et al.* (2007).

[11] Both the Pagan-Hall and the Breusch-Pagan statistics indicate that the null hypothesis of homoskedasticity is rejected at the 1% level.

[12] Baum *et al.* (2007) provides a useful guide to IV and GMM estimation and their implementation in Stata.

[13] These regressions are performed using the *xtivreg2* program in Stata (Schaffer, 2005). The validity of the instruments employed is tested by means of the Wald F-statistics based on the Kleibergen-Paap *rk* statistics which is robust in presence of heteroskedasticity. It excludes the hypothesis of weak instruments in both cases as it exceeds the rule of thumb, suggested by Staiger and Stock that the F statistic must be larger than 10). As for the exogeneity of the instruments, in both cases we rely on the Hansen-J statistics which strongly accept the exogeneity hypothesis of the instruments in both cases. See Baum *et al.* (2007) for a detailed explanation of test implementation in Stata and for references.

[14] The Newey-West approach is based on the Bartlett kernel function (which enters the formula of the feasible long-run covariance matrix of moment condition) whose *bandwidth* is chosen according to the common criterion which sets it equal to $T^{1/3}$ where T is the panel time dimension. See Baum *et al.* (2007) and the references therein.

However, estimating dynamic panel models with unobservable country fixed effects is not a straightforward task. Besides the well known "dynamic panel bias" that would arise if a naive Ordinary Least Square (OLS) aproach was applied to a dynamic fixed-effects model - whereby the lagged dependent variable would turn out to be endogenous to the fixed effects in the error term - usual strategies employed to treat and estimate fixed-effects models, like the Least Square Dummy Variable (LSDV) or the "Within-group transformation" estimators, are also well known to yield biased estimated coefficients. Anyway, the magnitude of such a bias was found to be inversely correlated with the time dimension of panel, i.e. it approaches zero as T approaches infinity (Nickell, 1981), which implies that those estimators perform well only when the time dimension of the panel is large enough - which is the case for most macro-panel data.[15] Judson and Owen (1999) compare the performance of alternative estimators in the context of a dynamic fixed-effects model for narrow (small N) and long (large T) panels typical of macro data.[16] Among their findings, they also stress that (i) the difference in the efficiency of those estimators become quite small, for "large enough" N and T and that (ii) when the outperforming LSDVC estimator (Kiviet, 1995) technique cannot be implemented[17] and $T = 30$, the LSDV represents a more than satisfactory alternative to the Anderson-Hsiao (1981) and Arellano-Bond (1991) GMM difference strategies, because the magnitude of the bias is relatively small.[18] Hence, we rely on this evidence and resort to the LSDV approach to estimate our dynamic models (5), (6) and (7). Moreover, in order to confer robustness to our LSDV estimates results, we repeat the estimation employing a restricted one-step "GMM system" (Arellano and Bover, 1995; Blundell and Bond, 1998) estimator as other studies do, like e.g. Edwards (2007). The GMM system estimator belongs to the group of consistent estimators for dynamic panel fixed-effects models that have been proposed in the literature in order to tackle the inconsistency of LSDV in that context.[19] Besides, the GMM system is particularly suitable to the extent that data used in the model suffer from some degree of persistence - whereby lagged level of persistent variables would only be weak instruments for the stationary first-differenced term, as it would be the case with the GMM difference estimator. However, when the time dimension of the panel is large, an evident drawback of (both difference and system) GMM approach is that it implies the proliferation of the number of instruments, which tends to explode in T. Using too many instruments can overfit the endogenous variables and bias the coefficient estimates, which is among the reasons both difference and system GMM are recommended for short (small T) and large (large N) panels, as argued in Roodman (2006; 2007). Our strategy aims at limiting instrument proliferation, thus preserving their reliability and improving the performance of Sargan tests for joint validity of those instruments, both by limiting the number of lags used as instruments in the

[15] Over the last two decades an extensive literature has dealt with this issue especially in the context of microeconometrics - that usually deals with wide (large N) and short (small T) panel dataset - providing a number of alternative suitable econometric strategies..

[16] They run a Monte-Carlo approach experiment in the spirit of Kiviet (1995) in order to compare the efficiency of the LSDV estimator, the LSDV corrected (LSDVC) estimator by Kiviet (1995), the Anderson-Hsiao (1981) IV difference estimator and the Arellano-Bond (1991) GMM difference estimator, according to different dataset dimensions and degrees of persistence of the lagged dependent variable.

[17] Bruno (2005) provides a STATA routine able to implement a LSDVC estimator which, however, is not viable in presence of endogenous regressors other than the lagged dependent variable, which unfortunately is our case.

[18] Harrys and Matyas (2004) show that when N is small enough, the LSDV estimator performs just as well as the Arellano-Bond (1991) GMM difference estimator.

[19] These techniques share the common features of expunging fixed effects by first-differencing the data and of relying upon internal instrumentation of the lagged dependent variable that, once first-differenced, turns out to be correlated with the first-differenced error term. Anderson and Hsiao (1981) exploit a simple 2SLS - IV approach using the second lags of the dependent variable (either in difference or in levels) as instruments; Arellano and Bond (1991) resort to a GMM approach to derive a larger number (T-1) of internal instruments (in levels) to instrument the endogenous lagged differenced term, which gains efficiency with respect to Anderson and Hsiao approach.

GMM system regressions and by resorting to a "collapsed" form of the instrumenting matrix (Roodman, 2006).

3 Results

Tables 1-4 contain the results of our main regressions' estimates. In particular, Tables 1-2 contain results relative to the whole panel, whereas Tables 3-4 contain results relative to a "restricted" sample of countries. In fact, from the descriptive statistics of our sample (see Table A1 in Data Appendix) the presence of some extreme outlier countries - such as Iceland, Luxembourg, Korea and Mexico - can be easily detected. In order to verify the robustness of our benchmark results, we exclude these countries from our OECD sample, thus resorting to a restricted sample over which we test again our empirical models. Results of the static and dynamic models estimations are displayed, respectively, in Tables 1 and 3, and Tables 2 and 4. Hansen-J and Sargan tests output for the exogeneity of the instruments employed in either 2SLS and GMM estimations is always provided when IV regressions results are presented, while the Arellano-Bond (Arellano and Bond, 1991) tests for autocorrelation in the error structure are reasonably provided only when GMM system estimations output is presented. It is worth noticing that the null hypothesis for all these tests should be accepted for valid estimations, which is always the case in our regressions.

First of all, we can see from our tables that the Ramey and Ramey type of result is confirmed both in our static and dynamic models, on the complete sample and on the restricted sample, although the (negative) coefficient of volatility is sometimes not statistically significant. In particular, it is worth stressing that regardless of the sample chosen, GDP volatility coefficient always turns out to be significantly negative in the context of the static IV regressions i.e. once we properly account for endogeneity which is found to affect investment volatility and the investment share of GDP. We infer from this that disregarding endogeneity would imply a substantially downward biased significance of coefficient estimates. On the other hand, volatility of GDP always fails to be statistically significant within the dynamic regression context regardless of the estimation strategy employed. Then, we also observe that when volatility of GDP is included in addition to volatility of consumption, investments and public expenditure, it is never statistically significant at standard significance level, although the sign of its coefficient is always negative.

In terms of the positive or negative impact on mean growth of the various components of volatility, the most striking and seemingly very robust result is the negative and almost always statistically significant coefficient attached to the volatility of consumption. As we argued in the introduction, this might be taken to mean that what is really harmful to economic growth is market incompleteness, revealed by the fact that volatility of production and income cannot be dampened by real or financial markets, and spill over to consumption. Moreover, volatility in consumption directly affects agents and make them more vulnerable and less prone to accept additional risks, which might endanger their willingness to engage in more risky, and on average more profitable investment opportunities.

On the same ground, the result concerning the impact of public expenditure volatility on mean growth is also quite remarkable. The sign of the coefficient is positive and almost always statistically significant across model specifications, estimations strategies and samples, suggesting in a fairly robust way that volatility in public expenditure is not harmful, but rather beneficial for growth. This lends some support to the view that public expenditures becomes more volatile when it is used to dampen economic fluctuations, originating from both idiosyncratic and aggregate shocks.

On the other hand, the results concerning volatility in the investment component of GDP growth are less clear cut, at least in terms of statistical significance of the estimated coefficients. If in the case of the benchmark sample the investment volatility coefficients become statistically significant only once we control for endogeneity in the context of the IV regressions and are not statistically significant in the non-IV case, the opposite occurs in the case of the restricted sample (cfr. Tables 1 and 3). Hence, we argue that unobserved characteristics imply a downard bias of the ceofficient's significance in the former case whereas a spurious relationship - that we eliminate by resorting to the IV strategy - occurs in the latter. However, across most model specifications, except for the dynamic model estimated on the restricted sample, volatility of investments exerts a positive impact on mean growth. If we recall that volatility of investment *demand* is what we are really talking about, then more volatility can be interpreted as a larger sensitivity of investments to aggregate economic fluctuations, which is a necessary condition for the efficient working of such mechanisms as the ones advocated by neo-Schumpeterians' opportunity cost argument (see e.g. Aghion and Saint-Paul, 1998; Saint-Paul, 1993; Davis and Haltiwanger, 1989; and Caballero and Hammour, 1993).

Finally, the sign of the other regressors, which we added as control variables following Levine and Renelt (1992), meet our prior expectations though with some exceptions that will be duly stressed in the following paragraph. First of all, as expected, dynamic models estimations show that lagged GDP growth is always strongly and significantly correlated to current growth. Then, the negative and statistical significant estimated coefficient of the intial level of GDP can be interpreted as a proof of the beta-convergence hypothesis. Moreover, as all our models specifications are endowed with structural variables and country-specific fixed effects, we can interpret that result as verifying the conditional beta-convergnece hypothesis.

According to our results, a higher level of education foster more growth, though the estimated coefficient never achieves standard statistical significance. However, it is likely that the slow-moving behavior of this variable is absorbed by the country fixed effects which are always included in the regressions presented, as they capture any unobservable slow-moving country characteristic by construction. Carrying out OLS regressions which do not account for country specific effects (whose results are available upon request) provides positive and significant coefficients estimates for education in almost all models specifications and for both samples.

As for the estimates of the impact of population growth rates on GDP growth, results are quite non-robust across estimation strategies, models and samples employed. In fact, the expected negative sign of the estimated coefficient is verified only by static non IV regressions, showing statistical significance only when the complete sample is considered. Turning to dynamic models estimations, population growth coefficient reverts to positive sign but never appears statistically significant at standard levels.

Eventually, another unexpected result comes from the estimated coefficient of investment share of GDP in the context of the IV static and dynamic regressions, as it appears to be significatively negative. By contrast, the expected positive and statistically significant sign is only provided by the non-IV estimates. However, as this variable is verified to be endogenous across all models specifications and samples, we tend to rely on the (counterintuitive) results provided by the instrumented estimates, possibly generated by a convergence-like mechanism.

Insert Tables (1-4) here

3.1 Population weighted regressions

The results so far are obtained from models that assign all countries equal weights, regardless of their relative size. In other words, results are equally influenced by, e.g., the U.S. and Sweden notwithstanding the substantial differences in their population size. Therefore, as additional robustness check, we run a set of population-weighted regressions for both the static and the dynamic models and for both the complete and the restricted samples. The estimations strategies do not differ from those employed in our benchmark not-weighted regressions. However, since the GMM approach is not allowed when weights are employed, we resort to the 2SLS-IV method when we need to run instrumented variables regressions in order to account for endogeneity. This experiment is intended to verify whether the evidence provided by our main regressions is driven by small countries and the corresponding results are presented in Tables 5-8. Broadly speaking, we see that the impact of overall GDP volatility on growth is more ambiguous, and seems to crucially depend on the sample: significantly negative for the overall sample, while being significantly positive for the restricted sample. Moreover, unlike in the unweighted regressions, the impact of overall GDP volatility when the three distinct sources of volatility are included often plays a statistically significant role, with a positive sign. It is maybe useful to remember the interpretation of this coefficient, which should capture the impact of volatility in net trades and, though probably to a lesser extent, the impact of covariances among the various components of volatility. Investment volatility is still linked to more growth, except in the case of the dynamic estimation on a restricted sample. On the other hand, the volatility in public expenditure ceases to be significant for all model specifications and all samples. Once again, the most robust and clear cut relationship remains the negative one between consumption volatility and mean growth.

Insert Tables (5-8) here

4 Concluding remarks

This paper tries to complement the existing empirical literature on volatility and growth by decomposing volatility of GDP and using some of the components (Consumption, Investment and Public Expenditure) in standard growth equations *à la* Ramey and Ramey (1995), estimated by a variety of econometric methods, to assess the robustness of the results. The underlying idea is that key to understanding the reasons why GDP volatility should influence mean growth in either way is an assessment of the drivers of such a volatility (in other words whether it is consumption, investment or public expenditure that makes GDP unstable should really make a difference).

We suggest that attaching a positive or negative sign to the impact of the various components of GDP volatility could also help solving the apparent lack of unanimity affecting the results presented in the recent empirical literature, whose contributions make clear that different estimation techniques and, above all, different samples, may yield different results.

Among the various components of overall GDP growth volatility we focus on consumption, investments and public expenditure volatility, leaving out volatility in net trades and the covariances between all of these variables. The most striking result we obtain is a remarkably robust and strong negative relationship between consumption volatility and mean growth. This we interpret as evidence that lack of market completeness discourage riskier and more profitable investmemnts and depress consumption, by fostering more precautionary savings. On the other hand, once we control for this particular factor, investment volatility is often positively associated to mean growth, as well as volatility in government expenditures. It is worth recalling that our measures of volatility relate to the demand side of the economy. It would also be interesting, as a future extension of this work, to relate mean growth to other measures of volatility, computed from variables related to the supply side of an economy, such as the volatility in the returns of labour and capital, and productivity.

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Tables

Table 1 - Dependent variable: growth rate of per capita GDP. Regressors: volatility of GDP growth, consumption growth, investment growth, government consumption growth and control variables. Sample: OECD countries (25 countries). Horizon: 1978-2007. Annual observations. All regressions include year dummies.

Static models estimations						
ESTIMATION	FE	FE	FE	FE-IV GMM	FE-IV GMM	FE-IV GMM
GDP volatility	-0.127		0.177	-0.417*		-0.981
	(-0.88)		(0.69)	(-1.93)		(-1.62)
Consumption volatility		-0.549***	-0.613***		-0.907**	-0.525***
		(-3.28)	(-3.46)		(-3.06)	(-2.50)
Investment volatility		0.049	0.012		0.154	0.334*
		(1.18)	(0.21)		(1.56)	(1.77)
Government consumption volatility		0.460***	0.443***		0.323*	0.442***
		(3.83)	(3.72)		(1.86)	(2.71)
Education	0.003	0.003	0.003	0.005	0.002	0.003
	(0.58)	(0.66)	(0.50)	(0.60)	(0.31)	(0.51)
Population Growth	-0.736*	-0.823**	-0.863**	0.501	0.340	0.542
	(-1.72)	(-2.04)	(-2.21)	(0.89)	(0.67)	(1.00)
Initial GDP	-0.050***	-0.032**	-0.031**	-0.066***	-0.035**	-0.041**
	(-3.52)	(-2.23)	(-2.20)	(-4.15)	(-2.11)	(-2.58)
Investment share of GDP	0.084***	0.083***	0.084***	-0.106***	-0.084***	-0.082***
	(6.73)	(7.19)	(7.26)	(-3.28)	(-3.22)	(-3.25)
Observations	750	750	750	675	675	675
Instruments	no	no	no	yes	yes	yes
Hansen J statistic (p-value)				0.321	0.76	0.87
Kleibergen-Paap Wald F statistic				69.231	41.711	27.638

Note: T-statistics in parenthesis, robust SEs. * indicates singificance at 10%, ** indicates significance at 5%, *** indicates singificance at 1%.

Table 2 - Dependent variable: growth rate of per capita GDP. Regressors: lagged growth rate of per capita GDP, volatility of GDP growth, consumption growth, investment growth, government consumption growth and control variables. Sample: OECD countries (25 countries). Horizon: 1978-2007. All regressions include year dummies.

Dynamic models estimations						
ESTIMATION	LSDV IV 2sls	LSDV IV 2sls	LSDV IV 2sls	GMM-SYS	GMM-SYS	GMM-SYS
GDP volatility	-0.248		-0.931	-0.053		-0.392
	(-1.59)		(-1.43)	(-0.29)		(-0.56)
Consumption volatility		-0.769***	-0.396**		-0.470**	-0.304
		(-2.83)	(-2.16)		(-2.11)	(-1.26)
Investment volatility		0.169*	0.341*		0.13	0.195
		(1.78)	(1.66)		(1.66)	(0.92)
Government consumption volatility		0.252*	0.372***		0.330*	0.360**
		(1.85)	(2.70)		(2.05)	(2.12)
GDP growth (t-1)	0.365***	0.309***	0.299***	0.375***	0.340***	0.345***
	(4.95)	(4.33)	(4.02)	(4.44)	(4.24)	(4.33)
Education	0.004	0.003	0.004	0.007	0.008	0.009
	(0.66)	(0.48)	(0.68)	(0.66)	(0.83)	(0.77)
Population Growth	0.100	-0.024	0.16	-0.440	-0.534	-0.522
	(0.22)	(-0.06)	(0.33)	(-0.92)	(-1.08)	(-0.98)
Initial GDP	-0.048***	-0.021	-0.028**	-0.015	-0.013	-0.015
	(-3.90)	(-1.64)	(-2.12)	(-0.77)	(-0.68)	(-0.65)
Investment share of GDP	-0.085***	-0.064**	-0.060***	-0.075**	-0.068**	-0.075**
	(-3.49)	(-3.14)	(-3.00)	(-2.37)	(-2.17)	(-2.24)
Observations	675	675	675	725	725	725
Country dummies	Yes	Yes	Yes	No	No	No
Instruments	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F statistic	140.47	56.569	23.352			
Hansen J /Sargan test (p-value)	0.715	0.738	0.654	0.243	0.592	0.558
Arellano Bond test (AR2)				0.837	0.707	0.752

Note: T-statistics in parenthesis, robust SEs. * indicates singificance at 10%, ** indicates significance at 5%, *** indicates singificance at 1%.

Table 3 - Dependent variable: growth rate of per capita GDP. Regressors: volatility of GDP growth, consumption growth, investment growth, government consumption growth and control variables. Sample: OECD countries (21 countries). Horizon: 1978-2007. Annual observations. All regressions include year dummies.

Static models estimations - Restricted sample						
ESTIMATION	FE	FE	FE	FE-IV GMM	FE-IV GMM	FE-IV GMM
GDP volatility	-0.806		0.038	-0.583**		-0.214
	(-0.41)		(0.15)	(-2.24)		(-0.66)
Consumption volatility		-0.941***	-0.953***		-0.881***	-0.816***
		(-4.63)	(-4.56)		(-4.07)	(-3.48)
Investment volatility		0.105**	0.096*		-0.025	0.016
		(2.37)	(1.74)		(-0.41)	(0.22)
Government consumption volatility		0.293***	0.291***		0.268*	0.285*
		(2.68)	(2.65)		(1.65)	(1.75)
Education	0.005	0.005	0.005	0.006	0.004	0.005
	(1.27)	(1.23)	(1.24)	(0.69)	(0.58)	(0.62)
Population Growth	-0.497	-0.331	-0.335	0.761	0.922	0.920
	(-1.14)	(-0.86)	(-0.87)	(1.14)	(1.49)	(1.50)
Initial GDP	-0.066***	-0.054***	-0.054***	-0.077***	-0.065***	-0.065***
	(-3.32)	(-2.85)	(-2.84)	(-3.51)	(-3.18)	(-3.22)
Investment share of GDP	0.056***	0.062***	0.062***	-0.089***	-0.080***	-0.079***
	(4.79)	(5.82)	(5.82)	(-3.95)	(-3.00)	(-2.99)
Observations	630	630	630	567	567	567
Instruments	no	no	no	yes	yes	yes
Hansen J statistic (p-value)				0.118	0.234	0.258
Kleibergen-Paap Wald F statistic				90.809	89.438	90.061

Note: T-statistics in parenthesis, robust SEs. * indicates singificance at 10%, ** indicates singificance at 5%, *** indicates singificance at 1%.

Table 4 - Dependent variable: growth rate of per capita GDP. Regressors: lagged growth rate of per capita GDP, volatility of GDP growth, consumption growth, investment growth, government consumption growth and control variables. Sample: OECD countries (21 countries). Horizon: 1978-2007. Annual observations. All regressions include year dummies.

Dynamic models estimations - Restricted sample

ESTIMATION	LSDV IV 2sls	LSDV IV 2sls	LSDV IV 2sls	SYS-GMM	SYS-GMM	SYS-GMM
GDP volatility	-0.339**		-0.089	-0.135		0.700
	(-1.99)		(-0.40)	(-0.63)		(1.54)
Consumption volatility		-0.586***	-0.560***		-0.386**	-0.562**
		(-3.65)	(-3.14)		(-2.17)	(-2.15)
Investment volatility		-0.020	-0.001		-0.059	-0.222*
		(-0.43)	(-0.02)		(-1.01)	(-1.79)
Government consumption volatility		0.235**	0.242**		0.291*	0.289*
		(2.04)	(2.06)		(1.79)	(1.72)
GDP growth (t-1)	0.478***	0.430***	0.428***	0.473***	0.432***	0.451***
	(7.30)	(6.92)	(6.89)	(4.14)	(3.58)	(3.53)
Education	0.004	0.004	0.004	-0.004	-0.001	-0.001
	(0.70)	(0.72)	(0.73)	(-0.32)	(-0.02)	(-0.13)
Population Growth	0.220	0.267	0.268	0.111	-0.112	-0.007
	(0.50)	(0.63)	(0.63)	(0.16)	(-0.22)	(-0.01)
Initial GDP	-0.036**	-0.032**	-0.034**	-0.012	-0.012	-0.012
	(-2.23)	(-2.23)	(-2.24)	(-0.56)	(-0.74)	(-0.62)
Investment share of GDP	-0.072***	-0.063***	-0.062***	-0.135**	-0.094*	-0.117***
	(-3.72)	(-3.40)	(-3.40)	(-2.47)	(-1.69)	(-2.66)
Observations	567	567	567	609	609	609
Country dummies	Yes	Yes	Yes	No	No	No
Instruments	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Wald F statistic	212.340	202.231	201.867			
Hansen J / Sargan test (p-value)	0.713	0.571	0.562	0.182	0.215	0.214
Arellano-Bond test (AR2) (p-value)				0.862	0.745	0.768

Note: T-statistics in parenthesis, robust SEs. * indicates singificance at 10%, ** indicates singificance at 5%, *** indicates singificance at 1%.

Table 5 - Dependent variable: growth rate of per capita GDP. Regressors: volatility of GDP growth, consumption growth, investment growth, government consumption growth and control variables. Sample: OECD countries (25 countries). Horizon: 1978-2007. Annual observations. All regressions include year dummies. All regressions are population-weighted.

Static models weighted estimations						
ESTIMATION	FE	FE	FE	FE-IV 2sls	FE-IV 2sls	FE-IV 2sls
GDP volatility	-0.073		0.311	-0.476***		-1.790**
	(-0.89)		(1.55)	(-3.94)		(-2.84)
Consumption volatility		-0.687***	-0.766***		-1.337***	-0.882***
		(-5.75)	(-5.90)		(-6.79)	(-4.68)
Investment volatility		0.086***	0.116		0.202***	0.625***
		(2.83)	(0.21)		(3.08)	(3.11)
Government consumption		0.066	0.036		-0.058	0.136
volatility		(0.57)	(0.753)		(-0.34)	(0.73)
Education	0.006	0.007*	0.008**	0.003	0.006	0.006
	(1.45)	(1.94)	(2.03)	(0.55)	(0.95)	(0.99)
Population Growth	-0.048	-0.203	-0.223	1.332***	1.05**	1.297***
	(-0.15)	(-0.65)	(-0.72)	(2.88)	(2.38)	(2.70)
Initial GDP	-0.042***	-0.016**	-0.017**	-0.057***	-0.100	-0.022*
	(-5.63)	(-2.21)	(-2.05)	(-5.18)	(-0.81)	(-1.69)
Investment share of GDP	0.115***	0.110***	0.110***	-0.132***	-0.108***	-0.119***
	(11.44)	(11.07)	(11.05)	(-5.19)	(-4.44)	(-4.28)
Observations	750	750	750	675	675	675
Instruments	no	no	no	yes	yes	yes
Sargan statistic (p-value)				0.807	0.514	0.852
Kleibergen-Paap Wald F statistic				133.016	87.75	40.079

Note: T-statistics in parenthesis, robust SEs. * indicates singificance at 10%, ** indicates singificance at 5%, *** indicates singificance at 1%.

Table 6 - Dependent variable: growth rate of per capita GDP. Regressors: lagged growth rate of per capita GDP, volatility of GDP growth, consumption growth, investment growth, government consumption growth and control variables. Sample: OECD countries (25 countries). Horizon: 1978-2007. Annual observations. All regressions include year dummies. All regressions are population-weighted.

Dynamic models weighted estimations						
ESTIMATION	LSDV	LSDV	LSDV	LSDV IV 2sls	LSDV IV 2sls	LSDV IV 2sls
GDP volatility	-0.042		0.396*	-0.271***		0.436*
	(-0.46)		(1.92)	(-2.71)		(1.76)
Consumption volatility		-0.583***	-0.683***		-0.515***	-0.630***
		(-4.67)	(-5.06)		(-3.51)	(-3.85)
Investment volatility		0.074***	-0.200		-0.120	-0.114
		(2.38)	(-0.34)		(-0.31)	(-1.64)
Government consumption volatility		0.013	-0.030		-0.075	-0.122
		(0.11)	(-0.20)		(-0.49)	(-0.79)
GDP growth (t-1)	0.183***	0.142***	0.142***	0.430***	0.399***	0.399***
	(4.70)	(3.59)	(3.61)	(8.65)	(7.92)	(7.92)
Education	0.004	0.005	0.005	0.005	0.005	0.005
	(0.86)	(1.19)	(1.28)	(0.88)	(1.00)	(0.98)
Population Growth	-0.282	-0.378	-0.414	0.518	0.360	0.346
	(-0.87)	(-1.17)	(-1.28)	(1.32)	(0.92)	(0.77)
Initial GDP	-0.032***	-0.139	-0.120	-0.036***	-0.019*	-0.017
	(-4.07)	(-1.59)	(-1.34)	(-3.68)	(-1.80)	(-1.56)
Investment share of GDP	0.092***	0.093***	0.093***	-0.096***	-0.099***	-0.096***
	(8.20)	(8.30)	(8.30)	(-4.96)	(-4.98)	(-4.99)
Observations	725	725	725	675	675	675
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Instruments	No	No	No	Yes	Yes	Yes
Kleibergen-Paap Wald F statistic				275.699	269.17	268.73
Sargan test (p-value)				0.136	0.166	0.208

Note: T-statistics in parenthesis, robust SEs. * indicates singificance at 10%, ** indicates singificance at 5%, *** indicates singificance at 1%.

Table 7 - Dependent variable: growth rate of per capita GDP. Regressors: volatility of GDP growth, consumption growth, investment growth, government consumption growth and control variables. Sample: OECD countries (21 countries). Horizon: 1978-2007. Annual observations. All regressions include year dummies. All regressions are population-weighted.

Static models weighted estimations - Restricted sample

ESTIMATION	FE	FE	FE	FE-IV 2sls	FE -IV 2sls	FE-IV 2sls
GDP volatility	0.319***		0.513**	0.224		0.859***
	(2.99)		(2.48)	(1.55)		(3.15)
Consumption volatility		-1.038***	-1.09***		-1.165***	-1.25***
		(-7.43)	(-7.78)		(-6.53)	(-7.02)
Investment volatility		0.139***	0.017		0.089**	-0.107
		(4.68)	(0.29)		(2.27)	(-1.44)
Government consumption		0.003	-0.020		-0.052	-0.106
volatility		(0.03)	(-0.19)		(-0.36)	(-0.73)
Education	0.004	0.007**	0.007**	-0.002	0.002	0.002
	(1.33)	(2.11)	(2.22)	(-0.41)	(0.48)	(0.31)
Population Growth	0.623*	0.626*	0.620*	2.36***	2.079***	2.059***
	(1.85)	(1.92)	(1.91)	(5.00)	(4.60)	(4.62)
Initial GDP	-0.039***		-0.023**	-0.0452***	-0.029**	-0.024**
	(-4.00)		(-2.45)	(-3.56)	(-2.38)	(-1.99)
Investment share of GDP	0.085***		0.080***	-0.097***	-0.091***	-0.089***
	(8.44)		(8.56)	(-4.91)	(-4.83)	(-4.80)
Observations	630	630	630	567	567	567
Instruments	no	no	no	yes	yes	yes
Hansen J statistic (p-value)				0.339	0.541	0.560
Kleibergen-Paap Wald F statistic				170.679	171.291	175.060

Note: T-statistics in parenthesis, robust SEs. * indicates singificance at 10%, ** indicates singificance at 5%, *** indicates singificance at 1%.

Table 8 - Dependent variable: growth rate of per capita GDP. Regressors: lagged growth rate of per capita GDP, volatility of GDP growth, consumption growth, investment growth, government consumption growth and control variables. Sample: OECD countries (21 countries). Horizon: 1978-2007. Annual observations. All regressions include year dummies. All regressions are population-weighted.

Dynamic models weighted estimations - Restricted sample

ESTIMATION	LSDV	LSDV	LSDV	LSDV IV 2sls	LSDV IV 2sls	LSDV-IV IV 2sls
GDP volatility	0.197*		0.511**	0.006		0.584**
	(1.78)		(2.40)	(0.04)		(2.40)
Consumption volatility		-0.825***	-0.889***		-0.731***	-0.800***
		(-5.61)	(-5.97)		(-4.46)	(-4.84)
Investment volatility		0.094***	-0.026		0.019	-0.113*
		(2.95)	(-0.44)		(0.53)	(-1.69)
Government consumption		-0.052	-0.070		-0.124	-0.159
volatility		(-0.47)	(-0.63)		(-0.96)	(-1.23)
GDP growth (t-1)	0.331***	0.272***	0.267***	0.497***	0.457***	0.445***
	(7.95)	(6.43)	(6.34)	(10.16)	(9.14)	(8.96)
Education	0.001	0.003	0.003	0.002	0.005	0.004
	(0.21)	(0.86)	(0.87)	(0.55)	(1.04)	(0.90)
Population Growth	0.104	0.161	0.187	0.58	0.525	0.549
	(0.29)	(0.46)	(0.54)	(1.42)	(1.30)	(1.36)
Initial GDP	-0.025**	-0.017*	-0.146	-0.021*	-0.013	-0.011
	(-2.51)	(-1.73)	(-1.50)	(-1.89)	(-1.22)	(-0.95)
Investment share of GDP	0.049***	0.053***	0.052***	-0.063***	-0.064***	-0.063***
	(4.66)	(5.12)	(5.05)	(-4.17)	(-4.23)	(-4.20)
Observations	609	609	609	567	567	567
Country dummies	yes	yes	yes	yes	yes	yes
Instruments	no	no	no	yes	yes	yes
Hansen J / Sargan test (p-value)				0.178	0.196	0.200
Kleibergen-Paap Wald F statistic				348.850	344.011	346.559

Note: T-statistics in parenthesis, robust SEs. * indicates singificance at 10%, ** indicates singificance at 5%, *** indicates singificance at 1%.

Data appendix

Table A1 - List of Countries in the main Sample and Averaged Volatilities over the Period 1978 -2007

COUNTRY	GDP GROWTH	OUTPUT VOLATILITY	CONSUMPTION VOLATILITY	INVESTMENT VOLATILITY	GOV. CONSUMPT VOLATILITY
Australia	0.0234	0.0203	0.0132	0.0785	0.0153
Austria	0.0206	0.0199	0.0170	0.0592	0.0100
Belgium	0.0206	0.0176	0.0124	0.0745	0.0148
Canada	0.0193	0.0238	0.0177	0.0792	0.0161
Denmark	0.0210	0.0225	0.0232	0.0891	0.0169
Finland	0.0257	0.0388	0.0262	0.1030	0.0194
France	0.0163	0.0151	0.0107	0.0554	0.0139
Germany	0.0192	0.0170	0.0142	0.0547	0.0166
Greece	0.0236	0.0264	0.0209	0.0849	0.0402
Hungary	0.0196	0.0320	0.0361	0.1184	0.0411
Iceland	0.0414	0.0404	0.0499	0.1474	0.0197
Ireland	0.0221	0.0389	0.0287	0.1059	0.0408
Italy	0.0196	0.0170	0.0191	0.0502	0.0180
Japan	0.0200	0.0215	0.0160	0.0016	0.0120
Korea	0.0557	0.0519	0.0454	0.1162	0.0230
Luxembourg	0.0384	0.0306	0.0183	0.1010	0.0213
Mexico	0.0139	0.0428	0.0400	0.1404	0.0318
Netherlands	0.0180	0.0178	0.0186	0.0544	0.0189
New Zealand	0.0258	0.0198	0.0184	0.0902	0.0219
Norway	0.0168	0.0209	0.0232	0.0869	0.0158
Portugal	0.0244	0.0320	0.0241	0.1025	0.0282
Spain	0.0258	0.0219	0.0205	0.0629	0.0178
Sweden	0.0194	0.0212	0.0214	0.0887	0.0137
Switzerland	0.0130	0.0190	0.0090	0.0610	0.0176
United Kingdom	0.0179	0.0188	0.0194	0.0683	0.0116
United States	0.0204	0.0212	0.0142	0.0736	0.0163

Table A2 - Descriptive statistics

DESCRIPTIVE STATISTICS					
Series	Obs	Mean	Std. Dev.	Min	Max
GDP growth	750	0.0233	.0287	-0.1302	0.11639
GDP volatility	750	0.0232	.0147	0.0036	0.0957
Consumption volatility	750	0.0186	.0142	0.0022	0.0987
Investment volatility	750	0.0798	.0476	0.0079	0.323
Government consumption volatility	750	0.0162	.0100	0.002	0.0646
Investment share of GDP	750	28.81	5.6367	16.0422	53.5848
Education	750	42.23	13.67	9.76	73.42
Population Growth	750	0.006	.0050	-0.0046	0.0241
Initial level of GDP	750	22541.93	8156.53	3980.23	66065.33

Table A3 - Data sources and descriptions

VARIABLE NAME	DEFINITION and CONSTRUCTION	SOURCE
GDP growth rate	Percentage growth rate of real GDP per capita in constant prices. Reference year: 1996, Laspeyres index.	Penn World Tables 6.3
GDP volatility	Standard deviation of real GDP growth rate. Yearly series.	Penn World Tables 6.3
Consumption volatility	Standard deviation of real consumption growth rate (Real GDP times consumption share of GDP). Yearly series.	Penn World Tables 6.3
Investment volatility	Standard deviation of real Investment growth rate (Real GDP times Investment share of GDP). Yearly series.	Penn World Tables 6.3
Gov. Consumption volatility	Standard deviation of real public consumption growth rate (Real GDP times Government Cons.share of GDP) Yearly series.	Penn World Tables 6.3
Investment share of GDP	Log level of the investment share of real GDP. Yearly series.	Penn World Tables 6.3
Initial GDP	Log level of GDP on the 1st year of the window the corresp. volatility is computed. Yearly series.	Penn World Tables 6.3
Population growth rate	Percentage growth rate of population. Yearly series.	Penn World Tables 6.3
Education	Logarithm of the Percentage of Secondary Schooling Attained in Population aged 25 years and over.	Barro-Lee dataset (2010)