Further Cross–Country Evidence on the link Between Growth, Volatility and Business Cycles

Kory Kroft
Department of Economics
University of California, Berkeley
Berkeley, CA
94720-3880

Huw Lloyd–Ellis
Department of Economics
Queen's University
Kinsgton, Ontario
K7L 3N6

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Abstract

Recent empirical work finds a robust, negative cross–country relationship between growth and volatility. Various mechanisms have been proposed through which growth and fluctuations may be related. Some of these emphasize the role of year–to–year uncertainty and its impact on growth–promoting activities. Others emphasize structural interactions between business cycle movements and economic growth. In this article we assess whether growth is more strongly correlated with short term forecast uncertainty or medium/long term business cycle movements. Our evidence suggests that the majority of the negative relationship is coming from the interaction between growth and business cycle movements. The correlation of growth with more high frequency volatility is ambiguous or even positive.

Key Words: Growth, uncertainty, endogenous cycles
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1 Introduction

In recent decades, macroeconomists have tended to study the sources of fluctuations and the determinants of growth separately. However, recent theoretical and empirical work has given cause to question this standard dichotomy by demonstrating that volatility may be related to growth. One can distinguish between two classes of mechanism through which growth and fluctuations may be related. One class emphasizes the response of investors to uncertainty about the future which, in turn, affects average long–run growth. The other class emphasizes the structural interaction between the growth process and major business cycle fluctuations associated with a switch from recession to boom phases (such fluctuations might be more closely related to NBER cycle dates). As we discuss below, both types of mechanism may be responsible for either a negative or positive relationship between volatility and growth. Our objective in this paper is to try to determine empirically the extent to which each is relevant.

Although it is often presumed that uncertainty will have adverse consequence for investment and hence growth, the theoretical literature in fact suggests that the impact may be positive or negative. For example, while Abel (1983) shows that with symmetric costs of adjustment, a mean–preserving spread in price volatility will tend to raise investment, Pindyck (1988) shows that the opposite may be true when adjustment costs are asymmetric (e.g. if investments are irreversible). Cabellero (1991) demonstrates that perfect competition and constant returns in production is likely to result in a positive relationship, whereas imperfect competition and decreasing returns to scale will yield a negative one. Aizenman and Marion (1993) construct an endogenous growth model, in which investors face a random tax on capital that can take on two values, high or low, and investments that are irreversible. This setup creates an option value of postponing an investment, since by delaying the decision to invest, one can learn more about future tax regimes. The model shows that an increase in policy uncertainty can reduce investment, and therefore growth, in some circumstances.

The second class of theories focus on the structural relationship between fluctuations and growth–promoting activities that may arise, even in a deterministic environment. Some emphasize the causal impacts of business cycle fluctuations on long–run productivity growth. For example Sakellaris and Spilimbergo (1999) find that education enrollment is counter-cyclical for OECD countries. Similarly, by lowering wages, recessions may reduce the opportunity costs of innovative effort and induce greater productivity improvements (see Aghion and Saint Paul, 1998).

Schumpeter (1927) emphasizes causality in the other direction — the advances that generate long–run growth can cause cyclical fluctuations. This may be because new innovations require reorganization and restructuring before they can be used in practice thereby drawing resources out of production. Recently, Helpman and Trajtenberg (1998) formalizes these "Schumpeterian cycles" and find that the size of recessions are positively correlated with average growth.[1] Francois and Lloyd-Ellis (2002) develop a theory of growth and cycles in which fluctuations arise because of strategic clustering of implementation across sectors.[2] They find that growth and volatility are negatively related across economies. In all these theories the impact of fluctuations does not arise through the affects of aggregate uncertainty, but rather through a structural relationship between business cycles and growth.

Several papers have attempted to estimate the empirical relationship between volatility and growth across countries. In most cases these involve regressions of the average growth rate over a given sample period on the standard deviation of the growth rate or some other measure of uncertainty. Both Komendi and Meguire (1985) and Grier and Tullock (1989), for example, find a positive relationship between mean growth and its standard deviation. In contrast Aizenman and Marion (1993) find a negative relationship between growth and policy uncertainty.[3] However it is difficult to interpret what volatility is supposed to represent in such regressions. Ramey and Ramey (1995) go beyond this approach by constructing an econometric model in which the volatility measure is interpreted as forecast uncertainty. Using pooled time series, cross–country data, and controlling for other growth correlates, they uncover a significant and robust partial correlation between growth and volatility.

In this article, we build on Ramey and Ramey's analysis by developing an econometric specification that decomposes aggregate volatility into structural, business cycle fluctuations and residual forecast uncertainty.[4] This allows us to consider the hypothesis that it is business cycle shifts that generate the negative relationship between growth and volatility, rather than year–to–year uncertainty. Our specification hinges on the assumption that economic actors can condition

[1] See also Jovanovic and Rob (1990), Cheng and Dinopoulos (1992), Aghion and Howitt (1998) and Li (2000).

[2] The existence of such implementation cycles was first formalized by Shleifer (1986), but his model did not allow for endogenous growth. Matsuyama (1999) and Francois and Shi (1999) develop related theories.

[3] In their statistical model, government consumption and investment, tax rates, monetary growth are among some of the variables that define the policies. The uncertainty is captured by the part of these policies that is not explained.

[4] Relatedly, Saint Paul (1993) finds that very low-frequency movements in output (greater than 16 years) are positively related to average growth, whereas high-frequency (between 2 and 4 years) movements are negatively related to average growth.

on which phase (recession or boom) of the business cycle they are in. The estimates that we obtain indicate a significant and robust, negative correlation between growth and *between–phase* volatility — the component of volatility associated with medium term shifts between recessions and booms. In contrast growth appears, if anything, to be positively correlated with *within–phase* volatility — the average standard deviation within recessions and booms. These results are robust to the inclusion of other growth correlates and hold true in both a 92 country sample and an OECD country sample.

Some of the theories mentioned above imply that investment acts as a conduit between growth and volatility. However Ramey and Ramey (1995) find no evidence of any relationship between investment and overall volatility. Thus they conclude that little of the effect of volatility on growth seems to flow through investment. Aizenman and Marion (1999) further examine the relationship between investment and volatility. Unlike Ramey and Ramey they find that volatility is in fact correlated with investment, when investment is disaggregated into public and private investment.[5] Here we also consider the role of investment. Our estimates suggest that average investment rates bear little relationship to volatility at business–cycle frequencies, but are significantly *positively* related to within–phase volatility. We also consider the role of investment in human capital.

The rest of the paper proceeds as follows. In Section 2 we provide some simple correlations between cross–country growth rates and alternative measures of volatility. In Section 3 we develop an econometric specification that allows us to isolate the relationships between growth and volatility that are due to structural business cycle movements and forecast uncertainty, while controlling for other growth correlates. Section 4 considers some alternative avenues for the relationships we observe, and Section 5 provides a summary and concluding remarks.

2 Basic Correlations

Using real per capita GDP from the Summers–Heston data set, Ramey and Ramey (1995) compute average growth and volatility for two samples of countries: a 24-country sample that consists of OECD countries only, and a 92-country sample that includes less-developed countries. The OECD sample contains observations from 1952–1988, whereas the 92 country sample contains only observations from 1962–1985. They measure volatility using the standard deviation of per capita annual growth rates:

[5] Since the sample of countries that they use is rather different, it is difficult to compare their results directly.

$$\sigma_i = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(g_{it} - \overline{g}_i)^2} \tag{1}$$

where g_{it} is the growth rate of country i in year t, T is the number of periods and $\overline{g}_i = \frac{1}{T}\sum_{t=1}^{T} g_{it}$.

As a first look at the data, they run cross–country regressions of growth on volatility to generate simple correlations. Their results for the 92-country sample are

$$\begin{array}{lll} \overline{g}_i = & 0.030 & -\ 0.153\sigma_i \\ & (7.7) & (-2.3) \end{array} \tag{2}$$

$R^2 = 0.057$ (t-statistics in parentheses), and for the OECD sample

$$\begin{array}{lll} \overline{g}_i = & 0.026 & +\ 0.147\sigma_i \\ & (3.70) & (0.67) \end{array} \tag{3}$$

$R^2 = 0.020$. Note in particular, that the results for the 92 country sample suggest a significant, negative simple correlation, while the OECD sample suggests a *positive* (though insignificant) one.

As a first pass for our analysis, we identify phases of negative (recession, denoted r) and positive growth (expansions, denoted e) in the data for each country and decompose the overall variance into variance within and between these phases. That is we compute within–phase volatility as

$$\sigma_{iw} = \sqrt{\frac{1}{T}\left(\sum_{t\in r}(g_{it} - \bar{g}_{ir})^2 + \sum_{t\in e}(g_{it} - \bar{g}_{ie})^2\right)}, \tag{4}$$

and between–phase volatility as

$$\sigma_{ib} = \sqrt{\frac{T_{ir}}{T}\left(\bar{g}_{ir} - \bar{g}_i\right)^2 + \frac{T_{ie}}{T}\left(\bar{g}_{ie} - \bar{g}_i\right)^2}. \tag{5}$$

Here T_{ir} and T_{ie} denote the number of years the country is in recession and in expansion, respectively, and $\overline{g}_{ir} = \frac{1}{T_{ir}}\sum_{t\in r} g_{it}$ and $\overline{g}_{ie} = \frac{1}{T_{ie}}\sum_{t\in e} g_{it}$ are the average growth rates during recessions and expansions. It is straightforward to show that

$$\sigma_i^2 = \sigma_{iw}^2 + \sigma_{ib}^2. \tag{6}$$

In constructing these volatility measures several caveats should be noted. First, our definition of recessions and expansions differ from standard definitions such as the ones used by the NBER. Ours is based purely on movements in GDP per capita, and reflects annual fluctuations not quarterly ones. As a result, our recession and expansion phases do not necessarily coincide with those recorded by others (although for the US they are pretty similar). Second, in our analysis, output growth must be negative for a period to qualify as a recession phase, not merely below trend as is sometimes assumed. Our reasoning here is that periods of negative growth are structurally distinct phases rather than "run–of–the–mill" fluctuations. Finally, at the beginning and end of the sample period for a country, phases are truncated. This means that we may sometimes underestimate the total time an economy is in recession or expansion. In our empirical analysis below, we do not adjust for this. However for the simple correlation results we have experimented with removing incomplete phases from the calculations, and the qualitative results remain unchanged.

Using the same data and samples as Ramey and Ramey (1995) we consider the joint relationship of our volatility measures with average growth. A cross-country regression of mean growth on within– and between–phase volatility for the 92-country sample yields

$$\begin{array}{rlll} \overline{g}_i = & 0.031 & +0.635\sigma_{iw} & -0.831\sigma_{ib} \\ & (8.79) & (3.63) & (-4.99) \end{array} \tag{7}$$

$R^2 = 0.114$, and the result for the OECD sample is

$$\begin{array}{rlll} \overline{g}_i = & 0.020 & +1.128\sigma_{iw} & -0.764\sigma_{ib} \\ & (3.69) & (4.03) & (-3.32) \end{array} \tag{8}$$

$R^2 = 0.02$. These regressions both indicate a positive and significant partial correlation between within-phase volatility and mean growth and a negative and significant partial correlation between between-phase volatility and mean growth. That the coefficient on overall standard deviation is positive in the OECD sample can be attributed to the fact that the positive coefficient on the within-phase term dominates the negative coefficient on the between-phase term. In contrast, the negative impact of between–phase volatility appears to outweigh the positive impact of within–phase volatility in the 92-country sample.

Note that in the OECD sample, 57% of overall volatility may be attributed to within-phase volatility with the remaining 43% coming from between-phase volatility. In the 92-country sample, 47% may be attributed to within-phase volatility and 53% to between-phase volatility. Since this is roughly 50-50 for each sample, the results obtained cannot be attributed to the fact that one source "accounts" for more of the volatility observed than another source. The fact that proportionately less of the variance is within-phase in less-developed countries (LDC's) is probably due to the fact that they exhibit more "small" reversals in growth which, it may be argued, do not constitute significant recessions. However, their impact on the variance seems to be small. To see this, notice that the proportion of within-phase volatility coming from LDC's is roughly 40%, once OECD, or developed, countries have been removed from the 92-country sample.

3 A Phase–Dependent Growth Process

These simple cross–country regressions do not tell us how robust these correlations are since they omit several variables that have been found to be important for growth across countries. Nor do they allow an interpretation of the two types of volatility along the lines suggested in the introduction: one could think of them as representing the effects of uncertainty or of deterministic fluctuations. In their analysis, Ramey and Ramey (1995) go on to interpret overall volatility as a forecast error and hence interpret it as year–to–year uncertainty regarding output growth. Using pooled cross–country time–series data, they estimate the following model using the maximum–likelihood method:

$$g_{it} = \boldsymbol{\theta}\mathbf{X}_{it} + \lambda\sigma_i + u_{it} \tag{9}$$

where $\mathbf{X}_{it}$ represents a vector of country–specific explanatory variables, and

$$u_{it} = \sigma_i \varepsilon_t, \qquad \varepsilon_t \sim N(0,1). \tag{10}$$

This formulation is equivalent to a special case of an "ARCH–in–means" (ARCH–M) model in which heteroskedasticity is captured by variation in a country dummy.

Ramey and Ramey use a vector of variables for $\mathbf{X}_{it}$ that were found by Levine and Renelt (1992) to be robust correlates of growth across countries. The variables include (i) average investment as a fraction of GDP, (ii) average population growth, (iii) initial human capital and (iv) initial per capita GDP. With the exception of human capital, all variables are from the Summers and Heston (1991) data set. The human capital variable is taken from Barro (1991) and Barro and Lee (1993). Table 1 reproduces their results. These suggest a robust negative partial correlation between growth and overall volatility in the innovation process, although for OECD countries this correlation is not significant at the 5% level. This result is superficially consistent with several of the theories discussed above that emphasize the impact of uncertainty on investment decisions. However Ramey and Ramey find little evidence of a direct impact of such uncertainty on investment (see below).

Table 1: Relationship between Growth and Volatility (Ramey and Ramey, 1995)

(Conditional on Levine–Renelt Variables)

Independent Variable	92–Country Sample (2,208 observations)	OECD Sample (888 observations)
Constant	0.07	0.16
	(3.72)	(5.73)
Volatility (σ_i)	-2.11	-0.39
	(-2.61)	(-1.92)
Average investment share of GDP	0.13	0.07
	(7.63)	(2.76)
Average population growth rate	-0.06	0.21
	(-0.38)	(0.70)
Initial human capital	0.0008	0.0001
	(1.18)	(2.00)
Initial per capital GDP	-0.009	-0.017
	(-3.61)	(-5.70)

Notes: (1) t–statistics in parentheses
(2) Standard errors computed from covariance of analytic first derivatives

In our analysis, we go beyond Ramey and Ramey (1995) by allowing for the possibility that fluctuations have a structural component as well as a component associated with uncertainty. We capture this notion by assuming that economic actors know the "state" of the economy (i.e. recession or expansion) at the beginning of each period, and can take this into account when forecasting growth and making their decisions. Specifically, we introduce the following generalized econometric specification where growth in country i at time t in state s is given by

$$g_{ist} = \boldsymbol{\theta}\mathbf{X}_{it} + \lambda_w \sigma_{iw} + \lambda_b \sigma_{ib} + v_{ist} \tag{11}$$

where

$$v_{ist} = \sigma_{iw}\varepsilon_{it} + \mu_{is}, \qquad \varepsilon_{it} \sim N(0,1) \tag{12}$$

$$\mu_{is} = \begin{cases} \mu_{ie} & \text{with probability } p_i = \frac{T_{ie}}{T} \\ \mu_{ir} & \text{with probability } 1 - p_i \end{cases} \tag{13}$$

Here $p_i\mu_{ie} + (1 - p_i)\mu_{ir} = 0$, and so the implied between–phase volatility is estimated by

$$\sigma_{ib} = \sqrt{p_i\mu_{ie}^2 + (1 - p_i)\mu_{ir}^2} \tag{14}$$

Although we continue to treat within–phase volatility as forecast uncertainty, we assume that the growth rate can be conditioned on the state of the economy. Under this identifying assumption the model can be expressed as

$$g_{it} = \boldsymbol{\theta}\mathbf{X}_{it} + \sum_{i=1}^{n} \mu_{ie} Z_{iet} + \sum_{i=1}^{n} \mu_{ir} Z_{irt} + \lambda_w \sigma_{iw} + \lambda_b \sigma_{ib} + u_{it} \tag{15}$$

where n denotes the number of countries, Z_{ist} takes on the value 1 when country i is in state $s \in \{e, r\}$ and zero otherwise, and

$$u_{it} = \sigma_{iw} \varepsilon_t, \qquad \varepsilon_t \sim N(0, 1) \tag{16}$$

To estimate this model note that $\mu_{ie} = \mu_{ir} - \frac{\mu_{ir}}{p_i}$, and from (14), $\sigma_{ib} = \mu_{ir}\sqrt{\frac{1-p_i}{p_i}}$. We further assume that the likelihood of a given country i being in an expansion, p_i, is known. Substituting then yields

$$g_{it} = \theta X_{it} + \sum_{i=1}^{n} \mu_{ir} \left(1 - \frac{Z_{iet}}{p_i}\right) + \lambda_w \sigma_{iw} + \lambda_b \mu_{ir} \sqrt{\frac{1-p_i}{p_i}} + u_{it}. \tag{17}$$

Note that this is a nonlinear ARCH-M model, which nests Ramey and Ramey's (1995) ARCH-M model. Their model is a special case of ours where all of the μ_{ir} parameters are set to zero. The additional variables inserted here account for low/medium frequency movements in output, or business cycles, leaving only the high frequency movements, those within recessions and expansions, to be captured by the standard deviation of the innovation term. In this way, we decompose the overall volatility into components that we interpret as year–to–year uncertainty and structural business cycle movements.

Table 2: Relationship between Growth and Both Measures of Volatility

(Conditional on Levine–Renelt Variables)

Independent Variable	92–Country Sample (2,208 observations)	OECD Sample (888 observations)
Constant	0.00132	0.095
	(0.022)	(1.89)
Within–phase volatility (σ_{iw})	2.63	0.90
	(4.69)	(1.44)
Between–phase volatility (σ_{ib})	-2.65	-1.11
	(-6.35)	(-2.33)
Average investment share of GDP	-0.01	-0.004
	(-0.26)	(-0.073)
Average population growth rate	0.58	0.28
	(1.24)	(0.62)
Initial human capital	0.001	-0.00001
	(0.66)	(-0.096)
Initial per capital GDP	0.002	(-0.0008)
	(0.25)	(-1.30)

Notes: See Table 1

We estimate the parameters of this model by maximum likelihood. The main parameter estimates are shown in Table 2. The full model includes estimated values for the μ_{ir} parameters (one for each country) all of which are significant and negative. (These are available from the authors upon request.) Just as the between-phase volatility is inversely related to growth in the simple correlations in Section 2, so too is the estimated measure of between-phase volatility here. Also, the coefficient on within-phase volatility remains qualitatively similar to the corresponding coefficient in the simple correlation. However, once other control variables are included, the coefficient on σ_w becomes insignificant in the OECD sample. Thus, the relationship between within-phase volatility and growth appears to be less robust than for the 92–country sample. The coefficient of between-phase volatility, σ_b, on the other hand, remains significant in both samples, controlling for other correlates.

Figures 1 and 2 present partial correlations between average growth rates, within-phase volatility, and between-phase volatility for the OECD sample, after removing the effects of the Levine–Renelt variables and the other measure of volatility. This clearly depicts the strength of the negative partial correlation of growth with between–phase volatility relative to that with within–phase volatility. Notice that the relationship between average growth and between-phase volatility does not seem to be induced by any outliers. These results therefore demonstrates the robustness of the link between growth and between-phase volatility, and lend support to the idea that the negative relationship documented by Ramey and Ramey (1995) is accounted for mainly by between-phase volatility.

4 Possible Explanations

In Table 1 the majority of the coefficients on the Levine-Renelt variables are significant across both samples. However, once the between and within-phase volatility have been decomposed in Table 2, these coefficients have become individually insignificant. This is especially true for the coefficients on investment and human capital. This phenomenon may be due to the fact that the variables are related to volatility, only when volatility is disaggregated into within– and between–phase components. In this section, we explore further the interaction between our volatility measures and the other explanatory variables.

4.1 Volatility and Investment

Several of the theories discussed in the introduction suggest that countries with more volatile growth rates should have lower growth because of lower investment. To consider this possibility we estimated the same model as in Table 2 but excluded the investment variable from the model. Table 3A documents the consequences for the parameter estimates on the two components of volatility in each sample. When investment is included in the model, the coefficient on both measures of volatility rises (in absolute terms) in both samples. Thus, conditioning on investment seems to strengthen the relationship between growth and both measures of volatility. In contrast, Ramey and Ramey (1995) find no systematic effect when overall volatility is used.

Table 3: Growth, Volatility and Investment

Specification	92–Country Sample	OECD Sample
A. Growth Equations (MLE)		
Coefficient on between–phase volatility		
— investment included	-2.65 (-6.35)	-1.11 (-2.33)
— investment excluded	-2.59 (-7.10)	-1.08 (-2.98)
Coefficient on within–phase volatility		
— investment included	2.63 (4.69)	0.90 (1.44)
— investment excluded	2.54 (5.27)	0.86 (1.78)
B. Investment Equations (OLS)		
Coefficient on between–phase volatility	0.19 (0.45)	-2.23 (-1.26)
Coefficient on within–phase volatility	1.06 (13.69)	0.81 (3.17)

Notes: See Table 1

To explore this issue further, we ran a cross–country OLS regression of the investment to GDP ratio on the two measures of volatility (as estimated in Table 2, with the investment variable included) controlling for the other Levine–Renelt variables. As can be seen from Table 3B, the correlation with between–phase volatility is insignificant in both samples. In contrast, the correlation with within–phase volatility is positive and significant in both samples. Thus, while the negative relationship of growth with between-phase volatility does not appear to be associated with investment, the positive relationship with within–phase volatility may, in part, be coming through this avenue.

4.2 Volatility and Human Capital

Other theories discussed in the introduction suggests that the relationship between growth and volatility may be induced by human capital. One possible explanation for this is that changes in the volatility of output result in changes in human capital, and therefore, long-run growth. This idea is explored in Sakellaris and Spilimbergo (1999). These authors study the effects of the business cycle on human capital. Specifically, they investigate how the education enrollment of foreign students in the U.S. is influenced by business cycles in corresponding foreign countries. Their findings indicate that education enrollment is counter-cyclical for OECD countries. Thus, it is quite plausible that human capital is a channel through which volatility and growth are linked.

Table 4: Growth, Volatility and Human Capital

Specification	92–Country Sample	OECD Sample
A. Growth Equations (MLE)		
Coefficient on between–phase volatility		
— Human capital included	-2.65 (-6.35)	-1.11 (-2.33)
— Human capital excluded	-2.69 (-6.31)	-1.08 (-2.50)
Coefficient on within–phase volatility		
— Human capital included	2.63 (4.69)	0.90 (1.44)
— Human capital excluded	2.66 (4.70)	0.85 (1.57)
B. Human Capital Equations (OLS)		
Coefficient on between–phase volatility	-20.21 (-2.53)	-758.29 (-0.96)
Coefficient on within–phase volatility	-17.40 (-10.63)	394.36 (3.57)

Notes: See Table 1.

We therefore repeated the same experiment as we conducted for investment, but for the human capital variable. The results are reported in Table 4. When human capital is added as a control variable, the coefficient on both measures of volatility falls (in absolute value) in the 92–country sample, and rises in the OECD sample. As before, we explored the effect further by running an OLS regression of the human capital variables on the estimated values of volatility from the model in Table 2 and the other Levine–Renelt variables. In this case, human capital investment is negatively correlated with both types of volatility in the 92 country sample. For the OECD sample, it is not significantly related to between–phase volatility, but significantly and positively related to within–phase volatility.

5 Concluding Remarks

In this paper, we have explored in more detail the empirical cross-country relationship between average growth and fluctuations in growth rates. In particular, we distinguish between fluctuations that may be interpreted as year–to–year uncertainty and fluctuations that reflect structural business cycle shifts between recessions and expansions. We developed an econometric model that allows for this distinction and estimated the partial correlations of growth with volatility between phases of the business cycle and with volatility within those phases. Overall, we find that a significant negative correlation between growth and medium–term business–cycle fluctuations, and a significant positive correlation between growth and short–term, year–to year fluctuations. These correlations emerge in both an OECD and a 92–country sample, and are robust to the inclusion of other standard control variables.

We also considered the possibility that either investment or human capital may act as a conduit in the relationships between volatility and growth. Our estimates suggest that average investment rates bear little relationship to volatility at business–cycle frequencies, but are positively related to within–cycle volatility. However, there is no systematic correlation between human capital and the two measures of volatility. One interpretation of these results is that short–run uncertainty generates a positive investment response (as in Abel, 1983, for example) and hence a positive growth impact, while business cycle movements and growth are negatively related through a structural mechanism (as in Francois and Lloyd–Ellis, 2002, for example). It should be remembered, however, that while our results are broadly consistent with such an interpretation, the relationships between variables presented in this paper do not tell us the direction of causality.

Data Appendix

The data we use here is identical to that used by Ramey and Ramey (1995), and so a direct comparison of our results is valid.

Output — Log of Summers–Heston (1991) variable "Real GDP per capita, 1985 international prices; Chain index (RGDPCH)."

Initial Output — Log of Summers–Heston (1991) variable "Real GDP per capita, 1985 international prices; Laspeyres index (RGDP2)."

Population Growth — The log difference of Summers–Heston (1991) population variable.

Investment Share of GDP — Summers–Heston (1991) "real Gross Domestic Investment, private and public; % of RGDPCH; 1985 international prices" divided by 100.

Human Capital — For the 92 country sample: average schooling years in the total population over age 25 in 1960 from Barro and Lee (1993). For the OECD sample: secondary schooling from Barro (1991).

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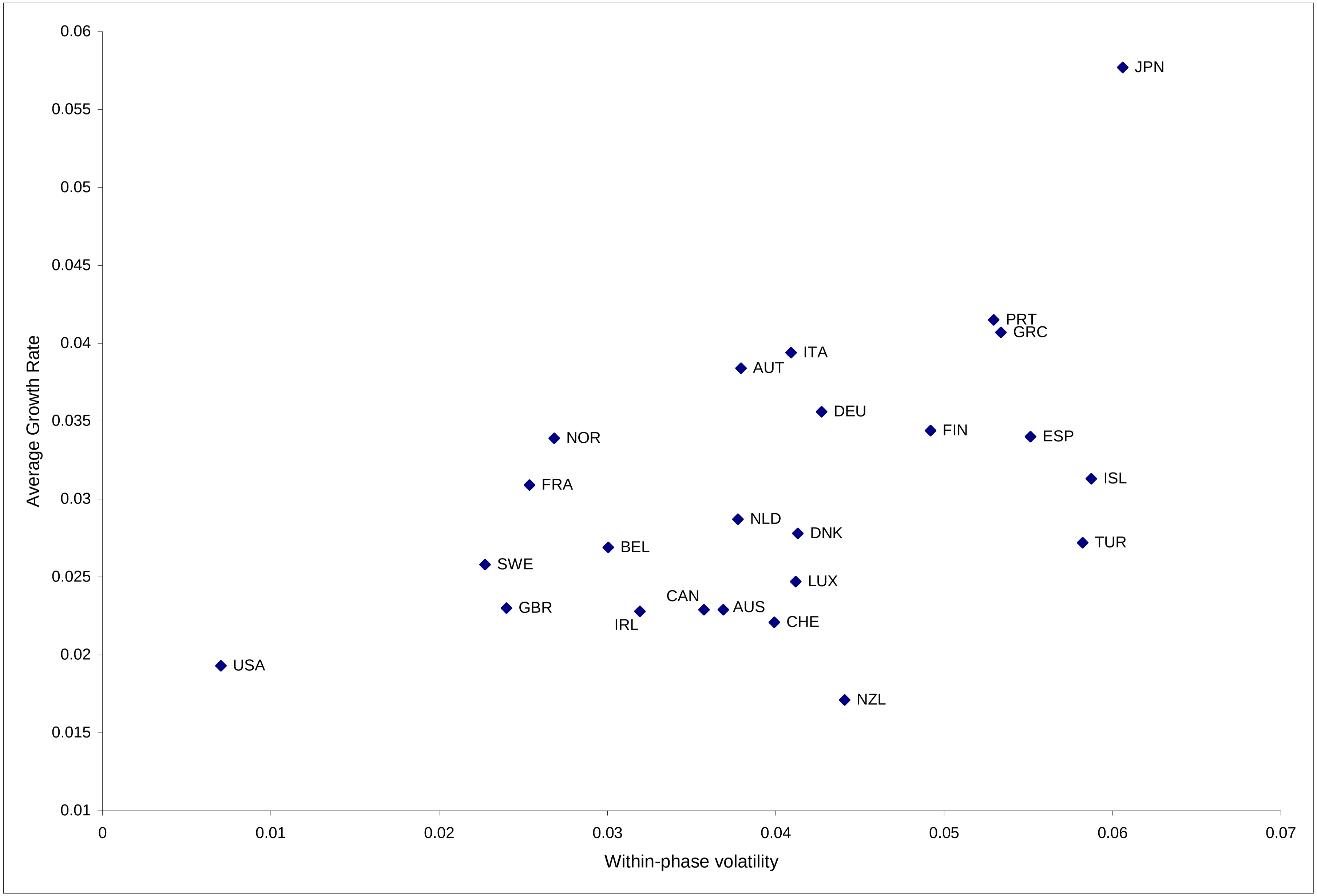

Figure 1: Partial Correlation between Growth and Within Phase Volatility (OECD Sample)

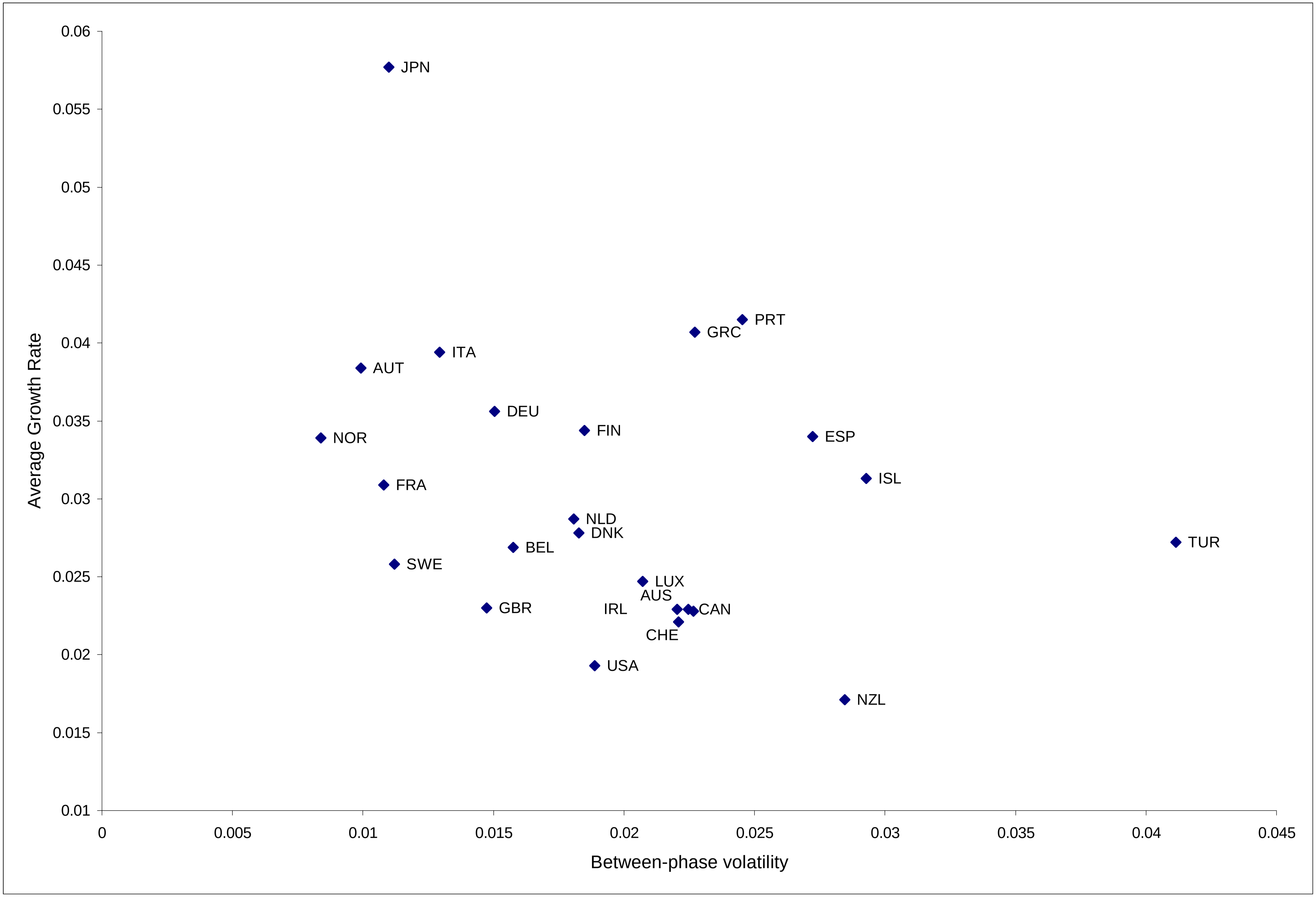

Figure 2: Partial Correlation between Growth and Between-Phase Volatility (OECD Sample)