Are Average Growth Rate and Volatility Related?

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Abstract

The empirical relationship between average growth rate and volatility of growth rates, both over time and across countries, has important policy implications, which depend critically on the sign of the relationship. Following Ramey and Ramey (1995) a wide consensus has been building that, in the post WWII data, the correlation is negative. We replicate their result and then find that it is not robust to either the definition of growth rate, or the composition of the sample. We show that the use of log difference as growth rates, as in Ramey and Ramey, creates a strong bias towards finding a negative relationship. Further, we exhaustively investigate this relationship, for various growth rates, across time, countries, within groups of countries and states in the Unites States. We use different methods and control variables for this inquiry. Our analysis suggests that there is no significant relationship between the two variables in question. However, we observe that the volatility of growth rates differs widely across countries, particularly between democratic and non-democratic countries. The latter finding is quite robust to a variety of controls, definitions of growth rates and time periods. We claim it is an important fact that existing political-economic models cannot explain.

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There exists a large literature devoted to studies of cross-country growth rates. By comparison, the literature that focuses on differences in the volatility of growth rates across countries is rather small. In this small but increasingly important literature the question that many concentrate on is whether there is any relationship between average growth rate and volatility of the growth rates, and, if yes, how are they related. Results in the empirical literature vary widely, with reports of both positive and negative relationship, but following Ramey and Ramey (1995) a wide consensus has been building that the correlation is negative. In this paper, we address the robustness of these results. We use the same methodology as used in the earlier papers, but we use a larger dataset, longer time-period, different subsets of the data and time-period, and different definitions of growth rates to verify the existence and the sign of the relationship. Our analysis suggests that there is no significant relationship between average growth rate and volatility of growth rates.

However, we observe that the volatility of growth rates differs widely across countries, an aspect that is not well studied. Our analysis suggest that this difference is particularly high between democratic and non-democratic countries. This finding is quite robust to a variety of controls, definitions of growth rates and time periods.

There are significant policy implications of the relationship between average growth rate and volatility of growth rates, which, moreover, depends on the sign of the relationship. A negative relationship between the two would imply that all policies that reduce short run aggregate movements also increase the long term growth rate. Indeed, it is commonly assumed that this is the case. In fact, this belief is one of the main justifications for short run "stabilization" policies, which often refers to policies aimed at reducing volatility. The World Bank and the IMF routinely advise governments to reduce fluctuations to achieve higher growth rates. [1]

However, the policy prescription of reducing volatility cannot be justified by the prospect of increasing growth if the average growth rate and the volatility of growth rates are positively related. In fact, if the relationship is positive, then the policymakers are faced with dilemma; reducing fluctuations also reduces the long term growth rate. Finally, if there is no relationship between the two, then all policies used to manage volatility do not influence growth rates anyway [2].

Empirical studies on this issue, as mentioned earlier, have yielded rather contrasting conclusions. Most commonly cited is the study by Ramey and Ramey (1995), which finds that the average growth rate decreases as volatility of growth rates increases. They draw their conclusion from data consisting of a set of 92 countries for the period 1962-1985 and also separately from a data set of OECD countries for the same period. In contrast, in an earlier study for a set of 47 countries for

[1] A large number of working papers and economic reports published by the World Bank and IMF recommend reducing volatility to achieve a higher growth rate. When we searched the "Documents and Reports" of World Bank using the keyword "stabilization" in October 2003, the search result gave us 837 documents. A similar search at the IMF website returned 1848 documents. For example, in an Economic Report "Brazil - Stability for Growth and Poverty Reduction" (World Bank, 2003), published by the World Bank, it says that "... even short run volatility, ..., can have persistent effects on growth."

[2] Please note that here we are not trying to ask the question whether reducing volatility is worthwhile. Volatility may have other effects, particularly welfare effects, which might justify policies aimed to manage volatility. What we are pointing out here is that one of the main justifications of such policies is that reducing volatility increases average growth and our intention is to question that justification.

the period 1950-1977, Kormendi and Meguire (1985) found that average annual growth rates were positively related to the volatility of growth rates. Grier and Tullock (1989) corroborate the Kormendi and Meguire (1985) result using a sample of 113 countries for the period of 1950-1981.

One objective of this paper is to empirically address this important question - whether the volatility of growth rates in any way affects the average long run growth rate? To answer this question we first replicate the results of Ramey and Ramey (1995) using the same data they used. We find, even in the same data, the relationship is sensitive to the choice of the definition of the growth rate - the definition of growth rate as the log difference in GDP per capita creates a negative bias. We then use data on a large set of countries (112 countries for the largest sample) for a long time period (1870-2000 for time series, 1961-2000 for cross-section samples) to check the robustness of the relationship. To investigate the relationship within a homogenous group we use a sample of all the U.S. states. In our analysis, we find no conclusive evidence of any significant relationship between the two, even after controlling for other variables.

We further ask if such a relationship exists within some subset of countries, based on either regional, economic, or institutional similarities. We fail to find any clear evidence to that effect either.

Though we do not find any relationship between average growth rate and volatility of growth rates, we observe that there exist significant differences in volatilities across countries. This is robust to various controls. We further observe that volatility of growth rates are significantly different across countries which are democratic and counties which are not. We use two different datasets, Polity III data and Gastil Scale, to separate countries into two groups, democratic and non-democratic and find the difference to be significant in both cases.

The organization of the paper is as follows. In the next section we check whether results differ if we use different definitions of growth rates. In the following section we test the robustness of the relationship using data from different time periods, with and without controls. Next we test the relationship in a time-series data, following which we check if the relationship is significant within various homogenous groups. In the penultimate section we study the differences in volatility of growth rates across countries, not in relation to the average growth rates. The final section concludes the paper.

1 Does the Definition of Growth Rate Matter?

In this section we examine the robustness of the relationship between average growth rate and volatility of growth rates in the way we define the growth rate. We check if how we define growth rates matters in determining the relationship between the two. In particular we are interested to ascertain if using log difference of GDP per capita as an approximation for the growth rate, as used by Ramey and Ramey (1995), biases the findings. We regress the average growth rates against the volatilities of growth rates. We do this twice - once for each of the following definition of growth rates:

Log approximation: $g_t^L = log(y_t/y_{t-1})$,

Standard definition: $g_t = (y_t - y_{t-1})/y_{t-1}$.

We use the same dataset used by Ramey and Ramey (1995) for this section. The analysis uses data on 92 countries for 1962-1985 from PWT 5.0. The results are reported in table 1. When we use the first definition of growth rates we are actually replicating the results reported in Ramey and Ramey (1985). Thus, what is reported in the first column is exactly what they have found, the coefficient is negative and significant. However, when we use the standard definition of growth rate in the regression, we find that the relationship is no longer significant. Thus, choice of definition of growth rate matters - use of log difference of GDP per capita as an approximation for growth rates biases the relationship to be negative.

Table 1: Average Growth Rate Vs. Volatility: Different Definitions of Growth Rate

Definition	g_t^L	g_t
Coefficient	-0.1535	-0.0604
t-statistic	(-2.3366)	(-0.8846)

Data: PWT 5.0 from http://econ.ucsd.edu/ vramey/research/volat/volat.html

Notice, the two definitions are related, $g_t^L = \log(1 + g_t)$. We can expand log to get,

$$g_t^L = \log(1 + g_t) = g_t - \frac{1}{2}g_t^2 + \frac{1}{3}g_t^3 - \cdots = g_t - e_t, \tag{1}$$

where, $e_t = \frac{1}{2}g_t^2 - \frac{1}{3}g_t^3 + \cdots$. The error term, e_t, is small when growth rates are near zero and the two definitions are close. However, as g_t increases, e_t is not completely insignificant. The log function being a strictly concave function "squeezes" higher growth rates more than low growth rates. Thus, volatility of growth rates of countries which tend to have high growth rates across time will be lower when the log approximation is used to measure growth rate than when the standard definition is used.

To understand how the log definition of growth rates biases towards finding a negative relationship, let us consider a simple example.

Example: Suppose there are two countries, 1 and 2, with average growth rates $\overline{g^1} < \overline{g^2}$, but the growth rates in any period in both countries are drawn from the same distribution. For simplicity let us assume that in each time period the growth rate in country $i, i = 1, 2$, can take one of the following two values:

$$g_t^i = \begin{cases} \overline{g^i} + \varepsilon & : \quad \text{with probability } \frac{1}{2} \\ \overline{g^i} - \varepsilon & : \quad \text{with probability } \frac{1}{2} \end{cases}$$

That is, the growth rate in any period can be either high or low, but the standard deviation of growth rates in both the countries is equal, $\sigma^1 = \sigma^2$.

If the log approximation is used to calculate the growth rates, the order of the average growth rates do not change, i.e., $\overline{g^{L1}} < \overline{g^{L2}}$. However, it can be easily shown that the standard deviation of growth rates for country 1 in this case is greater than that in country 2, $\sigma^{L,1} > \sigma^{L,2}$.

To summarize we find that if we have $\overline{g^1} < \overline{g^2}$ and $\sigma^1 = \sigma^2$, when we use the standard definition of growth rates, then when we use the log approximation we get $\overline{g^{L1}} < \overline{g^{L2}}$ and $\sigma^{L,1} > \sigma^{L,2}$. If we generalize this for N countries, we get that if $\overline{g^1} < \overline{g^2} < \cdots < \overline{g^N}$ and $\sigma^1 = \sigma^2 = \cdots = \sigma^N$ for the standard definition of growth rates, then for the log definition of growth rates $\sigma^{L,1} > \sigma^{L,2} > \cdots > \sigma^{L,N}$.

Thus even though there is no relationship between average growth rate and volatility of growth rates when we use the standard definition to measure growth rates, there will be a negative relationship between average growth rate and volatility of growth rates when log approximation is used to measure growth rates.

The above discussion and the example makes it clear that use of log approximation as a measure for growth rates will create a bias towards finding a negative relationship between average growth rate and volatility of growth rates. So, in the rest of the paper when we look for the existence of the relationship between the two variables, we report results using the standard definition of growth rates.

2 Worldwide Relationship

We now proceed to check the robustness of the relationship across various datasets and time-periods. We begin our exploration using a sample of all countries for which data was available for the relevant period in Penn World Tables, version 6.1. Using this sample we take two different approaches to investigate the relationship between average growth rate and volatility of growth rates.

The first approach is based on a simple idea: if we have two groups of countries such that, on an average, growth rates are different across groups, then the average volatilities of those two groups will also be different if the two variables are related.

We divide the sample of 109 countries in two groups based on the average growth rate for the period of 1960 to 1996. We order the countries according their average growth rates in that period and put the top 40% of the countries in the first group, we call them "high growth countries". The second group consists of the bottom 40% of the countries, referred to as "low growth countries". The average growth rate for the low growth rate countries is 0.0027 while the average growth rate for the high growth countries is 0.0378, higher by a factor of 14. Now, If average growth rate and volatility are related then we would expect the volatilities

Table 2: Volatility Across Groups with Different Growth Rates

	Mean Growth Rate		Mean Volatility	
	Low Growth Rate Countries	High Growth Rate Countries	Low Growth Rate Countries	High Growth Rate Countries
All	0.0027	0.0378	0.0595	0.0527

Data: PWT 6.1

to be significantly different for these two groups of countries given that the growth rates are different.

However, we find that there is no significant difference between the mean volatilities of these two groups of countries - the mean standard deviation for low growth countries is just 1.1 times that of mean standard deviation for the low growth countries. Thus, on an average the two groups of countries which differ in their growth rates are not much different in terms of their volatility of growth rates.

We extend our analysis to somewhat control for the income differences across countries. So now, we first divide all countries according to their initial income and call these groups “rich” and “poor”. We used the 1961 real GDP per capita as the initial income. Based on that poorest 40% was considered poor, while the richest 40% of the countries made up the rich. Thus the poor group included those countries whose real GDP per capita in 1961 was less than $1694.00 and the rich group consisted of those whose initial income was greater than $2776.7. Each group consists of 44 countries. Then within each of these groups, rich and poor, we divide the countries according to their growth rates as described in the previous exercise. So there are 18 countries in each sub-group (like “rich low growth countries”). The results are summarized in table 2.

Table 3: Volatility Across Groups with Different Growth Rates, Controlling for Income

	Mean Growth Rate		Mean Volatility	
	Low Growth Rate Countries	High Growth Rate Countries	Low Growth Rate Countries	High Growth Rate Countries
Poor	-0.0013	0.0397	0.0663	0.0635
Rich	0.0091	0.0372	0.0441	0.0466

Data: PWT 6.1

The results for each of the groups, poor and rich, portray the same picture as before. In both groups the average growth rates across low growth countries and high growth countries differ substantially but the average volatilities across them are quite similar. In the poor group, for example, the mean growth rates are (-)0.0013 for the low growth group of countries in contrast to 0.0397 for the high growth group of countries. However, the mean volatilities for those two respective groups are practically the same, 0.0663 and 0.0635.

So, what we get from the above analysis is that even within similar income groups, the mean volatilities are quite similar across groups with very different average growth rates. This seems to suggest that there is no relation between average growth rates and the volatility of growth rates. To verify this initial finding we use a second method of analysis - regression between the two variables.

2.1 Regressions between Average Growth Rate and Volatility of Growth Rates

We regress average growth rates against the volatilities of growth rates to investigate the relationship between the two.

The first sample for which we run that regression consists of all possible countries we could find data for. This set includes 112 countries for the period of 1961 to 1996 and a slightly smaller set, 108 countries, for a longer period, 1961-2000. We run all our regressions for these periods and also some other sub periods.

We run the regressions for different set of time periods for two reasons. One, to be sure that the results we get are independent of the choice of time period for analysis. And, two, so that we have a set of regression for the period which coincides with the time period for Ramey and Ramey (1995)'s analysis, given that their result has attracted a lot of attention.

Thus we report results of our analysis for the period of 1962-1985 [3], 1985-2000, 1962-1996 and 1962-2000.

There is also an issue of what is a better measure of "average growth rate for the period". First, one can take the average of annual growth rates for the period. Second, we use the relation $y_t = (1+g)^t y_0$ to find the (geometric) mean growth rate for the period. We use both these methods to calculate average growth rates and run separate regressions. Volatility of growth rate is measured as the standard deviation of all the annual growth rates for the period in both regressions.

The results of simple regressions between average growth rates and standard

[3] 1962-1985 is the range for the growth rates, so the data actually ranges from 1961-1985. In all other cases too, the sample period in the text refers to the years for which growth rate data has been used.

deviations of growth rates, for the different time periods mentioned above and for both measures of average growth rates, are reported in table 4.

Table 4: Growth vs. Volatility Regression: All Countries

		Average of Annual Growth Rates			(Geometric) Mean Growth Rate		
Period	Countries	slope	t-stat	significance	slope	t-stat	significance
1962-1985	112	0.0423	0.6862	N	-0.0475	-0.7954	N
1962-1996	112	-0.0827	-1.3431	N	-0.1633	-2.7146	Y
1962-2000	99	-0.0544	-1.1483	N	-0.1370	-2.9521	Y
1985-2000	108	0.0458	0.9050	N	-0.0419	-0.8560	N

Data: PWT 6.1

The results of these set of regressions are interesting. We find that if we take average growth rate of a country for the given period as the average of all annual growth rates in that period, then no matter what period we consider, the regression coefficient is always insignificant (sometimes the sign is also positive, albeit insignificant). When we calculate the average growth rate as the geometric mean, we find for the period 1962-1985, which is the period of analysis in Ramey & Ramey, and 1985-2000 it is still insignificant. However, if we take either 1962-2000 or 1962-1996, the regression coefficient is significant and negative. Thus, the outcome of the analysis is clearly dependent on the measure of average growth rate and also the time period of the analysis.

We also run all of the above regressions on a set of countries that exclude oil exporters [4] The results are the same.

Further, we use the full sample of countries available and run regressions of

[4] Dummy for oil exporting countries taken from Easterly and Kraay (2000).

average growth rates against standard deviation decade by decade (i.e., for 1962-1970, 1971-1980, 1981-1990, 1991-2000). In all these regressions, except 1991-2000, the coefficient of regressions are insignificant (the sign is positive in some cases and negative in others, but insignificant). For 1991-2000, however, the slope coefficient is negative and significant.

Thus, so far we don't get any conclusive evidence of a robust relationship between the average growth rate and volatility of growth rate. Whatever relationship seems to exist in a few cases does not survive choice of different time periods and measure of average growth rates. However, it is possible that we get a more consistent relationship if we control for certain variables in the regressions - which is what we do next.

2.2 Regressions with Control Variables

To carry on our investigation, we further run regressions between the average growth rate and volatility of growth rates, but now add various controls as independent variables in the regressions. Ramey and Ramey (1995) use the following set of modified Levine-Renelt (1992) control variables:

- Average investment fraction of GDP.
- Average population growth rate.
- Initial human capital.
- Initial per capita GDP (in log terms).

Kormendi and Meguire (1985) also use a similar set of instruments. Following these papers we use the same set of controls. Data on all variables, except human capital, are from PWT 6.1. For initial human capital, we use the average schooling years in the total population over age 25 in the year 1960. This data is from Barro-Lee data set [5].

Further, we use the panel estimation strategy (method A) similar to the one in Ramey and Ramey (1995), which is described by the following equations.

$$g_{y_{it}} = \alpha\sigma_{y_i} + \beta\mathbf{X_i} + \epsilon_{it} \tag{2}$$

$$\epsilon_{it} \sim N(0, \sigma_i^2), \quad i = 1, \cdots, I; \quad t = 1, \cdots, T \tag{3}$$

where $g_{y_{it}}$ is the growth rate of country i at time t and σ_{y_i} is the standard deviation of the growth rate for the time period 1 to T. X_i is the set of instruments for country i (including a constant).

We estimate the panel using MLE. Note, that in this estimation (equation (2)) the dependent variable varies across time (for each country), but all the independent variable, except the residuals, varies only across countries and not time.

In our second estimation strategy (method B), the difference from the first is that now the dependent variable is the mean growth rate for each country. So now the dependent variable also time invariant. Thus, equation (2) becomes,

$$g_{y_i} = \alpha\sigma_{y_i} + \beta\mathbf{X_i} + \epsilon_i \tag{4}$$

The estimate of coefficients are essentially the same in both the estimation methods if we use the average of annual growth rates as the mean growth rate for the period. The t-statistic, however, differs. In case of geometric growth rates those two methods differ on both counts.

[5] Available at http://www.nuff.ox.ac.uk/Economics/Growth/barlee.htm

Table 5: Full Sample with Control Variables

Period	no. of countries	constant	**volatility**	Av. Inv. share	Av. Pop. gr. rate	Initial Human Cap.	ln(Initial GDP/cap.)
1962-1985	83	0.0731	-0.0505	0.0013	-0.2318	0.0006	-0.0084
(t-stat)		(4.0678)	(-0.8757)	(8.1118)	(-1.4819)	(0.7587)	(-3.8742)
1962-1996	83	0.1	-0.1125	0.0014	0.4239	0.0005	-0.0114
(t-stat)		(6.9182)	(-2.3048)	(10.2886)	(-3.2838)	(0.8425)	(-6.5364)
1962-2000	75	0.0965	-0.0662	0.0011	-0.5812	0.0006	-0.0102
(t-stat)		(6.9771)	(-1.2617)	(7.1077)	(-4.6567)	(1.1113)	(-6.1382)
1985-2000	75	0.0914	-0.115	0.0009	-0.9290	-0.0003	-0.0081
(t-stat)		(5.3587)	(-1.7328)	(4.3609)	(-6.1019)	(-0.4380)	(-3.9336)

Note: Results are for method A, as described in the text. Data: PWT 6.1 and Barro-Lee data set.

In table 5 we provide the results for method A, using all 112 countries and average of annual growth rates as the measure for average growth rates. We find that the coefficient for volatility is always insignificant, except for the sample period 1962-1996, where it is negative and significant. Using geometric averages we get similar results.

Using method B none of the coefficients are significant if we take average of annual growth rates, and negative and significant only for 1962-1996 using geometric average.

Thus, we fail to find any persistent relationship in this sample between the two variables in question, even when we use various control variables in the regressions. There are a few cases where the coefficient is negative, but as is evident, it depends on the choice of time period and the way the average is calculated. So, overall so far there is no persuasive evidence to suggest any definite relationship between the two variables.

3 Relationship Over Time

So far we have been using cross-section data to investigate the relationship, but now we probe the relationship using time series data. We want to find whether there is any systematic relationship between volatility of growth rate and average growth rate over time for any given country.

We use long time series data on many countries provided by Angus Maddison at his website [6] for these set of analysis.

We divide the available data in non-intersecting five year periods (like 1920-1924, 1925-1929, etc.) [7]and then for each country we run a regression of average growth rate against volatility (calculated for each five year period).

The results are summarized in the table 6. What we find from these regressions is that the coefficient on the volatility in the regression is insignificant for a vast majority of the countries, negatively significant for a few and positively significant [8] for even fewer countries. Thus, there is no conclusive evidence of any relationship between the two variables of interest, even within countries over time.

[6]http://www.eco.rug.nl/ Maddison

[7]We also divide in five year periods by moving the lowest year for the period by one year from the last period (like 1920-1924, 1921-1925, 1922-1926, etc.). Results are similar.

[8]An interesting observation for data sets that start before 1950 is that countries which were a part of the losing coalition in the second world war tends to have negative relationship between average growth and volatility. For example for the sample 1870-2001 countries with significant negative relationship include Austria, Germany, Italy, Japan and Spain apart from Australia.

Table 6: Time Series Results

	Number of Countries			
Period	Total	Negative Significance	Positive Significance	Insignificance
1870-2001	22	6	0	16
1900-2001	29	9	1	19
1950-2001	137	20	9	108

Data: http://www.eco.rug.nl/ Maddison

4 Relationship within Groups

So far, particularly in the cross-country analysis, we included in our samples all possible countries. Maybe such a sample is too diverse. Maybe we should consider groups whose members are somehow similar. That is precisely what we do next. We consider samples whose members are chosen based on some criteria. The first such group that we consider is not a set of countries, rather its constituents are all the states in US. Later, we consider groups comprising of small set of countries which have something in common between them, geographic, economic or institutional.

4.1 US States

One of the most homogenous group on which we test the existence and sign of the relationship of interest consist of the US states.

We have two different sets of data on real gross state product (GSP) for all US states. The first set of data is from Bernard and Jones (1996), available at Jones' webpage [9] ranging from 1963-1989. We denote that data set by BJ. The second

[9]http://emlab.berkeley.edu/users/chad/datasets.html

is from Bureau of Economic Analysis (BEA) website [10] for the period 1977-2001 (denoted by BEA). We calculate GSP per capita as well as GSP per employee for each data set and use them in our analysis. Thus, we analyze four sets of data [11].

Table 7: Average Growth vs. Volatility Regression: US States

		Average of Annual Growth Rates			(Geometric) Mean Growth Rate		
Data Set	Period	slope	t-stat	significance	slope	t-stat	significance
BJ - per employee	1963-1989	-0.2245	-1.2756	N	-0.2385	-1.4056	N
BJ - per capita	1963-1989	-0.1806	-1.3280	N	-0.2113	-1.6112	N
BEA - per employee	1977-2001	-0.1252	-1.1677	N	-0.1433	-1.5012	N
BEA - per capita	1977-2001	-0.1635	-1.6384	N	-0.1803	-2.0323	Y

Note: BJ - Bernard and Jones (1996)   BEA - Bureau of Economic Analysis.

Data:http://emlab.berkeley.edu/users/chad/datasets.html and

http://www.bea.doc.gov/bea/regional/data.htm

The results, summarized in table 7, clearly show a lack of significant relationship between the average growth and volatility of growth - the coefficient is never significant except once.

Further, we run the same set of regressions again but with log of initial income (which was taken to be the income in the first year of the sample time period) added as a control variable. Adding this variable to the regression changes the sign in two cases. Earlier, the sign was always negative, though almost always

[10] http://www.bea.doc.gov/bea/regional/data.htm

[11] Unfortunately, data for the common years did not match across the two data sets and hence we were unable to combine the two datasets. Also, Alaska was an outlier in all the data sets and was not included in the subsequent data sets for which the results are reported. Including Alaska makes many of the coefficients positive, often significant.

insignificant, but now two cases have positive significant coefficient (there is still one case of negative significance).

Thus, even in this homogenous group we find there is no significant and robust relation between the two variables.

4.2 OECD Countries

Next we consider some samples such that the constituent countries are chosen based on certain criteria. The first sample that we use for our investigation consists of the OECD member countries.

4.2.1 Simple Regressions

To begin with we consider only those OECD countries that were part of the OECD before 1990. These are the countries in the OECD group in the Ramey and Ramey (1995). There are 24 such countries (in some sample periods in our analysis we have 23 countries due to the merger of the two Germanies). The results of the regressions between the average growth rate and volatility for this sample are tabulated in table 8. Note, that in this table we do not provide the results for the period 1962-1996, since all countries in this sample have data till 2000.

The interesting aspect of the results is that now the regression coefficient is always positive, though insignificant at 5% confidence level (some are significant at 10% confidence level, denoted by $N^\star$ in the table).

We repeat the exercise for a sample of all the countries that are currently OECD members and for which data was available for the relevant period (there are 25 or 28 such countries depending on the sample period). The results are similar; all regression coefficients are positive and mostly insignificant at 5% significance

Table 8: Subset of OECD Countries

	Average of Annual Growth Rates			(Geometric) Mean Growth Rate		
Period	slope	t-stat	significance	slope	t-stat	significance
1962-1985	0.3226	1.5575	N	0.2909	1.5013	N
1962-2000	0.3572	1.8310	$N^{\star}$	0.3333	1.7703	$N^{\star}$
1985-2000	0.4611	1.7733	$N^{\star}$	0.4474	1.7343	$N^{\star}$

Data: PWT 6.1

level but often significant at 10% significance level. In the case of 1962-2000 the coefficient is positive and significant even at 5% significance level (no matter how the mean is calculated).

4.2.2 Regressions with Control Variables

As we had done with the sample of all countries, here too we run another set of regressions in which we add certain control variables.

We add the same control variables as we did in the case of worldwide regressions, but now instead of the average schooling years in the total population over age 25 we use total gross enrollment ratio for secondary education in 1960 (following Ramey and Ramey (1995)).

In this case too, we do it for all countries currently in OECD as well those OECD countries who were a part of it before 1990. In table 9 we provide the result for the smaller set. Here too we find the coefficient is always insignificant (the sign is often positive).

The results are similar even if we use geometric mean.

Thus, even in the sample of OECD countries we fail to find any relationship

Table 9: Subset of OECD Countries

Period	no. of countries	constant	volatility	Av. Inv. share	Av. Pop. gr. rt	Initial Human Cap.	Initial GDP/cap.
1962-1985	23	0.1487	0.0995	0.0008	-0.1248	0.0120	-0.0162
(t-stat)		(4.2569)	(0.5949)	(2.9179)	(-0.4277)	(1.5569)	(-4.2337)
1962-2000	22	0.1247	0.1358	0.0004	-0.3169	0.0039	-0.0121
(t-stat)		(4.3409)	(0.8931)	(1.4293)	(-1.3474)	(0.6716)	(3.9736)

Note: Results are for Method 1, as described in the text.

Data: PWT 6.1 and Barro-Lee data set.

between average growth rate and volatility of growth rate.

4.3 Geographic Regions

Next we divide all countries in different geographic regions and look for any patterns within each region.

We run regressions between average growth rate and volatility of growth rates for each of the groups. In table 10 we put down all cases of significance. For all other cases (regions or time-periods) the coefficient is insignificant[12].

For most of the regions the coefficient is insignificant. Some very disparate group of countries, the African countries and West Europe with or without Canada and US, have significant coefficients. The sign of the coefficients are positive.

We also run regressions on the complimentary groups. Thus, for example, we

[12]In PWT 6.1 data, North Africa is grouped along with Middle East, so while analyzing just African Countries (and the complimentary set) we did the analysis twice, first we took all African countries except the North African countries and second, we took all African countries plus the Middle Eastern countries. The results are quite similar.

[13]As mentioned earlier in the text, we calculate the average growth rate in two ways, A stands for the average of annual growth rates, where as G stands for the average growth rate calculated using the relation $y_t = y_0(1 + g)^t$.

Table 10: Regions where the coefficient is significant

Sign	Region	Period	Average Type [13]
positive	Africa	1962-1985	A
	Africa	1985-2000	A
	West Europe	1962-2000	A,G
	West Europe, Canada & US	1962-2000	A,G
negative	None	All Periods	A,G

Data: PWT 6.1

run a regression on all African countries and another on the complimentary group of countries - for all countries in the world excluding African countries. When we take the sample of countries that are compliment to the considered group, we get results very similar to the results obtained using all possible countries, the coefficient of regression is often insignificant but sometimes negatively significant. The only exception to this was the case when we ran the regressions on all except African countries for the period 1962-1985, the coefficient of volatility of growth rate was positive and significant. Thus, for 1962-85, regression on both, the set of African countries as well as the compliment set gives us positively significant coefficients.

So, even this exercise seems to suggest that the two variables are no related. Again we expand our investigation of relationship among groups of countries within a geographical regions to include control variables in the regressions.

4.3.1 With Control Variables

When we run the regressions for each region with the control variables included in the regressions, we find that the regions where we had positive significance, the coefficient for volatility is no longer significant. The rest of the regional results are similar to the case without the instruments, i.e., still insignificant.

Hence, we find no relationship between average growth and volatility even within any geographical region.

4.4 Groups According to Socio-Political Conditions

Our next criterion for classification of countries is based on social and political institutions and stability of the country. The conjecture here is that maybe if we control for the political system then we can find some pattern in the relationship of the two variables of interest. To this end, we use two distinct measures of political system widely used by Political Scientists, the Polity III data by Jaggers and Gurr (1996) and the Gastil Scale published by Freedom House.

4.4.1 Polity III data

We divide the countries in two groups Democracies and Non-Democracies. To do that we use the commonly used Polity III data (Jaggers and Gurr (1996)). This data assigns a value between 0 and 10 to all countries for each year, 0 being the least democratic and 10 being the most democratic. We use this data to group countries in two groups in two distinct ways. First, we classify a country as non-democracy if the country did not have democracy in at least three years or in other words if it has democracy scores of 0 or 1 in at least three years. There are 68 countries for data set till 1996 (62 when we extend the analysis till 2000) which are classified as non-democracies. There are 34 democratic countries (32 when extended till 2000). Second, we add up democracy scores for each country over all years (1960-1994) and classify a country as non-democracy if the sum is below certain cut-off [14]. Now we have 61 countries classified as not democracies (42 if data till 2000 used) and 45 democratic countries (42 for data till 2000).

Then we run regressions between the two variable of interest for each group, for each sample periods. None of the regression coefficients in these regressions, except for non-democracies in the period 1985-2000 (which is negative and significant when we take the geometric average) are significant. Often the coefficients are positive, though insignificant.

Adding the various control variables in the regressions we find non-democracies tend to have significant negative coefficient for some periods, while the rest are insignificant.

So, overall this division also does not produce a stable relationship between the average growth rate an volatility of growth rates within any of the groups.

4.4.2 Gastil Scale

The Gastil Scales give two seven point indices, one for "Political Freedom" and another for "Civil Rights" for each country for each year (from 1972-73 to 2001-2002). In these scales, 1 denotes the best performance while 7 is the worst. We take mean of these indices for each year and take the average of that over the years to divide the countries in two groups. We take the cut-off value of 3.5, so countries greater or equal to that value is classified as non-democratic. Note, that even though we use the name democratic and non-democratic, this index captures a somewhat broader picture of political stability in a country by using the two different indices.

[14] The maximum possible score for any year is 10, so for 35 years a sum of 350 is the maximum possible. We set the cut-off at 150.

Using this classification we find that none of the regressions between the average growth rate and volatility of growth rate yield any significant coefficient. However, when control variables are added, countries which are classified as "non-democratic" have significant negative coefficient for the period 1962-1996 and 1985-2000. The rest are insignificant.

Thus, a clear relationship does not emerge on the relationship within one group. However, we observe that the volatility of the group of countries which are classified as non-democratic is significantly higher than the volatility of the other group. We create a dummy variable for democratic countries and run a regression of the standard deviation of the growth rate against the dummy variable. The coefficient is highly significant in all possible sample periods and no matter what index we choose (Gastil or Polity) to separate the democratic countries from the rest. This result is interesting and suggests that we look into differences of volatility of growth rates across countries independent of its relationship to the growth rate. Also, the difference in the levels of volatility of growth rates of these two groups of countries may be the reason why in some regressions we see some significant relationship when actually there is probably no such relationship.

5 Differences in Volatility of Growth Rates Across Countries

As already stated that there exists a wide dispersion in the volatilities of growth rates across countries. For the period 1961-1996 the highest volatility (standard deviation) is 0.149 (Guinea-Bissau) while the lowest is 0.0172 (Norway), the mean being 0.0551. Though we fail to find any clear relationship between average growth rates and volatility of growth rates there emerges a stable pattern of the volatilities across countries. What we find is that volatility of growth rate is negatively related to the initial income, i.e., for the period under consideration countries that start off rich tend to have less volatile growth rates than countries which are poor to begin with.

Also, we divide the world into various groups to verify whether such a relationship between volatility of growth rates and initial income exists within such groups. For that purpose we run the regression between volatility of growth rates and initial income on just OECD countries [15]. There is a significant relationship between volatility and initial income in this sample too. The results are same when we take countries according to geographic regions like Africa.The results are summarized in the table 11.

We also divide the countries in two categories, democratic and non-democratic [16] and test the relationship in each of the two groups. In this case, however, we find that volatility is often not significantly related to initial income within each of the two groups. An interesting observation emerges - countries which are non-democratic on an average experience more volatile growth rates. The mean standard deviation of growth rates in non-democratic countries is almost twice as much as the mean standard deviation of growth rates in the democratic countries, irrespective of the criterion used to divide countries in to the two groups. In fact,

[15]As in our earlier analysis of relationship between average growth and volatility, we do the analysis for OECD countries twice - once with countries that were in OECD before 1990 and the other with all present OECD members that we have data on. The result is similar in both cases, volatility and initial income are negatively related.

[16]Again, we divide the countries in these two groups twice, once using the democracy scores in Polity data and then again using the Gastil scale. The results are similar.

Table 11: Volatility Vs. Initial Income

Sample	Coeff.
World	-0.0156 (-5.7968)
World	-0.0088 (-2.9310)
World	-0.0097 (-2.8089)
OECD	-0.0062 (-2.2948)

Data: PWT 6.1

the mean volatility in non-democratic countries is close to the maximum volatility observed in democratic countries.

This is an interesting observation and needs further investigation.

6 Conclusion

To answer the central question of this study, whether there is a relationship between average growth rate and the volatility of the growth rate, we find that there is no systematic evidence to suggest that such a relationship exists. After an extensive and thorough study of this relationship what we find is that it depends on how the growth rate is defined. Use of log approximation as a definition of growth rate creates a bias towards finding a negative relationship between average growth rate and volatility of growth rates. The relationship also depends on the choice of data set, in particular the period chosen. We were unable to find any consistent relationship between average growth rate and volatility of growth rate for any subset of countries either. Thus, whatever justifications the policies aimed at reducing volatilities might have, achieving higher growth is not one of them.

However, we did find that there is a systematic difference in volatilities of growth rates across countries. In particular we observe that non-democratic countries are more volatile than democratic countries. The reasons for such differences need to be investigated further and is the focus of our next paper.

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Appendix

A LIST OF ALL COUNTRIES

In the following table, N in any cell indicates that data for the corresponding country was not a part of that sample.

PWT 6.1 ncode	PWT 6.1 ccode	Without Control Variables				With Control Variables			
		1962-96	1962-00	1962-85	1985-00	1962-96	1962-00	1962-85	1985-01
AGO	1		N		N	N	N	N	N
ARG	3								
ATG	5	N	N	N		N	N	N	N
AUS	6								
AUT	7								
BDI	9					N	N	N	N
BEL	10								
BEN	11					N	N	N	N
BFA	12					N	N	N	N
BGD	13								
BLZ	18	N	N	N		N	N	N	N
BOL	20								
BRA	21								
BRB	22								
BWA	24		N		N		N		N
CAF	25		N		N	N	N	N	N
CAN	26								
CHE	27								
CHL	28								
CHN	29					N	N	N	N
CIV	30					N	N	N	N
CMR	31					N	N	N	N
COG	32					N	N	N	N
COL	33								
COM	34					N	N	N	N
CPV	35					N	N	N	N

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CRI	36								
CYP	38		N		N		N		N
DNK	42								
DOM	43								
DZA	44								
ECU	45								
EGY	46					N	N	N	N
ESP	48								
ETH	50					N	N	N	N
FIN	51								
FJI	52		N		N		N		N
FRA	53								
GAB	54					N	N	N	N
GBR	55								
GER	57	N	N	N		N	N	N	N
GHA	58								
GIN	59					N	N	N	N
GMB	60					N	N	N	N
GNB	61					N	N	N	N
GNQ	62		N		N	N	N	N	N
GRC	63								
GRD	64	N	N	N		N	N	N	N
GTM	65								
GUY	66		N		N		N		N
HKG	67								
HND	68								
HUN	71	N	N	N		N	N	N	
IDN	72								
IND	73								
IRL	74								
IRN	75								
ISL	76								
ISR	77								
ITA	78								
JAM	79								
JOR	80								
JPN	81								
KEN	83								
KNA	86	N	N	N		N	N	N	N
KOR	87								
LCA	91	N	N	N		N	N	N	
LKA	92								
LSO	93								
LUX	95					N	N	N	N
MAR	98					N	N	N	N
MDG	100					N	N	N	N
MEX	101								

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MLI	103					N	N	N	N
MOZ	106								
MRT	107		N		N	N	N	N	N
MUS	108								
MWI	109								
MYS	110								
NAM	111		N		N	N	N	N	N
NER	112								
NGA	113					N	N	N	N
NIC	114								
NLD	115								
NOR	116								
NPL	117								
NZL	118								
PAK	120								
PAN	121								
PER	122								
PHL	123								
PNG	124		N		N		N		N
POL	125	N	N	N		N	N	N	
PRT	127								
PRY	128								
ROM	130					N	N	N	N
RWA	132					N	N	N	N
SEN	135								
SGP	136		N		N		N		N
SLE	137		N		N		N		N
SLV	138								
SWE	142								
SYC	144								
SYR	145								
TCD	146					N	N	N	N
TGO	147								
THA	148								
TTO	151								
TUN	152								
TUR	153								
TWN	154		N		N	N	N	N	N
TZA	155								N
UGA	156								
URY	158								
USA	159								
VCT	161	N	N	N		N	N	N	
VEN	162								
ZAF	165								
ZAR	166		N		N		N		N
ZMB	167								

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ZWE	168								
No. of countries	N	112	98	112	107	83	75	83	78

B Summary Statistics

Summary statistics of the various variables used in this paper.

Summary Statistics for 1962-96 data without control variables, 112 countries

Variable	Min	Max	Mean	Median	St.Dev.
log Initial GDP	5.9273	9.7087	7.7766	7.7833	0.9078
St.Dev. of GDP Growth Rates	1.7659	15.3014	5.5641	4.7113	2.9286
Arithmetic Av. Growth Rate	-2.5442	7.5089	1.9897	2.0796	1.9072
Geometric Av. Growth Rate	-3.3883	6.8059	1.6945	1.8376	1.9085

Summary Statistics for 1962-96 data with control variables, 83 countries

Variable	Min	Max	Mean	Median	St.Dev.
log Initial GDP	5.9273	9.7087	7.9750	7.9222	0.8816
Av. Investment Share	1.9620	42.2114	17.3925	17.8481	7.6681
Av. Population Gr. rate	0.2972	4.6205	1.9720	2.2254	0.9918
St.Dev. of GDP Growth Rates	1.7659	12.5250	4.8422	4.4063	2.2787
Arithmetic Av. Growth Rate	-2.5442	7.5089	2.1912	2.2009	1.7575
Geometric Av. Growth Rate	-3.3883	6.5861	1.9419	2.0644	1.7586
Av. Years of Schooling	0.0720	9.6120	3.4090	2.9870	2.4271

C LIST OF OECD COUNTRIES

Australia	Korea⋆
Austria	Luxembourg
Belgium	Mexico⋆
Canada	Netherland
Denmark	New Zealand
Finland	Norway
France	Poland⋆
Germany⋆⋆	Portugal
Greece	Spain
Hungary⋆	Sweden
Iceland	Switzerland
Ireland	Turkey
Italy	United Kingdom
Japan	USA

⋆: countries which were not in OECD before 1990.

⋆⋆: Germany is included only in the period 1985-2000.

D COUNTRY GROUPS ACCORDING TO GASTIL SCALE

DEMOCRATIC COUNTRIES		NON-DEMOCRATIC COUNTRIES	
Argentina	Japan	Algeria	Mexico
Australia	Luxembourg	Bangladesh	Morocco
Austria	Mauritius	Benin	Nepal
Barbados	Netherlands	Burundi	Niger
Belgium	New Zealand	Burkina Faso	Nigeria
Bolivia	Norway	Cameroon	Pakistan
Botswana	Portugal	Central African Republic	Panama
Brazil	Spain	Chile	Paraguay
Canada	Sri Lanka	China	Peru
Columbia	Sweden	Congo, Dem. Rep.	Philippines
Costa Rica	Switzerland	Congo, Republic of	Romania
Cyprus	Trinidad and Tobago	Cote d'Ivoire	Rwanda
Denmark	United Kingdom	Egypt	Senegal
Dominican Republic	Uruguay	Equatorial Guinea	Sierra Leone
El-Salvador	USA	Ethiopia	Singapore
Ecuador	Venezuela	Gabon	Syria
Fiji		Ghana	South Africa
Finland		Guatemala	South Korea
France		Guinea	Taiwan
Gambia		Indonesia	Tanzania
Greece		Iran	Thailand
Guyana		Jordan	Togo
Honduras		Kenya	Tunisia
Iceland		Lesotho	Turkey
India		Madagascar	Uganda
Ireland		Malawi	Zambia
Israel		Malaysia	Zimbabwe
Italy		Mali	Chad
Jamaica		Mauritania	