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Growth, Volatility and Education: Panel Evidence from Developing Countries

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ABSTRACT

The investigation of the growth-volatility link is an important one in empirical macroeconomics. There is no empirical evidence supporting the predictions of recent theoretical models that incorporate and explicitly recognize the role of human capital in this link. The objective of the study is to examine whether the significance of volatility-growth relationship varies according to the average years of education. Using a panel data, we empirically show how the detrimental effect of output volatility on growth is diluted by education. The main contribution of our work is that while the level of volatility negatively affects growth, the effect is mediated via education. This is true even for countries with low as well as moderately high levels of volatility. This finding is consistent with Canton's (2000) theoretical work. We also provide robustness checks and policy implications of our finding.

JEL Classification : E32, F43, O40, O49

Keywords: Growth, volatility, education, system GMM

INTRODUCTION

Despite the fact that, traditionally, long-term growth and short-term cyclical volatility have been treated as distinct economic phenomena that should be analyzed separately, a recent strand of literature has moved away from this conventional wisdom. Theoretical and empirical analyses have provided support and intuition behind the idea that volatility may constitute a significant part in the determination of long-term economic prospects, as these are appropriately reflected by the average rate of economic growth (Blackburn and Varvarigos, 2008).

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Theoretical work demonstrates ambiguous conclusions to the sign of the volatility-growth relationship. Canton (2002) constructs a stochastic two-sector model of endogenous growth to analyze the impact of cyclical volatility on long-term growth. His model predicts that growth will be higher during business cycle fluctuations because people engage in precautionary savings and dedicate more for human capital investment. The model presented by Blackburn and Galindev (2003) is a simple stochastic model in which internal and external learning behavior results in improving productivity. The study integrates both types of learning into a single framework and finds that growth and volatility are prone to be positive if internal learning mainly drives technological change. Varvarigos (2007, 2008) on the other hand, constructs a model that shows inflation is harmful for growth but inflation volatility has a positive effect on growth. The model also identifies increases in real money balances holding as a new channel in which inflation volatility exerts a positive effect on growth. This mechanism however is quite different with the seminal paper by Dotsey and Sarte (2000) where they argue the positive effect of volatility on growth lies in the direct precautionary increase in investment.

Recent analysis has also examined the factors that help to mitigate the negative effects of volatility where different approaches are featured in the literature, each with different empirical implications (Chong and Gradstein, 2009). For example, Rodrik (1999) shows domestic social conflicts and institutional ability as the channel through which volatility negatively affects growth. Aghion and Banerjee (2005) discuss two possible channels. First, it is through precautionary saving and second through its effect on long-term investment under imperfect credit market. In another study, Aghion *et al*. (2005, 2009) focus on the importance of financial development or credit constraint. Theoretically, their model predicts that volatility has negative effect on productivity growth especially when countries face stringent credit constraints. This is verified by the empirical test on a panel of countries; the interaction term between volatility and financial development is positively correlated to growth.

The financial and institutional quality channels argue that volatility has adverse effect on growth. Empirical work provides support to the argument (Rodrik, 1999; Aghion *et al*., 2009 and Chong and Gradstein, 2009). The human capital channel predicts a positive relationship, hence an increase in growth. Despite growing emphasis given to human capital accumulation by theoretical work, existing evidence on empirical work is scarce and inconclusive. The role of education/human capital in the growth volatility nexus is largely ignored in empirical studies and our analyses in this study fills in the gap.

The objective of this paper is to contribute to this emerging literature and revisit the channel through which the relationship between volatility and growth is mediated. We examine empirically the significance of education/human capital accumulation in the growth-volatility relationship. In this regard, our study is very close to Aghion and Banarjee (2005) who study the role of financial development in the growth-volatility relationship. Our main findings are summarized as follows. While we verify the assertion from the majority of existing studies (Ramey and Ramey 1995; Hnatkovska and Loayza, 2005; Badinger, 2010) who argue that volatility has a mitigating effect on economic growth, the implications become drastically different once we explicitly account for education. In particular, we find that, for a subset of low income and high volatility countries, the interaction of education and volatility has a positive and significant effect on economic growth.

The findings confirm the importance of education/human capital for moderating the detrimental effect of volatility on growth. Specifically, our evidence provides support to the predictions derived from the theoretical models of Blackburn and Galindev (2003), Canton (2002), Varvarigos (2008) and Blackburn and Varvarigos (2008). These studies argue that volatility generates a precautionary demand for investment in human capital; hence, it may actually promote a higher growth rate.

The paper is organized as follows. Section 2 describes the data used followed by the model methodology we adopted in section 3. Section 4 presents our findings and discussion of the results. By adopting a sample splitting technique we checked the robustness of our findings and the outcome of this exercise are presented in section 5. Section 6 calculates the marginal effects of the volatility conditional on education to analyze the effect of volatility on economic growth and the computation is done at the minimum, mean and maximum level of education. Then the paper concludes.

MODEL AND METHODOLOGY

We model the per capita GDP as a function of education and several other control variables mentioned in the data description. Our constructed model is dynamic, where we allow the persistence of other determinants due to slow adjustment to changes (see Baltagi *et al*., 2009; Bobba and Coviello, 2007). Hence, we estimate the following model:

$$GR_{it} = \alpha + \beta_1 \ln Y_{i,t-1} + \beta_2 \ln EDUC_{i,t-1} + \beta_3 VOL_{i,t-1} + \beta_4 X_{i,t-1} + \mu_{it} \quad (1)$$

i and t represent country and 5-year interval time period respectively. GR_{it} is the growth rate proxied by the log difference of the real GDP per capita. $Y_{i,t-1}$ is the initial real GDP per capita which captures the convergence effects. The independent variables are: $EDUC_{i,t-1}$which is the years of schooling, $VOL_{i,t-1}$ is the volatility of output and $X_{i,t-1}$ is a vector of control variables mentioned in the data section above. The error term, μ consists of country and time-specific effects and is given by:

$$\mu_{it} = \eta_i + \gamma_t + \varepsilon_{it} \quad (2)$$

η_i denotes the country specific effects that are time invariant for example geographical location. γ_t is the time specific fixed effects which is able to capture the effect crises experience by countries in the sample. ε_{it} is independent and identically distributed with mean 0 and constant variance σ^2 .

To investigate whether the impact of volatility is conditional on human capital investment, we expand the above equation by including an interaction term of education and volatility. This is a key aspect of our analysis in this paper. The interaction term is estimated by adding $\beta_5(lnEDUC_{i,t-1} * VOL_{i,t-1})$ to equation (1) as follows:

$$GR_{it} = \alpha + \beta_1 \ln Y_{i,t-1} + \beta_2 \ln EDUC_{i,t-1} + \beta_3 VOL_{i,t-1} + \beta_4 X_{i,t-1} + \beta_5 (\ln EDUC_{i,t-1} * VOL_{i,t-1}) + \mu_{it} \quad (3)$$

Our main variable of interest is the interaction term which examines whether the volatility-growth relationship varies with years of education. Lagging the explanatory variables by one period is useful to address the strong assumption of exogeneity, which entails zero covariance between the regressors and the error term. It also eliminates the potential bias in the estimates that comes from contemporaneous shocks to growth and any of our explanatory variables (Baltagi *et al*., 2009).

Equation (3) hypothesizes that education and volatility are significant determinants of economic growth. The interaction term between the variables is expected to support the theoretical expectations drawn by Canton (2002), Blackburn and Galindev (2003), Varvarigos (2008) and Blackburn and Varvarigos (2008). The marginal effect of education in the presence of volatility can be calculated using the partial derivatives of education with respect to volatility. Similarly, we use the partial derivatives of volatility with respect to education to calculate for the marginal effect of volatility in the presence of education. The calculations are as follows:

$$\frac{\delta GR_{it}}{\delta \ln(EDUC_{i,t-1})} = \beta_2 + \beta_5 VOL_{i,t-1} \quad (4)$$

$$\frac{\delta GR_{it}}{\delta (VOL_{i,t-1})} = \beta_3 + \beta_5 \ln EDUC_{i,t-1} \quad (5)$$

We choose the two-step system GMM estimator due to its relative advantage in improving precision and reducing finite-sample bias, (Baltagi, 2008; Blundell and Bond, 2000). This estimator is applicable in the presence of time-invariant regressor (which is volatility in our case) that is wiped out by the difference GMM estimator. It is also more appropriate than one-step system GMM due to potential autocorrelation.

The followings are the illustration of the dynamic panel system GMM technique. Consider the general form of the empirical model:

$$y_{it} - y_{it-1} = (\alpha - 1) y_{it-1} + X'_{it}\beta + \eta_i + \gamma_t + \varepsilon_{it} \quad (6)$$

Where y is the logarithm of real GDP per capita, X is the set of explanatory variables other than the lagged of GDP per capita, η is an unobserved country specific effects, γ is time-specific effects, ε is the independent and identically distributed error term, and i and t represent the country and time period, respectively. Equation (6) can be rewritten as:

$$y_{it} = \alpha y_{it-1} + X'_{it}\beta + \eta_i + \gamma_t + \varepsilon_{it} \quad (7)$$

To eliminate the country specific effects, we take the first difference of equation (7) which results in equation (8).

$$\Delta y_{it} = \alpha \Delta y_{it-1} + \Delta X'_{it}\beta + \Delta\gamma_i + \Delta\varepsilon_{it} \quad (8)$$

The system GMM overcomes the bias problems of the difference GMM estimator by taking both equations (6) and (8) together. The estimator assumes that the country specific effects are uncorrelated with the first difference of the dependent variable and the independent variables. Consequently, along with the usual assumptions of the difference GMM, system GMM has two extra moment conditions, which are the correlation between the dependent variable and the error term and the independent variables and the error term. The moment conditions are illustrated below:

$$E\ [\Delta Y_{i,t-s}, \Delta\varepsilon_{i,t}\ ] = 0, \ For\ s \geq 2,\ t = 3, \ldots T$$
$$E\ [\Delta\ X_{i,t-s}, \Delta\varepsilon_{i,t}\ ] = 0, \ For\ s \geq 2,\ t = 3, \ldots T \quad (9)$$

The efficiency and consistency of the GMM estimator depend on the absence of serial correlation and the validity of lagged values as instruments. To test for autocorrelation, we apply the Arellano-Bond test of autocorrelation. The test has the null hypothesis of no autocorrelation and test whether the differenced error term is correlated. The test rejects the null hypothesis for AR (1) but should not reject the null for AR (2). To test the validity of the instruments, we conduct the Hansen J test of over-identifying restrictions. The null hypothesis of this test is the instruments are exogenous. This test has a Chi-square distribution with j-k degrees of freedom; where j and k is the number of instruments number of regressors, respectively.

DATA DESCRIPTION

Our data comes from a panel dataset of 100 developing countries in Asia, Latin America and Africa over a 40-year period from 1970 to 2010. The sample countries are chosen based on the availability of data used. We average the variables over five-year intervals. The number of observations varies across specifications depending on the control variables used. The human capital stock is of interest, thus we utilize the Barro and Lee (2010) education data from and use the average years of schooling as a proxy for education. This dataset provides educational attainment data for 146 countries in 5-year intervals from 1950 to 2010 for the population aged 15 years and above and 25 years and above. Based on insights from the theory and previous empirical work, we control for other variables commonly used in growth regression. These include initial real GDP per capita (*Initial* GDP), investment in physical capital (*Investment*), the degree of openness (*Openness*) and population growth (*Population*).We compute growth as the log difference of real GDP per capita from PWT 7.0. Volatility is then measured as the standard deviations of average growth from 1970-2010.The major sources of our data are World Bank-World Development Indicators (2010) and Penn World Tables 7.0 (henceforth PWT 7.0).

RESULTS

Table 1 presents the estimation results. The results in column 1-3 report estimates from Pooled Ordinary Least Squares (OLS) and column 4-6 are estimates from two-step system GMM. OLS estimations show an expected positive and significant education on growth over the period. When volatility is added into the regression, the coefficient is negative and significant. The OLS result is in consistent with Ramey and Ramey (1995) among others; although the coefficient for volatility in this study is very small. The value is also lower compared to Hnatkovska and Loayza (2005) whose work controls for initial GDP, education and financial development. As expected, education has a significant positive effect on growth, but volatility has the opposite effect under both models without the interaction term, hence confirming the findings of existing literature. The results for the two-step system GMM are very close suggesting the robustness of the result. For example, controlling for other variables, increasing one year of education will contribute to growth by 0.009 percent, which is within the range of the previous estimator. When volatility is added into the regression, education loses its significance.

We then add an interaction term between education and volatility to the model. Contrary to the studies cited earlier, we do not find a positive and significant effect between education and volatility on growth as seen in column 3 and 6. However, we will further analyze the effect of volatility on growth conditional on education by calculating the marginal effects of volatility on growth at the minimum, mean and maximum level of education in the next section to show that the detrimental effect of volatility and growth is mitigated through education or investment in human capital.Confirming the convergence hypothesis, the coefficient on initial GDP per capita is significantly negative in specifications with or without the interaction term. Investment in physical capital is significant in both models. Openness to trade appears insignificant in all models. In addition, population growth is significant with the expected sign in all columns.

We note that in the two-step system GMM results all the diagnostics are satisfactory. The Hansen test does not reject the null of valid instruments. As expected, the absence of first order serial correlations is rejected while the absence of second order serial correlation is not rejected. Thus, the system GMM is the preferred and more appropriate estimator when endogeneity and weak instruments bias are taken into account. As such, we will discuss the results from system GMM estimation for the rest of the paper.

Table 1 Panel Evidence for Education and Volatility: Baseline Model

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	OLS	OLS	OLS	SYSTEM	SYSTEM	SYSTEM
Initial GDP$_{(t-1)}$	-0.007***	-0.007***	-0.008***	-0.011**	-0.013***	-0.016***
	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.005)
Education$_{(t-1)}$	0.008***	0.006**	0.016***	0.009*	0.005	0.025**
	(0.003)	(0.003)	(0.005)	(0.005)	(0.005)	(0.010)
Volatility(t-1)		-0.009***	-0.009***		-0.014***	-0.017***
		(0.003)	(0.003)		(0.004)	(0.003)
Educ$_{(t-1)}$ *Vol$_{(t-1)}$			0.001			0.003
			(0.001)			(0.002)

Table 1 (Cont.)

Investment$_{(t-1)}$	0.007*	0.006*	0.007*	0.017*	0.017*	0.013
	(0.004)	(0.004)	(0.004)	(0.009)	(0.009)	(0.014)
Openness$_{(t-1)}$	0.001	0.002	0.001	-0.004	-0.000	-0.000
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.006)
Population$_{(t-1)}$	-0.034***	-0.035***	-0.033**	-0.053**	-0.056**	-0.055*
	(0.012)	(0.013)	(0.014)	(0.026)	(0.027)	(0.031)
Constant	-0.050	-0.078**	-0.071*	-0.077	-0.132	-0.121
	(0.033)	(0.036)	(0.039)	(0.072)	(0.086)	(0.088)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	655	655	655	655	655	655
R-squared	0.156	0.181	0.206			
AR1 [*p-value*]				0.01	0.01	0.04
AR2 [*p-value*]				0.87	0.72	0.69
Hansen J [*p-value*]				0.27	0.33	0.75

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is the log difference of GDP per capita. Educ*Vol is the interaction term between education and volatility. The number of countries included in the regression is 100 developing countries. Significant time dummies are included in every regression

Robustness Check

To examine the robustness of our findings, we split the sample of countries into two categories because non-negligible changes in estimated coefficients might arise when the sample studied changes (Bergh and Henrekson, 2011) [1].Countries with real GDP per capita below (above) the mean are classified as low (high) income. Further we extend our analysis on the subset of countries according to the level of volatility. This is also done following Turnovsky and Chattopadhyay (2003) which show differences in behavior among the level of volatility within the sample considered.

Table 2 below presents the results for system GMM regressions. The results however indicate that there is no significant association between education and growth for both samples. Volatility has a significant negative effect in low-income countries suggesting the stronger and more damaging impact of volatility to their growth than to more resilient high-income economies. In contrast, volatility is insignificant in the volatility subsamples, but the effect is robust with the expected sign. The interaction of education and volatility has insignificant effect on growth for both subsets. The specifications also pass the autocorrelation tests. In addition, the over-identifying tests are satisfactory, but as previous sub-samples, the test is robust but weakened by many instruments.

[1] We do not differentiate the countries following World Bank's specification because most of the countries in the sample fall in the 'middle income' countries. If we differentiate between lower and upper middle income economies, the sample would be constrained and estimating a constrained sample of a small number of observations may cause sample selection bias.

Table 2 Panel Evidence for Education and Volatility: Robustness Check

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low Income		High Income		Low Volatility		High Volatility	
Initial $GDP_{(t-1)}$	-0.017**	-0.024***	-0.029***	-0.019	-0.008	-0.004	-0.025	-0.021
	(0.008)	(0.007)	(0.007)	(0.014)	(0.005)	(0.006)	(0.017)	(0.020)
$Education_{(t-1)}$	0.006	0.024**	-0.000	0.018	0.000	0.004	0.012	0.028
	(0.006)	(0.010)	(0.009)	(0.012)	(0.005)	(0.009)	(0.009)	(0.022)
$Volatility_{(t-1)}$	-0.013**	-0.012***	-0.011*	-0.011**	-0.004	-0.008**	-0.009	-0.009
	(0.006)	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.010)	(0.011)
$Educ*Vol_{(t-1)}$		0.003		0.001		0.001		0.003
		(0.002)		(0.002)		(0.002)		(0.005)
$Investment_{(t-1)}$	0.024**	0.016	0.006	0.003	0.016**	0.016*	0.008	0.012
	(0.012)	(0.012)	(0.013)	(0.017)	(0.007)	(0.008)	(0.014)	(0.025)
$Openness_{(t-1)}$	-0.004	0.001	0.004	0.003	-0.004	-0.003	0.015	0.014
	(0.007)	(0.008)	(0.005)	(0.006)	(0.003)	(0.003)	(0.019)	(0.021)
$Population_{(t-1)}$	-0.053	-0.058*	-0.063**	-0.041	-0.056***	-0.041**	-0.068**	-0.048
	(0.035)	(0.032)	(0.024)	(0.045)	(0.012)	(0.016)	(0.033)	(0.046)
Constant	-0.094	-0.062	0.034	-0.006	-0.112**	-0.117**	-0.097	-0.097
	(0.112)	(0.096)	(0.100)	(0.116)	(0.056)	(0.058)	(0.107)	(0.149)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	392	337	263	226	422	362	233	201
AR1 [*p-value*]	0.02	0.08	0.01	0.02	0.00	0.00	0.02	0.10
AR2 [*p-value*]	0.81	0.84	0.62	0.99	0.97	0.25	0.96	0.83
Hansen J[*p-value*]	0.99	1.00	1.00	1.00	0.99	1.00	1.00	1.00

Notes: Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The dependent variable is the log difference of GDP per capita. Educ*Vol is the interaction term between education and volatility. Low-income countries consist of 59 countries and high-income countries consist of 49 countries. Low-volatility countries consist of 61 countries and high-volatility countries consist of 39 countries. Significant time dummies are included in every regression.

Marginal Effects of Volatility Conditional on Education

To analyze the effect of volatility on economic growth conditional on education, we calculate the marginal effects of volatility on growth at the minimum, mean and maximum level of education. This is done to show that the importance of education in mitigating the damaging effect of volatility on economic growth. The results for the derivatives of volatility are reported in Table 3. We can see that for each method, the negative effect of volatility becomes smaller with higher years of education. For example, for the pooled OLS, at the minimum years of education (-1.609), volatility is expected to decrease growth by 0.012 percent but the effect is reduced to 0.007 at the mean years of education (1.313). For system GMM, the negative effect of volatility is reduced from 0.021 to 0.011 from the minimum to maximum years of education for the sample countries.

The above result is considered the main contribution of our paper. Volatility is harmful for growth and the effect of education is not always positive and significant, but it is proven to mitigate the harmful effect of volatility on growth. Theory provides the intuition behind our significant marginal effects. Volatility induces a precautionary investment in education. A corresponding interpretation is that during recessions, individuals invest more in human capital than in physical capital to improve their employment prospects. This is because, education is an effective guard in bad times; educated and skilled workers are more likely to be hired during recessions compared to unskilled or uneducated workers.

We observe a similar result for different levels of income; i.e. dividing the sample does not change the main result. On the other hand, when we compare the low and high volatility countries, the results differ significantly. With more education, the low volatility countries have the ability to reduce the damaging effect of volatility on growth. However, higher years of education do not significantly affect the level of volatility for the high volatility subset.

We find support for our hypothesis; although the interaction effect is insignificant, the overall effect (calculated from the derivatives) shows that education has a mitigating effect on volatility. The findings are true regardless of level of income although and in less volatile countries. A possible explanation is that as countries are more developed, they have the financial and institution quality necessary to make them resistant to the effects of volatility. The result is also consistent with the fact that if volatile countries are very low-income countries, promoting and investing more education will help to increase economic growth.

Table 3 Marginal Effects of Volatility on Economic Growth Conditional on Education

	Evaluated at		
Specification	Minimum	Mean	Maximum
Pooled OLS	-0.012**	-0.007**	-0.006
	(0.004)	(0.003)	(0.004)
System GMM	-0.021***	-0.013***	-0.011**
	(0.005)	(0.004)	(0.005)
Level of Income			
i) Low	-0.016**	-0.009*	-0.006
	(0.006)	(0.005)	(0.007)

Table 3 (Cont.)

ii) High	-0.013**	-0.009*	-0.008
	(0.006)	(0.005)	(0.006)
Level of Volatility			
i) Low	-0.009*	-0.007**	-0.007
	(0.005)	(0.004)	(0.005)
ii) High	-0.013	-0.005	-0.002
	(0.014)	(0.013)	(0.017)

CONCLUSIONS

This paper shows the role of education in understanding the growth-volatility nexus. We find education as a channel to alleviate the adverse effect of volatility on growth. This complements the predictions of the stochastic growth models that examine the impact of volatility on economic growth and the importance of human capital in this relationship. In our case, education serves to minimize the negative impact of volatility. Robustness checks on our work reveal that the extenuating effect of education does not depend on a country's level of income, but is only significant for low volatility countries.

Our empirical work sheds an important insight on the mechanism through which volatility impacts growth. The intuition behind the results is that education enhances productivity, innovation and facilitates entrepreneurship when in turn lead to growth. The result suggests the fact that the relationship between growth and volatility is attributed to years of schooling or education. It also provides evidence that economic growth and incidence of growth volatility are fundamentally linked with endogenously determined structural variables such as human capital accumulation. Therefore, the interaction of education with business cycle fluctuations needs to be considered explicitly in the future for a better understanding of the growth-volatility link. From a policy perspective, there is a merit in continuous investment in education even during economic crisis to abate the detrimental effect of volatility instead of engaging in austerity measures which often include public expenditure cuts.

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