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Education in the Growth-Volatility  
Relationship**

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# Panel data Evidence on the Role of Education in the Growth-Volatility Relationship

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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. Using a panel data, we show empirically how the detrimental effect of output volatility on growth is diluted by education. We provide robustness checks and policy implications of our finding.*

**Keywords:** Growth, volatility, education, dynamic system (GMM)

**JEL classification:** E32, F43, O40, O49.

## 1. Introduction

Despite the fact that, traditionally, long-term growth and short-term cyclical volatility have been treated as distinct economic phenomena that should be analysed 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.<sup>2</sup>

The purpose of this paper is to contribute to this emerging literature by examining empirically the significance of education/human capital accumulation in the growth-volatility relationship. Our main finding can be summarised 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 countries, the interaction of education and volatility has a positive and significant effect on economic growth. Our evidence provides support to the predictions derived by the theoretical models of Blackburn and Galindev (2003), Canton (2002), Varvarigos (2008) and Blackburn and Varvarigos (2008), who argue that volatility generates a precautionary demand for investment in human capital; hence, it may actually promote a higher growth rate. Specifically, Canton (2002) constructed a stochastic two-sector model of endogenous growth to analyze the impact of cyclical volatility on long term growth. His model predicted that growth will be higher during business cycle fluctuations because people engage in precautionary savings and dedicate more for human capital accumulation. Aghion and Banerjee (2005) discuss the two

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<sup>2</sup> Theoretically, the relationship between growth and volatility is analysed in the papers by Dotsey and Sarte (2000); Blackburn and Galindev (2003); Blackburn and Pelloni (2004); Varvarigos (2007, 2008); Blackburn and Varvarigos (2008) among others. Empirical analyses on the issue include the papers by Ramey and Ramey (1995); Hnatkovska and Loayza(2005); Badinger (2010).

ways through which volatility affects growth. First, it is through precautionary saving and second through its effect on long term investment under imperfect credit market. Varvarigos (2007; 2008) and Blackburn and Galindev (2003) build an overlapping generation model and conjecture the presence of a ‘high growth/high welfare’ equilibrium and elimination of growth volatility when there is sufficiently high share of public education. In a stochastic model, Blackburn and Galindev (2003) shows that the link between growth and volatility is prone to be positive if technological changes are driven by internal learning. Despite a growing emphasis given to human capital accumulation by theoretical work, its role in the growth-volatility nexus is largely ignored in empirical work (Badinger, 2010; Ramey and Ramey, 1995).

## 2. Data and Descriptive Statistics

Our data comes from a panel data of 100 developing countries in Asia, Latin America and Africa over a 40 year period from 1970 to 2009. The data on education is reported in five year intervals. Hence, we considered 5-year averages of all other variables. The sources of our data are the World Development Indicators (WDI) of the World Bank and Penn World Tables 6.3 (henceforth PWT 6.3). As in Barro and Lee (2010), education captures the average number of years of schooling of the adult population aged 25 and above. Castello and Domenech (2002) argue that the labour force in developing countries consists of young persons. Therefore, we investigated the robustness of our results based on the sample of individuals aged 15 and above. Based on insights from theory and previous empirical work, we control for other variables such as initial real GDP per capita, investment in physical capital and trade openness (Barro and Sala-i-Martin, 1995; Podrecca & Carmeci, 2004). Volatility is measured as the standard deviation of growth from 1970-2009. Data for growth and the control variables are from PWT 6.3 and the WDI of the World Bank (2010).

## 3. Model

We model the growth of per capita GDP as a function of education, initial level of GDP per capita, investment, trade openness and volatility of output. We augment the model by adding an interaction term between education and volatility. Due to its relative advantage in improving precision and reducing finite-sample bias, we use the two-step dynamic system GMM estimator (Baltagi, 2008; Blundell et al. 2000). This estimator is preferred to difference GMM estimator in the presence of time-invariant regressors and it is more appropriate than one-step system GMM due to potential autocorrelation. Our model allows for the fact that not only growth but also other determinants such as education can be persistent because of slow adjustment to changes (Baltagi et al. 2009; Bobba and Coviello, 2007). Hence, our growth (t) model is given by;

$$GR_{it} = \beta_0 + \gamma GR_{it-1} + \delta Y_{i0} + \beta_1 E_{it-1} + \beta_2 VOL_{it-1} + \beta_3 (E_{it-1} * VOL_{it-1}) + \beta_4 X_{it-1} + u_{it} \quad (1)$$

where GR is the growth rate of country i at year t defined as the log difference in real GDP per capita between time t and t-1. The lagged value of GR is included on the right hand side to capture persistence and mean-reverting dynamics in growth. Y is the initial real GDP per capita which captures convergence effects. E is education; VOL is output volatility and X represents a vector of other relevant variables. The error term, u consists of country and time-specific effects and is given by;  $u_{it} = \eta_i + \varepsilon_t + v_{it}$  where v is iid  $(0, \sigma^2)$ . The main variable of interest is the

interaction term which examines whether the growth -volatility relationship varies according to the average 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  $v_{it}$ . 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).

#### 4. Results

The key results are presented in table 1 which reports estimates from Pooled Ordinary Least Squares (panels A1 & B1) and dynamic two-step system GMM (panels A2 & B2). All estimations are conducted after removing outliers<sup>3</sup>. While panels A1 and A2, respectively, provide estimates without the interaction term of education and volatility for Pooled OLS and system GMM estimators, panels B1 and B2 give their counterparts with interaction. As expected, education has a significant positive effect on growth. But volatility has the opposite effect under both models without the interaction term (Ramey and Ramey, 1995; Hnatkowska and Loayza, 2005). In models with the interaction term, the negative influence of volatility disappears and becomes significantly positive. Some studies find a positive effect of volatility on growth but the transmission channels are explicitly spelt out (Caporale and McKiernan, 1998). We show that education is a key route through which we observe a significant positive growth-volatility relationship. Theory provides the intuition behind our significantly positive interactive term. Volatility induces precautionary savings and individuals invest in education during crisis times to mitigate future risk. During recessions, individuals invest more in human capital than in physical capital accumulation to improve their employment prospects. Confirming the convergence hypothesis, the coefficient on initial GDP per capita is significantly negative in specifications with or without the interaction term.

We note that in the two-step dynamic system GMM results all the diagnostics are satisfactory. The Hansen test does not reject the null of valid instruments. However, Baltagi (2008) and Roodman (2009) highlight the potential bias in the estimated results that come from instrument proliferation. Even if there are efficiency improvements, the problem of too many instruments is a valid concern in the GMM estimation framework because it weakens the Hansen/Sargan tests for overidentifying restrictions. The instrument proliferation arises because the number of moment conditions increases with T. Therefore, we also estimated our models to create one instrument for each variable and lag distance, rather than one for each time period, variable and lag distance. This avoids the bias coming from too many instruments even if it reduces statistical efficiency<sup>4</sup>. As expected, the absence of first order serial correlations is rejected while the absence of second serial correlation is not rejected.

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<sup>3</sup> We conduct the GRUBBS test for outliers.

<sup>4</sup> The additional results with reduced number of instruments show the validity of the overidentifying restrictions both for the results in tables 1 and 2 and are available upon request.

**Table 1: The Growth-Volatility Link with and without interaction with Education**

Dep. Variable	Pooled		Two-Step GMM Dynamic Panel	
	OLS		Model	
Growth(t)	(A1)	(B1)	(A2)	(B2)
Growth(t-1)	0.0013 (0.085)	-0.000677 (0.087)	-0.0743 (0.102)	-0.0716 (0.103)
	0.0048**			
Schooling(t-1)	* (0.001)	0.0006 (0.002)	0.0077*** (0.003)	0.0010 (0.003)
Volatility(t-1)	-0.1900* (0.099)	-0.340** (0.152)	-0.1941** (0.0951)	-0.384*** (0.144)
Schooling*Volatility		0.0503** (0.022)		0.0604** (0.025)
	-	-		
Initial GDP(t-1)	0.0032** *	0.0030** *	-0.0041*** (0.002)	-0.0035** (0.002)
Investment(t-1)	0.0012 (0.001)	0.0016 (0.002)	-0.0012 (0.004)	0.0011 (0.004)
Openness(t-1)	0.0013 (0.001)	0.0013 (0.001)	0.0013 (0.002)	0.0005 (0.002)
Time Effects	Yes	Yes	Yes	Yes
Constant	0.0269** *	0.0279** *	0.0397*** (0.010)	0.0377*** (0.011)
Observations	655	655	655	655
R-squared	0.154	0.168	-	-
AR(1), p-value	-	-	-1.88(0.060)	1.94(0.053)
AR(2), p-value	-	-	0.56(0.576)	0.50(0.614)
Hansen test( p-value)	-	-	77.15(0.32)	76.51(0.34)

Notes: Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## 5. Robustness Check

To examine robustness of our finding, 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). Countries with real GDP per capita below (above) the mean are classified as low (high) income. Further, we split countries into low and high volatile economies based on whether their volatility level is below and above the mean respectively<sup>5</sup>. For brevity, table 2 presents only GMM based estimates with the interaction term. The four columns provide the results for low and high income (Y) countries and low and high volatile (V) economies. Volatility is significantly negative in low income countries suggesting the stronger

<sup>5</sup> Further robustness check includes examining whether our result holds when we consider the schooling of those aged 15 & above which show no qualitative changes (e.g. sign reversal and statistical significance). We provide these results upon request.

and more damaging impact of volatility to their growth than to more resilient high income economies. Volatility is detrimental to growth only in low volatile economies. The positive and significant interaction term holds only for low income and low volatility economies. A probable explanation is that as countries are more developed, they have the institutions, resilience and policies that counteract the damaging effects of volatility. As in table 1, we do not reject the over-identifying restrictions for the results reported in table 2 below. Further estimations reveal that the test results are satisfactory with or without restrictions on the instrument set used for estimation. The specifications also pass the autocorrelation tests by rejecting the absence of first order serial correlation but not the absence of second order serial correlation.

**Table 2: Robustness Checks by level of income(Y) and severity of volatility (V)-25 & above**

Dep. Variable Growth(t)	Two Step Dynamic GMM Estimator			
	Low Y	High Y	Low V	High V
Growth(t-1)	-0.116 (0.134)	0.0419 (0.104)	0.0783 (0.100)	-0.157 (0.133)
Schooling(t-1)	-0.00303 (0.00384)	0.00226 (0.00520)	0.000794 (0.00226)	-0.00633 (0.00715)
Volatility(t-1)	-0.433** (0.166)	-0.237 (0.181)	-0.355* (0.201)	-0.200 (0.404)
Schooling(t-1)*Volatility(t-1)	0.0743* (0.0371)	0.0359 (0.0361)	0.0660** (0.0274)	0.0711 (0.0539)
Initial GDP(t-1)	-0.00497 (0.00346)	-0.0114*** (0.00291)	-0.00435*** (0.00122)	-0.00280 (0.00267)
Investment(t-1)	0.0116** (0.00477)	-0.00496 (0.00446)	0.00239 (0.00279)	0.00375 (0.00815)
Openness(t-1)	-0.00297 (0.00256)	0.00271 (0.00233)	-0.00220* (0.00129)	0.00420 (0.00515)
Time effects	Yes	Yes	Yes	Yes
Constant	0.0362* (0.0216)	0.113*** (0.0252)	0.0471*** (0.00986)	0.00464 (0.0236)
AR(1), p-value	-1.77(0.07)	-2.44(0.01)	-4.05(0.00)	-1.43(0.15)
AR(2), p-value	0.27(0.78)	0.88(0.38)	1.01(0.31)	-0.03(0.97)
Hansen test(p-value)	41.84(0.99)	25.03(1.00)	43.41(0.99)	31.97(1.00)
Observations	392	263	422	233

Notes: Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## Conclusions

This paper shows the role of education in understanding the growth-volatility link. Taken along, volatility is detrimental to growth but its joint interaction with education yields a significantly positive impact on growth. Our empirical analysis reveals that education can be the mechanism through which volatility impacts growth positively. Our result is congruent with predictions of theoretical models that explicitly consider education as an engine of growth and also those that examine the impact of public policy (e.g. expenditure on education) on the growth-volatility nexus. We argue that education serves to dilute and eradicate the impact of volatility. However,

robustness checks reveal that the significantly positive interaction term depends on a country's level of income and volatility. The possible explanation of the positive interaction term is that education promotes productivity, innovation and facilitates entrepreneurship which in turn leads to growth. The link between growth and volatility is attributed to public economics issues and fundamentals such as education. We provide evidence that growth rates of economies and incidence of growth volatility are inherently linked with endogenously determined structural variables such as education. Therefore, the interaction of education with business cycle fluctuations needs to be considered explicitly 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 diffuse the detrimental effect of growth in the future instead of engaging in austerity measures which often include wholesale public expenditure cuts including funding for education.

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