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GROWTH AND VOLATILITY

ABSTRACT

This paper has two objectives. First, to establish empirically a U-shaped relation between GDP growth rate and income volatility. The backward as well as the fast-growing countries have had extensive volatility; but developed nations by contrast have enjoyed much more stable income. Second, to present a macroeconomic model to study how growth and volatility evolve together. The twin endogenous variables are financial liberalization interacting with liquidity constraints. Opening LDC financial markets could raise or lower their long-term income and growth rates, depending on the severity of existing liquidity constraints. Financial liberalization and removing financial market imperfections unambiguously worsen income volatility. (*JEL* E32, O16)

There is little doubt that economic development profoundly influences and is influenced by the social, economic and political fabrics of a society. In this complex interaction several key variables evolve together and their co-movements are well-documented in the literature. Simon Kuznets (1955) discovers the inverted-U-shaped relation between GDP per capita and the distribution of income. Robert Barro and Xavier Sala-i-Martin (1991, 1992, 1995), Robert Barro, Gregory Mankiw and Xavier Sala-i-Martin (1995), Gregory Mankiw, David Romer and David Weil (1992), Peter Klenow and Andrés Rodríguez-Clare (1997) and others find a negative relation between income and growth rate and thus establish with varying degrees of confidence a pattern of income convergence. Mariano Torras and James Boyce (1998), Hemamala Hettige, Muthukumara Mani and David Wheeler (2000), and Erwin Bulte and Daan van Soest (2001) find a Kuznet-type of relation between GDP per capita and some pollution indices.

Is the speed of growth also related to volatility and business cycles? The first of two objectives of this paper is to unify some conflicting evidence that has emerged in the recent literature. Roger Kormendi and Philip Meguire (1985), Inspired by Fisher Black (1979) who argues that high returns are necessary rewards to risk taking, show that mean real GDP growth rates over the period of 1950's to 70's for forty-six countries are *positively* and significantly related to the standard deviation of real GDP growth rates over the same period. Their reported regression coefficient of 0.53 implies that emerging countries such as South Korea, which has had mean growth rate (7.3 percent) roughly twice of that of the US (3.5 percent)[1], would expect about fifty percent higher income volatility (3.8 percent standard deviation of growth rates for Korea vis-à-vis 2.7 percent for US). Kevin Grier and Gordon Tullock (1989), using a wider pooled sample of 113 countries, again find a *positive* and significant regression coefficient of 0.17. However, when Grier and Tullock (1989) divide the sample into regions, the coefficient is positive and significant only for Africa (0.152), but *negative* and not significant for Americas

(-0.051) and Asia (-0.133). Contrarily, Garey Ramey and Valerie Ramey (1995) use a 92-countries Robert Summers and Alan Heston (1991) data and find that "countries with higher volatility have *lower* growth" (p.1138).[2]

Section I of the present paper establishes, using two separate data sets to improve robustness, a snap-shot U-shaped relation between grows and volatility (see Figure 1). The backward and often negative-growth countries, many of them from Africa, and the fastest growing ones, many of them from Asia, have suffered the greatest volatility. The developed countries on the other hand, mainly from Europe and North America, have enjoyed much more stable income by comparison.

Put Figure 1 about here

What lie behind this proposed U-shaped growth-volatility relation? First of all, agrarian societies and those relying on primitive production are particularly vulnerable to floods, droughts, diseases and other natural calamities. This probably explains why poor and contracting African countries suffer from extraordinary volatility. Unfortunately, for those embarking on an industrialize drive, the road to prosperity is equally treacherous and unyielding. Historians (Eric Hobsbawm, 1968; Alexander Gerschenkron, 1962; Douglass North and Robert Thomas, 1973; Nathan Rosenberg and L.E. Birdzell, Jr. 1986) have described how industrialization in England and Europe brought *revolutionary* changes to their economies and their societies. In many ways the experience of newly industrializing countries is also harrowing. As followers they have to catch up, which necessitates growing at an extraordinary speed. Led by Japan, Asian countries such as Korea, Taiwan, Hong Kong and Singapore have sustained a remarkable growth rate of five to seven percent over several decades. Such results however are often achieved by targeting

certain growth industries at the expense of diversification.[3] Daron Acemoglu and Fabrizio Zilibotti (1997) and Aart Kraay and Jaume Ventura (2001) show that a risk-return tradeoff explains the positive association between growth and volatility. Mature capitalist economies on the other hand, well-diversified and grew steadily at two to three percent per annum, have enjoyed much lower volatility by comparison as they sit 'comfortably' at the trough of the U-shaped relation shown in Figure 1.

But diversification is unlikely to account for everything behind the growth-volatility nexus. The recent financial crises in Asia and South America have revealed itself to be a clear suspect for investigation. A large literature now exists on capital flows, liquidity constraints, and financial market development. Many have established theoretically (Jeremy Greenwood and Boyan Jovanovic, 1990; Valerie Bencivenga and Bruce Smith, 1991; Gilles Saint-Paul, 1992; Valerie Bencivenga, Bruce Smith and Ross Starr, 1996) and empirically (Geert Bekaert, Campbell Harvey and Christian Lundblad, 2001) that financial market development sustains growth. Nobuhiro Kiyotaki and John Moore (1997) show that liquidity-constrained markets rely on collaterals such as properties to secure loans, leading to a mechanism that magnifies business cycles. More recently and after the Asian financial crisis of 1997 Guillermo Calvo (1998) and Enrique Mendoza (2001) argue that it is the “sudden stops” instead of foreign fund inflows that cause a crash. Graciela Kaminsky and Reinhart Carmen (1999) point out that financial liberalization often precedes such sudden stops. Roberto Chang and Andres Velasco (2001) demonstrate that financial liberalization can aggravate the illiquidity of banks, thus increases their vulnerability.

All these models just mentioned focus on either growth or volatility, but *not* the joined evolution of both. The second half of the present paper therefore attempts to build a macroeconomic model to complement the above literature. It establishes that financial

liberalization in liquidity-constrained countries can either promote or retard growth, but it must unambiguously increase volatility. This conclusion is consistent with a view that seems to be gaining momentum at present (Christopher Gilbert, Andrew Powell and David Vines, 1999; Paul Collier and Jan Willem Gunning, 1999), which argues that premature financial liberalization has been flawed and financial institutions such as the IMF and the World Bank should redefine their roles in facilitating economic development and in crises management. The model presented below lends theoretical backing to such policy recommendations. Another novel result emerges from this model that removing financial market imperfection also worsens income volatility.

The following sections are organized as follows. Section I shows, using the Summers and Heston (1991) data and the World Bank (1995) World Data separately, that a U-shaped curve exists between growth and volatility. Section II presents a macroeconomic model to explain the tail part of the U-shaped curve. Section III concludes the paper.

I. The Empirics of Growth and Volatility: a U-Shaped Curve

Ramey and Ramey (1995, p.1140) find, using a 92-country Summers and Heston (1991) sample from 1962 to 1985 (data reproduced in Table 1 below),

$$\overline{\Delta y_i} = \underset{(7.7)}{0.030} - \underset{(-2.3)}{0.154}\sigma_i, \qquad R^2 = 0.057 \tag{1}$$

where $\overline{\Delta y_i}$ is mean per capita annual growth rate from 1962-85 and σ_i is its standard deviation. Ramey and Ramey (1995) also use OECD country samples (not reproduced here), and the coefficient for σ_i turns out to be positive but not significant (+0.147, t statistics is 0.67), R^2 = 0.02. When controlling for initial investment share of GDP, initial population growth rate, initial human capital, initial per capita GDP and other trend variables, both the Summer and Heston

sample and the OECD sample yield a consistently negative and significant coefficient (for Summer and Heston -0.178, t statistics -2.43; for OECD -0.949, t statistics -4.09). From this they conclude that "countries with higher volatility have lower growth." (p.1138).

Put Table 1 about here

Put Figure 2 about here

The weak R-square reported in Ramey and Remay's study just quoted is a matter of concern. Since growth rate and standard deviation are probably both endogenously determined, it matters little as to which one to put on the Y-axis, and Figure 2 plots standard deviation against mean growth rate from the 92-country sample. On inspection it is not clear if the relation is really linear. Again using the 92-country data, putting instead standard deviation as the dependent variable and adding a quadratic term, the OLS regression result turns out to dominate the linear regression (1)

$$\underset{\quad (13.74)}{\sigma_i = 6.42} \; - \; \underset{\quad (-3.07)}{1.02\overline{\Delta y_i}} \; + \underset{\quad (2.21)}{0.13\overline{\Delta y_i}^{\,2}} \qquad R^2 = 0.11. \tag{2}$$

A U-shaped curve clearly gives a better fit to the data than the linear model in Ramey and Ramey (1995).

The regression can be fined in a number of ways. In Figure 2 only six out of the 92 have standard deviation above 10 percent. These countries are, in descending order of standard deviation Iraq (17.47%), Nicaragua (13.35%), Uganda (12.59%), Iran (11.21%), Algeria (11.64%) and Syria (10.25%). Historical record readily shows that each of these seven countries

suffered either protracted war or national disasters during this period of 1962 to 1985.[4] Eliminate the six countries the remaining 86-countries yields

$$\underset{\quad\ (20.65)\ \ (-5.48)\ \ (4.17)}{\sigma_i = 5.84 \ - \ 1.08\overline{\Delta y_i} \ + 0.15\overline{\Delta y_i}^{\,2}} \qquad R^2 = 0.26 \tag{3}$$

which is a significant improvement from both regressions (1) and (2).

Splitting the U-shaped curve into three piece-wise linear segments yields further insights. The first group, taken as those with mean growth rate less than two percent per year, thirty-eight countries in total, yields the following OLS relation

$$\underset{\quad\ (18.9)\ \ (-2.44)}{\sigma_i = 6.02 \ - \ 0.64\overline{\Delta y_i}} \qquad R^2 = 0.14. \tag{4}$$

Eighteen of the twenty-two African countries fall into this category, and eight among them have negative mean annual growth rates from 1962 to 1985. Regression (4) implies that a one percent *slower* growth, such as Liberia's –0.83 percent compared to Malawi's 0.88 percent, would lead to a 2/3 percentage point *rise* in volatility (Malawi's standard deviation is 5.31 percent compared to Liberia's 6.22 percents).

The second group, taken as those with mean growth rate between two to three percents, twenty-five countries in total, yields an insignificant OLS coefficient for mean growth rate -0.05 with t-ratio –0.04 and R-square 7.05×10^{-5}. For this group growth is not related to volatility, which has a mean standard deviation of 3.83 percents. The US, UK, Germany, France and most other European developed nations are found in this category.

The third category, taken as those with mean growth rate greater than three percent per annum, twenty-two countries in total, yields the following OLS result

$$\underset{\quad\ (1.19)\ \ (2.66)}{\sigma_i = 1.28 \ + \ 0.63\overline{\Delta y_i}} \qquad R^2 = 0.26. \tag{5}$$

Although several European countries such as Norway, Finland and Italy fall into this category, rather more conspicuous are several newly industrializing countries, namely South Korea, Singapore, Hong Kong and Taiwan situated at the tail end of the U-shaped curve with high growth rate and standard deviation up in the 4-percent region. Regression (5) implies that a one percent *faster* growth rate is associated with 2/3-percentage point *greater* volatility (compare Singapore's 5.9 percent growth and 4.46 percent standard deviation with Thailand's 3.82 percent growth and 2.97 percent standard deviation).

To boost robustness the above exercise is repeated on a 66-country sample extracted from the World Bank's World Data of 1995. The list of countries with their 29-year mean growth rates and standard deviation of annual growth from 1964-1993 is presented in Table 2. The scattered plot of the sample is presented in Figure 3.[5]

Put Table 2 about here

Put Figure 3 about here

The quadratic regression equation for the 66-country data is

$$\sigma_i = \underset{(11.49)}{5.01} - \underset{(-3.94)}{1.21}\overline{\Delta y_i} + \underset{(5.03)}{22.07}\overline{\Delta y_i}^2 \qquad R^2 = 0.3. \tag{6}$$

and it clearly bears a close resemblance to that from Summers and Heston data reported in regression (3) above.

Instead of splitting into piece-wise categories, two debt-related explanatory variables are obtained -

(1) debt/GDP(1993) = total debt stock at year t / GDP at 1993 (last year of data);

(2) $\%\Delta debt(71-93)$ = [debt/GDP(93)-debt/GDP(71)]/ [debt/GDP(71)].

A quadratic regression including the two debt-related variables for the 66-country data gives

$$\sigma_i = \underset{(6.38)}{3.96} - \underset{(-2.42)}{0.83}\overline{\Delta y_i} + \underset{(4.04)}{18.44}\overline{\Delta y_i}^{\,2} + \underset{(1.14)}{0.01} debt/GDP(93) + \underset{(2.04)}{0.78}\,\%\,\Delta\, debt(71-93) \tag{7}$$

with R^2 = 0.36. Again the U-shaped relationship between growth and volatility is clear discernable. In addition, increase in indebtedness has a positive and significant impact on volatility.

Two possible explanations for the U-shaped curve, such as climatic uncertainty on its falling segment, and risk-return tradeoff on the rising segment, were briefly examined in the introductory section above. It was argued that the impact of external debt on growth and volatility is not well understood. Debt, growth, and volatility, are all likely to be endogenously determined. More truly exogenous variables are liquidity constraints in consumption and investment, or financial liberalization that is often used as a condition for securing loans. How would they interact in the evolution of growth and volatility? In order to shed light on this question a simple model is presented in the next section.

II. Growth, Volatility and Liquidity Constraints: a Theoretical Exploration

Consider the accounting identity at time t between income Y, foreign capital net inflow F, consumption C, investment I, government expenditure G (assumed exogenous):

$$Y_t + F_t = C_t + I_t + G_t\,. \tag{8}$$

In order to put liquidity constraints and financial liberalization center-stage, the dynamic character of this system of income determination arises from capital *flow* F_t, which is linked to the past via interest payments on accumulated debt *stock*.[6]

Financial liberalization refers to measures that open a country's financial market to foreign influences: abolishing credit controls, deregulating interest rates, relaxing entry into the banking and the financial services industry, privatizing the banking sector, and freeing international capital-flows. The World Bank often advocates these policies as conditions to grant development loans, and the IMF would use them as conditions for extending help in crisis management. As policy measures it will be treated as exogenous in what follows. A distinguishing characteristic of financial liberalization is that it can be implemented within a relatively short period of time.

By contrast, another set of variables, to be called 'liquidity constraints' below, evolves only slowly and it cannot be easily altered by government or institutional policies. There exists evidence in the literature indicating especially in less developed countries that consumption (Robert Hall, 1978; Tullio Jappelli and Marco Pagano, 1989), and investment (Carolyn Jenkins, 1998; Joshua Greene and Delano Villanueva, 1991; Leonce Ndikumana, 1999, 2000), are both subject to liquidity constraints. For instance, the manner and the ease with which credits are extended and secured evolve with the social culture and the economic habits of a nation. Jappelli and Pagano (1989) report that nearly half (45%) of all housing loans in the US and the UK are extended to homebuyers 29 years or younger, but this occurs much more rarely in Japan and Italy (17% and 21% respectively). They also show that such phenomena owe at least partly to liquidity constraints being less tight in the US and the UK. In many instances liquidity constraints reflects market imperfections, which are so ingrained into supply and demand behavior that only democratization, strengthening of the rule of law, adoption of international

accounting and banking practices are capable of relaxing liquidity constraints. Further, market imperfections abound in investment credits allocation in LDCs such as Indonesia, Thailand, the Philippines or China PRC. Those who have close connections (guan-xi in China and cronyism in Indonesia) with central government or bank officials invariably have easier access to money credits than others. Like financial liberalization, liquidity constraints are treated as exogenous in what follows. Unlike financial liberalization, they evolve slowly and will play the role of parameters instead of policy instruments.

The variables that appear in equation (8) will now be discussed in detail.

A. *Capital Flows*

The flow of foreign funds, denoted F_t, consists of two parts: *fresh loan* (denoted L_t) and *debt servicing* (rD_t, where r is exogenous and constant international interest rate and D_t is cumulated debt stock outstanding at t).[7] Hence

(9) $$F_t = L_t - rD_t .$$

Fresh loan and debt servicing will now be examined in turn.

Foreign loans reflects foreign investment, which is attracted by economic development of a country, which is in turn captured primarily by growth rates $(Y_t - Y_{t-1})$. Foreign loans can therefore be written as $\beta_0 (Y_t - Y_{t-1})$. The focus of this model is very much on β_0, which gauges how open a country is to international financial markets. A country totally closed to foreign capital markets would have $\beta_0 = 0$. Financial liberalization measures will be modeled as a rise in β_0.

(10) $$L_t = \beta_0 (Y_t - Y_{t-1}), \quad \beta_0 > 0.$$

Debt stock at *t*, D_t may be thought of as having been accumulated since a long time ago, and it is simplest and perfectly general to take it to the extreme:

(11) $D_t = L_t + L_{t-1} + L_{t-2} + ... + L_{-\infty}$.

Using equation (10) and summing,

$$\beta_0 \left(Y_t - Y_{t-1} + Y_{t-1} - Y_{t-2} + Y_{t-2} - Y_{t-3} + ... - Y_{-\infty} \right) = \beta_0 \left(Y_t - Y_{-\infty} \right).$$

For convenience and without loss of generality assume $Y_{-\infty}$ to be so negligible that both can be ignored. This gives

(12) $D_t = \beta_0 Y_t$,

and finally

(13) $F_t = \beta_0 \cdot \left[(1-r) Y_t - Y_{t-1} \right]$.

As mentioned earlier, foreign funds in the form of equation (13) link current variables to past incomes and provide the dynamic element in what follows.

B. *Consumption*

On the determination of consumption, recent empirical work has found little support for the life-cycle permanent incomes (LC-PI) theories (Marjorie Flavin, 1981; Hall and Mishkin, 1982; Fumio Hayashi 1982). Instead there is growing evidence (Hall, 1978; Jappelli and Pagano, 1989, discussed above) that liquidity constraints significantly determine consumption behavior especially in developing countries. Apart from market imperfection, liquidity constraints tighten with accumulated debt stock outstanding. The more one has borrowed, the more reluctant will lenders offer fresh loans, under a given (imperfect) market setting.

For the problem at hand a linear consumption function will suffice:

(14) $C_t = cY_t - \tilde{c}D_t$,

where $0 < c < 1$ is the marginal propensity to consume. For convenience a labeling convention will henceforth be adopted - that a parameter z reflecting liquidity constraints will be denoted $\tilde{z}$. Here $\tilde{c} > 0$ *rises* with the severity of the constraint on consumption, given the debt already incurred. The interactive term $\tilde{c}D_t$ in (14) means that a rise in D_t puts a brake on consumption. The brake is harder if $\tilde{c}$ is large, as would be the case in a country with badly-developed financial infrastructure.

C. *Investment*

Like consumption, investment is subject to liquidity constraints. Empirical evidence shows that development in the financial infrastructure encourages domestic investment but external indebtedness discourages it (Jenkins, 1998; Greene and Villanueva, 1991; Ndikumana, 2000). The idea of "debt overhang" discussed in Paul Krugman (1988) points to a similar but slightly subtler relation. A debt overhang creates a tradeoff between financing and forgiving a debt for the creditors. The debt therefore distorts domestic investment incentives since "the benefits of good performance go largely to creditors rather than itself" (Krugman (1988), p. 253). The more indebted a debt-overhang country is, the less incentive there is to invest in good projects.

Again a linear form for investment suffices to capture such liquidity-constrained investment:

(15) $I_t = \bar{I} - ir - \tilde{i}\, D_t$,

where $\bar{I}$ is autonomous (depreciation-related) consumption, i is interest-sensitivity of investment, r is the lending rate and for convenience taken to be the same as the rate on which debts are serviced. The parameter $\tilde{i}$ constrains investment given debt stock D_t. A country with a lesser developed financial market has a *higher* value of $\tilde{i}$.

D. *Long-Term Stationary Income*

Using equations (9), (12), (13), (14) and (15) in (8) and solving for Y_t yields

(16) $\quad Y_t - AY_{t-1} = K$,

where

(17) $\quad A = \dfrac{\beta_0}{(1-c) + \beta_0(1 + \tilde{i} + \tilde{c} - r)}$,

(18) $\quad K = \dfrac{(G + \bar{I} - i\,r)}{(1-c) + \beta_0(1 + \tilde{i} + \tilde{c} - r)}$.

On inspection it is immediate that $A > 0$ and $K > 0$ hold. The long-term stationary equilibrium income is given by the particular integral of the first-order difference equation (16)

(19) $\quad Y_p = \dfrac{(G + \bar{I} - i\,r)}{(1-c) + \beta_0(\tilde{i} + \tilde{c} - r)}$.

PROPOSITION 1: *Short-term financial liberalization* $\left\{\begin{matrix}\text{raises}\\ \text{lowers}\end{matrix}\right\}$ Y_p *if* $\left\{\begin{matrix}(\tilde{c} + \tilde{i}) < r\\ (\tilde{c} + \tilde{i}) > r\end{matrix}\right\}$.

PROOF. $\dfrac{dY_p}{d\,\beta_0} = \alpha\,(r - \tilde{i} - \tilde{c})$ where $\alpha = \dfrac{(G_0 + \bar{I} - i\,r)}{[(1-c) + \beta_0(\tilde{i} + \tilde{c} - r)]^2} > 0$ from (20).

Thus financial liberalization raises longer-term steady state income (and short-term growth rate en route to the steady state) *if the liquidity constraints are not too tight*, i.e. if the banking and other financial infrastructure of the economy is sufficiently well developed. The main insight from Proposition 1, however, is that *premature liberalization of the financial market lowers long-term steady state income and growth*. The reason is as follows. Financial liberalization encourages inflow of foreign debts according to equation (10). Such funds are made available for domestic spending which creates multiple expansions of current income. The resulting increase in debt, however, tightens liquidity constraints and reduces consumption and investment (equations (14) and (15)). If the constraint-induced falls in consumption and investment outweigh the initial expansion, income falls.

It is interesting to note from Proposition 1 that the higher is interest rate *r*, the less likely would financial liberalization adversely effect steady state income. The reason is that interest rate reduces net foreign fund inflow via debt servicing (equation (9)), thus curbing the funds-induced rounds of income expansion. Less debt is accumulated as a result (equations (10), (11) and (12)), and this counteracts the additional constraints on consumption and investment.

It is simple and routine to check that $\frac{dY_p}{d\tilde{c}} < 0$ and $\frac{dY_p}{d\tilde{i}} < 0$; thus long-term improvement in the financial infrastructure and the reduction in financial market imperfection *unambiguously raise* steady state income and growth. Infrastructural reform is a much safer policy than financial liberalization, as Jeffrey Sachs (1997) and Joseph Stiglitz (2001), among others, have argued repeatedly.

E. *Volatility*

The complementary function of the first-order difference equation (16) is given by

(20) $Y_c = \Phi(A)^t$,

where Φ is an arbitrary constant having a scaling effect on income volatility. Volatility is fundamentally governed by the sign and the magnitude of $A = \dfrac{\beta_0}{(1-c)+\beta_0(1+\tilde{i}+\tilde{c}-r)}$ (from equation (17)). In the World Data all relevant lending rates average to about 10 percent for the period 1964-93. In any case it is safe to assume that long-term lending rates do not persist above 100 percent per annum. The following result is then easy to establish.

PROPOSITION 2: *Suppose r<1 holds, then*

(i) *The dynamic system represented by equations (16) to (18) is stepwise convergent.*

(ii) *A rise in* β_0*, i.e. financial liberalization unambiguously worsens volatility.*

(iii) *A fall in* $\tilde{c}$ *or* $\tilde{i}$*, i.e. reducing liquidity constraints in consumption or investment, again unambiguously worsens stability.*

PROOF: First, r<1 implies 0< A <1, which establishes *(i)*.

Second, $\dfrac{dA}{d\beta_0} = \dfrac{(1-c)}{[1-c+\beta_0(1+\tilde{c}+\tilde{i}-r)]^2} > 0$, which proves *(ii)*.

Finally, $\dfrac{dA}{d\tilde{c}} = \dfrac{dA}{d\tilde{i}} = \dfrac{-\beta_0}{[1-c+\beta_0(1+\tilde{c}+\tilde{i}-r)]^2} < 0$, which proves *(iii)*.

Proposition 2*(i)* says that after an exogenous shock forces current GDP off its long-term steady state, the shock will eventual wear off but the time it takes for GDP to return to its steady state is longer the larger is the size of A.

In order to understand 2*(ii)* and 2*(iii)* it is important to understand the dynamic elements that links current variables to past variables. The stronger is such element, the longer GDP would linger off its steady state and greater would be volatility measured in terms of standard deviation of GDP. The first dynamic link hinges on β_0, which attracts foreign funds, which in turn translates into expenditures and multiple expansions in income. The bigger is β_0, the longer would such after-shocks linger on and the greater would be volatility. This explains Proposition 2*(ii)*.

But external inflows of funds accumulate into debt stocks. The second dynamic link hinges on consumption and investment, or more precisely on the brake applied on consumption and investment by external debt stock accumulated. At one extreme when liquidity constraints are prohibitively tight, any external shock in the form of external inflows of funds would be immediately dissipated before transmitting into additional consumption and investment. At the other extreme when liquidity constraints are very slack, the effect of foreign funds inflow on consumption and investment would be totally unhindered, and the multiple expansions on income would be at its maximum. This is why tight liquidity constraint *reduces* volatility and conversely, as stated in Proposition 2*(iii)*.

By way of practical implication Proposition 2*(iii)* is provocative and somewhat discouraging. While opinion have been mounting that premature financial liberalization may do more harm than good to a developing nation, few would perhaps expect removing financial market imperfection to have the perverse effect of worsening volatility. The model and the last

paragraph point out how it could happen. More empirical and theoretic research is well justified in this direction.

A final and simple result may be stated as follows.

PROPOSITION 3: *Suppose r*<1. *Increases in c or r unambiguously worsen volatility.*

PROOF: $\frac{dA}{dc} > 0$ and $\frac{dA}{dr} > 0$.

A greater marginal propensity to consume allows an external shock to have greater impact on consumption, pushing current GDP further off its long-term steady state and requiring a longer time for GDP to return to the steady state. Interest rate according to equations (9) and (13) constitutes another dynamic link between current and past income.

The effect of interest rate on volatility can be understood as follows. Suppose an external shock lifts current income temporarily to a higher level. There will be an inflow of foreign funds in response to the higher income. The higher is interest rate, income would have to stay longer above the original level in order to service the result rise in debt stock.

According to the World Data, Asian countries have $c \cong 0.64$, compared to $c \cong 0.73$ for South American countries and $c \cong 0.71$ for African countries. On this alone Asian countries should have less volatility. By the same token, the high lending rate in the 1980's may be partly to blame for the greater instability in the 1980's than the 60's. This is consistent with the view held by many in the economic and financial profession.

III. Summary and Conclusion

Though many questions about growth and volatility remain, the twin objectives set out in this essay have to a large extent been achieved. First, it has unified conflicting evidence in the literature, which sometimes reports a positive association between growth and volatility (Kormendi and Meguire (1985); Grier and Tullock (1989)), yet at other times a negative one (Ramey and Ramey (1995)). Section I above establishes that the relation is more likely a U-shaped one. Added confidence is achieved by repeating the exercise on two separate data sets - the Summers and Heston (1991) and the World Bank (1995) World Data. In addition, country indebtedness is found to have a positive impact on volatility.

It is important to emphasize that this U-shaped curve is a cross-sectional snap-shot of nations at different stages of their economic development. It is *not* a sequential growth path that a country would go through. It does not predict for instance that a poor African nation could greatly reduce her volatility by embarking on an industrialization drive. On the contrary, as the experience of newly industrializing nations has shown, the path to prosperity is indeed far from plain sailing. Just as backwardness implies a high degree of income volatility because of climatic and other uncertainties, so too is the catching up process a bumpy one albeit for a different set of reasons. Fortunately however, there is light at the end of the tunnel of growth. Successful industrialization offers not only a high level of income, but also reduced volatility, as the developed nations situated at the trough of the U-shaped curve aptly demonstrate.

The second objective of this paper is to understand what lies behind the U-shaped growth-volatility nexus. A number of plausible explanations already exist – that primitive production is at the peril of natural uncertainties, that industrialization is inherently hazardous, and that catching up implies industrial targeting and the inability to spread one's eggs in too

many baskets. What is less well understood is the impact of financial liberalization and liquidity constraints on growth and volatility. The dynamic macroeconomic model in Section II of this paper addresses this issue. A number of insights emerge from solving a first order difference equation of this model. Some of the conclusions are intuitive, others more novel and provocative.

First, financial liberalization raises long-term steady state income and thus growth rate if the liquidity constraints on consumption and investment are not too tight; but it reduces income and growth rate otherwise (Proposition 1). In addition, financial liberalization invariably and unambiguously worsens income volatility (Proposition 2(*ii*)). Countries such as Indonesia, the Philippines, or Thailand where severe liquidity constraints exist owing to extensive financial market imperfections (e.g. non-transparent banking and lending practices and primitive accounting standards), overt financial liberalization such as those recommended by international financial institutions at the beginning of the 1990's would lead not only to fluctuations but also lower long-term income. This much seems to have been borne out by the recent financial crisis in Asia.

Second, relaxation of liquidity constraints by eliminating financial market imperfections no doubt raises long-term national income and growth, but it is found to have an unambiguously adverse effect on volatility (Proposition 2(*iii*)). What lies behind this result is the fact that lower liquidity constraint opens the economy to the ebbs and flows of foreign capital, and consequently every external shock asserts greater influence on consumption, investment, and national income. This result is novel, almost provocative, and opens a new direction for research that could prove important and fruitful in the future.

Two caveats of this paper should be mentioned in closing. First, the regressions performed in Section I are meant only to establish the pattern of relations between growth and volatility, not causality. It is believed that both are determined by some other variables such as

debt, financial flows, or technology. It would indeed be interesting and important to develop more sophisticated econometric tests to discriminate between competing explanations for the growth – volatility nexus. This is left as a topic for future research.

Second, the macroeconomic system of Section II, which involves a simple first-order difference equation, strictly speaking solves for long-term steady state income only. A rise in steady state income necessitates growth in the short-term in order to reach the higher level of income. It would indeed be interesting and important to reexamine the growth – volatility relation from, for example, the angle of human capital accumulation and increasing returns. Again this is left for future research.

REFERENCES

Acemoglu, Daron and Zilibotti, Fabrizio. “Was Prometheus Unbound by Chance? Risk, Diversification and Growth,” *Journal of Political Economy*, August 1997, *105*(4), pp.709-751.

Barro, Robert J.; Mankiw, Gregory N. and Sala-i-Martin, Xavier. "Capital Mobility in Neoclassical Models of Growth." *American Economic Review*, March 1995, *85*(1), pp.103-115.

Barro, Robert J. and Sala-i-Martin, Xavier. "Convergence Across States and Regions." *Brookings Papers on Economic Activities*, 1991, 1, pp.107-82.

_____ and _____. "Convergence." *Journal of Political Economy*, April 1992, *100*(2), pp.223-51.

_____ and _____. *Economic Growth*, McGraw-Hill, NY, 1995.

Bekaert, Geert,; Harvey, Campbell R. and Lundblad, Christian. "Does Financial Liberalization Spur Growth?" National Bureau of Economic Research (Cambridge, MA) Working Paper No. 8245, 2001.

Bencivenga, Valerie R. and Smith, Bruce D. "Financial Intermediation and Endogenous Growth." *Review of Economic Studies*, April 1991, *58*(2), pp.195-209.

_____; _____ and Starr, Ross M. "Equity Markets, Transactions Costs, and Capital Accumulation: An Illustration." *The World Bank Economic Review,* 1996, 10, pp.241-265.

Black, Fisher. "Business Cycles in General Equilibrium." Unpublished MIT Working Paper (MIT, Cambridge, MA), 1979.

Bulte, Erwin H. and van Soest, Daan P. “Environmental degradation in developing countries: Households and the (reverse) Environmental Kuznets Curve.” *Journal of Development Economics*, June 2001, *65*(1), pp.225-35.

Calvo, Guillermo A. "Capital Flows and Capital-Market Crises: The Simple Economics of Sudden Stops." *Journal of Applied Economics*, 1998, 1, pp.35-54.

Chang, Roberto and Velasco, Andres. "A Model of Financial Crises in Emerging Markets." *Quarterly Journal of Economics*, May 2001, *116*(2), pp.489-517.

Collier, Paul and Gunning, Jan Willem. "The IMF's Role in Structure Adjustment." *The Economic Journal*, November 1999, 109, pp.F634-F651.

Flavin, Marjorie A. "Excess Sensitivity of Consumption to Changing Expectations about Future Income." *Journal of Political Economy*, October 1981, *89*(5), pp.974-1009.

Gerschenkron, Alexandar. *Economic Backwardness in Historical Perspective: A Book of Essays.* Cambridge: Belknap Press of Harvard University Press, 1962.

Gilbert, Christopher; Powell, Andrew and Vines, David. "Positioning the World Bank." *The Economic Journal*, November 1999, 109, pp.F599-F633.

Greene, Joshua and Delano, Villanueva. “Private Investment in Developing Countries: An Empirical Analysis.” *IMF Staff Papers*, March 1991, *38*(1), pp.33-58.

Grier, Kevin B. and Tullock, Gordon. “An Empirical Analysis of Cross-National Economic Growth, 1951-80.” *Journal of Monetary Economics*, September 1989, *24*(2), pp.259-76.

Greenwood, Jeremy and Jovanovic, Boyan. "Financial Development, Growth, and the Distribution of Income." *Journal of Political Economy*, October 1990, *98*(1), pp.1076-1107.

Hall, Robert E. "Stochastic Implications of the Life-Cycle Permanent Income Hypothesis." *Journal of Political Economy*, 1978, *86*(6), pp.971-87.

_____ and Mishkin, Frederic S. "The Sensitivity of Consumption to Transitory Income: Estimates from Panel Data on Households." *Econometrica*, March 1982, *50*(2), pp.461-81.

Hayashi, Fumio. "The Permanent Income Hypothesis: Estimation and Testing by Instrumental Variables." *Journal of Political Economy*, October 1982, *90*(5), pp.895-916.

Hettige, Hamamala,; Mani, Muthukumara and Wheeler, David. "Industrial pollution in economic development: The environmental Kuznets curve revisited." *Journal of Development Economics*, August 2000, *62*(2), pp.445-76.

Hobsbawm, Eric J. *Industry and Empire: An Economic History of Britain since 1750*. New York: Penguin, 1968.

Jappelli, Tullio and Pagano, Marco. "Consumption and Capital Market Imperfections: An International Comparison." *American Economic Review*, December 1989, *79*(5), pp.1088-1105.

Jenkins, Carolyn. "Determinants of Private Investment in Zimbabwe." *Journal of African Economies*, 1998, *7*(1), pp.34-61.

Kaminsky, Graciela L. and Carmen, Reinhart M.. "The twin crises: The causes of banking and balance-of-payments problems." *The American Economic Review*, June 1999, *89*(3), pp.473-500.

Kiyotaki, Nobuhiro and Moore, John. "Credit Cycles," *Journal of Political Economy*, April 1997, *105*(2), pp.211-48.

Klenow, Peter J. and Rodríguez-Clare, Andrés. "Economic Growth: A Review Essay." *Journal of Monetary Economics*, 1997, 40, pp.597-617.

Kormendi, Roger C. and Meguire, Philip G. "Macro-economic Determinants of Growth: Cross-Country Evidence." *Journal of Monetary Economics*, September 1985, *16*(2), pp. 141-63.

Kraay, Aart and Ventura, Jaume. "Comparative Advantage and the Cross-section of Business Cycles." National Bureau of Economic Research (Cambridge, MA) Working Paper No. 8104, 2001.

Krugman, Paul. "Financing vs. Forgiving a Debt Overhang." *Journal of Development Economics*, 1988, 29, pp.253-68.

Kuznets, Simon. "Economic Growth and Income Inequality." *American Economic Review*, March 1955, *45*(1), pp.1-28.

Mankiw, Gregory N.; Romer, David and Weil, David N. "A contribution to the Empirics of Economic Growth." *Quarterly Journal of Economics*, May 1992, *107*(2), pp.407-437.

Mendoza, Enrique G. "Credit, Prices, and Crashes: Business Cycles with a Sudden Stop." National Bureau of Economic Research (Cambridge, MA) Working Paper No. 8338, 2001.

Ndikumana, Leonce. "Debt Service, Financing Constraints, and Fixed Investment: Evidence from Panel Data." *Journal of Post Keynesian Economics*, 1999, 22, pp.455-78.

_____. "Financial Determinants of Domestic Investment in Sub-Saharan Africa: Evidence from Panel Data." *World Development*, 2000, *28*(2), pp.381-400.

North, Douglass C. and Thomas, Robert Paul. *The Rise of the Western World: A New Economic History.* Cambridge: Cambridge University Press, 1973.

Ramey, Garey and Ramey, Valerie A. "Cross-Country Evidence on the Link Between Volatility and Growth." *American Economic Review*, December 1995, *85*(5), pp.1138-51.

Rosenberg, Nathan and Birdzell Jr. L.E. *How the West Grew Rich: The Economic Transformation of the Industrial World.* New York: Basic Books, 1986.

Sachs, Jeffrey. "The IMF Is a Power Unto Itself." *The Financial Times*, December 11, 1997.

Saint-Paul, Gilles. "Technological Choice, Financial Markets and Economic Development." *European Economic Review*, 1992, 36, pp.763-81.

Stiglitz, Joseph E. "Failure of the Fund: Rethinking the IMF Response." *Harvard International Review*, Summer 2001, pp.14-18.

Summers, Robert and Heston, Alan. "The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988." *Quarterly Journal of Economics*, May 1991, *106*(2), pp. 327-68.

Torras, Mariano and Boyce, James K. "Income, inequality, and pollution: a reassessment of the environmental Kuznets Curve." *Ecological Economics*, May 1998, *25*(2), pp.147-160.

World Bank: International Bank for Reconstruction and Development. World Data (1995).

Table 1. 92-country Summers and Heston (1991) data for the years 1962-85*

		Mean	SD			Mean	SD
Africa	Algeria (DZA)	3.34	11.64	Asia	Afghanistan (AFG)	-0.28	4.26
	Botswana (BWA)	6.85	7.39		Bangladesh (BGD)	0.39	8.17
	Ghana (GHA)	-0.97	5.08		Burma (BUR)	2.75	5.45
	Kenya (KEN)	1.76	5.58		Hong Kong (HKG)	5.97	4.05
	Lesotho (LSO)	5.35	8.46		India (IND)	0.75	3.62
	Liberia (LBR)	-0.83	6.22		Iran (IRN)	2.64	11.21
	Malawi (MWI)	0.88	5.31		Iraq (IRQ)	0.88	17.47
	Mauritius (MUS)	2.19	5.87		Israel (ISR)	3.21	4.48
	Mozambique (MOZ)	-2.06	7.91		Japan (JPN)	5.24	3.62
	Niger (NER)	0.088	8.46		Jordan (JOR)	2.47	7.35
	Senegal (Sen)	-0.057	4.59		Malaysia (MYS)	3.92	4.33
	Sierra Leone (SLE)	0.47	5.99		Nepal (NPL)	0.89	4.14
	South Africa (ZAF)	1.64	4.87		Pakistan (PAK)	2.21	3.78
	Sudan (SDN)	-0.29	7.59		Philippines (PHL)	1.53	3.78
	Swaziland (SWZ)	1.59	7.51		Singapore (SGP)	5.9	4.46
	Tanzania (TZA)	2.55	5.38		South Korea (KOR)	5.84	4.49
	Togo (TGO)	1.95	6.61		Sri Lanka (LKA)	1.71	5.09
	Tunisia (TUN)	3.18	3.43		Syria (SYR)	4.13	10.25
	Uganda (UGA)	0.83	12.59		Taiwan (OAN)	6.28	3.03
	Zaire (ZAR)	0.035	7.51		Thailand (THA)	3.82	2.97
	Zambia (ZMB)	-1.73	7.11	Europe	Austria (AUT)	3.27	1.9
	Zimbabwe (ZWE)	1.68	6.19		Belgium (BEL)	2.72	2.5
North Am, Central Am, and Caribbean					Cyprus (CYR)	4.62	10.02
	Barbados (BRB)	2.47	4.83		Denmark (DNK)	2.72	2.83
	Canada (CAN)	2.76	2.98		Finland (FIN)	3.31	3.12
	Costa Rica (CRI)	2.14	3.76		France (FRA)	2.97	2.04
	Dominican Rep (DOM)	2.44	6.77		West Germany (DEU)	2.59	2.42
	El Salvador (SLV)	1.34	4.9		Greece (GRC)	4.17	3.84
	Guatemala (GTM)	1.11	2.86		Iceland (ISL)	3.37	4.09
	Haiti (HTI)	0.24	4.13		Ireland (IRL)	2.39	2.87
	Honduras (HND)	1.36	3.6		Italy (ITA)	3.35	2.76
	Jamaica (JAM)	1.09	4.99		Malta (MLT)	5.56	4.17
	Mexico (MEX)	2.55	3.88		Netherlands (NLD)	2.7	2.41
	Nicaragua (NIC)	0.1	13.35		Norway (NOR)	3.61	1.84
	Panama (PAN)	3.28	3.45		Portugal (PRT)	4.01	4.66
	Trinidad and Tobago (TTO)	1.57	8.8		Spain (ESP)	3.08	3.51
	United States (USA)	2.14	2.59		Sweden (SWE)	2.49	1.81
South Am	Argentina (ARG)	0.41	4.24		Switzerland (CHE)	1.53	2.44
	Bolivia (BOL)	1.3	4.08		Turkey (TUR)	2.66	3.6
	Brazil (BRA)	2.89	4.79		United Kingdom (GBR)	2.06	2.2
	Chile (CHL)	0.63	6.16		Yugoslavia (YUG)	3.92	4.49
	Colombia (COL)	2.23	3.04	Pacific	Australia (AUS)	2.45	2.57
	Ecuador (ECU)	2.67	4.94		Fiji (FJI)	1.54	5.42
	Guyana (GUY)	-1.12	9.67		New Zealand (NZL)	1.46	3.29
	Paraguay (PRY)	2.68	5.15		Papua New Guinea (PNG)	1.34	5.72
	Peru (PER)	0.84	4.95				
	Uruguay (URY)	0.13	5.04				
	Venezuela (VEN)	1.51	6.51				

* Source: Ramey and Ramey (1995, p.1149).

Table 2. Mean growth rates and standard deviation for 66-country, 1964-93*

		Mean	SD			Mean	SD
Africa	Botswana	7.05	8.18	S. Am	Argentina	1.00	4.70
	Burundi	2.12	6.36		Brazil	2.84	4.79
	Cameroon	0.79	7.88		Chile	2.25	5.63
	Chad	-0.25	7.70		Colombia	2.16	1.83
	Congo	2.55	7.01		Costa Rica	2.01	3.48
	Ghana	-0.67	5.20		Ecuador	2.35	5.72
	Guyana	0.41	5.11		El Salvador	0.39	3.59
	Kenya	1.88	5.25		Guatemala	0.97	2.92
	Nigeria	0.42	7.59		Honduras	1.18	3.22
	Oman	8.09	19.13		Mexico	1.81	3.26
	Rwanda	0.97	5.47		Paraguay	2.16	3.93
	Sierra Leone	0.36	4.78		Peru	-0.21	5.46
	Somalia	0.10	9.37		Puerto Rico	3.34	3.30
	South Africa	0.12	2.74		Uruguay	1.24	4.44
	Sudan	-0.14	6.99		Venezuela	-0.39	4.12
	Swaziland	1.81	6.96	DCs	Australia	1.91	2.18
	Togo	-0.08	6.20		Austria	2.86	2.06
	Trinidad and Tobago	0.64	4.87		Belgium	2.59	2.16
	Zaire	-2.13	4.72		Canada	2.19	2.42
	Zambia	-1.41	4.56		Denmark	2.06	1.96
	Zimbabwe	1.12	5.94		Finland	2.45	3.51
S-E Asia	Bangladesh	0.81	4.41		France	2.46	1.79
	China	6.89	7.66		Germany	2.86	2.88
	Hong Kong	6.08	4.30		Italy	2.94	2.38
	India	1.88	3.43		Japan	4.49	3.33
	Indonesia	4.03	2.53		Luxembourg	2.35	3.08
	Korea, Republic of	7.55	3.86		Netherlands	2.13	1.90
	Malaysia	4.34	2.92		New Zealand	1.18	3.20
	Nepal	0.73	3.14		Norway	3.03	1.81
	Philippines	1.08	3.52		Spain	2.85	2.53
	Singapore	7.16	3.29		Sweden	1.59	1.96
	Thailand	5.35	2.74		Switzerland	1.25	2.53
					United Kingdom	1.88	2.09
					United States	1.78	2.25

*Source: World Bank (1995).

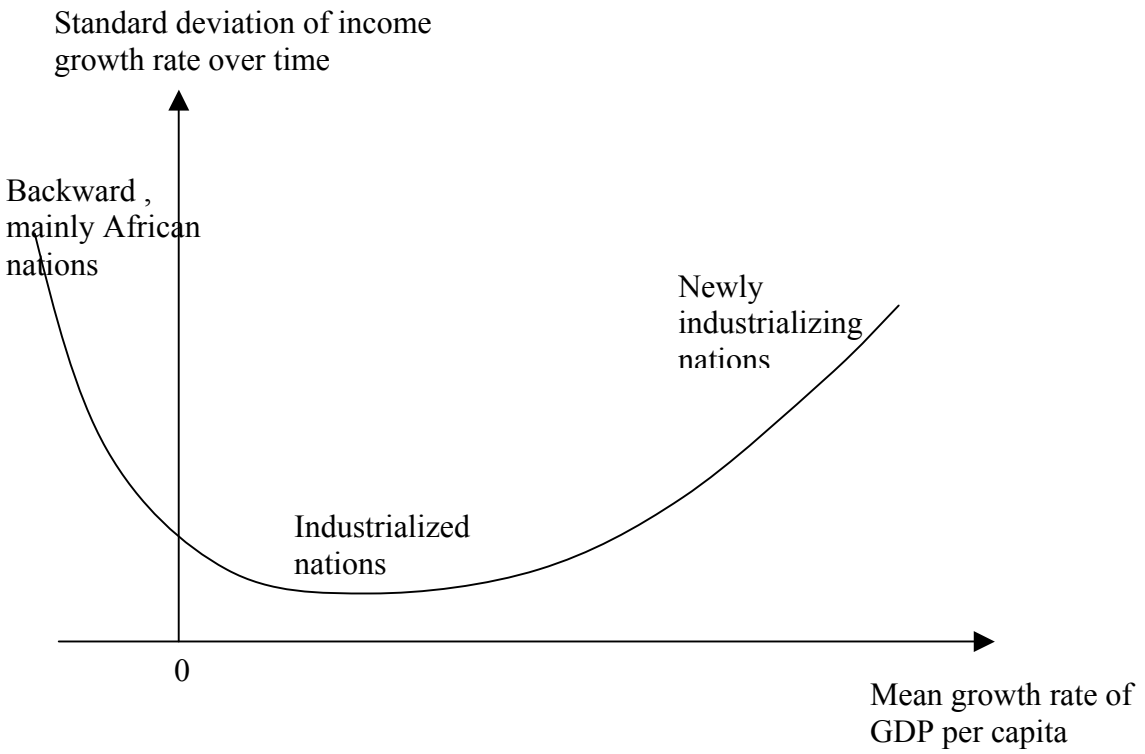

Figure 1. A U-Shaped Curve between Volatility and the Speed of Growth

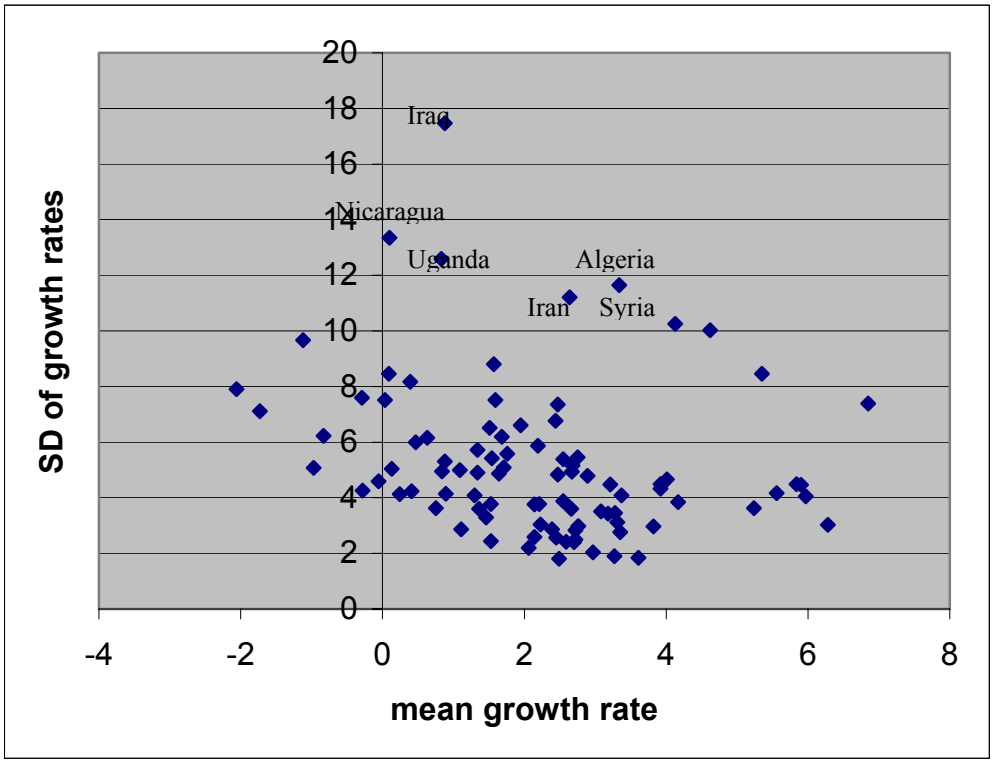

Figure 2. The U-Shaped Curve Between Mean Growth Rate and Volatility, 92-country, 1962-85.
Source: Summers and Heston (1991).

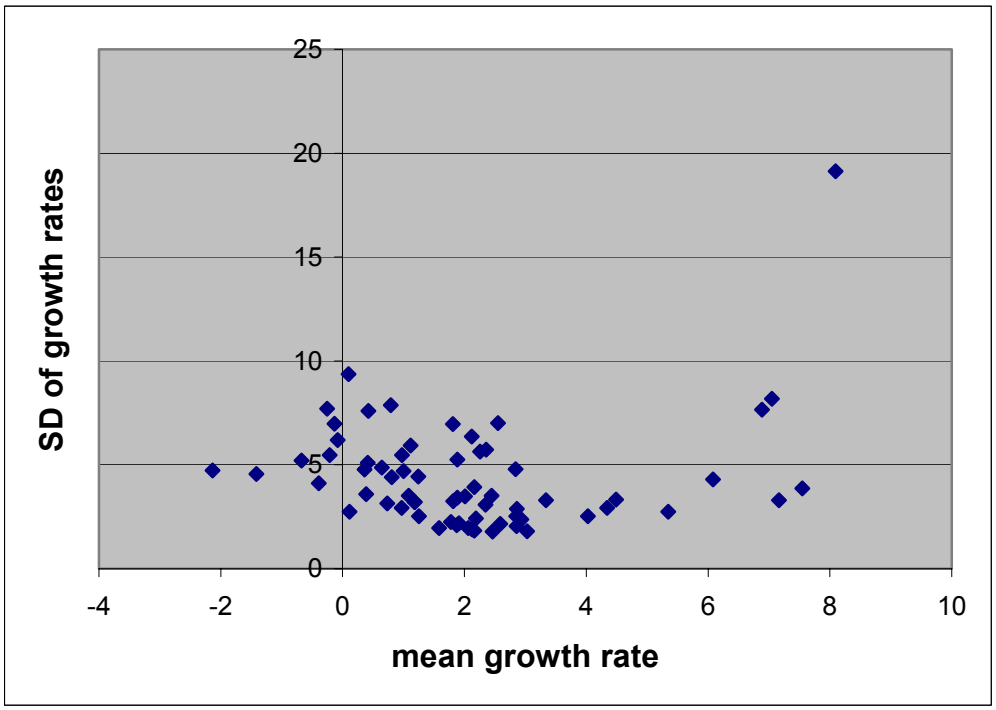

Figure 3. The U-Shaped Curve Between Mean Growth Rate and Volatility, 66-country, 1964-93.

Source: World Bank (1995).

Footnotes

[1] Such numbers are obtained from the Summers and Heston (1991) data for the period 1962-85.

[2] By putting standard deviation as the independent variable, Remay and Remay (1995) arguably studied the causal effect flowing from volatility to growth. This is consistent with Aizenman and Marion (1993) who found persistent policy uncertainty negatively affect growth by reducing investment. What is probably closer to the truth is that both growth and volatility are endogenously determined by more fundamentally exogenous variables such as liquidity constraints, financial liberalization, and methods of (human) capital accumulation.

[3] Many Asian countries are hit by the US economic slowdown in 2001. Singapore, having recovered more successfully than many others from the 1997 crisis, plunged into deeper recession than most - not surprising since forty-six percent of her export is electronics to the US market. The heavy reliance of Taiwan, Korea, Hong Kong and Singapore on just a few industries illustrates aptly the source of their income volatility.

[4] The Islamic revolution overthrew the Shah of *Iran* in 1979, an opportunity exploited by Saddam Husayn who had became President of *Iraq* in July that year. A protracted and costly war broke out in September 1980. On December 23, 1972, a powerful earthquake shook *Nicaragua*, destroying most of the capital city. The earthquake left approximately 10,000 dead and some 50,000 families homeless, and destroyed 80 percent of Managua's commercial buildings. The Sandinista Revolution overthrew the corrupt Somoza regime later in the 70's, but the effect of the earthquake and the revolution had profound effect on economic stability in the country. The murderous eight-year regime of Idi Amin in the 1970's devastated the *Uganda* economy and cost the lives of an estimated 300,000 victims. *Algeria* battled against European colonialists in the early 1960s but the war national liberation and its aftermath severely disrupted Algeria's society and economy. In addition to the physical destruction, the exodus of the colons deprived the

country of most of its managers, civil servants, engineers, teachers, physicians, and skilled workers. Yet, throughout much of the decade unemployment in Algeria seldom fell below 70 percent. *Syria* fought two wars, 1967 and then 1973, against Israeli. These wars toke heavy toll both on Assad's regime and on the *Syrian* economy. The ethnic problem of *Cyprus* where Turkish and Greek Cypriots lived together on the island for almost five centuries erupted in 1974 when the Turk army invaded Cyprus. Thousands of Cypriots lost their lives, and many more thousands refugees fled their country. The UN Security Council in Resolution 367/1975 "regrets the unilateral decision of 13 February 1975 declaring a part of the Republic of Cyprus would become a Federated Turkish State". This devastated the Cyprus economy for many years to come.

[5] Oman's exceptionally high growth rate and standard deviation owe much to its heavy reliance on the hydrocarbon sector, which went through turbulent upswings in the 1970's and collapse in 1985-86. We do not exclude Oman from the regressions, but its exclusion would not have made any significant difference in our results.

[6] In the Samuelson accelerator system it was consumption and investment that links the present to the past.

[7] Capital flows quite generally include both non-equity loans as well as those for direct investment purposes. Thus debt servicing should in principle include profit repatriation, but the distinction between the interest rate and profit rates is ignored since it would not significantly affect the argument in this paper. Principle repayment is also ignored for the sake of simplicity. The results of this paper do not fundamentally depend on the constancy assumption of the interest rate over time.