# ECONOMIC VULNERABILITY AND ECONOMIC GROWTH: SOME RESULTS FROM A NEO-CLASSICAL GROWTH MODELLING APPROACH

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This paper incorporates economic vulnerability, defined as the increased proneness of certain economies to downside risks, within a neo-classical economic growth model to seek an explanation to the observation that a number of vulnerable economies enjoy high per capita output levels. Steady state results indicate that the more vulnerable economy would tend to have a higher per capita capital stock and output but a lower per capita consumption level, as resources are allocated to counteract vulnerability. Dynamic modelling results indicate that vulnerability reduces the speed of convergence between economies at different states of development.

## 1. INTRODUCTION

The past decades have seen renewed interest in the study of supply-side dynamics that impinge on long-term economic growth. The basic analytical framework employed in this context is the so-called growth accounting exercise pioneered by Solow (1957). Recent comprehensive growth accounting exercises, most notably Senhadji (1999) and Bosworth *et al.* (1995), find that total factor productivity growth is generally larger in developed than in developing countries, but it is more volatile in the latter, accounting chiefly for the fact that output growth in developing countries is twice as variable as in developed ones. Convergence between poor and rich countries is observed, but it occurs at a very slow pace.

In terms of the policy debate on economic development, the focus of this literature centres on the degree of convergence of per capita output between countries at different levels of development and on the extent to which increases in output could be sustained over the long term, as for example, in Romer (1987). From a perspective that emphasises the risks to economic development, Briguglio (1992, 1993) pioneered the research on

economic vulnerability that examines the proneness of countries to shocks in their performance. There emerged a strand of literature proposing alternative measurements, and sometimes definitions, of economic vulnerability. An important conclusion of this research is the fact that owing to their smallness and relative isolation, a number of relatively high per capita income countries can be more vulnerable than countries at a lower level of development. This gave rise to the so-called "vulnerability dilemma."

The stages at which the separate research fields of economic growth and economic vulnerability have come to call for an exploration of their possible links. On one hand, while acknowledging that per capita output is an incomplete indicator of human welfare, it may be argued that vulnerability per se does not enter the human welfare function at the same level as income and consumption. The usefulness of the vulnerability concept would therefore increase if it is shown to have a bearing on the more important determinants of human welfare. On the other hand, the study of economic growth could benefit from the consideration of a possibly important explanatory variable in the form of economic vulnerability.

This paper contributes to this debate by hypothesizing that the increased economic risks implied by vulnerability have important effects on per capita output levels, economic growth and the process of economic convergence. In order to develop this hypothesis, the workings and conclusions of the neo-classical growth model are reviewed, together with the principal findings of studies on economic vulnerability. A variant of the neo-classical growth model incorporating vulnerability is developed next and its steady state and dynamic results are compared to those of the baseline growth model. On the basis of the findings, the paper suggests a possible approach towards the resolution of the "vulnerability dilemma." It also provides possible explanations to empirical observations regarding the development of total factor productivity growth and the heightened economic vulnerability of small states.

## 2.   A REVIEW OF BACKGROUND CONCEPTS: THE NEO-CLASSICAL GROWTH MODEL AND ECONOMIC VULNERABILITY

The basic structure of the general equilibrium neo-classical growth model, based on original work by Cass (1965), Koopmans (1965), Ramsey (1928), Solow (1956), and Swan (1956), features households owning the factor inputs, labour and capital, involved in the production of a homogenous good that can be consumed or invested. Households maximise the sum of discounted future utility under rational expectations by choosing consumption, saving, labour force participation and fertility. Goods and factor markets are assumed to clear. Following Inada (1963), the production function features positive and diminishing marginal products with respect to each input, exhibits constant returns to scale and marginal products approach infinity as factor inputs approach zero and vice-versa. The utility function has the same marginal conditions as the production function.

As consumption and physical capital rise in the course of economic growth, the marginal utility of consumption and the marginal product of capital decline, progressively leading to smaller rates of consumption growth. This process goes on until a steady state of zero consumption and output grow is reached, ignoring the effects of total factor productivity growth. This important result yields the notion of convergence whereby poor economies growth faster than rich ones in a process of catching-up. The convergence to steady state properties of this model are documented in Barro and Sala-i-Martin (1995).

The economy would not continue to accumulate physical capital per capita once that its marginal product falls to just cover the depreciation rate, the rate of utility discounting and population growth. The steady state consumption permitted by the steady state capital stock would provide just sufficient saving to keep per capita physical capital constant in view of depreciation and population growth. Thus, according to this model, economies which achieve a high per capita income level and which are consequently expected to grow fast for long periods are those characterised by deep parameters involving low a population growth rate, low physical capital depreciation, and a low rate of future utility discounting.

This model is to serve as a baseline case against which the effects of economic vulnerability, including considerations regarding total factor productivity growth, are assessed.

The concept of economic vulnerability emerged from the study of the specific weaknesses of small island states that would account for increased risks to economic growth and performance without being necessarily reflected in per capita output levels. According to Guillaumont (1999), "vulnerability means the risk of being harmed, wounded (negatively affected) by unforeseen events, in general and in economics as well." Vulnerability may thus be viewed as an economy's proneness to downside risks. The literature on economic vulnerability is still developing, with new definitions, determinants and measurement procedures being suggested.

The characteristics that are most likely to result in vulnerability are documented in Briguglio (1992, 1993, 1995, and 1997), Chander (1996), UNCTAD (1997), Easter (1998) and Crowards (1999). These include economic smallness, which constrains a country's production possibilities and ability to reap economies of scale as well as a high degree of economic openness that increases susceptibility to economic conditions in the rest of the world. Lack of diversification of productive activities, especially in the export sector, is another potential source of vulnerability, as would be a strong dependence on imports with low price elasticities and limited import substitution possibilities. Insularity, peripherality and remoteness, leading to high transport costs and reduced attractiveness for business and investment are also recognized as important determinants of economic vulnerability. The absence of competitive markets, the relatively large size of public sector activity engendered by smallness and the lack of absorption capacity for technology, investment and international development initiatives are other important sources of economic vulnerability.

It is suggested that other factors that can be viewed to give rise to economic vulnerability include the dependence on exports with relatively high income and price elasticities as well as openness to vulnerable markets. These are probably the genuine sources of vulnerability rather than trade openness per se, which could actually give rise to economic strengths out of the possible diversification into external markets and the potential for investment and technology transfer that would arise.

In an attempt to measure the economic vulnerability phenomenon, economic vulnerability indices have been constructed, generally including a relatively small number of variables, often limited to three or four. One reason for this is that many economic variables are correlated with each other and one variable could be used to represent others. Other reasons are that many variables complicate the procedure and data for certain variables are not available across countries. The most frequent variables used in the economic vulnerability indices relate to economic openness, export concentration, dependence on imports of energy and peripherality. Other approaches attempt to measure vulnerability in terms of the variability of output and similar indicators. An important consideration in this approach is that it is tantamount to measuring the manifestation rather than the actual causes of the phenomenon.

The weaknesses of vulnerability indicators principally relate to the subjectivity in their computation, in particular with regard to the choice of variables, the method of measurement and the averaging procedure. The question of subjective choice of variables is difficult to resolve. This is, however, not a problem peculiar to the vulnerability indices but to most empirical work, especially that which purports to quantify data that is essentially qualitative. The measurement problems arise in part because of an absence of data for certain variables or for certain countries; different methods of statistical compilation across countries; and errors in measurements of the variables. Composite indices are averages of different sub-indices, and the single value which they produce may conceal divergences between the individual components or sub-indices, possibly hiding useful information. Furthermore, a composite index implies some form of trade-off between the sub-indices of the composite index and averaging would conceal, for example, situations where the effect of one variable cancels out the effect of another. In addition there is the problem of whether to take a simple average or a weighted average and, in the latter case, which weights are to be assigned to the different variables. In general, the weighting problem remains in the realm of subjectivity, with the simple average having a favourable edge on grounds of simplicity.

Various studies have generally concluded that there is very little correlation between vulnerability and per capita output or output growth. Indeed, Briguglio (1995) finds that certain economies with high per capita income such as Singapore or Malta are subject to a significant degree of vulnerability. This is not in conflict with the conceptual basis of economic vulnerability studies, in that per capita output is regarded as an incomplete indicator of human welfare in the context of economies that are prone to significant downside risks.

On the other hand, it may be argued that vulnerability per se does not enter the

human welfare function at the same level as economic growth or development. The usefulness of the vulnerability concept would therefore increase if it is shown to have a bearing on the more important determinants of human welfare. This can be postulated a priori on the grounds that the increased economic risks implied by vulnerability would have an effect on economic growth and per capita output levels.

## 3.   INCORPORATING VULNERABILITY IN A NEO-CLASSICAL GROWTH CONTEXT

Economic vulnerability thus implies increased sensitivity to shocks, and relatively greater susceptibility to shocks of an adverse nature. It is proposed that economic vulnerability can be incorporated in a neo-classical growth model by considering the physical capital stock and consumption possibilities as being subject to stochastic shocks within concave production and utility functions.

Modelling physical capital stock and consumption as stochastic variables would capture the sensitivity to a number of demand- and supply-side shocks that are typical in vulnerability studies. These would include adverse external demand shocks, which may reduce the effective utilisation of capital by making part of it redundant. Similar considerations would apply to positive technology shocks from which vulnerable countries do not benefit, putting them at a competitive disadvantage. Likewise, proneness to natural disasters could reduce an economy's capital stock and consumption possibilities. Unsuitable domestic economic policy shocks and political instability could have similar effects.

The concave production and utility functions would allow downside shocks to have relatively stronger effects than positive ones. In a concave production function exhibiting diminishing marginal product, a positive shock to the production factors would increase output by a smaller magnitude compared to the reduction in output from an equivalent reduction in production factors. The nature of the production and utility function would thus serve to determine the strength of the economic effects of shocks in the economy's capital stock and consumption possibilities.

Subject to the assumptions set out in the baseline model, the capital stock at time $t$, $K_t$, is presumed to be a random variable with expected value $\mathrm{K}_t$ and subject to exogenous shocks $\kappa_t$ which are identically and independently distributed with zero mean and constant variance, thus:

$$K_t = \mathrm{K}_t + \kappa_t, \tag{1}$$

where $\kappa_t \sim iid(0, \sigma^2_k)$

Similarly, consumption $c_t$, is modelled to be stochastic with expected value $c_t$ and subject to exogenous white noise shocks $\chi_t$, thus:

$$c_t = c_t + \chi_t, \tag{2}$$

where $\chi_t \sim iid(0, \sigma^2{}_x)$

The per capita intensity accumulation function can be written as:

$$\frac{dk_t}{dt} = f(k_t) - c_t - (n+d)k_t . \tag{3}$$

Considering, for the purposes of solving the dynamic utility maximisation problem, the expected value of Equation (3), we obtain:

$$\frac{dk_t}{dt} = E[f(k_t)] - c_t - (n+d)k_t . \tag{4}$$

Among the methods available to consider the effects of uncertainty on economic activity, as used in, for example, Machina (1987), Machina (1989), and Hirshleifer *et al.* (1992), the expected value of output can be expressed by means of a Taylor-expansion of the production function around the expected value of the capital stock $k_t$, thus:

$$E[f(k_t)] = E[f(k_t)] + E[f'(k_t)(k_t - k_t)] + E[0.5f''(k_t)(k_t - k_t)^2] + .... \tag{5}$$

Ignoring those parts of the expansion involving an exponent higher than two, on the basis of the assumption that moments for the stochastic variables that are higher than two are zero, we obtain:

$$\begin{aligned} E[f(k_t)] &= f(k_t) + 0.5f''(k_t)\mathrm{var}(k_t) \\ &= f(k_t) + 0.5f''(k_t)\sigma^2{}_\kappa , \end{aligned} \tag{5'}$$

Equation $(5')$ implies that due to the randomness of the physical capital stock, the expected output must be adjusted by a term reflecting the extent of shocks to the capital stock, $\sigma^2{}_\kappa$, and the susceptibility of the economy's output to such shocks, as given by $0.5f''(k_t)$. The negative sign on the latter term implied by a concave production function implies that the effect of variability of capital stock on the economy's expected output is negative. Thus, shocks in the physical capital stock can be expected to have effects on the rate of return on capital and thereby on the extent of capital accumulation, economic growth and steady state per capita output.

The susceptibility of the economy's expected output to shocks in factor inputs, as given by the second derivative of the production function, decreases in magnitude as the capital stock rises. This implies a heightened economic vulnerability for economies having a relatively low per capita capital. Moreover, it is dependent on the marginal

productivity of the volatile factor input. Considering a concave production function of the form, $f(k) = k^{\alpha}$ where $0 < \alpha < 1$, $f''(k) = \alpha(\alpha - 1)k^{(\alpha-2)}$, which implies that the magnitude of the $f''(k)$ initially rises with $\alpha$ but subsequently falls to zero as $\alpha$ approaches 1. This happens as initially, an increase in the output share of the volatile factor input would render the economy more susceptible to shocks in that input, as shown in Figure 1. As $\alpha$ continues to increase, however, this effect would be outweighed by the increase in marginal productivity of the factor input which reduces the asymmetric effects between positive and negative shocks, thus rendering the economy's expected output less vulnerable to fluctuations in the factor input. Therefore, the expected output of economies with an intermediate elasticity of physical capital tends to be more susceptible to the volatility of this factor input.
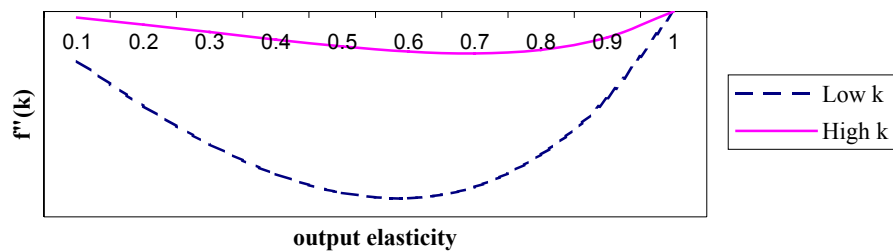


**Figure 1.**   The susceptibility of expected output to factor input shocks

In a similar manner, the expected utility of consumption in the wake of shocks can be expressed as:

$$E[u(c_t)] = u(c_t) + 0.5u''(c_t)\sigma^2{}_\chi,\tag{6}$$

Equation (6) implies that shocks to consumption possibilities reduce welfare in proportion to the concavity of the utility function, which indicates the strength of the consumption smoothing motive. This can be expected to have effects on saving behaviour and consequently on growth patterns. It may be further argued that the second derivative of the utility function and the consumption-smoothing motive are larger in magnitude in economies where consumption levels are relatively low. Thus, the welfare of developing economies would be more likely to be negatively influenced by shocks to their consumption possibilities.

The concept of economic vulnerability is in this way broken down into two

behavioural components, namely the extent of the shocks affecting production factors and consumption possibilities, and the susceptibility of an economy's production technology and welfare to such shocks. This is in line with Guillaumont (1999), who stresses that the risk of a country being harmed by an external shock is given by the size and the likelihood of the shock, the exposure to the shock and the ability of the country to react to it. It is here shown that while random shocks may be regarded as purely exogenous factors, the economy's susceptibility to such shocks may be viewed to change according to the state of development and to policy responses. In particular, it is found that susceptibility tends to decrease as an economy develops and as the elasticity of output to physical capital becomes sufficiently large.

## 4.   THE EFFECT OF ECONOMIC VULNERABILITY ON THE STEADY-STATE EQUILIBRIUM

In order to gauge the effects of economic vulnerability on the steady state equilibrium of the economy, we formulate the Hamiltonian to account for the expectations of utility and output within the context of stochastic consumption and capital stock levels as:

$$H_t = e^{-\theta t}[u(c_t) + 0.5u''(c_t)\sigma^2{}_\chi] + \lambda_t[f(k_t) + 0.5f''(k_t)\sigma^2{}_\kappa - c_t - (n+d)k_t]. \qquad (7)$$

The first-order conditions for maximisation imply that:

$$\lambda_t = e^{-\theta t}[u'(c_t) + 0.5u'''(c_t)\sigma^2{}_\chi], \qquad (8)$$

$$\frac{d\lambda_t}{dt} = -\lambda_t[f'(k_t) + 0.5f'''(k_t)\sigma^2{}_\kappa - (n+d)], \qquad (9)$$

Equation (8) implies that compared to the baseline neo-classical growth model, the shadow price of $k_t$ is in this model reduced by a factor reflecting consumption-side economic vulnerability. Likewise, the development of the shadow price of $k_t$ is influenced by production-side vulnerability, as shown in Equation (9). Simultaneously solving these two equations, we obtain an expression for the optimal time path of consumption as:

$$\frac{dc_t}{dt} = \eta_t[f'(k_t) + 0.5f'''(k_t)\sigma^2{}_\kappa - (n+d+\theta)], \qquad (10)$$

where $\eta_t = \dfrac{-u'(c_t) - 0.5 u'''(c_t)\sigma^2_{\chi}}{u''(c_t) + 0.5 u''''(c_t)\sigma^2_{\chi}}$

By virtue of the assumptions imposed on the utility function, the term $\eta_t$ is positive. This implies that consumption growth, which reflects the extent of saving in initial periods, responds positive to the marginal productivity of $k_t$ and negatively to the population growth rate, the depreciation rate and the utility discount rate. These results conform to those of the baseline model. Equation (10) also implies that consumption growth is increased by production-side shocks as the economy saves more to accumulate capital to offset the output effects of disturbances to the capital stock. On the other hand, $\eta_t$ is lower than the comparable term in the baseline model. Consumption-side vulnerability thus results in lower consumption growth and lower saving as the economy makes up for volatility-related welfare losses through higher initial consumption.

The saving behaviour of the economy is thus subject to two opposing effects. On the one hand, volatility in the capital stock increases saving to allow the economy to accumulate sufficient capital which would allow it more effectively to absorb the effects of such shocks. On the other hand, the welfare losses arising out of consumption volatility are met by higher consumption and consequently lower saving.

The consequences of these effects can be assessed by examining the steady state of the differential equations for the time paths of $c_t$ and $k_t$, Equations (10) and (4) respectively. Thus, the steady state physical output per capita is found as:

$$f'(k) + 0.5 f'''(k)\sigma^2_{\kappa} = n + d + \theta , \tag{11}$$

Equation (11) shows that the steady state level of per capita capital in this model is higher than that in the baseline model, with the consequence that its marginal productivity would be lower. The steady state level of per capita consumption is derived as:

$$c = f(k) + 0.5 f''(k)\sigma^2_{\kappa} - (n + d)k . \tag{12}$$

Thus, in spite of the higher expected value of capital stock per capita, it does not follow that the expected value of per capita consumption in steady state will in this case be higher than that in the baseline model, because of the deleterious effects of shocks to the capital stock as represented by the product of the concavity of the production function and the volatility of shocks to the capital stock. The end result would depend on the relative strength of these opposing effects. It is also noted that the characteristics of the utility function and variability to the consumption variable are immaterial to the steady state position of the economy.

For the purposes of addressing this issue, a numerical analysis is undertaken to evaluate the ratios of consumption and capital values in the economic vulnerability

model to those in the baseline model for different values of production function concavity and $\sigma^2_\kappa$ on the assumptions that $f(\mathrm{k}) = \mathrm{k}^\alpha$, $n+d+\theta = 0.1$ and $n+d = 0.08$. The results are shown in Figures 2 and 3 and indicate that for relatively low values of $\alpha$, the capital stock under the vulnerability model is higher than under the baseline model, and it tends to increase with the extent of the shocks to the capital stock $\sigma^2_\kappa$. The divergence in capital stocks and its sensitivity to the shocks tends to diminish with higher values of $\alpha$. With relation to per capita consumption, this is found to be invariably lower in the vulnerability model compared to the capital stock model, with the difference being principally accentuated at low values of $\alpha$ and high values of $\sigma^2_\kappa$. As the output share and the productivity of the accumulable factor increase, the results of the vulnerability growth model and of the baseline model tend to converge. This happens as in the limit, a value for $\alpha = 1$ would neutralise any adverse effects to output arising out of shocks to the production factor.
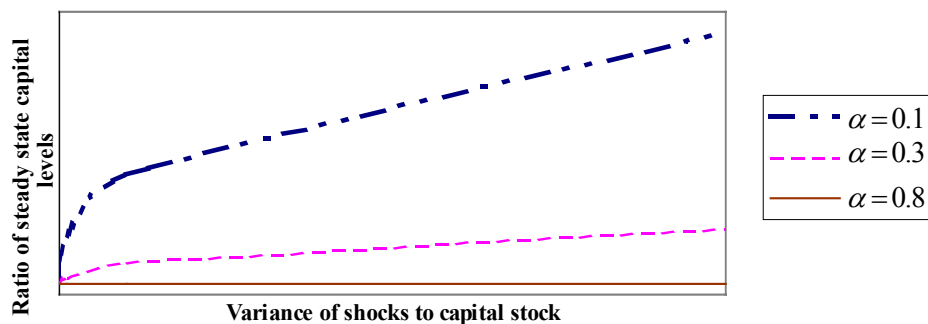


**Figure 2.** Ratio of steady state capital to baseline model results

It is thus concluded that the more economically vulnerable economies, characterised by relatively high volatility in their capital stock and a production technology that is susceptible to such shocks, tend to have a relatively higher per capita capital, and consequently output, but a relatively lower consumption per capita in steady state. These economies would need to dedicate a portion of their resources to overcome the difficulties of economic vulnerability and the marginal productivity of their capital would in steady state be lower. These effects are more accentuated in the case of economies where the capital stock and the output elasticity of physical capital are relatively low.
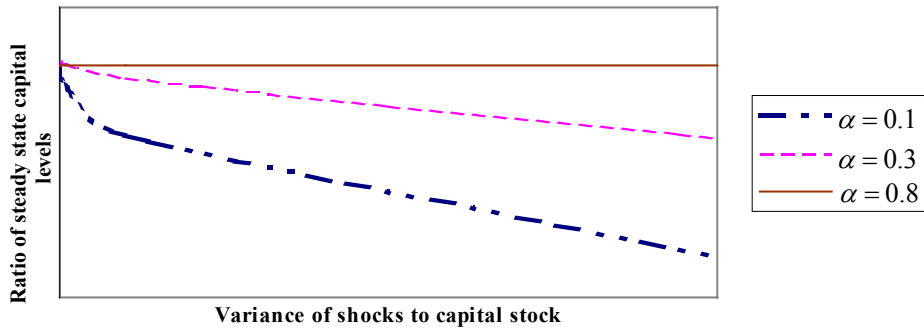
**Figure 3.**   Ratio of steady state consumption to baseline model results

## 5.   ECONOMIC VULNERABILITY AND CONVERGENCE TO STEADY STATE

The comparison between the steady state positions of the baseline economic growth and the vulnerability models, together with an analysis of the behaviour of the models when they are out of steady state, can be undertaken by means of a phase diagram as shown in Figure 4. The figure shows the relationships between per capita consumption and per capita capital for the steady state relations of the baseline model and for those of the model incorporating vulnerability.

The phase diagram replicates the results obtained in Figures 2 and 3 in the previous section. In the baseline model, the steady state per capita consumption that can be obtained at each level of steady state per capita capital is equal to the output of that capital less the allowances for physical capital depreciation and population growth that must be made to maintain per capita capital constant in steady state. In turn, the equilibrium steady state level of per capita capital accumulated is at the point where its marginal productivity covers its erosion through depreciation and population growth as well as the cost of postponing consumption as reflected in that rate of time preference. A higher level of marginal productivity would imply that it is profitable to accumulate further capital and vice-versa. The intersection of these two functions gives the per capita steady state capital and consumption. It is interesting to note that the level of per capita steady state capital is lower than that which would permit the maximum level of consumption. The per capita capital that would maximise steady state would be found as $f'(\mathrm{k}) = n + d,$ while the actual steady state capital is $f'(\mathrm{k}) = n + d + \theta$. The utility cost of postponing consumption thus results in a lower level of per capita capital than that which would maximise per capita consumption.
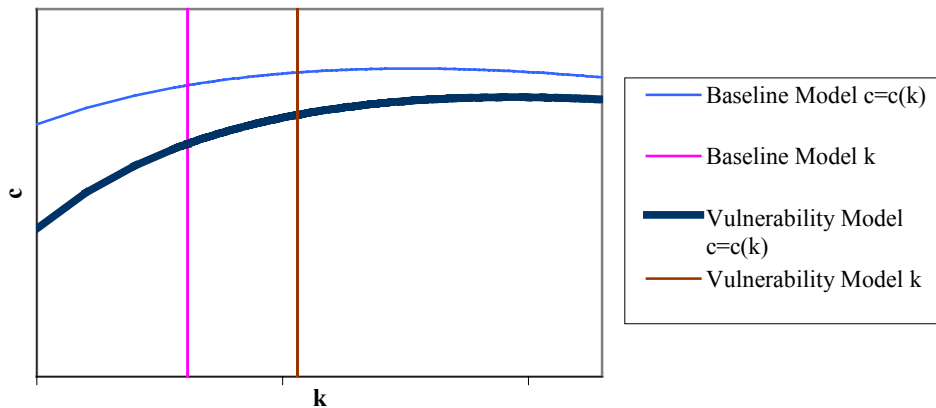
**Figure 4.**   Steady State and Convergence Properties of the Baseline
and Vulnerability Models

In the model incorporating vulnerability, the consumption relation behaves in a similar manner to that in the baseline model, with the important difference that it affords a lower level of steady state per capita consumption. This difference is due to the erosion of consumption possibilities generated by the volatility in the production factor and the effect of such volatility on output. As the latter approaches zero with an increase in k, the difference between the two consumption relations disappears. This indicates that developing economies bear the costs of vulnerability to a larger extent as they would be relatively more exposed to shocks. The steady state per capita capital in the vulnerability model is higher than that in the baseline model. The higher level of capital accumulated, and its consequent lower marginal productivity, is intended to offset the effects of its volatility. The vulnerability model however also features a steady state per capita capital that is lower than that required to maximise per capita consumption.

In terms of absolute convergence, it may be seen from Figure 4 that applying an initial value for k that is lower than steady state while assuming that c lies on the steady-state locus for each of the models, the responsiveness of consumption to an increase in capital under the vulnerability model would be stronger and goes on further than that under the baseline model. This is because the slope of the steady state consumption locus is higher for the model incorporating vulnerability, while the equilibrium steady state capital is larger. In this sense, therefore, it may be possible to

account for the relatively higher rates of consumption growth by economies subject to vulnerability, albeit their steady state consumption is lower. It is to be borne in mind that as these economies develop, their consumption can increase at a faster pace as growth tends to not only increase consumption possibilities but also to reduce the effects of vulnerability.

An experiment to assess the speed of convergence in the baseline and in the vulnerability models is designed whereby the values of the deep parameters are set at $n + d = 0.08$ and $n + d + \theta = 0.1$. The elasticity parameter of output with respect to the capital intensity, $\alpha$, is set at 0.4, a value that on the basis of the analysis presented in Figures 2 and 3 produces different steady state values for the two models. The utility elasticity with respect to consumption, which is only relevant for consumption growth in the vulnerability model, is set at 0.5. The values for the variances of the capital stock and consumption possibilities are arbitrarily set at positive values. Starting conditions for the capital stock and consumption are set at one half of the respective steady state values in each model. Figures 5a, band c show the time paths of the growth rates in the capital stock, output and consumption for the two models under these conditions.

It can be observed that in general, convergence to steady state is slower under the vulnerability model than under the baseline model. This is because the growth rates of output capital and consumption are lower in the initial phases of growth in the vulnerability model. This is mainly attributable to the deleterious effects of volatility in the capital stock on output, which hampers the rate of capital accumulation and therefore, the growth of output and consumption. It is however observed that at later stages of economic development, growth under the vulnerability model persists at a relatively higher level for a longer period of time. This is due to the differences between the steady state levels of capital, output and consumption under the two models. As discussed in the preceding section, the vulnerability model features higher steady state levels of capital and output, which accounts for the persistence of growth in these variables over a longer period of time. Such persistence is however not so evident in the case of consumption, which is in steady state lower in the vulnerability model compared to the baseline model.

It can thus be concluded that economic vulnerability does not have a monotonic effect on the rate of economic growth. Rather, vulnerability tends to slow down the output growth of relatively underdeveloped economies, but tends to accelerate the growth rate of more developed ones. The latter is due to the fact that the steady state output of vulnerable economies is relatively higher, while the damaging effects of vulnerability tend to diminish as the economy grows. In this sense, therefore, vulnerability can be viewed as a factor that retards convergence between developing and developed economies.
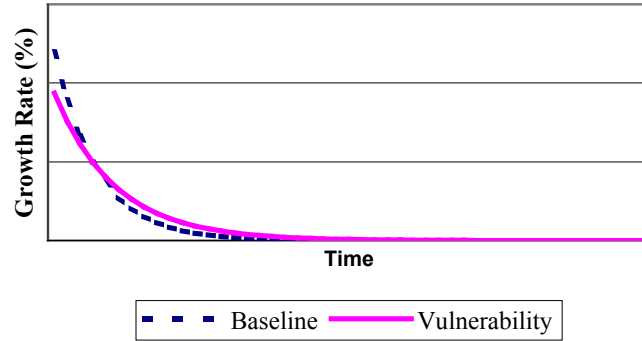
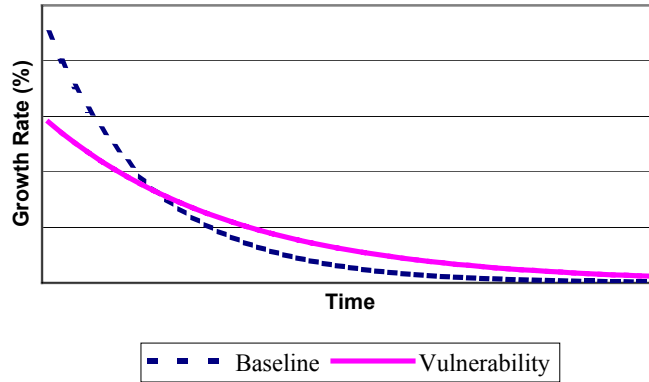**Figure 5a.** Convergence of Capital Stock to Steady State



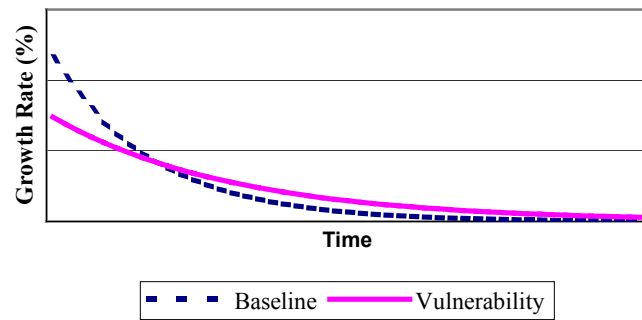**Figure 5b.** Convergence of Output to Steady State



**Figure 5c.** Convergence of Consumption to Steady State

## 6.   VULNERABILITY AND TOTAL FACTOR PRODUCTIVITY GROWTH

Vulnerability considerations could thus play a role in explaining observations regarding total factor productivity growth. It is to be noted that since the effects of vulnerability cannot be attributed clearly to the role of factor inputs within a neo-classical production function, they would fall within the nature of the residual typically defined as total factor productivity improvements in growth accounting exercises. Among the more recent and comprehensive of these is Senhadji (1999), who concluded, amongst other things that total factor productivity growth is larger in developed rather than developing economies, and that it is more volatile in the latter. The study also observed that total factor productivity growth declines with an increase in the share of capital in output. The study also observes a very slow speed of convergence between countries at different levels of economic development.

These observations fit within the results of the economic vulnerability model obtained here. The low total factor productivity growth for underdeveloped economies can be attributed to adverse effects on their output growth of their increased susceptibility to downside shocks demonstrated in the preceding section. The more volatile total factor productivity growth of such economies is another manifestation of their increased susceptibility to shocks discussed earlier on. The lower total factor productivity growth for economies with a higher capital intensity is consistent with the results obtained pointing to an increased susceptibility to downside shocks of economies which increase their capital share in output starting from a relatively low level, as shown in Figure 1. The slow speed of convergence can also be attributed to the effects of economic vulnerability, as discussed in the preceding section.

## 7.   VULNERABILITY AND SMALL ECONOMIES

Studies on economic vulnerability consistently show that this phenomenon is prevalent in small states. Using a vulnerability index based on the volume of trade to GDP ratio as a measure of exposure to foreign economic conditions, transport and freight costs as a percentage of exports as a proxy for remoteness and insularity, and the share of money damage caused by natural disasters in relation to GDP as an indicator of disaster proneness, Briguglio (1995) shows that out of 114 countries including both developed and developing ones, the small island states regularly show a very high vulnerability measurement. The vulnerability index proposed by the Commonwealth Secretariat (1997) composed of export diversification, export dependence and the impact of natural disasters shows that 26 out of 28 most vulnerable countries are small states.

It is interesting to categorise the characteristics of small economies that give rise to their pronounced vulnerability in terms of the extent of their exposure to exogenous shocks and their susceptibility to such shocks, in line with the model developed in this paper. The World Trade Organisation (2002) admits that there is as yet no general

agreement on the definition of economic smallness because of the different facets involved in this phenomenon that may be present to different extents in different countries. In this spirit, Srinivasan (1986) proposed that an appropriate definition of smallness should take into account a variety of factors including population and total income. In spite of this, the proxy that has been most widely used in the literature as a measure of country size is population, as in for example Commonwealth Secretariat - World Bank Joint Task Force (2000). An interesting definition by Davenport (2001) is based on a country's share in world trade.

The results of the model developed here show an increased vulnerability arising out of susceptibility to shocks for countries with a small capital to labour ratio. This could account for the heightened vulnerability of small states if such smallness is defined in terms of a scarcity of other production factors relative to labour, including physical capital, land, knowledge and technology. Definitions of small states based entirely on population size would not however fit within this explanation of vulnerability.

In view of the elusive nature of the causes of smallness, the World Trade Organisation (2002) discusses the consequences of smallness that would have a bearing on vulnerability. These include their proneness to economic and natural shocks, remoteness and isolation and an inability to reap economies of scale. The first of these clearly falls within the class of exogenous shocks contemplated in the model developed in this paper. Remoteness and isolation would merely serve as factors that compound the effects of these exogenous shocks. The inability to reap economies of scale is not, prima facie, a factor that accounts for increased vulnerability but for lower per capita income On the other hand, if it is viewed to be tantamount to the existence of constraints that preclude from the sufficient development of the capital stock in an economy, it would constitute a factor that increases an economy's susceptibility to exogenous shocks according to the model developed in this paper.

## 8.   CONCLUSION: TOWARDS A RESOLUTION OF THE ECONOMIC VULNERABILITY DILEMMA?

This paper shows an approach towards incorporating economic vulnerability, defined as the increased proneness of certain economies to downside risks to growth, within an economic growth model framework. The motivations behind this exercise originate from conceptual and empirical considerations. From a conceptual viewpoint, it is presumed that the literature on economic growth could benefit from explicit consideration of vulnerability issues. On the other, the literature on vulnerability, which has up to now been concerned with measurement issues, could benefit from a more solid theoretical framework. From an empirical viewpoint, an explanation to the observation that certain vulnerable economies enjoy high per capita output levels is sought.

Vulnerability is modelled by means of postulating stochastic shocks to an economy's capital stock and consumption possibilities. Its effects on an economy's output and

welfare are decomposed into those originating from the exogenous stochastic shocks and those attributable to the economy's specific susceptibility to such shocks. Within the context of concave utility and production functions, the susceptibility to downside shocks would be more accentuated than that to upside shocks. Moreover, this implies that susceptibility to downside exogenous shocks is more pronounced for economies having a relatively low per capita capital. This is because a diminution of capital stock would have more significant effects in these economies due to its relatively higher marginal productivity. Similar arguments apply for a diminution in consumption possibilities. The susceptibility to exogenous shocks initially rises with an increase in the output share of the volatile production factor but eventually falls as the rate at which its marginal productivity declines would diminish.

Steady state results indicate that the more vulnerable economy would tend to have a higher per capita capital stock and output but a lower consumption level. Thus, the vulnerable economy saves and invests more in order to overcome the effects of exogenous shocks, with a consequent lower marginal productivity of capital. On the other hand, the steady state consumption of a vulnerable economy is lower, as more resources are devoted towards saving to overcome vulnerability. This result is considered to provide a possible explanation for the fact that a number of vulnerable economies exhibit high levels of per capita income and saving. Such vulnerability would however still result in reduced welfare by eroding consumption possibilities.

Dynamic modelling results indicate that the model incorporating vulnerability exhibits the standard saddle-point equilibrium properties of Ramsey-Koopmans-Cass growth models. However, they tend to have a lower speed of convergence to steady state. Vulnerability tends to slow down the growth rates of relatively underdeveloped economies but it tends to increase the growth of more developed ones. Thus, vulnerability can be identified as a factor that reduces the speed of convergence between economies at different states of development.

The results derived in this exercise provide possible explanations for empirical observations regarding developments in total factor productivity growth and the heightened vulnerability of small economies.

There are at least three possible avenues for further research building upon this exercise. First, the model utilised here could be further enriched to capture additional aspects of vulnerability, such as possible correlations between capital stock and consumption possibilities shocks, the possible persistence of shocks or of their effects over time. To further assess the vulnerability characteristics of small economies, models with more than one commodity could be considered to study the effects of excessive concentration, as well as the implications of indivisibilities in the accumulation of capital. Second, the results suggest a new conceptual framework for measuring economic vulnerability, distinguishing between the exposure of an economy to exogenous shocks and the factors that affect an economy's susceptibility to such shocks. The latter are found to be mainly a function of the size of the capital stock of the economy. Finally, the results described here would need to be corroborated by further

empirical research, to assess whether they in practice hold in the context of present measures of vulnerability and other measures which may be obtained in the light of the above discussion.

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