

RESOURCE INEFFICIENCY AND POOR AGGREGATE ECONOMIC PERFORMANCE IN
AFRICAN COUNTRIES: THE CASE OF NAMIBIA, 1968-1992ⁱ

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Abstract

This essay develops a transcendental variable elasticity of substitution production function in which hypotheses concerning scale, output-input, and substitution elasticities can be examined. The objective is to determine the impacts of domestic resources on the pattern of economic performance. Using aggregate data for Namibia during the 1968-1992 period, the analysis finds constant returns to scale pre-1980, followed by diminishing returns to scale post-1980, representing a switch from flexible to rigid substitutes (complements), along with limited technical progress. The shift indicates widespread inefficiencies, and recommend resource improvement.

Keywords: transcendental production function, variable elasticity, economic growth Namibia, resource inefficiency.

JEL Code: O47, O55, O33, O38

This essay examines the impacts of changing domestic resources on the pattern of economic performance in developing countries using Namibia's data for the 1968-1992 period as an example.ⁱⁱ The examination develops a **transcendental variable elasticity of substitution** (trans-VES) production function in which hypotheses concerning production scale, output-input, and substitution (complementary) elasticities can be examined. The objective is to determine how a country may shift from growth to decline and stagnation. For example, prior to 1980 Namibia grew an annual average rate of two and a half percent, but declined by an average rate of one and a half percent between 1981 and 1985, and stagnated from 1986 to 1992.

Namibia was not alone in this decline and stagnation. In term of the growth of per capita income the richer of African countries have tended to converge slowly to OECD countries pre-1980, but post-1980 former have diverged discernably from the latter and converged to poorer African developing countries (Gapinski, 1996). It would seem that the shift from growth to decline and stagnation suggests the importance of domestic resources for sustainable growth. Yet, in Namibia's case, as in the cases of many other developing countries, attention continued to focus on external factors on the presumption that natural resource-rich developing countries do better de-emphasizing resource rents in primary activities and stressing secondary or higher rents in manufacturing and service sectors through the mechanism of free trade.ⁱⁱⁱ Foreign trade is clearly important for foreign capital

inflows and technology transfers from abroad, which are in turn essential for domestic resource building and technical progress (see Irwin, 1996).^{iv} Also by fostering competition foreign trade reduces X-inefficiencies associated with rent-seeking practices in the developing countries.

The economic success of the industrialized economies and newly industrializing countries (NICs) during the late 1980s and early 1990s supports the significance of trade in manufactures for economic growth. But how demonstrable as a miracle trade can be for many developing countries has come under scrutiny more intensely than before following the Asian financial crisis of the late 1990s. Long before the crisis Lucas (1993) showed with respect to the Asian NICs that growth was not a trade miracle, but rather a product of domestic resources (cf. Chow and Kellman, 1993). Lucas's assertion is neither new nor peculiar to the Asian NICs. Early on while acknowledging foreign trade as an extension of domestic markets and a source of additional capital for the "rude" economies, Adam Smith (1937) also envisioned the increasing role domestic resources come to play with increased resource scarcity (Chapter III). Although Ricardo's (1987) theory of resource rents modified the concept of scarcity to allow for the "consumptive and productive effects" of trade to expand resource availability, Smith's case that not all resources used in domestic production come from trade still stands (see Irwin, 1996). In fact Krugman (1996) observes that under global competition the gains from trade tend to be neutral, or even

smaller than the efficiency gains from domestic resources.^v

The remainder of this essay states the results obtained by using a familiar theory and an equally familiar, but not so widely utilized, production concept. The results show how resource inefficiencies can lead to a transition from economic growth to decline and stagnation. The essay is organized in five brief sections, an appendix, and a set of endnotes. Section 1 overviews selected literature and its problems. The analytical concept is described in section 2. Section 3 applies the model to Namibia's data, while Section 4 discusses the implications of results, and is followed by the conclusion in Section 5.

1. The Problematic Economic Growth Literature

Empirical research on the role of (domestic) resources in economic growth remain impaired by a number of well-known problems. First, the Solow (1957) growth accounting and neo-Solow (Arrow, 1962; Solow, 1997) learning-by-doing growth models assume exogenous resources, and go on to emphasize quality-adjusted labor (Romer, 1989; Mankiw, Romer and Weil, 1992; Barro, 1991, 1994; Barro and Sala i Martin, 1995; d'Autumne and Michel, 1995). Post-Solow (neo-Schumpeter) researchers seek to improve upon Solow and neo-Solow models by attempting to endogenize capital and technical change (Lucas 1988, 1993; Grossman and Helpman, 1991; 1994; Romer, 1990, 1993, 1994). Others such as Gould and Ruffin (1995) separate "human capital into its role as an input

to production and its role as a determinant of technological progress and long-run growth" (p.425).

Second, from the perspective of developing countries, a common problem is that the new growth models succeed more in criticizing the older models than in providing alternatives (Pack, 1994). In some cases the newer models seem to have swept discussions of the domestic growth sources and constraints under a [thick?] carpet of cross-sectional analyses the results of which have been more instructive than persuasive. As Solow (1994) and Pack (1994) point out, some of the studies lack the incisiveness which policy makers in individual countries need in order to take action (Solow, 1994; Pack, 1994). For instance, in an IMF staff paper Ghura and Hadjimichael (1996) modified Mankiw, Romer and Weil (1992) to examine the economic growth of a number of sub-Saharan African countries over the 1981-1992 period. However, the endogenous aspects of their model motivated in the theoretical part of the paper are ultimately never tested. Hence, the paper lacks the *prescriptive guts* that one would expect from it, and the individual African developing countries are left in the cold (once again) as to what policies to adopt and how.

Third, while the conventional production theory is based on the assumption of decreasing elasticities with respect to the scale of the operation (Ringstad, 1974), the preferred functional forms for analyzing production are invariably Cobb-Douglas and/or translog forms both restricted by the *a priori* assumptions of

constant returns to scale and unitary substitution elasticities. Even sophisticated convergence models continue to insist on a restrictive "shape of the production function" (Jones, 1997), an insistence which seems to dispute [mistakenly I think] Hicks' (1966) insight that given low rates of technical progress various elasticities tend to be negative. Among the few exceptions Arifovic, Bullard, and Duffy's (1997) suggested an innovative model of the economic transition from stagnation to growth through an adaptive learning process. While it enhances the understanding of how economies shift from poor to good performance, this model too leaves unexplained the experiences of many developing countries which have shifted from growth to decline and stagnation.

The problems relating to the form are difficult to understand since the preferred restrictive forms of the production function are special cases of capable **transcendental** functions (Halter, Carter, and Hocking, 1957). Transcendental forms are flexible, and in the past have been used satisfactorily to explain shifts in US manufacturing output (Lovell 1968, 1973; Mundalok, 1964; cf. Revenkar, 1971), and postwar Soviet bloc and Japanese industrial growth and decline (Baraim, 1994), and more recently EU economic integration (Zestos, 1996). Thus, transcendental forms seem suitable for analyzing shifts from growth to decline and stagnation observed in developing countries like Namibia.

2. Conceptual Framework

$$y_{t+\Delta} = A(X_i, \theta) e^{\theta' X_i} e^{\mu} \tau$$

2.1 Conventional Production

Assume that real aggregate GDP (y) is a **trans**-function of exogenous inputs (X_i), and some measure of technical progress (θ), i.e.,

where $A(\theta / \text{time})$ is the state of technology, α_i and β_i are partial coefficients of X_i and θ , respectively, e is the natural logarithmic base, β_i are trans-parameters measuring the degree and extent to which α_i adjusts to variations in production scale and input substitution (complementarity), μ is a normally distributed disturbance term, and $i = 1, \dots, m$ are types of X_i .^{vi}

From (1) the Cobb-Douglas special case is rejected for all $\beta_i > 0$, resulting in a non-linear function that is characterized by variable marginal products and elasticities of production and substitution (complementarity) over the range of inputs (Halter, Carter, and Hocking, 1957). Hence (1) is a suitable tool for analyzing the retrogressive transition from growth to decline and stagnation observed in developing countries like Namibia; it allows for factor interdependencies, and applies to all three stages of production (Beatie and Taylor, 1985). It also gives a better description of the production process over time because it permits production to take place in time intervals of discrete durations, each duration distinguished from the other by unique

$$\xi_i \sim \frac{\partial}{\partial X_i} \text{trans-MP}_i (X_i / y) \sim \frac{\partial}{\partial X_i} \theta_i \sim \frac{\partial}{\partial X_i} \theta_i' X_i,$$

events, and in which production efficiency can be a local rather than a global phenomenon. For instance, a production process that is on average inefficient over a period of years need not be inefficient every year within that period.

$$(2.1) \quad \text{trans-MP}_i \sim \frac{\partial}{\partial X_i} \left(\frac{y}{M} \right) \sim \frac{\partial}{\partial X_i} \left\{ \frac{y(\theta_i \sim \theta_i' X_i)}{X_i} \right\}.$$

The trans-marginal product of the i th input (trans-MP_i) is

$$\text{Eq. (2) suggests that } \text{trans-MP}_i = f(\text{conventional MP}_i / y^2 / X_i; \theta_i'),$$

$$\frac{\partial^2 y}{\partial X_i^2} \sim \frac{\partial}{\partial X_i} \left[\frac{y \{ (\theta_i \sim \theta_i' X_i) \}}{X_i^2} + \frac{\{ 2 \theta_i \theta_i' \}}{X_i} \sim \frac{\{ \theta_i \theta_i' \}}{X_i^2} \right]. \quad (2.2)$$

and falls or rises as,

Given (2) the optimal expansion path for any X_i can be related to output level such that variable short-run elasticities of X_i become

$$\epsilon_i \sim \sum_{i=1}^m \xi_i, \quad (4)$$

and the variable scale elasticity of production (ϵ) is,

where $\theta_i = \theta_i' = 0$. And so, (1) is constant-returns-to-scale

if $\sigma = 1$, which obtains only if $\sigma'_i > 0$. Thus the trans-marginal

(5)
 $\lambda_i = \frac{\text{trans-MP}_i}{\text{trans-MP}_j} = -\frac{x_i}{x_j} \frac{1}{\sigma_i}$,
 rate of technical substitution between inputs X_i and X_j (σ_i),
 is variable as well, where $\sigma_i > \sigma_j$, and $x_i > X_i/X_j$. So, the
 elasticity of substitution (σ_i) becomes

$$\dot{y} = a_0 + \sum_{i=1}^m \xi_i \dot{X}_i + \dot{\Delta} \tau \tag{8}$$

$$\eta_i = \xi_i (dx_i / \{d \lambda_i\}). \tag{6}$$

Hence, $\eta'_i > 0 \Rightarrow \Psi \text{ trans-MP}_i > 0 \Rightarrow \eta_i > \eta'_i X_i \Rightarrow d\eta_i/dt < 0$ for all $\eta'_i < 0$, which means that as $\eta_i \rightarrow 0$ one factor Hicks-substitutes another (Hicks, 1965; 1966, pp. 112-135, 373-384). However, if the rate of technical progress is weak and $\eta'_i \rightarrow 0$, successful Hicks-substitution would also mean a slow rate of output growth.

Taking the natural logarithms of both sides of (1) gives

where $a_0 = \ln A$. The rate of growth of (7) over time is

where θ / time^* is a constant rate of technical change, and the dot indicates the growth of the variable over which it stands.

Eq. (8) is one measure of economic growth; an alternative measure is the growth rate of output per factor,

$$\dot{y}^* = \sum_{i=1}^m \xi_i \dot{x}_i + \dot{\Delta} \tau \tag{9}$$

where $y^* = y/X_i$ and $x_i = X_j/X_i$.

2.2 Economic Growth with Quasi-Endogenous Technical Progress

$$\dot{y} = \sum_{i=1}^m \xi_i \dot{X}_i - \delta \tau \dot{A}$$

$$0; \quad \dot{y} = \sum_{i=1}^{m-1} \xi_i \dot{X}_i - \delta \tau \dot{A}$$

$$\ln A = a_0 + \delta \tau \theta \ln X$$

From (8) and (9), the implicit rates of technical change associated with output and productivity growth rates are:

For ϑ / time (10) is familiar; for ϑ time (10) is much richer than conventional theory usually suggests. In addition, from (7)

(11.1)

$$\ln A = a_0 + \delta \tau \theta \ln X$$

one can represent the state of technology as:

A

Alternatively,

Both (11.1) and (11.2) differ from the cases in which $\theta = 0$. In a Cobb-Douglas function of the form $y = Ae^{\theta X^2}$, ϑ is exogenous by assumption and is usually represented by calendar time (i.e., ϑ / time), such that $(dA/dt)/A = \theta / \text{time}$ is the conventional Solow constant. However, for a variable ϑ , $(dA/d\vartheta)/A = [\theta \text{ multiplied by the growth rate of } \vartheta]$, is not necessarily a Solow constant. In the case of θ / time has indirect implications for economic growth and direct effects on the state of technology; the latter θ has direct effect on technology but independent influence on economic growth. This suggests that trans-coefficients can be

interpreted as either adjusting for the technical efficiencies of short-run elasticities or as correcting for variations in the measured residual, producing a combined Hicks-neutral as well as Arrow-learning measure of technology as

$$A(\tau, t) \approx A_0 e^{\{\delta \tau + \Delta t\}} \approx A_0 e^{\{\delta [\text{PHI}(y')^{\phi}] + \bar{\Delta} t\}}, \quad (11.4a)$$

where N = the elasticity of technical progress, and $\vartheta = [A_0(N + 1)y'^N y]/y = My'^N$ is an index of total factor productivity which is a function of a cumulative learning activity y' in response to some other cumulative activity, Z' (see Amavilah, 1996; Harris, 1991). In this essay Z' is cumulative imports of intermediate inputs as a proxy for foreign capital, y' is cumulative GDP, Z'/y' is a place-holder for cumulative trade-induced total factor productivity (TFP), and ϑ is average annual TFP.

The term $M = A_0(N + 1)$ represents the adjustment on the initial state of technology in response to changes in learned technical progress - in this case learned via trade. At any point in time the new state of technology is raised or lowered by $A_0 N$ unless $N = 0$ in which case the effect of learning on technical change is zero, and the rate of technical progress equal to the rate of technical change, and is pure Solow. As d'Autumne and Michel (1995) and Cohen (1996) point out with respect to the Arrow and Solow original models, technical change is exogenous only in the limited sense that calendar time with which it is commonly associated is exogenous.

Take for granted that the effects of trade on economic growth via its influence on resource productivity. Substituting for M in (11.4a) and expanding gives,

$$A(\tau, t) \sim A_0 e^{\{\Psi \phi (1 + \{y'\}^{\phi}) + \Delta t\}}. \quad (11.4b)$$

Expressing (11.4b) in log terms shows the parts of technical progress: the first is represented by the unexplained residual ($\ln A_0$) a la Solow; the second, $\ln[\exp(\Theta N)]$, reflects the innate impulses toward change explained by the level and state of technology (Lewis, 1953); the third, $\ln[\exp(\Theta N y'^N)]$, generalizes the effects of learning on technical progress; and the fourth, t approximates the exogenous effects due to the evolution of time, assuming that N is a variable, but $*$ is a constant such that $\Theta = A_0 *$, is also a constant.^{vii} But if N is also a constant such that

$$A(\tau, t) = A_0 e^{\{\Omega (1 + \{y'\}^{\phi}) + \Delta t\}}. \quad (11.4c)$$

$\Theta N = \Sigma$, then

Again (11.4) shows that the efficiency of technical progress encompasses (i) the learning process, (ii) the adjustment to the state of technology, (iii) the time factor over which the learning process occurs, and (iv) the interactions among (i)-(iii) above. Hence, technical efficiency can be simultaneously Hicks-neutral and Arrow-learning. Thus, given positive impacts of factor productivities on economic growth, the effects of technical progress either (a) cancel each other out, leading to stagnation; (b) one effect can dominate the other(s), giving either ordinary growth or decline; or (c) two or more effects can amplify each other, yielding "miraculous" growth or decay. Growth (and for that matter decline and stagnation) happens because of the cumulative reflexes of mutual adaptation to production rules

and policies by which the laws of plural decision-making and mutual reinforcement accelerate (slow down) cumulative transformation (see Hoadley, 1997). From this one can conclude that the evolution of technical progress can be decomposed in ways which distinguish technological change from conventional technical change.

The ideas behind these specifications of technical progress are not new.^{viii} Salter (1966, Chap. 10) proposed that technical progress is a function of factor prices, factor biases, economies of scale, knowledge, and product prices (see Choi, 1983, Chap. 5). In minerals industries (11.4) is similar to dividing the Hicks-Solow residual into time-dependent and depletion-allied technical components as in Newcomb (1965; 1967), where the

(11.6)

$$y \sim A e^{\{ * R \sim t \}} F(X_i),$$

production function is specified as

R is the resource stock, depleting at the rate of $*$, and t is time measuring technical change, evolving at the rate of \sim).

This simple concept marries Hicks and Arrow theoretically, and empirically offers an interesting perspective on technical progress. In its background is the idea that technical progress depends on human knowledge, *ceteris paribus*. Human knowledge is a function of the psychological and social nature of man. The most important element in the *ceteris paribus* bag as a determinant of

progress is time. As Bury (1932) put it, "... the possibility of progress is guaranteed by the high probability of an immense time to progress in" (p. 6). In other words, given sufficient time to learn progress ultimately follows. Hence, the essence of time in Solow-type models is that people discount the future at a positive rate of time preference.

2.3 Hypotheses

The trans-function outlined so far allows for simple, indirect, but powerful tests of the hypotheses and assumptions underlying production in ways that generalize conventional wisdom about the production process. For instance, if production time t is earlier than production time $t+j$, and the production output level y_t is smaller than or equal to production output level y_{t+j} , i.e., $t < t+j$ and $y_t \leq y_{t+j}$, then conventional production theory would suggest the following familiar hypotheses:

(12)

$$\begin{aligned}
 H_{\{01\}}: & \xi_i(t) = \xi_i(t+j) = \text{constant} \\
 H_{\{02\}}: & \epsilon(y_t) = \epsilon(y_{t+j}) = \text{constant} \\
 H_{\{03\}}: & \eta_i(t) = \eta_i(t+j) = \text{unity}
 \end{aligned}$$

These hypotheses are tested in the example that follows below.

3. Model Applied to Namibia's Data for 1968-1992

3.1 Namibia's Performance Problem

Historically Namibia has relied for growth more on vent-for-surplus in the traded primary sector than in either the traded secondary goods industries or in the non-traded secondary goods industries and tertiary services.^{ix} From the 1960s to the mid-1970s the primary sector accounted for the largest share of GDP, but its contribution fell from 50% of GDP in 1968 to 38% in 1992. Popular observers have attributed Namibia's decline and stagnation to the weak terms of commodity trade, and to exogenous factors such as weather, protectionist export markets, the small residual domestic market, and Apartheid policies. Consequently, a shift to traded secondary industries (viz., manufacturing) seemed reasonable.^x According to Davis (1994) South Africa's managed trade policies were ill-advised insomuch as they failed to stimulate rapid growth in secondary industries. In Namibia's case the share of secondary industrial output in the GDP averaged 9.5% throughout the 1968-1992 period (Ministry of Trade and Industry, 1993; Curry and Stoneman, 1993; World Bank, 1992). However, within the secondary sector manufacturing output grew by only about two percent over the 1970-1985 period and was mostly negative through 1992 (UNIDO, 1990; World Bank, 1992; Bank of Namibia, 1993; van der Linden, 1993; Murray, 1992; Investor, 1992; Amavilah, 1996; Ministry of Mines and Energy, 1993). By contrast the share of the country's GDP originating from the non-traded tertiary sector rose from 32% in 1968 to 55% in 1992. The

growth in the tertiary sector was accompanied by even faster government spending and slow private investment in the traded sectors (World Bank, 1992; Murray, 1992; Sherbourne, 1992).

The problem is that as a developing component of South Africa, Namibia's primary export-led growth was tied to private sector investment in resources, with the surplus gains from trade going to expand the comparative advantages of other traded sectors. As the terms of commodity trade worsened for developing countries as a group, South Africa endorsed strategic trade policies, encouraging public borrowing and transfers to the aggregate domestic economy including targeted manufactures (see Davis, 1994, Chap. 6). The failure of this endorsement to switch the economy from resource to innovation rents by garnishing productivity gains more broadly, as evident from the growth in GDP pre-1980 and decline and stagnation thereafter, suggests a pathological side to strategic growth policy independent of comparative advantages, in which inefficiencies of managed trade or even regressive technical change offset economic growth. To establish an empirical analysis of this pathology case requires focusing on domestic resources as well as finding a way around the problems of distinguishing regressive impacts within exogenous (Hicks or Solow-neutral) technical change, and endogenous (Arrow-learning) technological change on net output and factor productivities.

3.2 Model Specification

Assume that Namibia's real GDP and its growth rate are determined according to (7) and (8) respectively, in which X_i are exogenous total labor (L) and capital (K) inputs, (i.e., $y = f(L, K, \vartheta)$),

$$\ln y \sim a_0 + \alpha \ln L + \beta \ln K + \alpha' L + \beta' K + \delta \tau + \mu, \quad (13)$$

such that,

where L is the number of workers employed, K is domestic capital stock, and ϑ is a general index of trade-induced total factor productivity as a measure of technical progress. The growth rate

(13.1)

$$y \dot{\sim} \xi_L L \dot{\sim} \xi_K K \dot{\sim} \delta \tau \dot{\sim} \mu.$$

of (13) becomes

(13.2)

$$y \dot{\sim}^* \xi_K k \dot{\sim} + \delta \tau \dot{\sim}.$$

Taking L as a numeraire gives

Alternatively, dividing L into unskilled (L^*) and skilled (H)

$$\ln y \sim a_0 + \alpha^* \ln L^* + \beta \ln K + \gamma \ln H + \alpha^* L^* + \beta' K + \gamma' H + \delta \tau + \mu, \quad (14)$$

labor components such that $y = f(L^*, K, H, \vartheta)$ leads to

where $L^* = L - H$, $\xi_i = (\forall, \forall^*, \exists, (,)$, and $\xi_i' = (\forall', \forall^{*'}, \exists', (',)'$.

(14.1)

$$y \dot{\sim} \xi_{L^*} L^* \dot{\sim} + \xi_K K \dot{\sim} + \xi_H H \dot{\sim} + \delta \tau \dot{\sim}$$

The growth rate of (14) is

where $\xi_L = \forall + \forall' L$, $\xi_{L^*} = \forall^* + \forall^{*'} L$, $\xi_K = \exists + \exists' K$, $\xi_H = (+ (' H$, and

$\dot{y}_L = \dot{y}_{L^*} + \dot{y}_H$. The growth rate of average labor productivity in

(14.2)

$\dot{y} = \alpha \dot{P} + \beta \dot{K} + \gamma \dot{H}$

(14.1) is,

where $P^* = L^*/L$, $h = H/L$.^{xi}

3.3 Model Estimations and Results

Models (13) and (14) were estimated and tested for the years 1968-1992. The results follow below.

3.3.1 When Economic Growth is Growth of GDP

Table 1 shows that the results from the estimation of (13) accept a Cobb-Douglas production function with constant output-input elasticities, a "regressive rate of technical change" (Chambers, 1988), and decreasing returns to scale. The estimates of (14) in **Table 2** also give constant output-input elasticities of skilled and unskilled labor, but the elasticity of capital is variable, $\beta' < 0$. As **Figures 1a and 1b** indicate the goodness-of-fits are reasonable, considering the small size of the sample. In a later section it is argued that the results reveal a discernible break from growth pre-1980 to decline and stagnation thereafter, leaving little net growth for the whole period. For now note from **Figure 1b** that pre-1980 there were nine years of positive growth and about three years of decline. After 1980 the country saw negative growth during eight years and positive growth in only

five, leaving only three years of real growth overall in two and a half decades.

What happened? What happened is that the output elasticity of capital fell from 0.53 in 1969 to -0.22 in 1992. Annual production scales also dropped from 0.79 in 1969 to 0.42 for 1977, and continued to decline at an accelerating rate for the remaining years. In both cases the findings suggest capital as the key growth factor pre-1980, as well as the constraint post-1980. The mixed and negative signs for α and β are unexpected, but the usual econometric adjustments neither improve the significance nor correct the signs of the parameters, they probably reflects the problems of the small-size of the sample. However, even if the estimates were biased, they remain consistent and meaningful. And so, the low factor productivities, high R^2 , and the absence of a trend indicate poor performance in which the rate of cumulative learning has been high, but that of technical progress very low.

3.3.2 When Economic Growth is Growth of Labor Productivity

In an Ak-type model, K/L ratio and total factor productivity explained 23.3% of the changes in labor productivity. The coefficient of K/L was significant at 0.212 and that of θ at -0.280

Tables 1-2

Figures 1-2

constant, while that of skilled labor is a negative constant. The negative effect of skilled labor on economic growth is a disturbing, but not an unusual, result. Benhabib and Spiegel (1994) justified (< 0) with the fact that most developing countries had low initial stocks of skilled labor to begin with. This explanation seems plausible for Namibia where the supply of skilled workers, and hence its growth rate, remains limited to date.^{xii} As such the Namibian labor market overpaid skilled labor beyond the rate warranted by its marginal productivity.^{xiii} Another explanation may be that the assumption that skills are of equal productivity may be simply wrong: the efficiency of a skilled mine worker may be worth more than that of a skilled government employee. If so, from Hicks (1965) it is clear that if two laborers are of unequal efficiency, their marginal product can be zero [or negative], because "we cannot tell what would be the difference to the product if one man were removed from employment; for it all depends which man is removed" (Ch. II, p.28). Thirdly, skilled workers are concentrated in the tertiary sector which is dominated by government, and governments are generally better consumers than producers of GDP. Finally, as Cohen (1996) points out "poor countries are behind because they failed to raise their investment decisions above what it would take to compensate for their initial disadvantage" (p. 360) in technology. In this sense the problem in Namibia's case is not only of the low level of exogenous skills, but of endogenous skill building using whatever level of exogenous skills.

While the elasticities of labor were constant, the elasticities of capital turned out to be variable, i.e., $\epsilon_K = \exists - \exists'K = 0.668 - 0.00009K > \epsilon_L = \forall$. This finding agrees with that of Mankiw, Romer and Weil (1992), and Romer (1990) which found the productivity of physical capital for a cross-section of countries to be higher than that of labor. It is also consistent with studies which have found capital to determine output and labor productivity significantly more in small non-primary commodity producing developing countries than in small primary commodity producing developing countries like Namibia (Coppin, 1994; Ukpolo, 1994). De Long and Summers (1991) argue that even a $\exists < 0$ would be a reasonable result in the special cases in which investments are made in non-productive structures. Capital formation originating from investments in machines and equipment is necessary for long-run human capital accumulation and economic growth. In the case at hand, the effects of capital on economic growth are declining.

The first hypothesis in (12) is not accepted and possibly rejected because, although $\epsilon_L(t) = \epsilon_L(t+j) = \text{constant}$, $\epsilon_K(t) >> \epsilon_K(t+j) = \text{constant}$. The negative capital elasticities and the downward trend they represent suggest capital shallowing (**Figure 2a**). They also reveal that Namibia's economic decline/stagnation appears to have started around 1978 when the elasticity of capital fell below 20%. Obviously, one can attribute this fall to the worsening terms of trade; however, it is more likely than not that the South African policies that favored secondary industries

even though Namibia's

Figures 2a-2c

comparative advantages were in primary industries were responsible for the downturn, which can be discerned from the less-than-unity scales as well as decreasing returns (see **Figure 2b**). Unlike what conventional production theory would have predicted, the third hypothesis in (12) is firmly rejected because $O_i(t) \cdot O_i(t+j)$ is significantly less than one. Even as employment in the tertiary sector continued to rise, over time labor-capital substitution became rigid, discouraging capital formation (**Figure 2c**). The implication of all this is that technical inefficiencies attended the Namibian economy during the 1968-1992 years, such that, in the absence of technical progress, output fell as input substitution became rigid post-1980.

In terms of labor productivity, unskilled labor was the most significant factor in Namibia's performance. However, the effects of weakening capital productivity, along with the declining rate of technical progress, ensured a decline and stagnation. This makes sense. Wolff (1991) notes that the rate of technical change depends on capital. When capital productivity is high, economic growth depends less on exogenous forces such as technical change. With low capital productivity economic growth is determined mainly by exogenous technical change. Since capital productivity was weak, labor productivity constant, and the rate of technical progress not strong, economic decline and stagnation were inevitable. These results are also consistent with Gapinski's (1996) findings which show the share of capital in Namibia's output to be 24.8% of which -2.4%, 19.2%, and 5.6% are due to

depreciation, quantity, and quality of capital, respectively. By contrast, the marginal contribution of aggregate labor to output is 46.8%, of which the share of unskilled labor (quantity) is higher than that of skilled labor (quality).

Not only is the efficiency of aggregate capital lower than that of aggregate labor, its quality component is even lower than its quantity portion. Given the fact that equipment depreciated at a rate faster than the contribution of labor to growth, one can conclude that Namibia's growth difficulties post-1980 were problems in capital formation and technical progress. Again from the profiles of elasticities it is clear that these problems started in the 1970s and continued to worsen post-1980. One may argue that instead of the low productivity of capital leading to the economic decline and stagnation, instead it was slow economic growth, the effects of Apartheid laws on labor markets, and low labor education coupled by economic sanctions, which led to low rates of capital formation. Even so, empirical evidence weighs in favor of capital being the problem. For example, gross domestic investment per capita fell from US\$620 in 1980 to only US\$120 in 1993. The ratio of investment to GDP also dropped from 32.4% in 1980 to merely 9.6% in 1993 as did the savings-GDP ratio, which declined from 42.9% in 1980 to 3.7% in 1993. At the same time consumption increased to 63.2% of GDP in 1993 from 40.4% in 1980. Hence, a significant resource shift from production to consumption can be inferred, and with it the observed decline and stagnation. The negative effects of excessive consumption on

economic growth have been noted in a number of studies including Easterly and Rebelo's (1993) examination of the impacts of fiscal policies on the economic growth of 125 countries for the 1970-1988 period.

5. Conclusion and the Road Ahead

The results conclude that during 1968-1992 Namibia's production technologies were characterized by constant returns to scale pre-1980, and by decreasing returns to scale from 1981 to 1992. During those 25 years a small growth trend in GDP breaks down to significant positive growth pre-1980 followed by a significant decline and stagnation after 1980, which all but offsets the 25 year trend. The break came about as a result of serious resource inefficiencies as evidenced by falling capital productivities, in addition to the fall in the terms of trade. Policy attempts to stimulate manufacturing productivity fell short of expectations, while the size and growth of the tertiary sector (mainly government) increased sharply. The result was a reduction in the surplus generated from primary commodity exports.

This conclusion recommends that Namibia needs to (i) improve factor productivities if it hopes to stimulate above-average economic growth, and (ii) promote technical progress in order to sustain growth. Improving factor productivity would require fast skill building in order to bring down the wage rate to a level supported by the market. Capital accumulation and technical

progress depend not only on the surplus generated from trade, but also on how trade gains are used, and whether or not trade enhances learning, and therefore technical progress. There was a great deal of learning from trade; however, most of it was devoted to catching-up and very little went to endogenous knowledge creation.

The conclusion also suggests a number of areas for further research. For instance, to assume that physical and skill-building capital and technical change are exogenous, even for a developing country leaves unexplained many of the dynamic processes of growth, decline and stagnation. Admittedly cumulative learning aids capital inflows through foreign trade and direct foreign investments, but foreign trade and investment do not replace the importance of domestic resources to economic growth. On that score there is a great need for the study of the processes of capital formation in Namibia, and within that even greater need for identifying skills. A basic demand and supply model of skills would be helpful in the latter case.

Appendix - Further Notes

A.1 Data and Variables

The data used for the estimations were drawn from a number of sources, including the revised U.N. System of National Accounts (UNDEI, 1993), Leistner (1971), UNIDO (1990), World Bank (1992) and a variety of reports by the Economist Intelligence Unit, World Bank, and in Namibia itself the Ministries of Mines and Energy, Trade and Industry, and Finance, Bank of Namibia, and the Chamber of Mines of Namibia. All relevant monetary variables were "single-deflated" using the consumer price index (CPI) with 1980 as the base year. CPI is a poor, but the only deflator consistently available for Namibia (see Stone, 1992). The quality of the data remain open to the incumbent aggregation problems and measurement errors common to developing countries.

A.2 Econometric Facts and Assumptions

The single-equation stepwise ordinary least squares, corrected for serial correlation by the Cochrane-Orcutt technique, was used. Correction for heteroskedasticity of any unknown form was by White's (1980) heteroskedastic-consistent covariance matrix estimation. Significance tests of individual parameters were by t-ratios, and by the F-test for joint hypotheses. A number of P-values are also given. The random error term was assumed to be $\mu - N(E(\mu) = 0, E(\mu^2) = \Phi^2)$. The sample-size (N) is 25 observations, which divide into 13 years and 12 years for the pre- and post-1980 periods, respectively. The statistical significance is the usual 5% level, and the measures of regression goodness-of-fit is the adjusted R^2 , and the Jarques-Bera's statistic distributed as Chi-squared (see Davidson and MacKinnon, 1993; Green, 1990). The weaknesses of these tests in small samples are well-known.

A.3 Derivation of $\hat{\theta}$

The learning process takes a long time; so to calculate the $\hat{\theta}$ series for use in model estimations, the initial period 0 was 1960 and the end period T was 1992. The index of trade-induced

(1A)

$y' \sim \sum_{t=0}^T y_t \sim \text{experience}, \sim Z' \sim \sum_{t=0}^T Z_t = \text{response}.$

total factor productivity was derived as follows:

From these definitions, cumulative trade-induced total factor productivity is,

$$\tau' \sim \frac{1}{Z'} \frac{dZ'}{dy} \sim A \{y'\}^{\phi} \tag{2A}$$

where $N = \ln(2^N)/\ln(2)$ is the elasticity of progress, $2^N =$ the

$$Z' \sim \frac{dZ'}{dy} \sim \frac{d}{dy} \left\{ \frac{\Phi \{y'\}^{\phi}}{1 - 2^{-N}} \right\} \tag{3A}$$

learning rate, and $1 - 2^{-N}$ = the rate of progress. It follows that where $M = A_0(N + 1)$ is the adjustment on the initial state of technology in response to technical progress. The rate of learning was found to be higher than the rate of progress. The implication is that most learning is devoted to catching-up and little to endogenous knowledge creation (Cf. Cohen, 1996).

A.4 A Note on A

$$A(t) \sim A_0 e^{\Delta t} \sim \Psi \sim \dot{A} \sim \Delta \tag{4A}$$

Note that from (11.4),

$$A(\tau / t) \sim A_0 e^{\delta \tau} \sim \Psi \sim \dot{A} \sim \delta \sim \Psi \tag{5A}$$

If $\delta / t,$

Assuming that $\delta \quad t = 0,$

$$A(\tau, t) \sim A_0 e^{\Lambda \Omega \phi(\phi + 1)}$$

(6A)

$$A(\tau, t = 0) \sim A_0 e^{\Delta(\Phi\{y'\}^\phi)} \Psi \sim A \dot{\sim} \Lambda \{y'\}^{\phi - 1} y$$

But if learning takes place over and in time, i.e., $\vartheta =$

(7A)

$$A(\tau, t) \sim A_0 e^{\Delta(\Phi\{y'\}^\phi) + \Delta t} \Psi \sim A \dot{\sim} [\Lambda \{y'\}^{\phi - 1} + \Delta] y$$

$\vartheta[y'(t)]$, then,

where $\gamma = \Theta N^2 + \Theta N$ is a quadratic parabola that opens downward or upward for Θ nonzero, and N is not a constant. In other words,

It is assumed that dA/dt , $(dA/dy') \cdot (dy'/dt)$, and $(dA/dy) \cdot (dy/dt)$ are equal one (unity). In the case this is not true the form of technical progress becomes very complex.

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Notes

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ⁱⁱ Resources are assumed to have two parts: conventional factors of production mainly physical capital, labor, and land; and the "forces of progress" consisting of non-physical production inputs such as technical progress, human capital, and enriched "land" in the form of trade.

ⁱⁱⁱ See Ricardo's *Essay on Profit* in Sraffa (1951) and further interpretations in Samuelson (1994).

^{iv} Technical progress is taken to be made up of technical change and technological change.

^v Taken to the extreme the preceding observation may well be said to support Ludwig von Mises' (1979) maintained proposition that "what is lacking in order to make the Developing countries as prosperous as the United States is only one thing: capital, [and] these nations must accumulate domestic capital ... under the discipline of the market and not the discipline of the government" (p.86).

^{vi}. A function f is algebraic (non-transcendental) if $f^k(x) = f(x)^k$, otherwise it is transcendental (non-algebraic). The prefix "trans-" is used here referring to such a function and its derivatives.

^{vii}. Compare to Young (1991), noting that here $\vartheta = \vartheta(y'(t), N)$, unless when ϑ / t .

^{viii}. For other plausible forms and estimation techniques of A see Mitchell (1990) and Calum (1990), respectively.

^{ix}. The primary sector is made up of agriculture, fishing, and mining and quarrying. Non-traded secondary goods industries include construction, water, and electricity, while tertiary services is mainly government, tourism, and money and banking.

^x. At the time South Africa was also seeking ways to mitigate the effects of the economic sanctions against its Apartheid

policies. Apartheid policies and the sanctions they drew applied to Namibia until independence in 1990.

^{xi}. Total labor is the number of workers, whereas skilled labor are those with secondary education or better, plus some percentage of the labor force with seniority, assuming learning-by-doing. Some economists have used the average wage rate ("reservation wage rate") versus categories of labor, level of education, or some other formal measure of imputing skills (see Cox and Oaxaca, 1992). Capital is cumulative domestic investment starting in 1960 and ending in 1992. Domestic investment is net of depreciation, foreign payment of imported intermediate inputs (Z), capital inflows, and repayment of debt.

^{xii}. This statement does not deny the good reasons why the supply of skilled labor has been limited in Namibia.

^{xiii}. Many contributors to the Oxford Bulletin of Economics and Statistics, Special Issue on Human Capital and Economic Development, 1996 (February) distinguish "human capital stock effects", which are often negative, from "human capital accumulation effects" which tend to be positive.