Working Paper

Reflections on the Modelling of Caribbean Economies

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Abstract

This paper is a survey and assessment of a selection of economic models that are found in the Caribbean, chosen from two traditions of modelling: one, the medium/long term genre that has its roots in the work of Harrod and Domar, and the other, structural equation models in the Wharton/Cowles Commission tradition. A generalisation that emerges from both traditions is that potential growth in small open economies is determined on the supply side, by the capacity to supply internationally competitive goods and services, when competition is understood to mean comparable value for money spent on every quality of the product. It is also evident that capacity to supply depends on the supply of finance and on the quality of the labour force. The policy implications remain the subject of discussion, and further work is needed on issues of the mobility of capital and labour.

Keywords: Economic model, Caribbean economy, economic forecasting, growth model, economic policy, open economy, economic development.

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This paper is a critical appraisal of a selection of approaches to the modelling of Caribbean and other economies of similar size. The selection is based on the interests and experiences of the two authors. Part I of this essay discusses models of growth and development with a focus on the medium and long term. The models discussed in Part II are designed for use by policy makers engaged in the ongoing management of the economy. They must keep an eye on the medium and long-term trajectory of economic development, but they have the more immediate concern of assessing the current health of the economy, applying appropriate measures to maintain and, where, necessary restore the economy to health. In Part III of the paper we comment on insights derived from the analyses in Parts I and II.

Part I includes sections on the Harrod (1933) open economy model, the Prebisch (1950) centre-periphery model, the Seers (1962) centre-periphery model, and the balance-of-payments-constrained model of Alleyne and Francis (2008). Part I concludes with a suggested way forward for the analysis of growth and development. Part II contains sections on the dynamic stochastic general equilibrium (DSGE) model, on the match between that model and the Caribbean reality, on the IMF Internal Balance External Balance (FINEX) model, on the comparison between FINEX and the structures of Caribbean economies, and on models that are constituted from a structure of testable quantitative relationships. Part II ends with a suggested approach to the use of model-based forecasts for the economic management of small open economies (SOEs).

Part I. Selected Models of Growth for Caribbean Economies

This section presents an external review of a set of demand-led models that seek to explain the rate of growth of the output of open developing economies without reference to a concept of the development problem. The reference concept used for the review is that of an economy characterized by widespread undercapitalization of economic activity, as specified in Lewis (1954). The specification and dynamics of the growth path suggested by each model are first presented, taking care to represent how the model explains growth of demand. Then, key missing elements of the interdependent dynamic development process by which a Caribbean economy alters the structure and scale of demand are identified. It is suggested that, at best, by failing to represent the identified features, the demand-led growth models represent a process of growth without development that is unlikely to fit the observed paths of Caribbean economies. Details of the internal logical structure of the models are presented in James and Taylor (2021).

1. The Harrod Open Economy Model

Based on his open economy trade multiplier, Harrod (1933) proposed an export-led growth model, It can be described by the following variables separable differential equation:

1. $\frac{dY}{dt} = g(t)Y$

where Y is output and $g(t) = \frac{1}{\pi}\frac{dX}{X}$, with π the income elasticity of demand for imports. This export-led model is fully aggregated. There is no economic structure and it explains growth without reference to the fact that the evolution of exports and imports is tied closely to the evolution of a set of capacities, such as:

(i) capacity to develop institutions and adjust production techniques competitively; and (ii) capacity to change the structure of production, mainly by producing capital as part of the stock accumulated to create exports and surplus. The model ignores the process of competitive technical adjustment, productivity growth, and wage formation that optimize the flow of surplus, profits, and savings to underwrite investment for export creation. It also ignores the role of foreign capital inflows on which Caribbean economies tend to rely to develop their natural-resource exports. Instead, the institutions and the stock of capital are implicit and exogenous in the model, and it relies entirely on external demand forces to grow output, implicitly assuming that the economy has access to a stock of capital that enables competitive response to any type and level of demand it seeks to satisfy. Such a model cannot explain the time path of a Caribbean economy, which evolves by addressing the challenges posed by widespread undercapitalisation of economic activity.

2. *The Prebisch Centre-Periphery Model*

Prebisch (1950) essentially used Harrod's equation (1) to write growth paths for the "developed country" (y_{dc}), equipped with the capacity to produce manufactures, and the "under-developed country" (LDC), which is only capable of specialising in primary production. From equation (1), it is straightforward to show that:

$$2. \quad y_{dc} = \frac{\pi_{ldc}}{\pi_{dc}} \frac{\frac{dX_{dc}}{X_{dc}}}{\frac{dX_{ldc}}{X_{ldc}}} y_{ldc}$$

where π_{dc} is DC's income elasticity of demand for imports (which are the exports of LDC) and π_{ldc} is LDC's income elasticity of demand for imports (which are the exports of DC).

Equation (2) is the basis of Prebisch's pioneering centre-periphery analysis of the comparative gains from trade of developed and under-developed economies and related dependent development. Prebisch observed that the elasticities are consequences of the structure of production and the related international specialisations of the economies. Looking from the perspective of Latin America (and the Caribbean), LDCs are capital-deficient and land- or labour-abundant, and specialise in primary activities, especially agriculture, which incur diminishing returns to the use of these relatively abundant resources. Full-employment of the abundant resources is not guaranteed under these conditions and land rents or wages are accordingly kept low. Land- or labour-based output is correspondingly low-cost output which commands only a small share of the incomes of DCs. This also causes the DC income elasticity of demand for imports, π_{dc}, to be relatively low, where DC imports are LDC exports. On the other hand, the imports of LDC are the exports of DC. DC is capital abundant and specialises in manufactures, on which most of its income is spent. Similarly, the income elasticity of demand for manufactures by LDC (π_{ldc}) is relatively high, partly because LDC adopts the taste-patterns of DC as a result of structural and psychological dependence.

By (2), the rate of growth of DC will exceed the rate of growth of LDC, and DC will become relatively richer over time, unless $\frac{\frac{dX_{dc}}{X_{dc}}}{\frac{dX_{ldc}}{X_{ldc}}}$ adjusts downwards through faster growth of the exports of LDC than those of DC. However, it must also hold that LDC exports grow depending on the DC elasticity of demand for

imports, so that $\frac{dX_{ldc}}{X_{ldc}} = \pi_{dc}\frac{dY_{dc}}{Y_{dc}}$, which will be kept down by the low π_{dc}. On the other hand, $\frac{dX_{dc}}{X_{dc}} = \pi_{ldc}\frac{dY_{ldc}}{Y_{ldc}}$, which would drive up $\frac{dX_{dc}}{X_{dc}}$ on account of the high π_{ldc}. The corresponding patterns of imports will normally cause LDC to experience a persistent tendency to trade deficits, and, ultimately, balance of payments deficits on the current account. If growth rates are constrained to adjust to ensure a balance of trade and payments equilibrium, it would be necessary that $\frac{\frac{dX_{dc}}{X_{dc}}}{\frac{dX_{ldc}}{X_{ldc}}} = 1$, so imports do not grow faster than exports. This would result in balance of payments-constrained growth rates given by:

3. $y_{dc} = \frac{\pi_{ldc}}{\pi_{dc}}y_{ldc}$

By (3), the growth rate of DC will be persistently higher than that of LDC because of the underlying patterns of specialisation reflected in π_{dc} and π_{ldc}. It is this consequence that prompted Prebisch (1950) to promote industrialisation and the production of manufactures in Latin America.

Prebisch also considered how adverse price movements for primary exports reinforce the tendency to balance of trade deficits, essentially abandoning the Harrod assumption that the barter terms of trade (the ratio of the export price index to the import price index) is constant. The argument was couched in terms of the long-run movements in the terms of trade. Adverse movements of the prices of primary products tend to cause the price index of exports to fall leading to deterioration of the barter terms of trade. This is associated with a fall in export earnings and, hence, a fall in exports relative to imports along with a fall in income. By equation (2), the effect is a fall in the rate of growth of LDC and a rise in the rate of growth of DC. The only counter to this process is an inflow of foreign capital from DC that targets the export sector and causes exports to grow while improving the balance of payments and appreciating the exchange rate. This would simultaneously lower the domestic price of imports and improve the real terms of trade in favour of exports. The process would effectively increase $\frac{dX_{ldc}}{X_{ldc}}$ in equation (2) and the total effect of that payments response would be a desirable fall in $\frac{\frac{dX_{dc}}{X_{dc}}}{\frac{dX_{ldc}}{X_{ldc}}}$ that would raise the rate of growth of LDC. Prebisch did not place much store by this possible countervailing effect, emphasizing instead the dominant role of international industrial specialisation in shaping π_{dc} and π_{ldc} and, thus, in determining the tendency for LDCs to become comparatively poorer over time.

As with equation (1), the striking feature of equations (2) and (3) is that they ignore the underlying competitive strategy of the economy and the related evolution of the institutions and production techniques of the economy as well as the stock of capital that is deployed to produce exports and reshape the elasticities. Issues of productivity growth relative to factor payments to address diminishing returns in the production of manufactures and primaries are not addressed directly. It is evident that the key implicit factor that ultimately makes the model work is the difference in the capacity to produce capital to engage in international competition through piecewise continuous strategic innovative adjustment of techniques. This factor is shielded from view by treating manufactures as homogeneous, thereby failing too distinguish manufacture of capital from manufacture of consumer goods and the different roles these play in the development process. If an economy can make as much capital as it wishes, capital cannot be

economically scarce and can be developed to compete successfully and shape taste patterns locally and globally. It is this capacity that explains the abundance of capital and the production of manufactures in DC versus scarcity and production of primaries in LDC, the fact that both DC and LDC have a high income elasticity of demand for manufactures, the differences in the π_{dc} and π_{ldc}, and the DC's capacity to provide an inflow of capital to LDC in response to its growing balance of trade and balance of current payments deficits. A growth model with such limitations cannot fit the development path of a Caribbean economy taking steps to eliminate widespread undercapitalisation of economic activity. It also cannot explain how the Caribbean economy compensates for factor incomes going abroad by sufficient productivity growth through domestic capacity-building rooted in the development of capacity to produce capital and upgrade institutions as part of competitive strategy.

3. *The Seers Centre-Periphery Model of Growth*

In deriving his classic and insightful centre-periphery differential equation of the growth rate of developing countries, Seers (1962) also assumed balanced trade and a constant barter terms of trade. Seers classified countries as "centre" (c) countries which produce manufactures, and periphery (p) countries, which produce primary commodities. He understood that behind the differentiation and international specialisation was also an international division of power and influence in world affairs, hence his choice of labels.

Both the centre country and the periphery country have linear import functions (J_c,J_p) with characteristic autonomous imports (a_c and a_p) and characteristic marginal propensities to import ($b_c = \frac{dJ_c}{dY_c}$; $b_p = \frac{dJ_p}{dY_p}$). On this and the assumption that the rate of growth of the centre country is some constant rate, $\frac{dY_c}{Y_c dt} = r$, Seers derived the differential equation for the growth of the periphery country as:

4. $$\frac{dY_p}{Y_p dt} = r\left(1 - \frac{a_c - a_p}{b_p Y_p}\right)$$

However, based on the international specialisation in trade assumed by Seers, $a_c - a_p > 0$, it follows that $\frac{dY_p}{Y_p dt} < r$ and the periphery economy will perpetually grow at a slower rate than the centre country as long as the balance of trade is preserved. The periphery economy will become relatively poorer than the centre country over time, a result that is similar to that of Prebisch (1950). Moreover, per capita incomes will also further diverge in perpetuity if the population of the periphery country is growing faster than that of the centre country. As with Prebisch, Seers concluded that the fundamental solution to this problem is to change the production structure of the periphery economy to increase its production of manufactures, so that the import propensities would converge, $a_p \to a_c$, and the import and export equations of the countries would become more similar. A possible alternative is for the centre country to export some of its abundant capital to the periphery to build capacity to increase $\frac{dY_p}{Y_p dt}$, such that $\frac{dY_p}{Y_p dt} \to r$ from below, thereby growing at the same constant rate as the centre country. By equation (4), this requires $\frac{a_c - a_p}{b_p Y_p} \to 0$ and the rate of foreign capital inflows should also equal r so that the equation satisfies:

5. $\frac{dY_p}{Y_p dt} = \frac{dK_{cp}}{K_{cp} dt} = r$

where $\frac{dK_{cp}}{K_{cp} dt}$ is the rate of growth of the capital stock of the periphery fostered by the capital flows from the centre. The capital flows from the centre at the constant rate r would represent a liability to the periphery that is increasing at a constant rate and raising its debt-GDP ratio and its debt-servicing obligations. Once that ratio passes some threshold, such as 60% of GDP, the investors in the centre country would begin to get nervous and demand fundamental changes in the periphery to ensure debt sustainability. Ultimately, the fundamental changes needed in the periphery would be those that activate the structural changes proposed by Seers. This suggests that foreign capital inflows do not represent a long-run solution to the periphery's growth problem.

As in the case of Prebisch (1950), Seers did not trace the differentiation of centre and periphery to the capacity to produce capital and upgrade institutions, or to the related capacity to compete, solve problems, and shape taste and technology, and exports as well as imports. This is because the model also treated manufactures as homogeneous, and failed to distinguish manufacture of capital goods from manufacture of consumer goods and the different roles these play in the development process. The model therefore fails to represent the nature of competition and the necessity to develop domestic capacity to implement a viable competitive strategy in the form of timely piecewise continuous technical adjustment. Seers ignored the domestic savings constraint and the fact that the convergence of the production structures and income elasticities requires development of the same capacity. That is the capacity to produce capital, upgrade institutions, and grow competitive capacity and savings, so that both economies can become capital abundant and capable of shaping domestic and foreign technologies, tastes and preferences. Essentially, without a capacity to explain how exports and surplus are produced and therefore how the domestic savings constraint can be relaxed without reference to foreign savings, the Seers model also cannot fit the development path of a Caribbean economy that is actively growing its capacity to produce capital, compete and save. It also cannot fit the development path of an economy that initially relies on foreign capital inflows to develop its domestic resources at a cost of factor income outflows. Specifically, it cannot explain how such an economy compensates for those outflows of factor income by optimal adjustment of export and surplus production achieved through piecewise continuous technical adjustment rooted in the development of capacity to produce capital, especially in the form of knowledge, skills and self-confidence.

4. The Balance of Payments Constrained Growth Model of Alleyne and Francis

Informed by the Caribbean experience, Alleyne and Francis (2008) extended the balance of payments constrained growth model of Thirlwall and Hussain (1982) by observing that foreign capital flows (F are generally attended by costs which flow in the other direction as factor payments at a rate of return i. The latter payments are reported as investment income in the current account while F is reported in the capital account. Let P_d be the domestic price (index) of exports, P_j the price of imports, ε the domestic price of foreign currency, Y_j foreign GDP, and Y domestic GDP. The Alleyne and Francis (2008) growth equation is:

5. $$\frac{dY}{Ydt} = \frac{(1+\theta\eta+\psi)\left(\frac{dP_d}{P_d dt} - \frac{d\varepsilon}{\varepsilon dt} - \frac{dP_j}{P_j dt}\right) + \theta\gamma\frac{dY_j}{Y_j dt} + (1-\theta)\left(\frac{dF}{Fdt} - \frac{dP_d}{P_d dt}\right)}{\pi}$$

where $\theta = \frac{P_d X}{\varepsilon P_j J}$, $(1-\theta) = \frac{(1-i)F}{\varepsilon P_j J}$, $\eta < 0$ is the price elasticity of demand for exports, $\psi < 0$ is the price elasticity of demand for imports and $\pi > 0$ is the domestic income elasticity of demand for imports. Equation (6) updates Thirlwall and Hussain (1982) by adding the result that, for an economy that uses the safety valve of real foreign capital inflows to finance trade deficits and gain access to necessary imports, the effect on the domestic rate of growth falls the higher the rate of return on capital inflows. Further, if the law of one price holds, then $\gamma\frac{dY_j}{Y_j dt} = \frac{dX}{Xdt}$, where $\gamma > 0$ is the foreign income elasticity of demand for exports, so the rate of growth of the economy reduces to:

6. $$\frac{dY}{Ydt} = \frac{\theta\frac{dX}{Xdt} + (1-\theta)\left(\frac{dF}{Fdt} - \frac{dP_d}{P_d dt}\right)}{\pi}$$

Thus, an economy that relies on foreign capital inflows to finance trade deficits and gain access to necessary imports will have an increased rate of economic growth determined by the weighted sum of the rate of growth of its exports and the rate of growth of the real value of foreign capital inflows net of the real outflows of investment income. Moreover, considering $1-\theta$, the higher the rate of return on the real foreign capital inflows, the lower the rate of growth of the domestic economy. It is interesting that the model does not attempt to explain the competing role of domestic savings.

Even if the law of one price holds, it must be admitted that firms tend to compete on other technical and product characteristics, which leave the model mis-specified since these technical and product characteristics are not addressed. These characteristics, along with price differentiation, reflect differences in competitive strategy and innovative adjustment of techniques tied closely to the capacity of the local and foreign economy to produce capital and develop institutions. As economies build their capacities to produce capital and develop institutions on different trajectories and evolve towards exports of differentiated goods and services, the inability of some countries to bring winning solutions to market lead them to persistent balance of trade deficits, high indebtedness, and slow unsteady growth. On the other hand, countries that build capacity to produce capital, develop institutions, and proactively alter technology, output and productivity relative to unit primary factor costs can simultaneously slacken the savings constraint, raise the growth of export demand, slow the growth of import demand, easing the balance of payments constraint, and growing output and employment. However, such adjustments require introduction of realistic competition and competitive strategy into the arena of trade and hence into the export and import functions underlying the Alleyne and Francis (2008) model. As specified, it also cannot fit the dynamic pathways of Caribbean economies seeking to eliminate widespread undercapitalisation of economic activity. At best, it too explains growth without development.

5 The Way Forward - Growth with Development

To build models that can represent the observed processes of growth with development, it is first necessary to abandon the assumption of an abundant exogenous supply of capital, whether implicit or explicit in the previously reviewed models. Instead, it is necessary to embrace the assumption of

significant undercapitalisation of economic activity used by Lewis (1954) and Best (1968), with associated relatively abundant supplies of other productive factors, such as land that generates diminishing returns in the case of Latin America (Prebisch 1950) or labour that generates diminishing returns in the case of Caribbean island economies (Lewis 1954). We focus on the Caribbean case.

For this, instead of using the industry-agriculture sectoral decomposition of Lewis (1954), we use the sector decomposition of Best (1968) to accommodate the two modes of trade represented in the models. The core proposition of Best (1968; 1971; 1975) was that to understand the historical time path of the economy, it is appropriate to characterize the capitalisation of the system using two broad types of industrial sectors. One is a highly-capitalized sector that produces only resource-based exports, is dependent on foreign capital inflows and technologies and so is externally propelled, and trades by comparative advantage – the "plantations". The other is a highly undercapitalised "encompassing" civilisation-building sector, which hosts the relatively abundant supply of undereducated workers initially engaged mainly in producing consumer goods and services – the "residentiary sector". It can be observed that the plantation is the institutional form taken by foreign capital enters the economy to exploit natural resources that offer prospects of high profit as described by Lewis (1954). The residentiary sector is described as encompassing because, unlike the plantation sector, it has a subsector that produces capacity-building capital goods and services and a subsector that produces consumer supplies, each with characteristic technologies. It also has its own characteristic institutions, language, and sociology. Undercapitalisation is the result of limited capacity to use science-based knowledge and skills to produce problem-solving capital.

The economy features two modes of trade. In the residentiary sector, diminishing returns to labour results in a low marginal product of labour in productive activities, but it has underutilized potential to produce and rely on domestic capital to introduce innovative productive activities and methods, rely on residentiary savings, and engage in intra-industry trade. In the plantation sector, abundant capital and limited employment of labour creates a high marginal product of labour. The result is that when defined in terms of real opportunity costs as measured by the marginal product of labour, as clarified by Lewis (1954), it is rational for the economy to trade according to the comparative advantage held by the plantation-type activities. On the other hand, investment to develop the underutilized potential to produce and employ capital leads to continual expansion of capacity for intra-industry trade by the residentiary sector. Development of such an economy requires growth of capital production by, and capital per worker in, the residentiary sector to facilitate growth of productivity in its many activities that use domestic capital intensively.

By Lewis (1954), growth of capital per worker (k_l) depends on a rising rate of savings (s_p) from profits, which in turn depends on a rising rate of profit (r). Let $\aleph = \chi N$ be the number of employed workers adjusted for their level of knowledge, skills and self-confidence, and hence the capacity to innovate, and let w be the nominal wage rate. Under conditions of surplus labour, χ is very low and so is the quality of the workforce. Let K be the stock of capital assets used by workers, h the institutions serving the sectors, t sociological time, Y_j the output of the residentiary sector, and p the price level of the economy which closely mirrors the price level of the residentiary sector. For the growth of GDP per capita (y_p), we write:

7. $y_p = \frac{p}{\delta} y_l l_n n$

where $n = \frac{L}{P}$ is the labour force share of the population, p is the domestic price level, δ is the cost-of-living deflator, y_l is the productivity of labour and $l_n = \frac{\aleph}{L}$ is the employment rate. Now, let $b = \frac{Y_r}{Y}$ be the share of residentiary output in GDP, a proxy for the proportion of domestic income spent on residentiary output; so labelling J as imports, $1 - b = \frac{J}{Y}$ is the propensity to import. Choose $\delta = p^b \left(\varepsilon p_f\right)^{1-b}$, where p_f is the index of foreign (import) prices in domestic currency. Used in (7), this gives:

8. $y_p = \frac{p^{1-b}}{\left(\varepsilon p_f\right)^{1-b}} y_l l_n n = \left(\frac{p}{\varepsilon p_f}\right)^{1-b} y_l l_n n$

where $\frac{p}{p_f}$ is the terms of trade. Taking natural logs and differentiating gives:

9. $\frac{dy_p}{y_p} = (1-b)\left(\frac{dp}{p} - \frac{d\varepsilon}{\varepsilon} - \frac{dp_f}{p_f}\right) + \frac{dy_l}{y_l} + \frac{dl_n}{l_n} + \frac{dn}{n}$

Here, observe that economy-wide output per worker, y_l, can be represented as the average of the sectoral output per worker, y_j, weighted by the share of the labour force employed in each sector, $l_j = \frac{\aleph_j}{L}$. That is, for the two sectors of the economy:

10. $y_l = l_f y_f + l_r y_r$

where $\sum_j \ l_j = 1$. From (10), we can write:

11. $\frac{dy_l}{y_l} = \frac{Y_f}{Y}\frac{dy_f}{y_f} + \frac{Y_r}{Y}\frac{dy_r}{y_r} + \frac{Y_f}{Y}\frac{dl_f}{l_f} + \frac{Y_r}{Y}\frac{dl_r}{l_r}$

A central proposition of Lewis (1954) was that $\frac{dy_f}{y_f}$ is directly proportional to the rate of growth of capital per worker in the sector, which in turn depends on both the rate of development of domestic policy-making institutions (h) and the rate of inflow of foreign capital (savings) attracted by the prospective rate of profit in the sector ($s_{pf} r_f$. That is, the following relationship holds:

12. $\frac{dy_f}{y_f} \quad \beta_f \frac{dk_f}{k_f}$
$\frac{dk_f}{k_f} \quad s_{pf} r_f + \alpha_{hf} \frac{dh}{h}$

On the other hand, following Best (1968; 1971; 1975), $\frac{dy_r}{y_r}$ is proportional to the rate of growth of capital per worker, which depends on three related forces: (i) the rate of development of "independent thought", measurable by an index of the capacity to innovate (χ); (ii) the rate of institutional development and

associated capacity for sound policymaking ($\frac{dh}{h}$; and (iii) the rate of conversion of savings into capital, which is the product of the rate of savings from profits and the rate of profit in the residentiary sector ($s_{pr}r_r$). By Lewis (1954), growth of production of capital is supported by growth of the flow of credit (say through growing M_2) at concessional rates of interest, i. That is, the following recursive relationship holds:

13. $$\begin{matrix} \frac{dy_r}{y_r} \\ \frac{dk_r}{k_r} \end{matrix} \quad \begin{matrix} \beta_r \frac{dk_r}{k_r} \\ \alpha_r\chi + \alpha_{hr}\frac{dh}{h} + s_{pr}r_r + \alpha_m\frac{dM_2}{M_2} - \alpha_i i \end{matrix}$$

Consistent with the International Standard Classification of Occupations ISCO-08 (ILO, 2012), an implication of proposition (13) is that as worker quality and the related capacity to innovate grow, $\frac{dk_r}{k_r}$ increasingly reflects the rate of production of domestic capital.

In both (12) and (13), the rate of savings from profits from real economic activity is endogenous to the system. The main proposition of Lewis (1954; 1955) was that in any sector, and in the system as a whole, r is an endogenous rate that can be represented in the following dynamic form that exhibits the role of institutions in the economic process. This follows from the assumption that production of output in any sector j (Y_j) follows a Lewis (1954; 1955) composite production function in which employment of workers with knowledge, skills and self-confidence, $₦_j$, depends on its stock of contributed capital of capitalists, K_j, which in turn is influenced by the underlying policy-making institutions of the sector, h_j and sociological learning time (t. This allows both K_j and $₦_j$ to always be a result of production by some sector, either domestically or abroad, in the current period or in a previous one. That is:

14. $$Y_j(t) = f\left(₦_j\left(K_j\left(h(t)\right)\right)\right)$$

In equation (14), we define $₦_j = \chi_j N_j$, where χ_j is an index of the knowledge, skills, and self-confidence (human capital) per worker and N_j is the number of workers in the sector. Also, χ_j indexes the problem-solving and therefore innovative capacity of workers created under the influence of capital and the underlying institutions of the economy. In capitalism, K_j is used to put $₦_j$ to work and the technology of production embedded in (14) is defined by $\phi_j = \frac{₦_j}{K_j}$. Both K_j and χ_j are produced inputs, some locally and some imported. Thus, if we neglect intermediate inputs, including natural resources, an algebraic form that satisfies equation (14) is:

15. $$Y_j(t) = \phi_j(t)K_j\left(h_j(t)\right)$$

Both equations (14) and (15) admit Leibnitz's chain rule. The equations are interesting because they suggest that the education characteristics (χ_j) of the employed labour force shed light on the quality of the technology a sector can deploy. In general, the higher is χ_j the better the quality of the labour force, the better the technology a sector can deploy, the more problem-solving and innovative capacities it

possesses, and the higher the level and better the quality of output it can produce. The process of development relies on the existence of sectors, especially capital-producing sectors, that employ high and rapidly changing knowledge, skills and self-confidence, $\frac{d\aleph_j}{dK_j}$, defined as the ISCO-08 level 3 and level 4 skills, and hence high and rapidly changing $\phi_j(t)$ to generate high profit rates driven by high productivity growth rates.

If we assume that the rate of profit and the rate of interest on loans converge, and that workers come with hearts and minds, then the Lewis classical geometry of sector profits can be written as:

16. $r_j K_j = p_j Y_j - w_j \aleph_j$

The total differential of (16) gives the dynamic form of the rate of profit as

17. $r_j = \frac{(Nd\chi+\chi dN)/dK_j}{\left(1+\frac{K_j dr_j}{r_j dK_j}\right)}\left[\left(p_j \frac{dY_j}{d\aleph_j} - w_j\right) + \{p_j\left(l_f y_j + l_r y_r\right)\frac{\aleph_j dp_j}{p_j d\aleph_j} - w_j \frac{\aleph_j dw_j}{w_j d\aleph_j}\}\right]$

where, from the composite function in (14) we have used $\aleph_j(t) = \aleph_j\left(K_j\left(h(t)\right)\right)$ to get $\frac{d\aleph_j}{dK_j} = \frac{1}{\frac{dK_j dh_t}{dh_t\ dt}}\frac{Nd\chi+\chi dN}{dt}$. Thus, equation (17) says that the rate of profit in any sector depends on the product of two sets of forces. One factor is the rate of growth of employment and the knowledge and skills of employed workers induced by growth of the capital stock, both influenced by the rate of institutional development ($\frac{(Nd\chi+\chi dN)/dh}{\left(1+\frac{K_j dr_j}{r_j dK_j}\right)\frac{dK_j}{dh_t}}$). This describes a dynamic feedback process since growing knowledge, skills, and self-confidence then enables expanded production of new knowledge, skills and self-confidence, expanded production of capital and the upgrade of institutions, innovation and the introduction of new solutions to the local and global marketplace. The other factor is the sum of two gaps: (i) the gap between the value of the marginal product of labour and the nominal wage, $p_j \frac{dY_j}{d\aleph_j} - w_j$; and (ii) the gap between the employment elasticity of sector price level and the employment elasticity of the wage rate, $\{p\left(l_f y_f + l_r y_r\right)\frac{\aleph_j dp_j}{p_j d\aleph_j} - w_j \frac{\aleph_j dw_j}{w_j d\aleph_j}\}$.

According to Lewis (1954), the wage rate will tend to be suppressed because of the influence of under-education and other forms of undercapitalisation on the wage determination process. Let η be the economy-wide employment rate and ρ_j the markup on q_s, the average product of labour among the undereducated required to encourage movement of workers into high-skilled labour. Then, the rate of growth of a sector's wage rate is appropriately represented as:

18. $\frac{dw_j}{dt} = w\frac{d\eta}{(1+\eta)}; w_j(0) = \left(1+\rho_j\right)q_s$

Notice that equation (18) can be rewritten in Phillips curve form using $\eta = 1 - u$, where u is the unemployment rate (Phillips 1958). Equation (18) solves to:

19. $\omega_j = \left(1 + \rho_j\right) q_s (1 + \eta)$

Equation (19) indicates that even if the overt employment rate η could be pushed to full employment by contriving low-quality work for the undereducated, the residentiary sector's high degree of dependence on large numbers of undereducated workers will tend to keep q_s very low or falling and tend to suppress w_j even as $\eta \to 1$. This updates the Lewis (1954) model in which the approach to full employment would automatically raise the wage rate. To raise q_s, and hence the wage rate over time, it takes targeted policy to increase the education of workers and capitalisation of work in the sectors of the economy that employ the undereducated (Lewis, 1954).

Regarding the price level of the residentiary sector, mirrored by p in equation (7), we adopt the Lewis (1954; 1955) proposition, which holds that prices in the sector would rise as the money supply (say M_2) grows to increase the flow of credit at concessional interest rates to support domestic capital production. It would also grow with the exchange rate. On the other hand, demand suppression through rising interest rates, institutional development and rising sector productivity, once capital is put to work, would cause the sector's price level to fall, potentially to levels below the initial condition. That is:

20. $\frac{dp}{pdt} = \beta_m \frac{dM_2}{M_2} + \beta_\varepsilon \frac{d\varepsilon}{\varepsilon} - \beta_i i_r - \beta_h \frac{dh}{h} - c_5 \frac{dy_r}{y_r dt}; p(0) = p_0$

The sector output identity allows accounting for the influence of import dependence on the productivity of the knowledge, skills, and self-confidence of workers in generating supply to provision domestic society, y_r. A sector's total supply, Y_j, is its supply to provision domestic demand plus the real value of its exports, X_j. It can be assumed that, influenced by its capacity to innovate (χ_j), sector exports are a scalar multiple, $\alpha_{xj}(\chi_j)$, of sector imports evaluated with the real exchange rate, with $\alpha_{xj}(\chi_j) \geq 0$. In general, $\alpha_{xj}(\chi_j)$ reflects the changing extent to which the sector relies on supplementary foreign exchange to procure its imports, F_j, including by attracting foreign investment inflows. It must hold that a sector's net buildup of foreign exchange reserves is the sum of its export earnings plus its use of supplementary foreign exchange, at a cost equal to the international rate of interest, i_f, minus its use of foreign exchange to purchase imports. Then, it must also hold that:

21. $\frac{dF_j}{dt} = \left(1 - i_f\right) F_j + p_j X_j - \varepsilon p_f J_j$

By equation (21), when $\frac{dF_j}{dt} = 0$, the sector's current growth of foreign exchange supply just matches its use, much as is assumed by Alleyne and Francis (2008).

For any sector j, we can assume that the characteristics of its reliance on procuring supplementary foreign exchange to buy imports, F_j, can be summarized by direct proportionality to its exports, with the proportionality factor depending on the sector's capacity to innovate, χ_j, as discussed in Best (1971;

1975). This applies to both the plantation sector and the residentiary sector. That is, $F_j = \beta_j(\chi)P_jX_j; with \beta_j(\chi) \geq 0$ amounting to a measure of the external propulsion of the sector. In the plantation sector, $\beta(\chi)$ tends to be high (relative to 0) because of low χ_j and greater import dependence (for both capital and consumer supplies); and therefore, greater dependence on supplementary foreign exchange inflows relative to its exports. In the residentiary sector, $\beta(\chi)$ is low (closer to 0), because the sector tends to rely relatively more heavily on domestic inputs and innovations to support investment. As implied by Best (1968), intersectoral effects arise if the plantation sector experiences a boom or bust, such as through an increase or decrease in P_j or X_j, which can increase or decrease the supply of foreign exchange and make imports relatively more or less attractive to the residentiary sector. Notwithstanding, from (21) we can write:

22. $X_j\left(1 + (1 - i_f)\beta_j(\chi)\right) = \frac{\varepsilon p_{fj}}{p_j}J_j + \frac{dF_j}{p_j dt}$

Or,

23. $X_j = \alpha_{xj}(\chi)\left(\frac{\varepsilon p_f}{p_j}J_j + \frac{dF_j}{p_j dt}\right)$

Equation (23) implies that $\alpha_{xj} = \frac{1}{1+(1-i_f)\beta_j(\chi)}$. Notice that if $\beta_j(\chi) = 0$, then $\alpha_x(t) = 1$ and sector exports can support its demand for imports plus foreign exchange reserves. Also, higher $\beta(\chi)$ and therefore lower $\alpha_{xj}(\chi_j)$ implies greater dependence on foreign exchange (capital) inflows.

As in Best (1968), the imports are factor inputs, either used directly as capital inputs in production or used indirectly as means of reproduction of labour. If it is assumed that a sector holds no foreign exchange reserves, so $\frac{dF_j}{p_j dt} = 0$, then it follows that, for any sector j:

24. $y_j^d \aleph_j = Y_j - \alpha_{xj}(\chi)\frac{\varepsilon p_{fj}}{p_j}J_j$

Then, the total differential of (24) gives:

25. $y_j^d = \frac{dJ_j/d\aleph_j}{\left(1+\frac{\aleph_j dy_j^d}{y_j^d d\aleph_j}\right)}\left[\left(\frac{dY_j}{dJ_j} - \alpha_{xj}(\chi)\frac{\varepsilon p_{fj}}{p_j}\right) + \alpha_{xj}(\chi)\frac{\varepsilon p_{fj}}{p_j}\left\{\frac{J_j dp_j}{p_j dJ_j} - \left(\frac{J_j dp_{fj}}{p_{fj} dJ_j} + \frac{J_j d\varepsilon}{\varepsilon dJ_j} + \frac{J_j d\alpha_{xj}(\chi)}{\alpha_{xj}(\chi) dJ_j}\right)\right\}\right]$

In equation (25), $\frac{dJ_j}{d\aleph_j}$ is the marginal influence of increasing knowledge, skills, and self-confidence on imports, and $\frac{dY_j}{dJ_j}$ is the marginal product of sector imports. Thus, the factor $\frac{dJ_j}{d\aleph_j}$ raises domestic supply per worker, y_j^d, by rescaling the gap between the marginal product of imports and the real exchange rate $\left(\frac{dY_j}{dJ_j} - \alpha_{xj}(\chi)\frac{\varepsilon p_{fj}}{p_j}\right)$ as well as the import-induced gap $\alpha_{xj}(\chi)\frac{\varepsilon p_{fj}}{p_j}\left\{\frac{J_j dp_j}{p_j dJ_j} - \left(\frac{J_j dp_{fj}}{p_{fj} dJ_j} + \frac{J_j d\varepsilon}{\varepsilon dJ_j} + \frac{J_j d\alpha_{xj}(\chi)}{\alpha_{xj}(\chi) dJ_j}\right)\right\}$. Notice here that as growing domestic knowledge, skills and self-confidence reduce a sector's reliance on

supplementary foreign exchange, its rate of profit rises even if imports are growing based on its rising capacity to export. Notice too that higher i_f (and therefore higher factor income outflows) implies higher $\alpha_x(\chi)$, which induces a fall in $\left(\frac{dY_j}{dJ_j} - \alpha_{xj}(\chi)\frac{\varepsilon p_{fj}}{p_j}\right)$. This has the effect of lowering the rate of profit and slowing the rate of development, as suggested by Best (1968). On the other hand, as the capacity to export develops, reliance on supplementary foreign exchange inflows would fall, raising $\alpha_{xj}(\chi)$ while inducing a corresponding rise in the marginal product of imports ($\frac{dY_j}{dJ_j}$) that increases the rate of profit.

Equations (7) to (25) describe the development path of the economy. With abundant labour, the marginal product of labour, $\frac{dY_j}{d\aleph_j}$, is low in the residentiary sector and so is the wage, w_j. The residentiary sector hosts the reserve pool from which employees could be recruited to enable capital (development) spending, production of capital and increasingly capital-intensive output in both sectors. When capital spending targets expand capital-production and employment, both E_n and K_j grow, causing $p_j\frac{dY_j}{d\aleph_j}$ to grow while w_j is held down by competition among workers for newly created jobs. So, $p_j\frac{dY_j}{d\aleph_j} - w_j$ grows, raising the rate of profit. A similar effect is generated by a rising rate of inflation faster than the rate of wage increases induced by growing employment of better quality workers, which causes $p_j\left(l_f y_j + l_r y_r\right)\frac{\aleph_j dp_j}{p_j d\aleph_j} > w_j\frac{\aleph_j dw_j}{w_j d\aleph_j}$. Here, as institutions develop, one of the effects of increasing $\frac{(Nd\chi+\chi dN)}{dK_j}$ is to raise both y_j^f and y_j^d while transforming the internal structure of the sectors, causing economy-wide productivity to grow as captured by equations (11) to (25). This process also causes traditional exports to grow while increasing capacity for intra-industry exports. The rising rate of profit causes $s_{pr}r_r$ and $s_{pf}r_f$ to grow, enabling a rising k_l in the industrial sectors and thus in the economy as a whole. In turn, this drives up economy-wide productivity and GDP per capita. Moreover, all of these variables are interdependent, and therefore generate mutually reinforcing feedback.

As observed by Best (1968), in the sector that is externally propelled and trades in accordance with comparative advantage, both p_{fj} and p_j are determined abroad and $\frac{\varepsilon p_{fj}}{p_j}$ will tend to be very volatile, producing cycles of "golden age" and "gall and wormwood". Persistent volatility would also cause uncertainty about the sector profit rate and lower the flow of domestic retained earnings that validate investment. However, one would expect that as some residentiary subsectors increase their employment of ISCO-08 level 4 skills and thus their capacity to produce and use domestic capital and grow $\aleph_j$, they will acquire monopolistic price-making power and be able to raise p_j relative to p_{fj} in the process of engaging in intra-industry trade. This will lower $\frac{\varepsilon p_{fj}}{p_j}$ while growing $\frac{dY_j}{dJ_j}$ and hence the gap $\left(\frac{dY_j}{dJ_j} - \alpha_{xj}(\chi)\frac{\varepsilon p_{fj}}{p_j}\right)$. It will also increase the gap $\alpha_{xj}(\chi)\frac{\varepsilon p_{fj}}{p_j}\left\{\frac{J_j dp_j}{p_j dJ_j} - \left(\frac{J_j dp_{fj}}{p_{fj} dJ_j} + \frac{J_j d\varepsilon}{\varepsilon dJ_j} + \frac{J_j d\alpha_{xj}(\chi)}{\alpha_{xj}(\chi) dJ_j}\right)\right\}$, even as $\frac{J_j d\alpha_{xj}(\chi)}{\alpha_{xj}(\chi) dJ_j}$ is rising as a result of capital production and innovation. Innovation in such sectors will more than offset the demand-reducing effects of the increase in p_j. The overall effect will be to raise y_j^d and the rate of profit of the sector along with the investment-validating savings rate. Moreover, in the residentiary sector the capacity for intra-industry trade will also grow, raising exports per worker. As the capital-

producing and using subsectors increase their production and employment of advanced knowledge and skills as a share of total employment and increase their share of GDP, the effect will be to increase the rate of growth of output per worker and ultimately of GDP per capita.

The development process described by equations (7) to (25) is neither automatically delivered by markets nor perpetual. Sound policy, appropriately targeted, is necessary to stimulate capital accumulation in both sectors. Then, capital accumulation eventually causes capital to become abundant, exhaust the surplus labour pool in the residentiary sector, and cause $\{p_j(l_f y_j + l_r y_r)\frac{\aleph_j dp_j}{p_j d\aleph_j} \leftrightarrow w_j \frac{\aleph_j dw_j}{w_j d\aleph_j}\}$ as well as $\left(p_j \frac{dY_j}{d\aleph_j} \leftrightarrow w_j\right)$. Also, $\left(\frac{dY_j}{dJ_j} \leftrightarrow \alpha_{xj}(\chi)\frac{\varepsilon p_{fj}}{p_j}\right)$ and $\{\frac{J_j dp_j}{p_j dJ_j} \leftrightarrow \left(\frac{J_j dp_{fj}}{p_{fj} dJ_j} + \frac{J_j d\varepsilon}{\varepsilon dJ_j} + \frac{J_j d\alpha_{xj}(\chi)}{\alpha_{xj}(\chi) dJ_j}\right)\}$, led by a rising $\frac{J_j d\alpha_{xj}(\chi)}{\alpha_{xj}(\chi) dJ_j}$. Such convergence would eventually cause the rate of profit to fall to levels below which capital accumulation would cease and bring the development process to a halt.

Part II. Macroeconomic models for the economic policy manager

In this section of the paper we survey and comment on macroeconomic models that are intended for the design and implementation of ongoing economic policy in open economies that are small, as measured by population size and total GDP. As we move along the continuum from countries that have very large populations with GDP in the trillions of US dollars, to economies of a few hundred thousand people and GDP of less than one hundred billion US dollars, the production possibilities of the economy and its relationship to the rest of the world change, in ways that affect the outcomes of economic policies. The difference that size makes, and the implications for fiscal, monetary and exchange rate policies are fully explained in Worrell (2023, Section B) and Worrell (2024). We evaluate the models in this section on two criteria: how helpful they are to policy makers on the whole, and how well they reflect the economic structures and policy options open to policy makers in small economies (SOEs).

This section surveys three types of empirical model which are employed in the design of macroeconomic policy and preparation of economic forecasts by central banks, Treasuries, policy think tanks and research institutions in countries around the world. We begin with the Dynamic Stochastic General Equilibrium model (DSGE). DSGEs have come to enjoy considerable popularity in central banks and are also used by organs of the European Union and international institutions, including the IMF. Our discussion of the DSGE deals mainly with the difficulty of interpreting the results of analysis using this model, because of its extreme assumptions. Few policy making bodies rely on just one economic model, and the IMF also uses a home-grown model known by the acronym FINEX. The structure, behavioural relationships and policy implications of FINEX are very influential, because the model reflects the assumptions that underlie all analyses, not just by the IMF, but by policy makers of a majority of countries which are members of the Fund. Our discussion of FINEX focusses on its usefulness for SOEs; even though it avoids the difficult assumptions of the DSGE, equations included in FINEX must be modified in order to faithfully reflect the realities of the SOE. A third group of macroeconomic policy models uses a structure of related behavioural equations with no pretensions to market equilibrium tendencies. Models of this kind have been in continuous use for four decades or more, in major countries and in selected institutions.

6. *The Dynamic Stochastic General Equilibrium model*

The DSGE was born of a search for a model which is grounded in first principles of economic theory. The model sets up relationships between households, firms and the government for the supply and purchase of goods and services. Households choose how many hours to work and earn wages rather than enjoy leisure activities, so that the resulting balance maximises the household's utility. Firms maximise their profits subject to the availability and prices of labour and other factors of production, given the production technology they employ. Government provides public goods and services, and taxes equitably and efficiently to finance the resulting expenditure. The model is often modified by incorporating taxes which distort market incentives, by adapting relationships to reflect the persistence of habitual behaviour in the face of changing circumstances, and by adding costs of adjustment, such as for skills training. The periodic ups and downs of economic output are seen as the result of stochastic shocks which disturb market equilibrium. The model is used to analyse how economic agents react to these shocks, and to forecast the pattern of change that might be expected as a result.

A simplified DSGE model might be represented by an aggregate demand relationship with expected real expenditure, the expected real interest and other factors as arguments; an inverted aggregate supply relationship where the arguments are expected inflation and aggregate expenditure; and a monetary policy function in which the considerations are expected inflation compared with target inflation, and the distance between actual and potential output.

The simplest way of parameterising the DSGE is by way of calibration, using prior information. Calibration does not make for persuasive conclusions from the model, however, because the outcomes may be challenged on the basis of the priors, rather than the behaviours embedded in the model itself. Because of this, in practice the parameters of DSGEs usually include some estimated parameters. Ways of choosing parameters listed by Christiano, Eichenbaum and Trabandt (2018) include combinations of calibration, based on priors; limited information estimation, for example by minimising the distance between model and data responses to economic shocks using impulse responses from vector autoregressions; historical or narrative methods; and full information methods, using Bayesian estimation of parameters. Carabenciov et al. (2013, 31) is an example of a Bayesian approach that combines prior information with sample period data by weighting the coefficients of the estimated parameters by their standard deviations.

DSGE models are used for analysis and forecasting by the International Monetary Fund, the European Central Bank, the US Federal Reserve Bank, and the central banks of Canada, Sweden, the Czech Republic, Israel, Switzerland and Norway, among others (Christiano, Eichenbaum and Trabandt 2018, 132 and 133, footnotes).

Reservations about the use of the DSGE for macroeconomic analysis and forecasting are widespread, including from Nobel Prize winning economist Joseph Stiglitz (2018, 76): "… most of the core constituents of the DSGE model are flawed – sufficiently badly flawed that they do not provide even a good starting point for constructing a good macroeconomic model." Storm (2021) provides a lengthy but by no means exhaustive list of fundamental weaknesses of the DSGE; some items from his list are summarised in what follows.

The DSGE assumes that households maximise utility over their lifetimes, subject to an intertemporal budget constraint, by choosing how much to consume and how much to save in each period, based on their time preference and the interest rate. However, thanks to the existence of banks, there is actually no trade-off between consuming now and consuming in the future; bank credit allows the household to expand their productive capacity and capabilities, without tightening their belts. The existence of banks invalidates assumption of lifetime utility maximisation based on a choice at the margin between consuming now and consuming in the future.

Storm also points out that investment proves to be rather insensitive to changes in the real interest rate, and depends in practice only on expected aggregate demand. Increases in the capacity to supply, and therefore the growth in real output, are driven only by an accelerator mechanism. In the real world, credit-funded investment determines savings, and the real interest rate plays no part in the determination of investment and growth. Households do not decide how much to save on the basis of their time preference and interest rates, and banks do not simply intermediate the amount people decide to save; rather, credit is provided to investment projects that offer a competitive return, at the request of credit-worthy borrowers. The amount of investment depends on the supply of competitive projects, and that determines the amount of realised saving.

Another assumption embedded in the DSGE is that of rational expectations; it is presumed that rational firms and households assign probabilities to all future outcomes, and act in accordance with those probabilities. This assumption allows us either to predict behaviour based on our priors with respect to the probability distribution over time, or to infer the probability distribution from observed behaviour. Expectations are said to be rational when they are consistent with the probability distribution of future outcomes. However, as has been demonstrated by Taleb (2007)[3] and others, there are always events and outcomes which are entirely possible to which one cannot attach a possibility of their occurrence. This undermines the credibility of all models that incorporate rational expectations, including DSGEs.

The DSGE is an evolution of a real business cycle model: assuming that there is an equilibrium path of future changes in real GDP, defined as the potential income, actual GDP may deviate from potential in the short run as a result of demand shocks, but in the longer term real income tends to converge to potential, as determined by long-run supply factors. In practice, however, the dichotomy between the long run and short is problematic, because decisions made in the short run, whether in response to a shock or otherwise, impact potential output in the longer term. Macroeconomic policy needs to address the long-run implications for investment and growth potential, as well as the immediate response to any economic shock, at one and the same time.

The presumption that the DSGE gains credibility from its foundations in economic theory cannot be sustained because of problems of aggregation which are well known. Even if households and firms were all homogeneous within the economy, their aggregate behaviour would not be identical to the individual behaviour writ large, because of interactions among households and among firms, and transactions between individual households and individual firms. In any case, we know that households and firms are

[3] Taleb demonstrates that it is not possible to assign probabilities in advance to extremely rare events, and that there is a tendency, *ex post facto*, to find simplistic explanations for these events.

heterogeneous, differing in size, endowments and skills, preferences, wealth and a variety of circumstances that bear upon costs and utility.

Storm (2021) mentions other challenges of DSGE models, including the treatment of money and finance, the possibility of multiple equilibria, and the neglect of income distributional effects. Attempts have been made to capture monetary links to the real economy in DSGE models, with the addition of fractional reserve banking, financial frictions, liquidity constraints and a housing sector. However, it must be admitted that the treatment of money and finance in macroeconomic theory and modelling in general remains unsatisfactory. Macroeconomic theory and policy is bedevilled by obscurity and misperceptions about the sources of finance for investment, the relationship between interest rates and rates of return on investment, the role of banks, the function of securities exchanges, the nature of international finance and payments, and other aspects of money and finance.[4] The relationship between income distribution and economic growth is another dimension which is absent from DSGEs and most macroeconomic models of all kinds, though its importance has become apparent in recent years. Storm (2021) discusses a research programme to address the possibility of multiple equilibria in the DSGE framework, in an effort to explore alternative hypotheses about the impact of macroeconomic policies.

7. Critiques which challenge the fundamental assumptions of conventional approaches to Caribbean Economies

The Lewis (1954) and Best (1968) irrelevance critique applies to the set of dynamic stochastic general equilibrium (DSGE) models. All variants of the DSGE model assume a capital-abundant and internally propelled economy. If any industry offers a small increase in the market rate of interest above the natural rate, an indefinitely large supply of capital floods in to pursue the increase, driving the interest rate back to its natural level, bringing the slope back to zero, and causing an evolution of the natural rate of output in the process. International trade is not strictly relevant to the functioning of the economy. There is no role for innovation as a phenomenon driving intra-industry trade, and related competition for opportunity in international markets.

Further, all DSGE models rely on the concept of the set of steady state values, also normally referred to as the normal or natural state of the system under conditions of full employment, to which the system converges when unperturbed by shocks. Once the money supply is appropriately managed, the economy can attain full employment equilibrium. If it exists, then subject to the model's parameters, the full-employment steady state is usually found by solving the model's system of equations after setting all future values of variables equal to current values and dropping the expectations operator. Solving means representing all control variables in terms of the set of state variables and representation of the future values of state variables in terms of current values that represent the full employment condition. Thus, the models cannot apply to economies like those in the Caribbean in which the stock of capital leads to persistent underemployment or protracted unemployment of labour in large segments of the economy.

The models can only partially represent the concept of size defined in terms of the population and output, since it only incorporates output as Y_t. Population size is not accounted for, though a deterministic equation might be added for it, as is the case with the capital stock, as long as it is stationary.

[4] Some of these issues are discussed in Worrell (2023), Chapter 10.

In terms of institutions, only the central bank matters – this is another way to assert that capital is abundant and that the economic system is internally propelled to full employment by the dynamic mobility of capital under the motivation of competition to achieve optimal outcomes (profits). Government policy is not vital to shaping most aspects of the growth path of the economy, such as savings from profits, productivity growth, or transformation key capital-producing sectors. Joint decision-making is a side issue.

Despite the implied role of the competitive movement of capital among industries, the DSGE model cannot admit the real process of competition in the determination of the deviation of inflation from its steady state in the New Keynesian variant or in any other variant. The behaviour of profit maximizing firms is not based on the observation that actual firms in modern markets respond to continuously growing pressures to innovate and grow productivity.

8. The IMF's Internal Balance External Balance model, FINEX

Recognising that no one approach can provide an authoritative and exhaustive analysis of the complexities of international economic and financial markets, the IMF employs several approaches in its consultations with member countries, and in preparing forecasts of the world economy. While DSGE models play a leading role in the Fund's global forecasts and interactions with advanced economies, for various reasons, including discontinuities and other data inadequacies, the models used in discussion with emerging economies do not take household utility maximisation, firm cost minimisation and other theoretical precepts as their point of departure. Fund economists from the Fund's Development Studies Division have recently published a Working Paper (Berg et al. 2023) which provides a useful description of the Fund's Internal Balance External Balance (FINEX) model, and we rely heavily on that paper in what follows.

FINEX is described as a semi-structural macroeconomic model which incorporates insights from the DSGE literature, even though it does not have microeconomic foundations. It is said to belong to a class of Quarterly Projection Models (QPMs) which are structured around the familiar IS curve for identifying the equilibrium output, a Phillips curve which specifies the trade-off between inflation and unemployment, a Taylor rule which says how the central bank reacts to inflation which varies from its target, and the uncovered interest parity condition, which governs financial flows between the economy and the rest of the world. QPMs can be considered dynamic stochastic forward-looking models that may be used to analyse the impact of random shocks, but they lack explicit micro foundations. The policy problem they are employed to address is the appropriate response to a deviation of inflation from the central bank's target, taking account of the observed output gap.

The macroeconomic dynamic relationships of FINEX are structured to illustrate the interplay of internal balance, external balance and policy. For internal balance, output and inflation are determined by the interaction of demand and supply in the form of an extended IS curve and an associated set of Phillips curves. For external balance, the exchange rate adjusts to close the balance of payments through its effects on net exports. Financial flows respond according to the uncovered interest parity condition: the difference between domestic and foreign interest rates adjusted for expected exchange rate depreciation. Fiscal policy, monetary policy, foreign exchange intervention and controls on financial market flows are

in general functions of inflation, output, debt, the exchange rate, and other objectives (See Berg et al. 2023, 9). FINEX may be used for analysing and forecasting the effects of a wide range of policy options, including exchange rate strategies from hard pegs to pure floats with inflation targeting, setting of policy interest rates, foreign exchange intervention, the use of capital controls, setting of debt and deficit anchors for government expenditure, tax rate changes, and expenditure on productive public infrastructure. Most variables are decomposed into a trend and a gap, and the trends converge to steady state over time.

Understandably, the IMF is obliged to treat all member countries equitably, and it therefore applies this model to all countries that are categorised as emerging markets or developing, regardless of size. Unfortunately, the standard macroeconomic model on which FINEX is based does not fit the reality of small open economies in ways that are fundamental to the analysis. We highlight the crucial differences in what follows.

9. Comparison between FINEX and the reality for SOEs

FINEX is a demand-driven model: the real GDP is the sum of private consumption and investment, government consumption and investment, and exports, less imports. Real GDP may increase if government or private investment and consumption increase, if exports increase, or if there is a fall in imports. That is true for the US and China; it is not the case for Iceland, Mauritius, The Bahamas or Fiji. The demand for the internationally competitive exports and traded services of the SOE is infinitely large, and the only limit on their real GDP is their capacity to supply internationally competitive output. On the other hand, domestic consumption and investment cannot increase, whether by private or government initiative, unless exports increase, because all production, without exception, has a significant import content. Opportunities to substitute for imports to the SOE are very limited, so there is little or no scope for significantly reducing imports to increase foreign exchange availability. The reality for SOEs is that real GDP is a multiple of the production of exports of goods and services, and growth depends on the increase in the capacity to supply exports.

FINEX incorporates the standard macroeconomic assumptions that private consumption out of any given income is the result of a choice between current and future consumption (i.e. saving), and that the percentage of consumption changes with changes in the real interest rate. The corollary is that investment also changes with changes in the real interest rate, thanks to the savings-investment identity. However, in the open economy we have to take account of the import content of both consumption and investment. Imports must be purchased with foreign, not domestic, savings. Even if consumers choose to set aside a greater proportion of income as savings, much of the additional saving will be used to purchase foreign exchange to buy the imports needed for additional investments. *Ex post facto*, that portion of what the domestic private sector "saved" will turn out to be foreign savings (drawn from accumulated foreign reserves if there has been no increase in export earnings). What is more, additional domestic financial saving may be lent for consumer durables or augment the pool of excess liquidity, ending up as consumption rather than investment, because in normal circumstances there will be no internationally competitive investment projects which cannot secure needed funds from abroad, should there be a domestic liquidity shortage. In sum, both the consumption and investment equations in FINEX – and in all standard macroeconomic models – are mis-specified when applied to SOEs.

The export and import equations in FINEX are also a mis-specification of the behaviour of exporters and importers in SOEs. In FINEX exports depend on the real exchange rate, foreign demand and other factors. In reality, SOE exporters are atomistic sellers in an infinitely large international market, to which they can sell everything they can produce at the ruling international price. The export equation for the SOE must therefore be set up to reflect the fact that exports depend entirely on the capacity to supply internationally competitive products and services, and are unaffected by the exchange rate.

The exchange rate also plays no direct part in determining the volume of imports, which depend entirely on the purchasing power of local money. That is because the economy is so small that it has the capacity to produce only a handful of goods and services at internationally competitive prices, compared with the very wide range of products and services consumed by a modern economy. There is no significant potential for substituting for imports if their relative prices rise. Imports may be observed to decline in the wake of large depreciation of the exchange rate, but that is an income, not a substitution, effect, the result of depreciation-induced domestic inflation which has reduced the real international purchasing power of domestic incomes.

There is also an error in the FINEX specification of the financing items of the balance of payments, as applied to SOEs. FINEX specifies that, in addition to foreign direct investment, remittances and foreign aid (which are labelled exogenous sources), there is what is labelled an endogenous flow of finance, because it responds to differences between the domestic and foreign interest rate, adjusted for expected real exchange rate depreciation. Again, this may well be the case for India or Brazil, but the financial markets of Costa Rica and Botswana are too small and undeveloped to attract private finance from abroad purely on the basis of financial returns. The only financial flows to the SOE, apart from those labelled exogenous, are by way of bonds floated by governments whose credit is rated as investment grade and governments whose policies are being monitored by the IMF.

However, a form of uncovered interest parity does govern the outflows of finance from SOEs who have a domestic currency. The domestic currency of an SOE is inferior money, because the country is small and its international purchasing power is uncertain, compared with the US dollar. The international purchasing power of the rouble and the RNB are also uncertain, but because the countries are very large and have low import ratios, that uncertainty is not crucial, as it is for a SOE. There is therefore a country interest premium, in addition to expected exchange rate changes, that must be paid as an incentive to avoid capital flight, even in tranquil times. Domestic interest rates will usually settle at a level above comparable international rates which reflects market sentiment about the appropriate level of the premium. Should the central bank attempt to lower the country premium below what the market finds acceptable, we would expect to see a financial outflow. The existence of the country risk premium, about which it is difficult to generalise, is the first modification that needs to be incorporated into the model, to make is more realistic for application to the SOE. FINEX is sufficiently flexible to incorporate this change.

However, what is not reflected in the discussion of FINEX and other IMF models, is the fact that increases in the foreign-local interest differential will often provoke a financial outflow, the opposite of what policy makers intend. This will be the case whenever the market believes that the increase in the local interest premium is an attempt to ease pressure on the foreign exchange market which is caused by

an unresolved balance of payment disequilibrium. The interest rate defence does not work for SOEs, except as a stop-gap while other, more credible actions are being taken to restore balance to the external payments.

The assumption of a symmetrical response to interest differentials is key to the expected effects of monetary policy in FINEX; the central bank's policy rate is the preferred tool, except in very underdeveloped financial markets. However, in SOEs where the financial market is not distorted in some way it is usual to find that banks hold excess liquidity in local currency, much of it without remuneration, so the bank's discount rate has no purchase in the money market. Where a market for short term Treasury bills exists, the central bank may use open market operations to dampen excess volatility of the domestic interest rate, but it will be frustrated in any attempt to direct local interest rates against the trend of the international reference rate.

10. Structural models of the economy

The IMF's FINEX model may be viewed as a bridge between theory-based Real Business Cycle (RBC) models and the older tradition of structural models associated with the now defunct Wharton Econometric Forecasting Associates, the Cowles Foundation at Yale University and elsewhere. Structural models were the state of the art in the 1970s and 1980s, until they came under fire for their weak theoretical foundations, the fact that the equations of the models traded away statistical reliability for richness of structural specification, and because of the difficulty of incorporating simultaneous and feedback effects. Despite these limitations, structural models remain in use in the US, UK and elsewhere.

It was in an effort to supply the missing theoretical foundations for macroeconomic modelling that attention turned to DSGE and other real business cycle models. The hope was that fortifying the theoretical underpinnings of the economic structure of the model would produce more insightful analysis and better forecasting. Unfortunately, these hopes have been disappointed. There has been no improvement in forecasting performance and, because the theory uses extreme assumptions, it is more difficult to interpret the results from such models than it is for the structural models they were intended to replace.

Academic research has modified the assumptions of the RBC model in various ways in attempts to bring it closer to reality. Unfortunately, they add to the complexity of a model which is already difficult to interpret, because of its many other-worldly assumptions. As a result, despite their academic popularity, DSGEs and other real business cycle models remain inaccessible to policy makers, journalists and think tanks. What results is a bifurcation of academic research and policy making. The academic literature on macroeconomics is preoccupied with models that are grounded in theory and that have reliable statistical properties, whereas actual policies and strategies are based on simple notions of output-employment trade-offs, savings-investment balances, government debt ratios, and other rules of thumb, using back-of-the-envelope calculations.

There has been a parallel effort in academia to strengthen the credibility of econometric models by improving their statistical reliability. The early models were specified in levels and paid little attention to problems of serial correlation, omitted variables, model identification, multicollinearity and the like. This

was of necessity, rather than choice, because the techniques to address the statistical reliability issues were still being developed. Over the years, developments in statistical theory and practice have provided new approaches and tools to address these issues. Just as with theory, however, the combined use of techniques to improve goodness of fit in structural models with many equations, simultaneous relationships and feedback loops involve an impractical degree of complexity, and imply margins for probable outcomes which are so wide as to be unhelpful for the design of policy. Just as for theory, academia and the world of policy have moved in different directions. In this case, academia has abandoned structural models in favour of reduced forms and cross-section studies. However, reduced form models are black boxes which provide no insights into the complex behaviour which has led to the observed outcomes. As a consequence, the policy maker is offered little guidance as to the specific policies that should be implemented to guide behaviour so as to keep on track towards targets for growth, employment, external balance and other economic objectives.

A third challenge for policy makers is the fact that the data used in economic analysis are all concepts[5], rather than physical entities. The values of the series of "observations" reported in statistical records depend on the definitions used to construct the observation. The point may be illustrated by a concrete example. In 2018, the year of Barbados' most recent balance of payment crisis, the country's national debt was reported by the IMF (IMF 2018) as slightly below 150 percent of the country's GDP. However, using the definition of public sector debt recommended in the neglected "Public sector debt statistics: Guide for compilers and users" (IMF et al. 2011) gives a ratio of national debt to GDP of less than 100 percent. The definition recommended by that guide, a joint publication of the Bank for International Settlements, the Commonwealth Secretariat, the European Central Bank, the OECD, UNCTAD, the World Bank and the IMF, has not been widely adopted, and it was not used in the IMF report on Barbados. Examples of definitional inconsistencies are commonplace in economics, and the few international efforts to address this problem have had limited impact on actual practice.

Definition is only the beginning of the data problem. There is also the question of what should be aggregated within the definition of any data series. This may be illustrated by the issues with respect to the compilation of GDP. The compromises and inconsistencies which have come to be accepted in the standard compilation methodology are discussed in Coyle (2014).

Another data challenge policymakers face is the choice of unit of value. The unit of value for international comparisons of GDP is the US dollar. Individual countries will usually quote their GDP in local currency. As a result, the world ranking of currencies by size often changes because of changes in the US dollar values of local currencies. This affects countries in the top ten, except for the US and China, which are so much larger than all others. There is also the fact that the purchasing power of a standard basket of goods varies from country to country, in terms of US dollars. When the GDP in US dollars is adjusted for the purchasing power parities commonly used by the United Nations agencies, it turns out that China's adjusted GDP has been larger than that of the US since 2013. The Chinese have rejected this claim, however, on the basis that the basket of goods used for the computation of purchasing power parities needs to be revised.

[5] Until very recently, with the advent of Big Data, which provides us with data in the form of numbers of words, numbers of clicks, etc. The use of such data is still in an experimental stage.

There is a largely unrecognised and unresolved problem with respect to the prices at which all economic transactions are valued. In the models some economists write, prices are uniquely determined at the point of equilibrium between demand and supply in a market. In the real world prices are determined by implicit or explicit contracts, on markets which transcend national boundaries and go through several stages of supply and transformation. The same product is sold at differing US dollar equivalent prices in different countries. What is more, the price of any item of goods or services is unknown if no purchase and sale takes place. Indeed, a well-known tactic of the reluctant seller is to quote an offer price which is well out of the reach of potential buyers.

A further issue which has not seen much, if any, discussion in the literature is the arbitrary use of time in the preparation of economic data. The universal practice is to separate the data into observations delineated by convenient time markers, monthly, quarterly or yearly, or at greater or lesser frequencies. Then we find a way to treat these time-defined elements or their first or second moments as observations of a random variable, contrary to what we know to be the case. What is more, we compare the behaviour and test the relationships between these time-defined variables, even in circumstances where the periodicity that is appropriate for the *x* variable does not match that of the *y* variable. The problem may be illustrated by comparison of the treatment of the investment function in Worrell (1992, 97) and in Worrell (2023, 241-243). After many years of testing an annual investment function using standard statistical techniques (as in the former reference), in more recent times this author has opted for a more flexible specification that does not tie the equation into an annual model of adjustment. Instead, in the latter reference, the investment relationship is treated separately from the rest of the model, with a specification that is a combination of quantitative and qualitative information, and that is forecast on trends that are smoothed over several years.

11. An approach to model building for policy makers in SOEs

Worrell (2023, Chapter 14) deals at some length with the issues summarised in the previous sub-section, and others in the field of quantitative economics. Chapter 6 of the same book is devoted to a model which is similar to *FINEX* in its components, but which is adapted to reflect the economic structures of SOEs. The equations of the model are designed to reflect observed economic behaviour, and there is no attempt to define equilibrium in any market or to appeal to any microeconomic theory. What is gained by this approach, from the policy maker's perspective, is the ability to observe actual behaviour and compare with their expectations. That comparison informs the policy maker's reaction in the next round of policy discussions.

In the example of the use of the model in Worrell (2023, 243-248) there is no emphasis on the statistical reliability of the estimates and forecasts. This is a case of making a virtue of necessity, because macroeconomic data that is sufficiently up to date to be used for current ongoing policy decisions is always based on data that will be revised subsequently. Taking account of probable errors of measurement in the data, limited degrees of freedom of the estimation, international and domestic (fiscal) shocks, produces forecasts where the estimated range of outcomes is too wide to be of any practical use. Economic forecasts are usually issued at the mid-point of the estimated range, but this practice is unscientific. The data and models used in economic analysis produce forecasts which may lie anywhere within an impractically large interval.

However, point forecasts are very useful if we do not make a fetish of their supposed statistical properties. The real value of forecasts to the policymaker lies in setting benchmarks for critical variables on the way to short and medium term targets for investment, growth, employment, the balance of external payments, the national debt and other objectives. For example, if the policy maker's target is to increase investment to double the growth rate by the end of the fifth year of the projection, the model may be used to deduce investment targets for Years 1, 2, 3 and 4 of the projection. At the end of Year 1 an evaluation can be made as to whether the actual investment has been sufficient, and, because the structure of the economy is explicit in the model, policy options for adjustment can be identified where necessary.

Part III. An assessment

The conclusion which emerges from the analyses of both Parts I and II of this essay is that the growth of Caribbean and other small economies is supply-driven. At bottom, it is the capacity to supply internationally competitive goods and services – that is to say, products which offer value for the quality of product on offer that is at least equal to alternatives on the international market – that limits the national output and income, because the world market can absorb whatever quantity the SOE can sell at a competitive price. The growth challenge therefore reduces to a question of what policies the governments of SOEs may put in place that will promote investment, increase productivity and improve the overall productivity of the economy.

One element that seems essential for a favourable investment climate is prudent management of the public finances, so as to avoid excess pressure on the foreign currency market, exchange rate uncertainty and the flight of capital. In these circumstances, investment projects may be delayed or abandoned, country risk premiums rise and the country is at risk of being overlooked in favour of competing locations.

Government investment to improve the quality of the labour force is another important investment-promoting activity, especially in SOEs. Because of its small labour force, the SOE cannot compete against larger countries for low-skilled jobs that are outsourced from richer countries. Instead, they must seek to attract investment that requires a higher level of skill. A focus on education policy and the continuing improvement in educational achievement is a key element of the development strategy.

Government investment to improve health services has especially beneficial effects, contributing directly to the country's development as well as being an important element in its international competitiveness. The importance of the provision of good health services is reflected in the fact that improvements in the index for health have by far the most substantial impact on the overall *Human Development Index* score, for any given percentage increase, compared with improvements in average incomes and educational achievement of the same magnitude (See, for example, Worrell 2020, 11, Figure 3). In addition, improvements in health services contribute to the country's international competitiveness, attractiveness to investors and growth capacity (World Economic Forum 2020).

Among the major issues which remain to be fully explored are the implications for SOEs of the international mobility of finance and capital. Economists and policy makers in the Caribbean remain preoccupied by a perceived scarcity of finance for investment. In exploring why this is the case, research is needed into issues related to the quality of the labour supply, the capacity to innovate and related questions about the labour and financial markets.

The implications of the international mobility of labour is another area that needs to be further explored, including the implications of the brain drain for the SOE's policies aimed at improving the quality of the labour force. The higher the level of skill, the greater the opportunities for emigration, and the more remunerative the rewards of emigration, in general. It is already the case that some governments' efforts to improve the quality of the labour force have been attenuated by the brain drain. Migration may also be linked to the economy's growth potential via remittance flows, seasonal migration in tourism and agriculture, and foreign investment from members of the country's diaspora.

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