MACROECONOMICS AND FINANCE IN THE CARIBBEAN: QUANTITATIVE ANALYSES.

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Edited by

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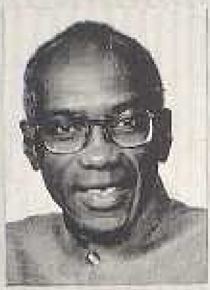
Roland Craigwell

Caribbean Centre for Monetary Studies

Macroeconomics and Finance in the Caribbean: Quantitative Analyses

This is the second publication in the Technical Paper Series of the Caribbean Centre for Monetary Studies. It follows the earlier *Problems and Challenges in Modelling and Forecasting Caribbean Economies*, edited by Shelton Nicholls, Patrick Watson and Hyginus Leon (CCMS, 1996). The present volume provides a capsule of the state of the art in quantitative economic analysis in the Caribbean. The concerns range through macroeconomic modelling, macroeconomic policy the effects of external shocks, the efficacy of monetary targets, the roots of inflation, the relationship of government expenditure to growth, risk and return in securities markets, and the quality and characteristics (seasonality etc) of data. There is an overarching concern about spurious correlation, and cointegration and error correction methodologies are employed whereever appropriate.

About the Editors



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Caribbean Centre for Monetary Studies

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PREFACE

Economists working at the central banks of Caricom countries and at the region's universities have forged a community of scholarship over the past three decades through the agency of the Caribbean Regional Programme of Monetary Studies (RPMS), until recently a special programme of the Institute of Social and Economic Research of the University of the West Indies and the Institute of Development Studies of the University of Guyana. The work of the RPMS has been of great benefit in the design and implementation of economic policy in the Caribbean, and in building the foundations for Caribbean economic integration. Research under RPMS auspices has produced a wealth of analysis of Caribbean finance, public finance, balance of payments and macroeconomic policy, documented in the Programme's publications. Equally important has been the interaction and cross fertilisation of ideas among central bankers and university economists, which has enriched the insights on Caribbean economies of all participants, many of whom have gone on to the highest levels of policy making in the region.

The RPMS has now matured into the Caribbean Centre for Monetary Studies (CCMS), to build and expand on this tradition of research that deepens our understanding of Caribbean economies. The papers in the present volume are revised versions of presentations at the CCMS conference in St Kitts in November 1995, where a section of the programme was devoted to quantitative analysis and modelling. It follows the publication of the first in the CCMS's new Technical Paper Series, *Problems and Challenges in Modelling and Forecasting Caribbean Economies*, edited by Shelton Nicholls, Patrick Watson and Hyginus Leon (CCMS, 1996). Here you will find a capsule of the state of the art in quantitative economic analysis in the Caribbean. The concerns range through macroeconomic modelling, macroeconomic policy, the effects of external shocks, the efficacy of monetary targets, the roots of inflation, the relationship of government expenditure to growth, risk and return in securities markets, and the quality and characteristics (seasonality, etc) of data. There is an overarching concern about spurious correlation, and cointegration and error correction methodologies are employed wherever appropriate.

The papers in this volume reflect current understanding of economic processes in the Caribbean. As is inevitable in economics much remains unsettled, and papers often end with an agenda for further research. We hope that the results reported here will be an incentive for others to join us in furthering these research programmes. Some ideas that emerge suggest need for reflection: reservations about the strength of financial stimuli on inflation seem to be indicated, perhaps greater confidence should repose in government expenditure and fiscal policy, and securities markets seem to be rather shallow.

Any publication such as this draws on the resources of persons other than the authors. Individual authors acknowledge their debts elsewhere in the volume. Here we must say thanks to Pamela Arthur, Arlette King, Sonia Mayers and Gloria Oxley, for cleaning up the text, pulling all the parts together and repairing the damage when our leading edge technology failed us. A special word of thanks is also due to Ms. Maureen David of the Central Bank of Trinidad and Tobago who did the final preparation of the camera-ready version of the publication.

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Roland Craigwell

February 1997

CHAPTER 1

AN OVERVIEW

DeLisle Worrell
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MACROECONOMICS AND FINANCE IN THE CARIBBEAN AN OVERVIEW

DeLisle Worrell
&
Roland Craigwell

The economic crises of the past two decades and the need for an active macroeconomic response have triggered considerable interest in the quantification of Caribbean economies. In recent years, a sizeable body of work has been compiled by young econometricians under the aegis of the Caribbean Regional Programme of Monetary Studies (RPMS). Each year the Annual Conference of the RPMS (now succeeded by the Caribbean Centre for Monetary Studies, CCMS) includes panels on econometric modelling and quantitative analysis which have uncovered ongoing work of great sophistication. The present collection of papers is a sampling of these efforts based on contributions to the 1995 Conference of the RPMS.

Inevitably, the papers offer no more than a glimpse of the economic processes at work and their policy implications. Even the most modern of econometric techniques gives definitive results only in limited circumstances. For example, cointegration procedures, which offer reliable results from serially correlated variables in certain cases, have been developed only for single equation models. A promising effort in this volume to address non-stationarity in multi-equation models shows clearly the difficulties that remain and the compromises that have to be made.

Further, even with single equations the conceptual foundations of best practice are controversial. Indeed economists are today increasingly suggesting that the popular "causality" test attributed to Granger is based on a notion of causality which is rejected by many philosophers. Because of this uncertainty economists are extremely cautious about using the results of these tests as a guide for policy, especially when the results violate our priors.

The picture is further clouded by the extent of aggregation used in empirical work, the simplification of economic processes to reduce the analysis to a manageable number of variables, the difficulty of finding close proxies for many variables and the weakness of some data.

As a result, this quantitative survey of current work in macroeconomics and finance is not intended to be definitive but rather a thought-provoking survey of the state of the art in the Caribbean. It reveals a great deal of searching economic analysis on-going in the Caribbean, using best practice. It suggests there is a greater wealth of data available than has often been admitted. Much of what has been done throws up puzzles that will undoubtedly motivate further research. Indeed, most authors continue to work on the issues reported here.

Watson and Teelucksingh explore the use of cointegration with small samples in a multi-equation model, using Trinidad and Tobago to illustrate. The discovery in the early 1980s of statistically dependable ways of estimating relationships between variables which are serially correlated has lifted a burden of guilt from the shoulders of econometricians. Ordinary least-squares procedures suitably applied may yield results whose probability may be reliably determined. The new cointegration procedures also allow a distinction between long-run relationships and short-term fluctuations - an attractive feature. However, one obtains reliable results only if there is a wealth of observations. For most countries, there are insufficient observations to allow for the estimation of large simultaneous equation systems. Yet, such systems are essential for policy-making and forecasting by government and the private sector. Highly aggregated systems with only a few behavioural equations lack the detail required by decision-makers.

Watson and Teelucksingh recommend a pragmatic approach to appraising spurious association in large-scale macroeconomic models. Conventional stationary tests whose power deteriorates badly with small samples should be treated as supplements to visual examination of correlation among residuals. Equations are accepted as cointegrated if the correlogram of residuals appears to be stationary. The tests which establish probability limits - adjusted Dickey-Fuller and cointegrating Durbin-Watson - are used to confirm impressions from the correlogram. Results of these tests are ignored if they contradict the visual examination because of their imprecision at small sample sizes.

The procedure is illustrated by estimating a structural model for Trinidad and Tobago which includes twelve behavioural relationships and many identities. There are equations for consumption and investment; output is the sum of all expenditure. Government expenditure is exogenous while the revenue depends on the tax rate, presumably a policy variable. There is a money demand equation and the financial system adjusts seamlessly to money demand, the public sector borrowing requirement and private capital flows (the last being exogenous). Exports depend on world income and relative prices, imports on domestic income and relative prices. The model details the interrelationship between the GDP deflator and the prices of imports, government services, retail prices and wages. There are also equations for the labour force and employment.

The model is estimated annually from 1970 to 1994 and the simulated outcome is compared with actuals using Theil's U statistic. The results are highly variable. The model is subjected to shocks and shown to converge in every case.

Holder and Williams explore the impact of the oil shock on the demand for imports in Trinidad and Tobago. During the 1980s the Trinidad and Tobago economy underwent a prolonged period of economic adjustment following the collapse of the price of oil in 1981. The Holder-Williams paper is motivated by the question whether adjustment may have been less painful had alternative government policies been followed. They discuss the nature of the Government of Trinidad and Tobago's responses to the oil boom of the 1970s in the context of theoretical notions of 'Dutch disease'. Their empirical results focus on factors affecting imports, so they give only a limited answer to the questions they raise about the suitability of economic policies.

Holder and Williams point out that a price hike in the booming sector may have an impact on production by attracting factors of production away from other tradable sectors and on prices by inflating the demand for domestic goods which are in inelastic supply, that is, non-tradables and goods protected by tariffs and quantitative restrictions. They present a summary of the Government of Trinidad and Tobago's policies in response to two shocks which brought windfalls to Trinidad and Tobago. Considerable portions of the windfall were accumulated in foreign reserves and invested domestically. Although less than half the windfall was consumed the rate of increase of consumption proved too high to be sustained. The situation was aggravated by Government subsidies which allowed excess consumption and rapid increases in wages.

Holder and Williams examine the factors affecting the demand for imports but do not attempt to measure the effect of demand pressure on prices. Only indirectly can inferences be drawn about the extent of 'Dutch disease', to the extent that import responses to expenditure are sluggish or where import demand outstrips foreign exchange earnings in the medium-term. The import demand is a function of permanent non-oil income, transitory non-oil income, oil revenues and relative prices. Relative prices depend on the terms of trade, quantitative restrictions, capital inflow, excess supplies of credit and domestic prices. The tests are done on a reduced form using cointegration. Holder and Williams find that income, the terms of trade, capital inflow and perhaps the retail price index have a positive impact on imports while the share of agriculture and the ratio of customs duty to income (a proxy for quantitative restrictions) have a negative impact.

McClean's contribution is an analysis of the demand for money in Barbados. His equation for money demand is derived from a structural model which incorporates features designed to represent the small open economy. They include the specification of a terms of trade effect making for a difference between output and income. Prices include a mark-up which is partly affected by domestic interest rates and indirect taxation. Wages are uniform throughout the economy and are set in a wage bargaining context where interest rates and tax rates are an important consideration along with the level of inflation. The model incorporates common features of small open models including a money supply that is related to the balance of payments and the growth of domestic assets of the central bank and a balance of trade which is affected by exchange rate expectations, excess supplies of money and arbitrage between domestic and foreign interest rates.

In a model of this sort there is a process of adjustment through which prices, incomes and the balance of payments adjust to eliminate any excess supply of money. The adjustment process has implications for the money demand function and for monetary policy. Because the adjustment process is endogenous strong feedback characterises the money demand function. McClean uses advanced time series methods to measure the strength of this feedback. The nature of the adjustment depends on behavioural responses and there should be no a priori notions about the importance of interest rate changes in securing monetary equilibrium. After careful analysis of the money demand function using quarterly data from the first quarter of 1976 to the fourth quarter of 1994 McClean concludes that disequilibrium in the preceding period and changes in income in the current period are the significant influences on the stock of money. Based on the findings he recommends that monetary policy be dedicated to managing the balance of payments, and not to interest or inflation targets, and that monetary expansion should always be avoided.

Cumberbatch's paper analyses inflation in Barbados. Her survey of previous studies of the determinants of inflation in Barbados indicated that imported prices were the most important source of inflation in every case, notwithstanding differences in model specification and estimation technique. Recent studies suggest wage push as an important source of inflation, give some credibility to the notion of aggregate demand as a stimulus to price changes and suggest productivity changes may be a moderating influence on inflation.

Cumberbatch's study is based on a model which allows for all these influences but acknowledges they will have different effects on the price of non-tradables - which need bear no relation to world prices - and on the price of tradables, which is driven towards world prices by trade flows. There is a relation between inflation in non-tradables and inflation in tradables because wages are uniform in the domestic economy for both tradables and non-tradables. Sectoral price differentials reflect productivity growth differentials and the speed of adjustment of the supply of non-tradables to changes in the demand for non-tradables. This model yields an inflation equation whose arguments are inflation in world prices, the lagged growth in output of non-tradables, the growth of income, interest rates, the growth of wages and changes in productivity. Cumberbatch's results confirm the influence of import prices. There is also a possible impact of unit labour cost - wages adjusted for productivity changes - interest rates and the growth of income.

Belgrave and Craigwell conduct an empirical investigation of the relation between different kinds of government expenditure and growth in Barbados using a single regression equation with variables intended to reflect the influence of external shocks. They also wanted to include a variable to represent changes in domestic policy but failed to come up with an acceptable proxy. They find that Government expenditures on agriculture, housing, health and public works are positively related to the growth of income and are therefore considered productive. Government capital expenditure is also considered productive. To the authors' dismay educational expenditure is at best insignificant. Also, current expenditure is unproductive - a result which seems at variance with previous findings, since all the components of current expenditure, with the exception of education, are found to be productive. The authors think their perverse results may be a result of too high a level of aggregation. It is also possible that the omission of policy variables has resulted in misspecification. Misguided policies which destabilize economies and inhibit investment may undo the potential benefit of government expenditure on human resource development and other productive expenditure.

Maurin explores the stationarity of a selection of monthly and quarterly series that exhibit seasonality. He illustrates, using graphs, that many Caribbean economic series appear to have seasonal and other systematic patterns of fluctuation. He reminds us that deseasonalizing data before use may introduce error if the seasonal variation is stochastic rather than deterministic. He provides a set of techniques for detecting serial correlation in series that exhibit seasonality and derives two tests to be used on Caribbean data - those due to Osborn, Chui, Smith and Birchenhall and to Hylleberg, Engel, Granger and Yoo. He also derives a test based on the decomposition of the series into different periodicities but does not employ it in the empirical work.

Maurin finds evidence of serial correlation at long-run frequencies (i.e. on an annual basis) but not at seasonal frequencies, that is, monthly and quarterly. His results indicate that seasonal adjustments made a priori using Box-Jenkins and similar methodologies impose an excessive correction.

Clarke and Francis illustrate ways of addressing the data requirements of econometric modelling using the quarterly National Accounts of Trinidad and Tobago. Quarterly macroeconomic data are essential for informed policymaking but definitive information based on comprehensive censuses is available only with a lag and only on an annual basis for the most part. Clarke and Francis explain how quarterly series may be built up using indicators and recommend that they be reconciled with annual data when that becomes available. They assess the practical difficulties of obtaining and compiling data for the indicators. They demonstrate the methodology with quarterly GDP estimates for Trinidad and Tobago.

Chapter 2

Macroeconomic Modelling and Cointegration in a Small Sampling Framework (With Application to Trinidad and Tobago)

Patrick Kent Watson
and
Sonja Sabita Teelucksingh

MACROECONOMIC MODELLING AND COINTEGRATION IN A SMALL SAMPLING FRAMEWORK
(WITH APPLICATION TO TRINIDAD AND TOBAGO)

Patrick Kent Watson
&
Sonja Sabita Teelucksingh

INTRODUCTION

This paper is essentially an essay in econometric methodology in which the principal objective is to carve out a procedure for applying the cointegration "technology" to multiple equation systems when only small data samples are available. A fundamental tenet of the paper is that much can be gained from the application of cointegration methods in modified form to large-scale econometric models notwithstanding the paucity of the data. Of particular interest is the potential of this method to isolate long-run (equilibrium) relations linking the variables in a system as well as the theoretical justification based on the Granger Representation Theorem - Engle and Granger (1987) - for the construction of error-correction mechanisms which model the short-run dynamics around such long-run relations. An heuristic step-by-step procedure for model estimation is proposed, which is illustrated in the case of a prototype model of the Trinidad and Tobago economy, and which, it is believed, employs good econometrics in the service of good economic decision-making. After all, this must be the ultimate objective of any development in econometric theory!

A cursory glance at some survey papers on cointegration such as Holden and Perman (1994) will convince the reader that, if anything, these methods are data hungry and, for best results, assume the existence of fairly lengthy time series. Unfortunately, the explosion in the econometric literature on cointegration has not been matched by any corresponding explosion in the availability of economic data, particularly in countries such as those of the English-speaking Caribbean - yet another focus of this paper - where a solid though somewhat unsound tradition in macroeconometric modelling has developed - see Watson (1987, 1994). Furthermore, data requirements increase almost exponentially with the number of variables in the system since this ultimately results in a greater number of relationships between the variables in the form of multiple equation systems. To compound the issue, where attention in the literature has been paid to the theoretical issues in the application of cointegration methods to multiple equation systems, the concern is with relatively small systems (no more than five or six equations) which does not even come close to a macroeconometric model even of the most modest size. See, for instance, Bagliano *et al.* (1991), Muscatelli *et al.* (1992) and Kunst and Neusser (1990).

The rest of this paper is set out as follows: in the following section, there is a brief discussion on macroeconometric modelling prior to cointegration analysis. Then the methodological framework for the application of cointegration methods to large systems using small samples is developed. The prototype macroeconometric model of the Trinidad and Tobago economy to which this procedure is applied is then laid out, followed by a section in which problems associated with the determination of the order of integration of the variables in the system are discussed. The results of parameter estimation using the proposed methodology are then given, followed by an evaluation of the fitted model based on its solution properties, including its stability and dynamic response to external stimuli.

Pre-Cointegration Macroeconometric Modelling

The hallmark of classical or "Cowles Commission" macroeconometric models is the construction of a structural form (SF) which contains specifications of individual equations rooted in economic theory and emphasizing the endogenous-exogenous dichotomy. Most (perhaps all) Caribbean macroeconometric models to date follow this tradition, for instance the Watson and Clarke (1995) and Hilaire *et al.* (1990) models of the Trinidad and Tobago economy and the UNDP (1991) model of the Jamaican economy. Notwithstanding the tremendous amount of intellectual and financial resources devoted by the Cowles Commission and other research groups to the development of consistent estimation procedures like Two-Stage Least Squares (2SLS), Three-Stage Least Squares (3SLS), Full Information Maximum Likelihood (FIML) Estimation and others, the dominant practice has been to employ the theoretically inferior Ordinary Least Squares (OLS) method in preference to these more fanciful procedures precisely because the data series are inadequate. It turned out, too, that in small data sets, OLS outpointed its rivals on other criteria, such as those based on the simulation (solution) of the model as a whole - see Smith (1980).

Perhaps the first moral of this story is that the time (and money!) devoted to the elaboration of fanciful mathematical procedures may have been better spent on the more mundane task of improving the economic data base, both in terms of quality and quantity of the data. But the more important lesson here seems to be that the need to answer burning questions of economic policy forced model builders into being pragmatic about the estimation exercise and, in the final analysis, to use a method that worked. It is this fundamental lesson that will be used in this paper to arrive at a useful solution to the thorny problem of application of the cointegration method to estimating a multiple equation system.

In fact, if the classical approach began to fall into disrepute, it was largely because of mistreatment of the data - "data mining" as it came to be called - which allowed the economic investigator to come to almost any conclusion within the framework of regression analysis. See Hendry (1980), Leamer (1983), Lovell (1983) and, for the Caribbean case, Watson (1987) and Leon (1989). It was largely to remedy such abuses that Davidson *et al.* (1978) published their seminal work on the General-to-Specific methodology which introduced as well the concept of the "error-correction mechanism" (ECM). A parallel development, spurred on no doubt by work on time series by Box and Jenkins (1970), Fuller (1976) and others, but more particularly by the work of Granger and Newbold (1974), was a growing interest in the inherent non-stationarity of economic data which might result in spurious (meaningless) regressions. This culminated in the paper by Engle and Granger (1987), perhaps the most influential contribution to the cointegration literature, which solves the spurious regression problem, interestingly enough within a framework involving the use of ECMs.

Steps in Macroeconometric Modelling with Cointegration

A preliminary step in the application of the cointegration methodology is the determination of the order of integration of the variables in the system. Tests, such as the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests, have been proposed for achieving this objective but they are unreliable in small samples and may even yield widely conflicting results - see Holden and Perman (1994). From the out-set, then, the economic investigator is faced with a problem although, as will be seen, this is the stage that presents him or her with the least difficulty. What to do?

> *It is proposed, in the presence of small samples, to lay greater emphasis on the plots of raw and differenced data as well as on plots of their correlograms in order to establish stationarity and to use the tests as backups. Given, too, the well known fact that the vast majority of economic series are I(1), then the I(1) hypothesis should only be rejected if the evidence is clear and indisputable.*

Cointegration has been applied relatively widely to single equation systems using the Engle-Granger (EG) two-step procedure. A long-run static specification of the model is formulated using the endogenous-exogenous dichotomy à la Cowles Commission and fitted by OLS. The OLS residuals, interpreted as the equilibrium error, are used to test for cointegration on the basis of standard type tests like the ADF, PP and the Cointegrating Regression Durbin-Watson (CRDW) tests. These residuals are also used in the specification of the short-run dynamic model to which OLS is also applied.

Consider in the first instance the case where there are only two variables involved. This is theoretically the only situation in which the EG procedure is applicable since the cointegrating vector (if it exists) is unique. OLS estimation of the long-run parameters is super-consistent and the standard t and F tests are applicable to the dynamic model. But concerns about the large small-sample bias (which can become intolerably large in sample sizes below 30) have led to the development of other procedures such as those proposed by Banerjee *et al.* (1986), Phillips and Hansen (1990) and Inder (1993). These methods lack the simplicity associated with the EG procedure and require specialist programming skills not usually available within the toolbox of a practising economist. For this and other reasons, they have not gained widespread popularity among practitioners. But even if we continue to use the EG procedure, the various tests of residuals mentioned above become unreliable in small samples and may conflict with each other.

> *At this stage, the economic investigator may also wish to rely on more naive methods such as the examination of the correlogram of the residuals in order to establish cointegrability. In the final analysis, he or she should be willing to reject the null of "no cointegration" if any of the tests, including the naive procedures, provide supporting evidence and he or she has a firm* a priori *conviction about the cointegrability of the variables.*

The situation becomes more complicated when more than two variables are introduced into the problem. In this case, there may be as many as (k-1) equilibrium relations, where k is the number of variables. A corollary to this is that a system of equations having r (behavioral) equations would admit exactly r cointegrating vectors from among the k variables of the system. In this case, the EG procedure (as well as the other single equation alternative estimation procedures) may yield coefficient estimates which are in fact linear combinations of the several cointegrating vectors and whose economic interpretation may not be immediately obvious. Furthermore, the *a priori* endogenous-exogenous dichotomy implied by the EG procedure and, for that matter, classical SF models as well as the restrictions on these SFs will not make sense except to the extent that they are verified by the determination of cointegrating vectors.

The Johansen (1988) procedure is theoretically capable of determining the number of cointegrating vectors and, as a first step, ought to be applied to the entire set of variables of interest to do just this. But there is a major difficulty in achieving this objective in small samples: there is likely to be a "degrees of freedom" problem for any but the smallest number of variables and the procedure would either fail outright or be quite inefficient in identifying the cointegrating and adjustment matrices. For instance, detection would be impossible in a case involving 10 variables and 25 data points, and this is clearly a cause for concern since most practical situations are likely to involve many more than 10 variables and almost certainly no more than 25 data points!

But even if it were possible to determine the number of cointegrating vectors, there still would remain the problem of the identification of the coefficients of each vector: these are usually obtained only after some arbitrary normalization is imposed. It remains an impossibility to identify the valid restrictions (with economically useful interpretations) on the SF compatible with the ECM established by the Johansen procedure.

How do we get out of this dilemma? For a small system, Bagliano *et al.* (1991) propose the following four steps:

1. From the implementation of the Johansen procedure, derive some information about the likely number of long-run equilibrium relations involving the variables under investigation.

2. On the basis of this information, theoretical hypotheses on the form of the equilibrium relations are formulated; the results from estimation of the cointegrating regressions so specified may provide a way of assessing the plausibility of such hypotheses.

3. The (lagged) ECM terms constructed as residuals from the estimation of the equilibrium relations are then in-

cluded in the reduced form of the system; such reduced form is then estimated and its congruency with the data evaluated.

4. Structural hypotheses on the behaviour of the system are specified in (3). Such hypotheses typically consist of exclusion restrictions on the ECM terms in each equation, in addition to the traditional hypotheses on simultaneous effects among the endogenous variables.

In small systems, the first step cannot be carried out for reasons already given. It is for this reason that the following is proposed as an alternative to Bagliano *et al.*'s Step 1:

1′. Using *a priori* economic reasoning, propose possible (static) long-run equilibrium relations similar in spirit to the classical methodology. The validity of each relation is either rejected or provisionally accepted using the first step of the EG 2-step procedure discussed above. In the case of rejection, an alternative long-run relation is proposed and tested in the same way.

There is of course the serious risk at this stage that more than one cointegrating vector may exist among this reduced set of variables. In small samples, however, the alternative is the absence of any assurance whatsoever of one or more cointegrating vectors. Once step 1′ is successfully completed for all proposed equilibrium relations, the following step is carried out:

2′. The (lagged) ECM terms constructed as residuals from the estimation of the equilibrium relations are then included in the reduced form of the system; the final form of the short-run dynamic equation retained will be based on General-to-Specific type testing of restrictions on lags as well as on the included ECM terms.

The lag structure of this equation as well as the number of ECMs to incorporate prior to beginning testing will be limited by the sample size available. Once again, some *a priori* economic reasoning must apply, especially in excluding some of the ECMs.

The third and final step in the procedure now follows:

3. The entire system incorporating the dynamic short-run equations as well as accounting and other identities is solved and the appropriateness (or otherwise) of the model as a whole determined on the basis of the simulation properties (including its dynamic stability).

These three steps are to be followed only when the sample size militates against the four steps proposed by Bagliano *et al.* Otherwise the latter are to be followed. This 3-step procedure will be applied to a prototype model of the Trinidad and Tobago economy which is presented in the following section.

A Prototype Macroeconometric Model of The Trinidad and Tobago Economy

Following Step 1′ outlined above, a prototype model of the Trinidad and Tobago economy is presented in Table 2.1 below:

TABLE 2.1
PROTOTYPE MODEL OF THE TRINIDAD AND TOBAGO ECONOMY

BLOC I	$Y = C + I + X - M$	(1.1)
Aggregate Expenditure Bloc	$C = C_p + C_g$	(1.2)
	$I = I_p + I_g + I_s$	(1.3)
	$C_p = f_1(Y, L_1/P_c, \ldots)$	(1.4)
	$I_p = f_2(Y, I_g, r, \ldots)$	(1.5)
BLOC 2	$GDEF = C_g{*}P_g + O_g - T$	(2.1)
Public Sector Bloc	$T = t{*}Y{*}P_y$	(2.2)
BLOC 3	$L_1/P_{c,} = h(Y, r \ldots)$	(3.1)
Financial Sector Bloc	$\Delta XD_g = GDEF - \Delta ID_g$	(3.2)
	$\Delta XD = \Delta XD_g + \Delta XD_o$	(3.3)
	$\Delta L = \Delta R + (\Delta ID_g - \Delta NBCR_g) + \Delta CR_p + \Delta L_o$	(3.4)
	$L_2 = L - L_1$	(3.5)
	$r = \frac{(1 + n)}{(P_r/P_{r-1})} - 1$	(3.6)
BLOC 4	$\Delta R = X{*}P_x - M{*}P_m + \Delta XD + \Delta DFI + \Delta R_o$	(4.1)
Balance of Payments Bloc	$X = X_1 + X_2 + X_o$	(4.2)
	$M = M_g + M_o$	(4.3)
	$X_2 = K_1(Y_w, P_e/P_w, \ldots)$	(4.4)
	$M_g = K_2(Y, P_m/P_r \ldots)$	(4.5)
BLOC 5	$P_y = I_1(w, P_r, P_x \ldots)$	(5.1)
Wages and Prices Bloc	$P_m = I_2(P_w, \ldots)$	(5.2)
	$P_g = I_3(w, P_x, \ldots)$	(5.3)
	$P_r = I_4(w, P_m, \ldots)$	(5.4)
	$w = I_5(P_r, U_R, C_g, \ldots)$	(5.5)
BLOC 6	$K = I_p + I_g + (1-g) K_{-1}$	(6.1)
Output and Employment Bloc	$UNEMP = N - EMP$	(6.2)
	$N = m_2(w, POP, Y, \ldots)$	(6.3)
	$U_R = UNEMP / N$	(6.4)
	$EMP = m_3(w, Y, \ldots)$	(6.5)

"Endogenous" Variables

C	=	Total Consumption Expenditure (constant prices)
C_p	=	Private Consumption Expenditure (constant prices)
EMP	=	Level of Employment
GDEF	=	Government Overall Budget Deficit (Central Government Borrowing Requirement)
I	=	Gross Capital Formation (constant prices)
I_p	=	Private Sector Fixed Capital Investment (constant prices)
K	=	Gross Capital Stock (constant prices)
L	=	Money Supply, M_2 (assumed equal to demand)
L_1	=	Money Supply, M_1 (assumed equal to demand)
L_2	=	Stock of Quasi Money
M	=	Imports of Goods and Services (constant prices)
M_g	=	Imports of Goods (constant prices)
N	=	Total Labour Force
P_c	=	Private Consumption Expenditure Deflator
P_g	=	Government Consumption Expenditure Deflator
P_m	=	Imports Deflator
P_r	=	Index of Domestic (Retail) Prices
P_y	=	National Output Deflator
r	=	Real rate of Interest
R	=	Stock of Foreign Assets
T	=	Government Tax Receipts
UNEMP	=	Level of Unemployment
U	=	Unemployment Rate
w	=	Wage Rate
X	=	Exports of Goods and Services (constant prices)
X_2	=	Non Petroleum Exports (constant prices)
Y	=	National Output (constant prices)
XD	=	Total External Indebtedness
XD_g	=	External Indebtedness of Central Government

"Exogenous" Variables

C_g	=	Government Consumption Expenditure (constant prices)
CR	=	Bank Credit to the Private Sector
DFI	=	Direct Foreign Investment Stock
I	=	Public Sector Fixed Capital Investment (constant prices)
I_s	=	Investment in Stock (constant prices)
ID_g	=	Internal Indebtedness of Central Government
L_o	=	Residual Factors Affecting Money Supply
M_s	=	Imports of Services
$NBCR_g$	=	Non Bank Credit to Central Government
O_g	=	Other Government Expenditure (Net)
POP	=	Size of Population
P_w	=	Index of World Prices
P_x	=	Exports Deflator
r^n	=	Nominal Rate of Interest
R_0	=	Residual Factors Affecting Stock of Foreign Assets
t	=	Tax rate
X_1	=	Petroleum Exports
X_0	=	Exports of Services
XD_o	=	External Indebtedness of Non Central Government Sector (including State Enterprises and Central Bank)
Y_w	=	World GDP
γ	=	Rate of Asset depletion

The model is a highly aggregated system containing six (6) interlocking blocs with 28 equations of which 14 are proposed long run behavioural relations which will be the subject of the estimation exercise and which will also be used, as indicated in Step 2' above, to construct the short-run equations. The other 14 are identities which will not be estimated but which will be part of the model solution exercise. The terms "exogenous" and "endogenous" are used reservedly since, strictly speaking, these terms are incorrect in the cointegration framework. At best, they represent the investigator's *a priori* hunches.

The existing data base of Trinidad and Tobago allows for much greater disaggregation and detail than appears in this prototype as can be gleaned, for instance, from the model constructed (in the traditional framework) by Watson and Clarke (1995). To some extent, the work of this paper is preliminary to the updating and upgrading of this larger model using the cointegration framework. But it can also be used as an immediate reference for situations, such as in the O.E.C.S. countries of the Caribbean region, where the existing data base may only suffice for a model of this size and complexity.

DETERMINATION OF THE ORDER OF INTEGRATION

The data selected to represent the various economic constructs appearing in the prototype model were obtained directly or calculated from a list of publications including the *National Accounts of Trinidad and Tobago* and the *Annual Statistical Digest* of the Central Statistical Office of Trinidad and Tobago, the *Quarterly Statistical Digest* and the *Annual Economic Survey* of the Central Bank of Trinidad and Tobago and the *International Financial Statistics* of the International Monetary Fund. Further details may be found in Watson and Clarke (1995).

As anticipated, most of the variables are I(1). In Table 2.2 below, only those appearing in behavioural equations and which were found not to be I(1), or not clearly so, are reported together with their ADF test statistics (the statistic in parentheses was calculated on the assumption of the presence of a deterministic trend):

TABLE 2.2
DETERMINATION OF ORDER OF INTEGRATION (D) OF SELECTED SERIES

Variable	ADF test statistic H_0: d=1 H_1: d=0	ADF test statistic H_0: d=2 H_1: d=1	ADF test statistic H_0: d=3 H_1: d=2	Decision
P_m	4.100	-1.821 * * *	-6.09 *	d = 2
	(0.3824)	(-3.029)	(-5.993*)	
P_r	14.64	0.0073	-5.38*	d = 2
	(-0.2519)	(-4.291**)	(-5.391*)	
P_m/P_r	-1.993* *			d = 0
	(-1.114)	(-4.826 *)		
Y_w	6.173	-1.294	-5.025 *	d = 1
	(-0.6043)			
P_w	4.187	-1.319	-3.72*	d = 2
	(-0.5013)	(-2.374)	(-3.639 **)	
P_y	5.973	-1.546	-6.48*	d = 2
	(-1.794)	(-3.835 **)		

* *rejection of H_0 at the 1% significance level*

** *rejection of H_0 at the 5% significance level*

*** *rejection of H_0 at the 10% significance level*

Note: *The statistics in parenthesis were calculated on assumption of a deterministic trend; those without parenthesis assume no trend.*

The correlogram of each series was inspected and used in the determination of the order of integration. Of particular interest is Y_w (which in the study is US GDP): an investigator may be tempted to classify it as an I(2) using the ADF test statistic but examination of the correlogram suggested strongly that it was a random walk and it was therefore retained as I(1). Chart 2.1 below shows the autocorrelation

(ACF) and partial correlation (PACF) of the first difference of this variable:

CHART 2.1

ACF/PACF OF DY

(The 95% confidence limits are shown as the pair of parallel lines)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |**. |	. |**. |	1	0.289	0.289	2.2679	0.132
.*| . |	.**| . |	2	-0.167	-0.274	3.0596	0.217
.*| . |	. | . |	3	-0.162	-0.025	3.8370	0.280
. | . |	. | . |	4	0.010	0.037	3.8402	0.428
. |**. |	. |**. |	5	0.308	0.290	6.9463	0.225
. | . |	.*| . |	6	0.064	-0.170	7.0870	0.313
.*| . |	. |* . |	7	-0.065	0.103	7.2405	0.404
. |* . |	. |**. |	8	0.145	0.230	8.0574	0.428
. | . |	.*| . |	9	0.035	-0.143	8.1082	0.523
. | . |	. | . |	10	-0.004	-0.010	8.1088	0.618
. | . |	. |* . |	11	0.030	0.137	8.1516	0.700
.**| . |	***| . |	12	-0.229	-0.385	10.869	0.540

The Ljung-Box (Q) statistic supports the hypothesis that DY_w is white noise or, equivalently, that Y_w is a random walk. This conclusion is further supported by the ADF test statistic (with trend) which is significant at the 5% level.

ESTIMATION OF THE PROTOTYPE MODEL

The behavioural equations were fitted following the procedure laid out in Steps 1′ and 2′ above. Estimation of the import price index equation was highly unsatisfactory and the results are not reported here. In some cases, a dummy variable (D) is introduced, which is equal to 1 if the observation is for the period 1974-81 (the period of the so-called oil boom) and 0 otherwise, and in others a trend variable (TIME) is introduced. W$ represents the total wage bill and is used in the calculation of average wages.

Each long run equation was constrained to contain variables which were I(1) or, in some exceptional cases, I(0). It is for this reason some of the price variables appear as inflation rates (which were shown to be I(1)) and not in their original "index" forms. Each equation was fitted by OLS and a test for cointegration was performed on each set of residuals. These tests include the classic ADF test, the CRDW test, as well as visual inspection of the correlograms.

Short-run equations were obtained using a "General-to-Specific" approach: to begin, all variables appearing in the long-run equation also appeared in the short-run equation with lag 0 and lag 1 in the first difference, together with a collection of ECMs (all with lag 1) which represent the estimated error correction terms obtained as the OLS residuals of the long-run fits (step one of the EG 2-step procedure). The last three letters of these variables are "ECM". Variables were progressively eliminated on the basis of restriction tests, leaving behind the equations which are shown below. It is interesting to note that each short run equation remains with only one ECM term: the one that was obtained from the corresponding long-run equation.

The results obtained are shown below and some justification is given for the long run equation retained. In particular, the CRDW and ADF statistics as well as the correlograms associated with the residuals from this equation are shown for all the cases considered.

Private Consumption Expenditure

$$\Delta C_p = \underset{(0.04625)}{4.97} + \underset{(1.68745)}{0.28901}\,\Delta Y + \underset{(2.83004)}{1.59143}\,\Delta(L_1/P_c) - \underset{(3.67244)}{0.86483}\,CPECM_{-1}$$

$\bar{R}^2 = 0.716$ DW = 1.73

$$CPECM = C_p - (208.3 + 0.340\,Y + 2.02\,L_1/P_c - 586.9\,D)$$

CRDW = 1.67 ADF = -3.75

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |* . |	. |* . |	1	0.093	0.093	0.2439	0.621
. |**. |	. |**. |	2	0.256	0.250	2.1696	0.338
. | . |	. *| . |	3	-0.047	-0.095	2.2365	0.525
.**| . |	.* | . |	4	-0.214	-0.290	3.7118	0.446
. *| . |	. | . |	5	-0.066	0.009	3.8585	0.570
***| . |	.* | . |	6	-0.320	-0.207	7.5013	0.277
. | . |	. | . |	7	0.002	0.034	7.5015	0.379
.**| . |	. *| . |	8	-0.221	-0.168	9.4428	0.306
. |* . |	. | . |	9	0.074	0.060	9.6754	0.377
. | . |	. *| . |	10	-0.053	-0.107	9.8031	0.458
. *| . |	.**| . |	11	-0.117	-0.202	10.462	0.489
. | . |	. *| . |	12	0.030	-0.066	10.510	0.571

The long-run regression was retained on the basis of the CRDW and examination of the correlogram of residuals revealed that the residuals were not simply stationary but white noise.

Private Investment Expenditure

$$\Delta I_p = 0.65999\,\Delta I_{p-1} - 0.18115\,\Delta Y_{-1} + 0.36015\,\Delta I_g - 0.7266\,IPECM_{-1}$$

(3.81822) (2.26727) (2.63458) (3.55875)

$\bar{R}^2 = 0.501$ DW = 1.82

$$IPECM = I_p - (-619.287 + 0.106\,Y + 0.366\,I_g - 1088.33\,r + 696.9\,D)$$

CRDW = 1.12 ADF = -2.741

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*** |	. |*** |	1	0.377	0.377	3.9913	0.046
***| . |	****| . |	2	-0.337	-0.558	7.3236	0.026
****| . |	.*| . |	3	-0.478	-0.119	14.344	0.002
.*| . |	. | . |	4	-0.120	0.017	14.804	0.005
. |**. |	. |*. |	5	0.260	0.074	17.081	0.004
. |*** |	. |*. |	6	0.332	0.105	20.999	0.002
. | . |	.**| . |	7	-0.049	-0.224	21.091	0.004
***| . |	.*| . |	8	-0.373	-0.099	26.623	0.001
.**| . |	. | . |	9	-0.269	-0.039	29.679	0.000
. | . |	.**| . |	10	-0.018	-0.207	29.693	0.001
. |**. |	. |*. |	11	0.209	0.073	31.804	0.001
. |*. |	.*| . |	12	0.132	-0.166	32.708	0.001

The long-run equation is here retained on the basis of the CRDW test and inspection of the correlogram which shows that the residuals are stationary.

Import Demand Equation

$$\Delta M_g = 0.28284\,\Delta Y - 1331.73\,\Delta(P_m/P_r)_{-1} - 0.86984\,MGECM_{-1}$$

$$(2.76685) \qquad (2.13164) \qquad (3.98297)$$

$$\bar{R}^2 = 0.530 \quad DW = 1.82$$

$$MGECM = M_g - [-2789.495 + 0.426\,Y - 343.7815\,(P_m/P_r)]$$

$$CRDW = 1.49 \quad ADF = -3.477$$

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |* . |	. |* . |	1	0.183	0.183	0.9380	0.333
. *| . |	. *| . |	2	-0.111	-0.149	1.2973	0.523
. |* . |	. |* . |	3	0.117	0.177	1.7138	0.634
. |* . |	. | . |	4	0.073	-0.008	1.8861	0.757
.**| . |	.**| . |	5	-0.217	-0.209	3.4702	0.628
.**| . |	. *| . |	6	-0.200	-0.127	4.8879	0.558
. | . |	. | . |	7	0.014	0.015	4.8949	0.673
. *| . |	. *| . |	8	-0.127	-0.142	5.5331	0.699
. | . |	. |* . |	9	-0.056	0.076	5.6673	0.773
. | . |	. *| . |	10	-0.010	-0.087	5.6717	0.842
. |* . |	. |* . |	11	0.122	0.127	6.3840	0.847
. |* . |	. | . |	12	0.082	0.019	6.7334	0.875

Both the CRDW and the Q statistics indicate that the residuals are white noise (and therefore stationary).

Money Demand Equation

$$\Delta L_1/P_c = 0.21043\,\Delta Y - 0.65801\,L1ECM_{-1}$$
$$\qquad (6.15889) \qquad (3.22188)$$

$$\bar{R}^2 = 0.701 \qquad DW = 1.95$$

$$L1ECM = L_1/P_c - (-1567.2 + 0.193\,Y - 255.5\,r)$$

$$CRDW = 1.35 \quad ADF = -3.44$$

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |**. |	. |**. |	1	0.292	0.292	2.4011	0.121
. | . |	.*| . |	2	-0.040	-0.137	2.4488	0.294
.*| . |	. | . |	3	-0.057	-0.004	2.5498	0.466
. | . |	. | . |	4	-0.055	-0.045	2.6461	0.619
. |* . |	. |* . |	5	0.116	0.156	3.1022	0.684
. |* . |	. | . |	6	0.109	0.016	3.5225	0.741
. | . |	. | . |	7	0.032	0.012	3.5620	0.829
. | . |	. | . |	8	-0.010	-0.010	3.5660	0.894
.*| . |	. | . |	9	-0.070	-0.048	3.7720	0.926
.*| . |	.*| . |	10	-0.131	-0.117	4.5440	0.919
.*| . |	.*| . |	11	-0.169	-0.136	5.9207	0.879
. | . |	. | . |	12	-0.039	0.028	6.0009	0.916

Although use of the ADF would not lead to rejection of the null hypothesis in this case, the CRDW test would and, indeed, inspection of the correlogram and the Q statistics indicates that the residuals are white noise.

Export Demand Equation

$$\Delta X_2 = -0.30585\,\Delta X_{2_{-1}} + 0.76436\,\Delta Y_w - 43933.6\,\Delta(P_x/P_w) - 0.65651\,X2ECM_{-1}$$

(1.57915) (2.38615) (1.62956) (3.52691)

$\bar{R}^2 = 0.449$ DW = 1.95

$$X2ECM = X_2 - [-813.9 + 0.887\,Y_w - 119939\,(P_x/P_w)]$$

CRDW = 1.44 ADF = -3.84 ***

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |**. |	. |**. |	1	0.229	0.229	1.4734	0.225
. |* . |	. | . |	2	0.114	0.065	1.8565	0.395
. *| . |	. *| . |	3	-0.073	-0.119	2.0213	0.568
. *| . |	. *| . |	4	-0.163	-0.139	2.8721	0.579
. |* . |	. |**. |	5	0.113	0.215	3.3023	0.653
. |* . |	. |* . |	6	0.138	0.110	3.9828	0.679
.**| . |	***| . |	7	-0.191	-0.364	5.3466	0.618
. | . |	. |* . |	8	0.025	0.141	5.3716	0.717
.**| . |	.**| . |	9	-0.301	-0.212	9.2011	0.419
.**| . |	. *| . |	10	-0.195	-0.169	10.914	0.364
. *| . |	. *| . |	11	-0.090	-0.068	11.306	0.418
. *| . |	. | . |	12	-0.122	0.004	12.083	0.439

This is a clear case: the ADF statistic is significant at 10% and, to boot, inspection of the correlogram of the residuals reveals that it is a white noise process.

Government Consumption Expenditure Deflator

$$\Delta P_g = 0.23993\,\Delta P_{g-1} + 0.03179\,\Delta(W\$/N)_{-1} - 0.64715\,PGECM_{-1}$$

(2.21352) (5.28358) (3.67470)

$\bar{R}^2 = 0.686$ DW = 1.89

$$PGECM = P_g - (0.12 + 0.0467\,(W\$/N) - 0.122\,P_x)$$

CRDW = 0.898 ADF = -2.48

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |**** |	. |**** |	1	0.506	0.506	7.1976	0.007
. | . |	***| . |	2	-0.034	-0.389	7.2312	0.027
.**| . |	. | . |	3	-0.254	-0.052	9.2055	0.027
***| . |	.**| . |	4	-0.359	-0.272	13.338	0.010
.**| . |	. |* . |	5	-0.200	0.116	14.692	0.012
.*| . |	.**| . |	6	-0.119	-0.293	15.194	0.019
.*| . |	.*| . |	7	-0.136	-0.077	15.889	0.026
. |* . |	. |**. |	8	0.155	0.311	16.848	0.032
. |**. |	. | . |	9	0.327	-0.020	21.354	0.011
. |* . |	.**| . |	10	0.096	-0.282	21.769	0.016
.*| . |	.*| . |	11	-0.172	-0.157	23.197	0.017
***| . |	. | . |	12	-0.333	-0.022	28.940	0.004

In this case, it was the level of the variable that was explained by the long run equation since P_g is I(1). Almost complete reliance was put on examination of the correlogram which shows that the residuals form a stationary process although it is possible that the CRDW would not contradict this conclusion.

Index of Retail Prices Equation

$$\Delta^2 \log P_r = 0.652\, \Delta^2 \log P_w - 0.673\, PRECM_{-1}$$

$$\qquad (4.480) \qquad\qquad (3.63)$$

$$\bar{R}^2 = 0.652 \qquad DW = 1.73$$

$$PRECM = \Delta \log P_r - (0.076 + 0.649\, \Delta \log P_w)$$

$$CRDW = 1.14 \quad ADF = -3.82^{**}$$

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.*| . |	.*| . |	1	-0.128	-0.128	0.4297	0.512
.**| . |	.**| . |	2	-0.279	-0.301	2.5662	0.277
. |**. |	. |*. |	3	0.256	0.191	4.4455	0.217
.*| . |	.*| . |	4	-0.091	-0.132	4.6962	0.320
***| . |	.**| . |	5	-0.368	-0.313	9.0127	0.109
. |*. |	. | . |	6	0.132	-0.055	9.6012	0.142
. |*. |	. | . |	7	0.095	-0.034	9.9236	0.193
.**| . |	.**| . |	8	-0.278	-0.200	12.893	0.116
. |**. |	. |*. |	9	0.203	0.094	14.590	0.103
. |*. |	. | . |	10	0.138	-0.056	15.429	0.117
. | . |	. |**. |	11	0.025	0.256	15.460	0.162
. | . |	.*| . |	12	-0.052	-0.098	15.601	0.210

In this case, it is the rate of inflation that is explained since P_r is I(2). The ADF statistic is significant at the 5% level and the correlogram shows that the series tested is white noise.

Wages Equation

$$\Delta w = -0.43316 + 0.66249\,\Delta w_{-1} - 60.4250\,\Delta U_R + 37.1482\,\Delta U_{R-1}$$
$$(1.27125) \quad (4.07747) \quad (3.43200) \quad (1.89952)$$

$$+ 0.01004\,\Delta C_g - 0.00459\,\Delta C_{g-1} - 0.99174\,WECM_{-1}$$
$$(8.90556) \quad (2.28620) \quad (4.99876)$$

$\bar{R}^2 = 0.846$ DW = 2.41

$$WECM = w - (-1.143356\,TIME + 0.012\,C_g - 52.892\,U_R)$$

CRDW = 1.40 ADF = -3.84 ***

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |**. |	. |**. |	1	0.257	0.257	1.8547	0.173
****| . |	*****| . |	2	-0.490	-0.595	8.9051	0.012
****| . |	.*| . |	3	-0.453	-0.165	15.204	0.002
. | . |	.*| . |	4	0.032	-0.073	15.238	0.004
. |**** |	. |**. |	5	0.491	0.298	23.385	0.000
. |**. |	. | . |	6	0.297	0.023	26.527	0.000
***| . |	.*| . |	7	-0.321	-0.172	30.389	0.000
***| . |	. | . |	8	-0.435	-0.030	37.906	0.000
. | . |	. | . |	9	-0.013	-0.010	37.913	0.000
. |* . |	.**| . |	10	0.180	-0.312	39.366	0.000
. |* . |	. | . |	11	0.158	-0.003	40.569	0.000
.*| . |	.**| . |	12	-0.159	-0.270	41.883	0.000

Both the CRDW and the ADF are significant and the correlogram shows that the series tested is a stationary process.

Employment Equation

$$\Delta EMP = 0.4245\ \Delta EMP_{-1} - 1.482\ \Delta w + 0.00678\ \Delta Y - 0.5668\ EMPECM_{-1}$$

(2.593) (1.537) (2.261) (3.45805)

$\bar{R}^2 = 0.41$ DW = 2.25

EMPECM = EMP -(179.6 - 3.46 w + 0.017 Y - 13.16 D)

CRDW = 1.01 ADF = -2.89

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |**** |	. |**** |	1	0.474	0.474	6.3221	0.012
. | . |	***| . |	2	-0.053	-0.358	6.4032	0.041
****| . |	***| . |	3	-0.491	-0.425	13.788	0.003
*****| . |	.**| . |	4	-0.601	-0.294	25.412	0.000
***| . |	. *| . |	5	-0.337	-0.089	29.246	0.000
. *| . |	***| . |	6	-0.101	-0.360	29.608	0.000
. |**. |	. |* . |	7	0.327	0.147	33.613	0.000
. |**** |	. | . |	8	0.468	-0.003	42.301	0.000
. |*** |	. | . |	9	0.344	-0.045	47.289	0.000
. | . |	. *| . |	10	0.031	-0.090	47.331	0.000
.**| . |	. |* . |	11	-0.256	0.068	50.483	0.000
.**| . |	. |* . |	12	-0.258	0.100	53.940	0.000

Inspection of the correlogram reveals that the residuals are a stationary process.

Labour Force Equation

$$\Delta N = 3.27745 + 0.16319\,\Delta POP + 0.00881\,\Delta X_t - 0.63144\,NECM_{-1}$$
$$(1.57284)\quad(1.76993)\qquad(2.27787)\qquad(3.02616)$$

$$\bar{R}^2 = 0.333 \qquad DW = 1.73$$

$$NECM = N - (243.03 + 0.147\,POP + 0.0107\,X_t + 3.37\,TIME)$$

$$CRDW = 1.25 \quad ADF = -3.23$$

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*** |	. |*** |	1	0.374	0.374	3.9432	0.047
.**| . |	***| . |	2	-0.225	-0.425	5.4338	0.066
****| . |	***| . |	3	-0.509	-0.326	13.383	0.004
***| . |	.*| . |	4	-0.364	-0.156	17.652	0.001
. | . |	.*| . |	5	-0.018	-0.068	17.663	0.003
. | . |	***| . |	6	0.029	-0.370	17.692	0.007
. |* . |	. |* . |	7	0.178	0.087	18.874	0.009
. |* . |	.*| . |	8	0.152	-0.114	19.795	0.011
. |* . |	.*| . |	9	0.066	-0.086	19.979	0.018
. | . |	. | . |	10	-0.026	-0.042	20.009	0.029
.**| . |	***| . |	11	-0.307	-0.394	24.562	0.011
.**| . |	.**| . |	12	-0.256	-0.245	27.971	0.006

In this case, the CRDW and the correlogram (which showed that the residuals from the long-run equation formed a stationary process) were used to justify the retention of the long-run equation.

National Output Deflator Equation

$$\Delta^2 \log P_y = 0.27782\ \Delta \log P_x - 0.26393\ \Delta \log P_{x-1} + 1.24308\ \Delta^2 \log P_r - 1.00149\ PYECM_{-1}$$

(5.70627) (5.75331) (4.74602) (4.15248)

$\bar{R}^2 = 0.8634$ DW = 1.95

$$PYECM = \Delta \log P_y - (-0.045 + 0.304\ \Delta \log P_x + 1.10\ \Delta \log P_r)$$

CRDW = 1.89 ADF = -4.24 **

ACF/PACF of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. | . |	. | . |	1	0.016	0.016	0.0073	0.932
. | . |	. | . |	2	0.027	0.027	0.0280	0.986
. |* . |	. |* . |	3	0.103	0.103	0.3463	0.951
.**| . |	.**| . |	4	-0.309	-0.317	3.3295	0.504
. | . |	. | . |	5	0.022	0.040	3.3459	0.647
. | . |	. | . |	6	-0.012	-0.008	3.3505	0.764
. | . |	. |* . |	7	0.032	0.109	3.3886	0.847
. | . |	. *| . |	8	0.061	-0.058	3.5340	0.897
. |* . |	. |* . |	9	0.066	0.096	3.7133	0.929
. | . |	. | . |	10	0.005	-0.035	3.7144	0.959
. | . |	. | . |	11	-0.013	0.036	3.7220	0.977
. *| . |	.**| . |	12	-0.156	-0.209	4.9937	0.958

This equation passes all the tests and the correlogram shows that the OLS residuals of the long run equation form a white noise process.

Solution of the Model

The model containing the estimated equations and the identities was solved using a Gauss-Seidel algorithm. The actual and simulated values are compared in Table 2.3 below:

Table 2.3

Comparison of Actual and Simulated Values of "Endogenous" Variables Using The Theil Inequality Coefficient and its Decomposition*

Variable	Variable Name	Theil's U	U_m	U_r	U_d
C	Total Consumption Expenditure	0.0744	0.0002	0.0050	0.9949
C_p	Private Consumption Expenditure	0.0975	0.0002	0.0011	0.9987
EMP	Employment	0.0228	0.0401	0.0005	0.9594
GDEF	Overall Govt. Budget Deficit	0.5026	0.2661	0.0113	0.7226
I	Gross Capital Formation	0.0941	0.0337	0.0363	0.9300
I_p	Private Investment	0.1929	0.0337	0.0532	0.9132
K	Capital Stock	0.0256	0.7521	0.0538	0.1940
L	Broad Money Supply	0.3156	0.0020	0.0599	0.9381
L_1	Narrow Money	0.1827	0.0353	0.3026	0.6621
L_2	Quasi Money	0.4276	0.0041	0.2240	0.7719
M	Imports of Goods and Services	0.0963	0.0011	0.0021	0.9968
M_g	Imports of Goods	0.1213	0.0011	0.0004	0.9985
N	Labour Force	0.0178	0.0020	0.0031	0.9949
P_g	Govt. Cons. Exp. Deflator	0.1453	0.3543	0.1050	0.5407
P_r	Domestic Prices	0.0995	0.5281	0.3444	0.1276
P_y	Implicit GDP Deflator	0.1132	0.7184	0.1095	0.1720
R	Foreign Exchange Reserves	0.6540	0.0020	0.5949	0.4031
r	Loan Rate	0.4702	0.0198	0.0000	0.9802
T	Government Revenue	0.0473	0.0003	0.0186	0.9811
UNEMP	Unemployment Level	0.1171	0.0590	0.2431	0.6979
U_R	Unemployment Rate	0.1051	0.0618	0.2957	0.6245
w	Wage Rate	0.0469	0.0321	0.0001	0.9678
W$	Total Wage Bill	0.1307	0.4175	0.1207	0.4618
X	Exports of Goods and Services	0.0333	0.0200	0.0560	0.9240
X_2	Non Petroleum Exports	0.1277	0.0200	0.2297	0.7503
DXD	External Debt	0.8573	0.2661	0.4384	0.2954
DXD_g	Central Govt. External Debt	2.0040	0.2661	0.5508	0.1831
Y	Gross Domestic Product	0.0445	0.0009	0.0203	0.9788

Theil's U = Theil's Inequality Coefficient
U_m = Proportion of Error due to Bias
U_r = Proportion of Error due to Variance
U_d = Proportion of Error due to Covariance
* The meaning and usefulness of these measures are explained in Maddala (1977)

Most of the variables perform very well on the basis of Theil's U: 20 (out of 28) have forecast errors of less than 20% and, of these, 12 are less than 10% and 6 between 10% and 15%. Of these, most also perform very well on the basis of the Theil decomposition with values of U_d above 90% (the ideal value is unity). Some variables, however, do not perform well on either criterion (like ΔXD and ΔXD_g) and we must investigate them further. To do this, we examine the time plots of the actual and simulated values shown in Exhibit 2.2 below:

CHART 2.2
TIME PLOTS OF ACTUAL AND SIMULATED VALUES

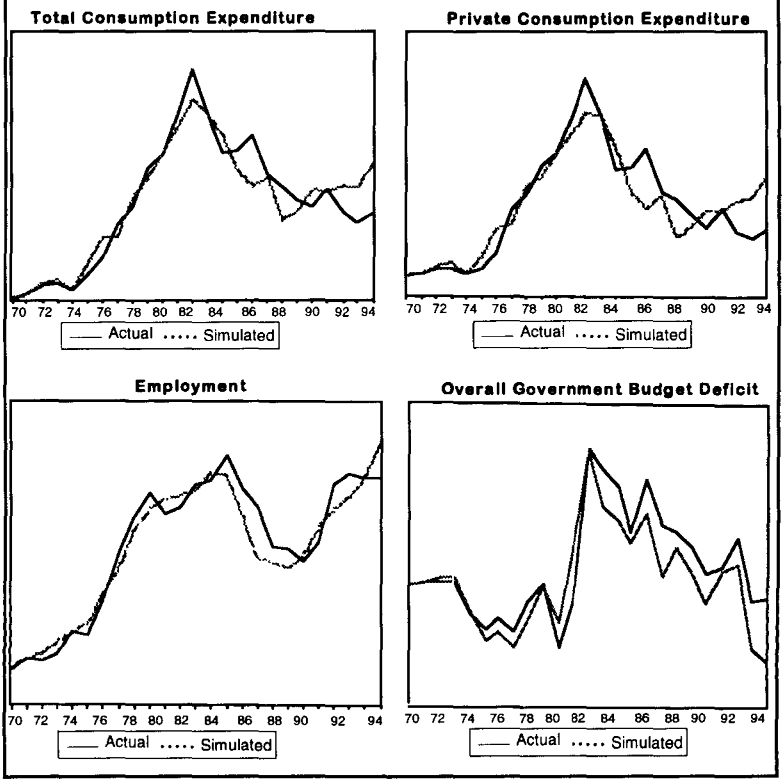


CHART 2.2
TIME PLOTS OF ACTUAL AND SIMULATED VALUES

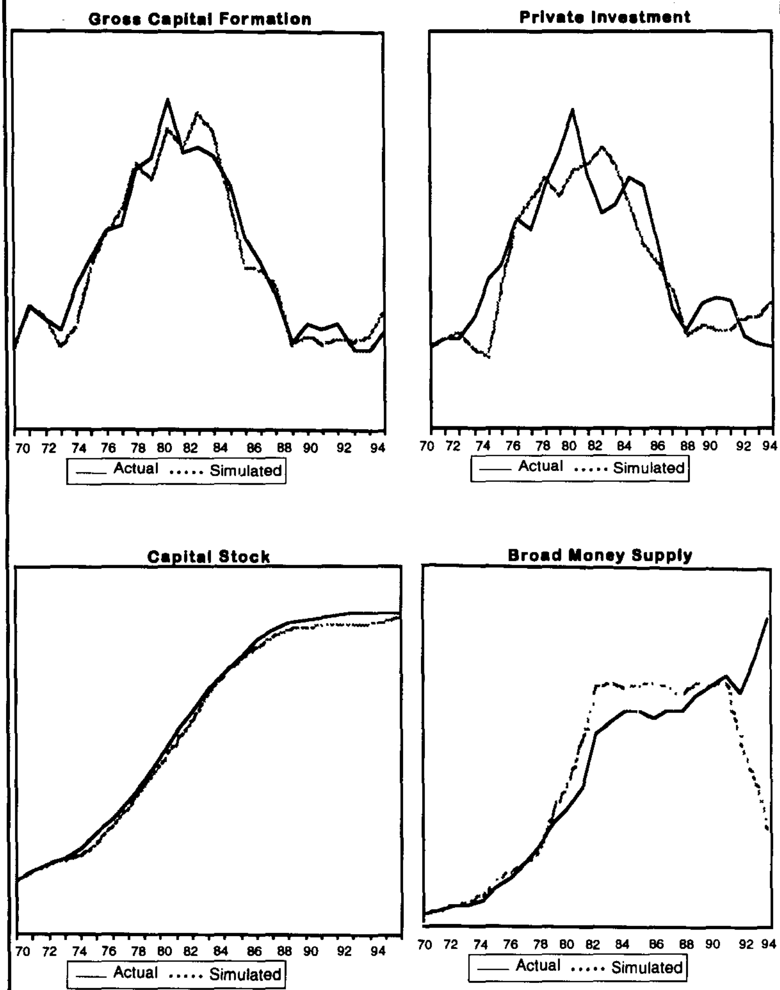


CHART 2.2
TIME PLOTS OF ACTUAL AND SIMULATED VALUES

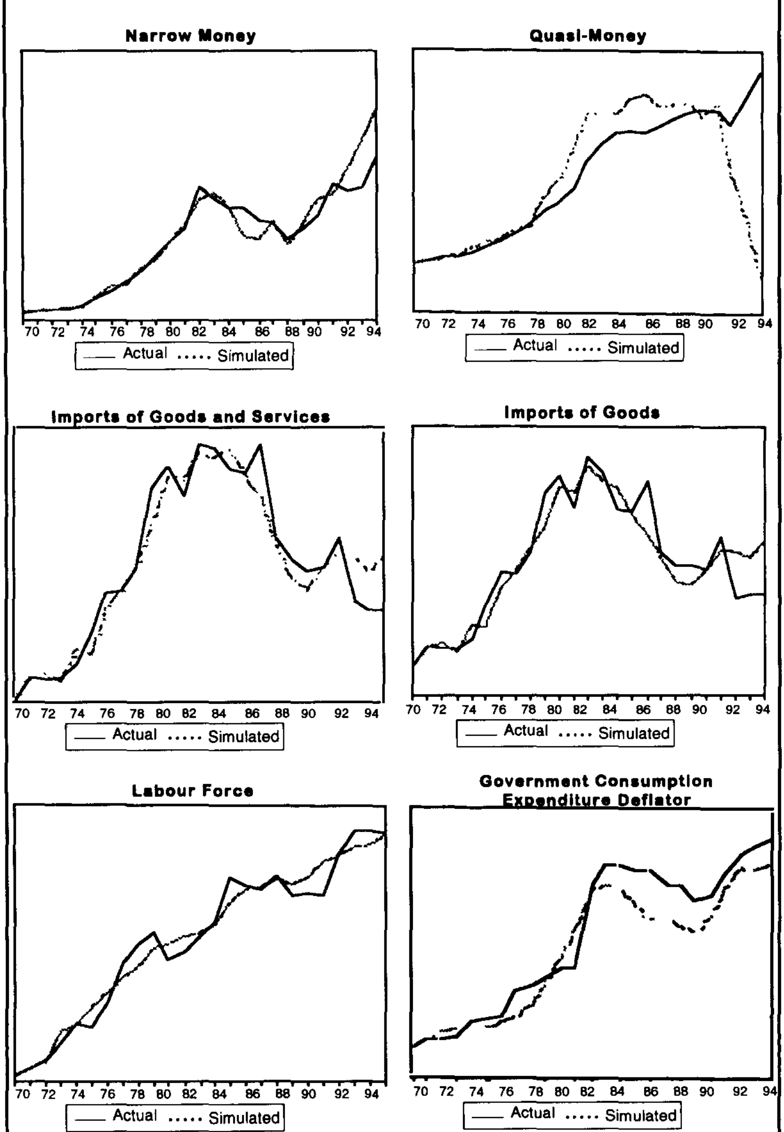


CHART 2.2
TIME PLOTS OF ACTUAL AND SIMULATED VALUES

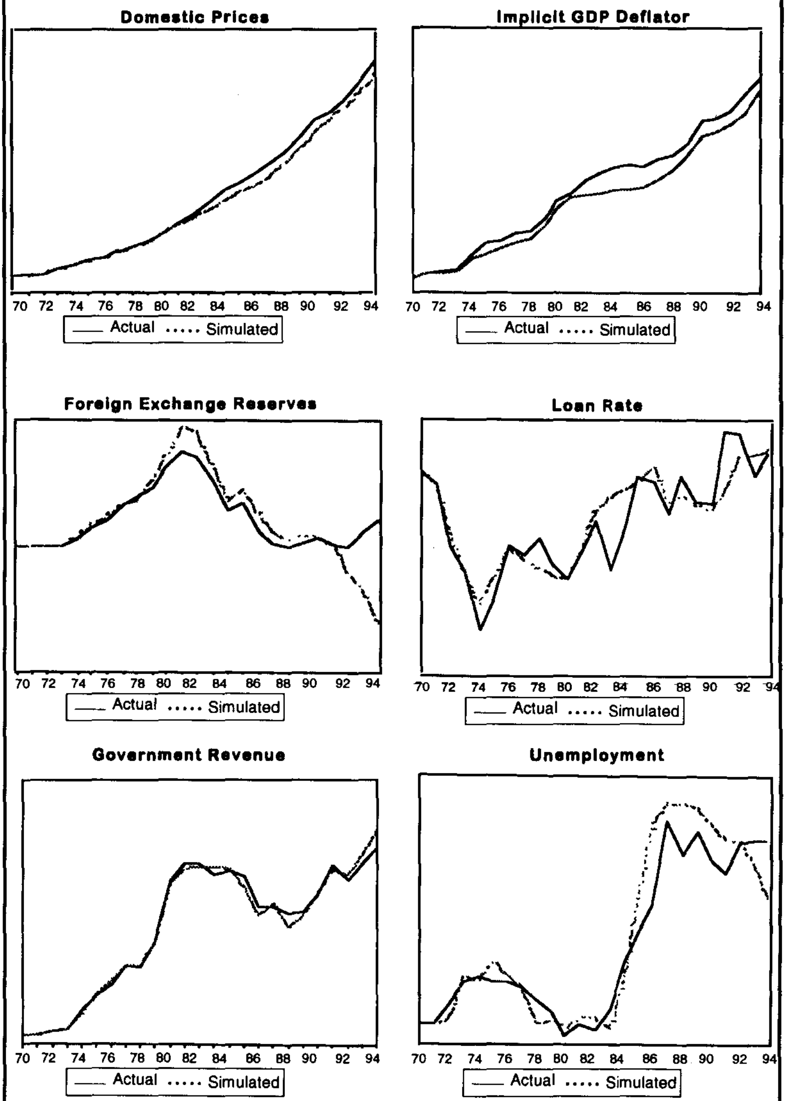


CHART 2.2
TIME PLOTS OF ACTUAL AND SIMULATED VALUES

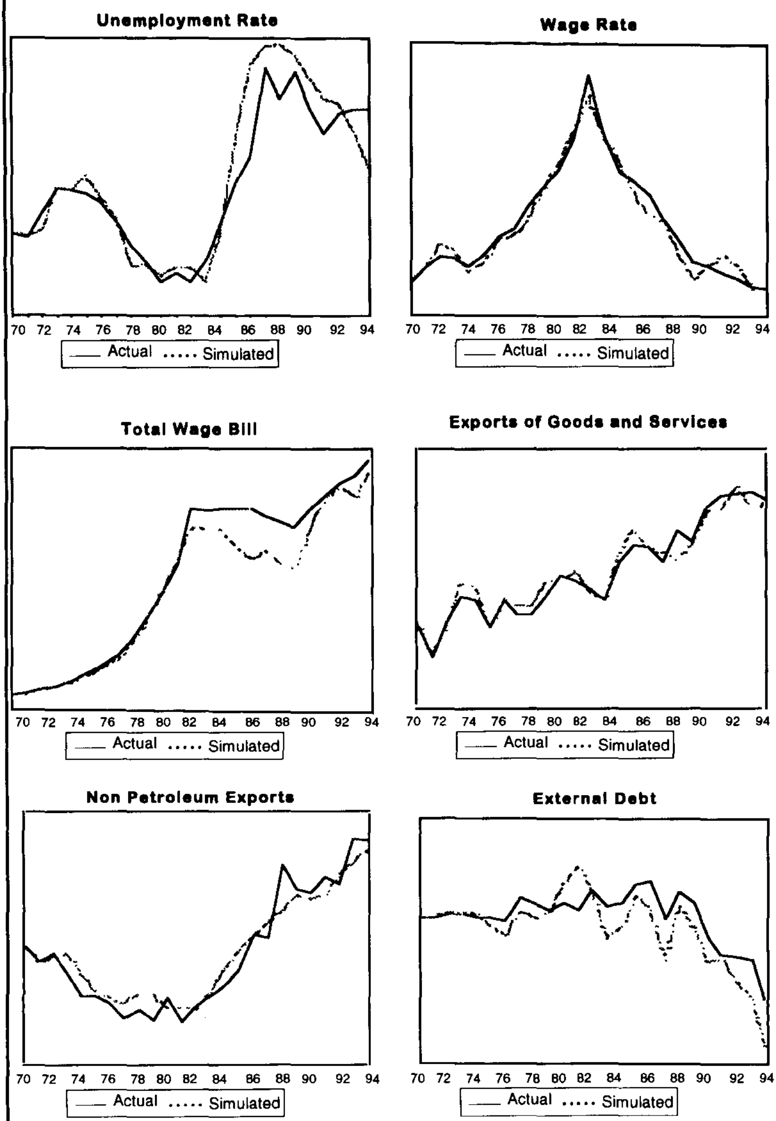
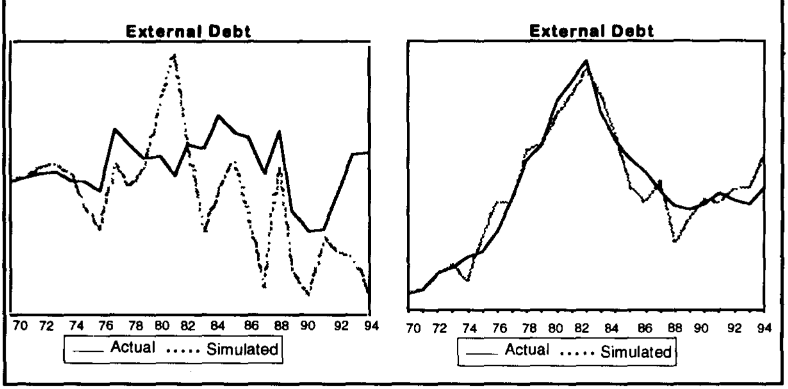


CHART 2.2
TIME PLOTS OF ACTUAL AND SIMULATED VALUES

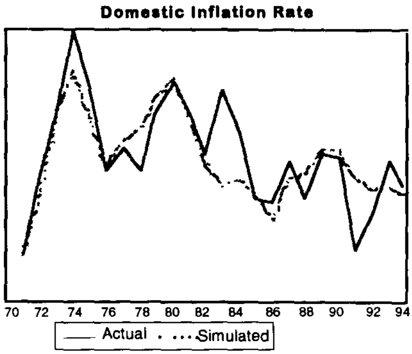


In many cases the plots shown strengthen the conclusion drawn from the use of the summary statistics in Table 2.3, even in the "weak" cases. Take for instance P_r for which U_d = 0.1276: the time paths shown are extremely close to each other and follow more or less the same pattern. Furthermore, when the rate of inflation is derived from these simulated values, it yields the following:

$$\begin{aligned} \text{Theil U} &= 0.2058 \\ U_m &= 0.0241 \\ U_r &= 0.0015 \\ U_d &= 0.9743 \end{aligned}$$

In addition, the time plots of the actual and simulated inflation rates shown in Exhibit 2.3 below strengthen the case even further:

CHART 2.3
TIME PLOTS OF ACTUAL AND SIMULATED VALUES



In fact, examination of the plots in Chart 2.2 reveals that, in many cases, the model fails to predict the movement of the last 3 years of the sample period (1992-4). This is particularly true of the variables that perform poorly (like ΔXD and ΔXD_g) and this might very well be because many of the values used over this sub period were merely preliminary estimates obtained from the Central Statistical Office.

The model was also subjected to exogenous shocks in order to establish its stability and the nature of its dynamic response to stimuli. In all cases considered, the model converged after the shock, which meant that it was stable. Furthermore, in no situation studied did the model behave in a manner for which no plausible theoretical explanation could be given. Consider, for instance, the multipliers resulting from a shock in oil exports (which might have arisen from a rise in the real oil price) on the overall government budget deficit (GDEF), the unemployment rate (U_R) and non oil exports (X_2):

TABLE 2.4
MULTIPLIERS BASED ON SUSTAINED INCREASE IN OIL EXPORTS

Year	Govt. Budget Deficit	Unemployment Rate	Non Oil Exports
1990	-0.880	-0.001%	-0.127
1991	-0.309	0%	-0.329
1992	-0.882	-0.002%	0.155
1993	-1.48	-0.005%	-0.434
1994	-1.88	-0.008%	-0.153

A sustained $1.00 increase in oil exports will cause the budget deficit to fall by $1.88 in the long run, the unemployment rate to fall marginally and non oil exports to fall by 15 cents (perhaps because more readily available foreign exchange will act as a disincentive to non oil exporters). All of these are reasonable conclusions to be drawn from a model of this kind.

CONCLUSION

The main purpose of this paper was to develop an econometric methodology for applying cointegration methods to a multiple equation system when data are scarce. It was not intended to present a model of the Trinidad & Tobago economy *per se* although the simple case presented here is quite promising and seems to augur well for the proposed methodology.

Indeed, it would appear that, as rudimentary as the prototype model is, it can still serve as a basis for forecasting and policy making decisions. Some corrections can be made to the equations in the form of "add factors" as is traditionally done to compensate for any shortfall in model accuracy but, of course, a more promising alternative is to "deepen and widen" the model through further disaggregation and other means and to use the cointegration methodology as proposed in this paper to obtain the required parameter estimates. This is the intended follow-up to the current exercise.

REFERENCES

Bagliano, F.C., C.A. Favero and A. Muscatelli (1991), "Cointegration and Simultaneous Models: an Application to the Italian Money Demand," *University of Glasgow Discussion Paper*, No. 9108.

Banerjee, A., J.J. Dolado, D.F. Hendry and G.W. Smith (1986), "Exploring Equilibrium Relationships in Econometrics through Static Models: Some Monte Carlo Evidence," *Oxford Bulletin of Economics and Statistics*, 48, 253-77.

Box, G.E.P. and G.M. Jenkins (1970), *Time Series Analysis: Forecasting and Control*, Holden-Day.

Davidson, J.H., D.F. Hendry, F. Sbra and S. Yeo (1978), "Econometric Modelling of the Aggregate Time-Series between Consumers' Expenditure and Income in the United Kingdom," *The Economic Journal*, 88, 661-692.

Engle, R. and Granger, C.W.J. (1987), "Cointegration and Error-Correction: Representation, Estimation and Testing," *Econometrica*, 55, 251-76.

Fuller, W.A. (1976), *Statistical Analysis of Time Series*, John Wiley & Sons.

Granger, C.W.J. and P. Newbold (1974), "Spurious Regressions in Econometrics," *Journal of Econometrics*, 55, 143-59.

Hendry, D.F. (1980), "Econometrics - Alchemy or Science?" *Economica*, 47, pp. 387-406.

Hilaire, D.L., S.M.A. Nicholls and A.J. Henry (1990), "Forecasting and Policy Evaluation in a Macroeconometric Model of the Trinidad & Tobago Economy," *Social and Economic Studies*, 39:4, 107 - 148.

Holden, D. and R. Perman (1994), "Unit Roots and Cointegration" in Bhaskara Rao, B., *Cointegration for the Applied Economist*, St. Martin Press.

Inder, B. (1993), "Estimating Long-Run Relationships in Economics," *Journal of Econometrics*, 57, 53-68.

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control*, 12, 231-54.

Kunst, R. and K. Neusser (1990), "Cointegration in a Macroeconomic System," *Journal of Applied Econometrics*, 5, 351-65.

Leamer, E.E. (1983), "Let's Take the Con out of Econometrics," *American Economic Review*, 23, 31-43.

Leon, H. (1989), "Econometric Modelling: a Methodological Interlude," *Social and Economic Studies*, 38:2, 185-213.

Lovell, M.C. (1983), "Data Mining," *Review of Economics and Statistics*, 65, 1-12.

Maddala, G.S. (1977), *Econometrics*, McGraw-Hill.

Muscatelli, V.A., T.G. Srinivasan and D. Vines (1992), "Demand and Supply Factors in the Determination of NIE Exports: A Simultaneous Error-Correction Model for Hong Kong," *The Economic Journal*, Vol. 102, no. 415, 1467 - 1477.

Phillips, P.C.B. and B.E. Hansen (1990), "Statistical Inference in Instrumental Variables Regression with I(1) Processes," *Review of Economic Studies*, 53, 99-125.

Smith, P. (1980), "On the Validation of Large-Scale Econometric Models," University of Southampton.

U.N.D.P. (1991), "Macro-Economic Model of Jamaica," *UNDP Project JAM/89/019.*

Watson, P.K. (1987), "On the Abuse of Statistical Criteria in the Evaluation of Econometric Models," *Social and Economic Studies*, 36:3, 119-48.

Watson, P.K. (1994), "Reflections on Macroeconometric Forecasting in the English Speaking Caribbean," *XXVI Regional Monetary Studies Conference*, Kingston, Jamaica, November 1994.

Watson, P.K. and R. Clarke (1995), "A Policy Oriented Macroeconometric Model of Trinidad and Tobago," *University of the West Indies, St. Augustine* (mimeo).

CHAPTER 3

TRINIDAD AND TOBAGO: MANAGING IMPORT DEMAND

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and
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Trinidad and Tobago: Managing Import Demand During Oil Shocks

Carlos Holder
&
Oral Williams

This is an edited version of the paper published in 'Stratégies de Developpement comparées dans la Caraibe', edited by Eyrc Edinval et al., L'Hermès, 1996. The views expressed are those of the authors and do not reflect policy positions on the the part of the Caribbean Development Bank. All errors are entirely the responsibility of the authors. The authors would like to thank DeLisle Worrell and Roland Craigwell for their comments and suggestions.

Introduction

The destabilising impact of a booming sector on the other economic sectors and economic growth (a phenomenon known as "Dutch disease") has been addressed by Corden (1984) and others. More relevant for this research, the impact of the oil price shock on the economy of Trinidad and Tobago has been documented by Auty and Gelb (1986). The present chapter seeks to: (a) give a critical assessment of the macroeconomic management during the windfall period; and (b) evaluate the effects of the windfall on import demand using recent developments in econometric analysis, an approach which, to the authors' knowledge, has not previously been attempted for Trinidad and Tobago. In particular, the fundamental determinants of the real exchange rates as they affect aggregate import demand are explored.

The study is presented in four sections. The following section starts with a general discussion of the impact of the "Dutch disease" on the open economy and proceeds by critically evaluating some of the policies undertaken by the Government of Trinidad and Tobago (GOTT) during the period. Section three outlines and discusses the theoretical underpinnings of the model utilised to analyse how the windfall impacted on import demand. Section four provides the methodological approach as well as a detailed discussion on the model results. The last section is devoted to providing some conclusions and policy implications of the research.

MACROECONOMIC MANAGEMENT DURING WINDFALL PERIOD

Theory notes that there are two major effects associated with a booming sector on the other sectors in the economy *viz* the resource movement and spending effects. The resource movement effect is manifested through the movement of mobile factors into the booming sector thereby bidding up rents and leading to contraction in the other sectors as the real exchange rate appreciates. This was manifested in Trinidad and Tobago by employment in the tradable sector declining by 10 percent to 94,600 in the 1974-81 period when compared with the 1966-73 period and employment in the non traded sector expanding by 31.7% to 245,800 over the same period. This may be attributed to

(a) resource movements out of the tradeable sector resulting in a contraction in output in this sector; and

(b) resource movements into the non tradeable sector which would be reflected in an expansion in output.

One variation in the core Dutch disease model provides an explanation for the anomaly of output expansion in the manufacturing sector which is typically classified as tradable. It is suggested that the manufacturing sector in many oil-exporting countries expanded for reasons related to protection afforded by quotas. This umbrella of protection results in divergencies between international and domestic prices rendering output in some sectors as semi-tradable (Neary and

Van Wijnbergen, 1986). This wedge between internal and external prices coupled with imperfect substitution between manufactures and imports results in the manufacturing sector benefitting from the effects of the boom. It is further suggested that excess demand that ensues from the increase in national income due to oil revenues, raises the relative price of manufacturing output and results in an expansion in output.

In the Trinidad and Tobago context, the resource effect may be small because the oil sector functions as an enclave and the main link to the domestic economy is via tax revenue and royalties to government (Hilaire, 1992). The spending effect through the increase in purchasing power should be greater than the resource effect. The spending effect impacts through an excess demand for non traded goods resulting in a real appreciation and an increase in the relative profitability of this sector and contraction of the traded goods sector. Identification of the recipient of the boom may have implications for the spending effect since government policies instituted during the boom may not be easily reversible. The rigidities associated with wages in the Trinidad and Tobago economy resulted in high recurrent costs. Attempts at removing cost of living allowances to partly reverse increases in wage costs resulted in labour disputes and litigation which the government subsequently lost.

The oil price hike has dominated economic performance in Trinidad and Tobago in the 1970s and after. It had a dramatic effect on income growth and led to a strengthening of fiscal, monetary and balance of payments performance especially between 1974 and 1981. During this period consumption expanded rapidly but was overshadowed by investment growth. Investment was spurred on largely by home construction and GOTT's public investment programme primarily in capital intensive energy based industry.

Auty and Gelb (1986) posit that 70 percent of the first windfall was invested abroad, 12 percent was invested domestically and 18 percent consumed while 50 percent of the second windfall was saved abroad, 25 percent domestically and 25 percent consumed. Nevertheless, the authors argue that the rate of increase of consumption was too great and suggest that more should have been saved. Consumption was encouraged by the authorities as a result of the several increases in allowances (exemptions) on income taxes as well as subsidies and indirectly by the level of domestically invested resources. Auty and Gelb estimated that deflated consumption increased by 27 percent of non-mining output compared with the base period of 1970-72 and as such accounted for a sizeable share of the second windfall. We agree with Cuddington (1986) and Hill and Mokgethi (1989) that increases in consumption from a temporary windfall should not exceed the rate of return on increases in wealth if the country is to sustain the increased consumption indefinitely.

The next issue pertains to the manner in which GOTT allocated savings. During both booms, the major portion of savings was allocated to increasing reserves. This helped to sterilise the effects on the monetary base but a question remains as to whether there was sufficient sterilisation. Domestically invested funds had a significant impact on domestic credit to the private sector which expanded appreciably during the two sub periods, moving from TT $665 million in 1974 to TT $7710 million in 1992.

Very little was spent on debt reduction. In fact the GOTT used its build up of reserves as a means of testing its ability to borrow abroad. The country's debt bearing capacity was used to cushion the adjustment and increased foreign borrowing was utilised to delay the adjustment process. The policy of increasing debt is efficacious only if the interest on debt is less than the interest on reserves. The reserve buildup was used to fuel consumption between the first and the second boom as well as after the boom period. This is evidenced by the level at which consumption was maintained and the consequent decline in reserve levels. A warning was issued by the IMF in their 1978 Staff report that:

> "While the Government's policy of using part of the increased oil revenue for the benefits of lower-income groups and for the improvements in the quality of life in Trinidad and Tobago can be justified, the staff feels that this policy if over emphasised, could lead to undesirably high levels of consumption. Considering that oil reserves are estimated to last only about 10 years at the projected rate of production, a word of caution is also in order about the Government's policy of reducing taxes. A continuation of such a policy could erode the non-oil tax base and lead to yet higher dependence on oil revenue, which now provides about 55 percent of total central government revenue".[1]

Further macroeconomic instability was manifested in the deterioration in the fiscal situation where the deficit amounted to 67 percent of oil revenues and the current account deficit US $1.9 billion. The emerging problem was recognised by the Trinidad and Tobago authorities when in successive budgets between 1973-1980 it was argued that the recurrent expenditure would present considerable difficulty if the revenue base were weakened. In fact from the late 1970s it should have been obvious that some adjustment was necessary. However, the reserve buildup allowed Trinidad and Tobago to postpone the implementation of necessary macroeconomic policies including the encouragement of food production.

The GOTT purchases of private companies, its involvement in the development of the gas based industries along with its massive expenditure on the social and economic infrastructure resulted in decreases in the rate of return largely through increasing labour costs and creation of bottlenecks. It also strained the capacity of the GOTT to properly analyse the projects undertaken, leading to long delays and massive overruns. We believe that the process of increasing investment above the trend rate created excess expenditure in the system. It might have been more prudent for the GOTT to have operated in a countercyclical manner thereby reducing pressure on wages and absorptive capacity in the boom period and picking up the slack during the "bust" period in order to stabilise the economy. Further in light of the inflationary pressures, restraint in the growth of public expenditures necessitated strengthening and control over the management of the budget, public sector investment programme and the operations of the entire public sector.

The increasing wage trend in the government and petroleum sectors resulted in demands for similar increases in other sectors. At this time the GOTT should have, with the assistance of the social partners, implemented a wages policy to slow the increase in wages especially in the other sectors. Instead the GOTT subsidised labour by creating "jobs" in the government sector, almost doubling employment in government. This "job" creation was accompanied by wages which exceeded those in lagging sectors, especially agriculture and manufacturing. Auty and Gelb (1986) argue that wage increases were in excess of both productivity gains and inflation. They further argued that despite subsidies and controls, inflation rose rapidly after the second oil boom. This rise in inflation may be attributed to the wage indexation policy which was in place at the time. The combination of rising wages and prices coupled with an expanding money supply led to an appreciation of the real exchange rate thereby making agricultural production in particular and the tradeable sector in general, uncompetitive and in the final analysis causing the demise of the agricultural sector. This resulted in the contraction of the tradeable sector outside of petroleum and an expansion of the non-tradeable sector. An incomes policy might have arrested the appreciation of the real exchange rate and reduced the dependence on the oil sector through diversification. Such an agreement with the trade unions, despite the inherent difficulties, would have relieved the pressures of accelerating wage growth on productivity and factor movements from labour intensive sectors.

The policies of increasing reserves by investing overseas, and the effort to diversify by utilising the abundant resource were consistent with the management of a temporary boom. However, the sizeable increase in consumption which was assisted through subsidies, tariff reductions and price controls, the rapid expansion in wage rates, the rising inflation and the expanding monetary base which led to the appreciation of the real exchange rate and contraction in the tradeable sector along with the procyclical nature of government expenditure were not.

Model Specification

We turn now to measuring the effect of the oil boom on imports. The import demand function employed in this study derives from traditional consumer theory where real imports are a function of real income and relative prices. Relative prices can include price indices for both the traded and non traded sectors as these commodity types form part of the consumption basket of consumers. However in this study the real exchange rate is used instead to allow for the transmission of terms of trade shocks to import demand behaviour. Formally, the import demand function is outlined as follows:

$$M_t = f\left(Y_p, Y_c, RER\right) \qquad (1)$$

where Y_p measures real permanent income, Y_c (real cyclical income) measures the direct effect of the oil shock on import demand and RER is the real exchange rate. However, Nyatepe-Coo (1994) argues that care must be exercised in defining a variable for sectoral changes indicative of "Dutch disease". Even where the agricultural sector is growing its share of GDP is likely to decline in a booming oil market. For this reason output in the agricultural sector is expressed as a ratio to non-oil GDP. The decomposition of output into permanent and shock components has been motivated by Khan and Ross (1975). Infinite import supply elasticity is assumed given the openness of the economy. However due to the presence of foreign exchange and trade restrictions in Trinidad & Tobago income and prices cannot be the sole determinants of import demand.

Three measures of real income are employed in the analysis. One measure motivated by Khan and Ross (1975), and by Nyatepe-Coo (1994) smoothes out the transitory and cyclical components of income due to temporary impacts of oil shocks on aggregate import demand by using a four year moving average. Alternatively, oil revenues are included in the income budget constraint since oil revenues are exogenous and output cannot be altered to finance imports because of OPEC arrangements. This measure of income defined by real non-oil GDP plus oil revenues was motivated by Saleh-Isfahani (1989), in examining the exogeneity of oil revenues as it they affect import demand in Nigeria. Finally, real gross domestic product is utilised as the third measure. An evaluation of these alternative methods was performed.

In accounting for the effectiveness of the real exchange rate in influencing import demand, real factors or economic fundamentals such as the terms of trade, quantitative restrictions, capital flows and the level of private consumption were assumed to be of major importance. This approach to the real exchange, which is a variation of an approach adopted by Edwards (1989), assumes the simultaneous attainment of internal and external equilibrium and generates a vector of equilibrium rates that vary over time. The real exchange rate becomes a major transmission mechanism for policy through changes in the domestic price level. Variability in the real exchange rate affects economic performance by acting as a mechanism through which resources are allocated between the tradeable and non tradeable sectors thus affecting productivity, adjustment costs and the length of the investment horizon.

The coefficient associated with the terms of trade is expected to be positive as improvement in the terms of trade results in increased spending on all goods raising domestic prices relative to foreign prices. Improvements in the terms of trade represent an increase in real income and increased purchasing power to consumers.

In the case of a fixed exchange rate, the available supply of foreign exchange may be inadequate in meeting import demand. Consequently, import data may not reflect desired imports as determined by real income and relative prices (Saleh-Isfahani, 1989). Hilaire (1992) demonstrated that exchange controls were generally tightened after the oil boom thus augmenting relative prices and real income, the determinants of real import demand in Trinidad and Tobago. If export earnings fall or there is a reduction in capital inflows governments invariably tighten import restrictions through quantitative controls. Increases in demand for imports in the face of quantitative restrictions tend to increase the rents to agents with the rights to import. However, tariffs on imports were constrained by the adherence to CARICOM Common External Tariff. Hilaire has demonstrated that there was a slight narrowing of the differential between domestic and foreign prices of imports over the first oil boom but this later widened over the second boom. Khan (1974) argues that the exclusion of quantitative restrictions leads to misspecification such that the error term will account for the difference between actual and desired imports.

Increases in net capital flows that arise for reasons that include removal of domestic capital controls, increases in net borrowing, increases in direct foreign investment or aid flows tend to appreciate the real exchange rate through increased spending on all goods. Unsustainable macroeconomic policies ultimately lead to an overvaluation of the real exchange rate and can result in a nominal devaluation as a short run corrective action. An excess supply of domestic credit is expected to increase domestic prices resulting in a real appreciation and may induce nominal devaluation. In order that the real exchange rate be constant domestic inflation must equal foreign inflation plus devaluation (Cottani et al., 1990).

The real exchange rate was specified as a function of the factors just discussed which tend to be the determinants of equilibrium:

$$RER = f(TOT, PCON, QR, CF, XSCRD) \qquad (2)$$

where TOT represents the terms of trade, PCON private consumption, QR quantitative restrictions, CF net capital inflows and XSCRD denotes an excess supply of domestic credit. The variable QR was included to show the impact if any of trade restrictions on the real exchange rate and XSCRD represents the impact of monetary effects on the real exchange rate. Edwards (1989) posits that fiscal imbalances in most developing countries are financed by money creation and expansion in domestic credit is expected to have short term effects on the real exchange rate through domestic prices. Increases in the level of quantitative restrictions reduce the degree of openness and can lead to an appreciation of the real exchange rate. Increases in private consumption augmented by the distribution of the oil windfall will trace through to domestic prices resulting in an appreciation of the real exchange rate. Net capital inflows, to the extent that they are not sterilised by the Central Bank, tend to enhance spending resulting in an appreciated real exchange rate.

Substitution of equation 2 in equation 1 leads to the following reduced form:

$$M_t = f(Y_p, Y_c, TOT, PCON, QR, CF, POL) \qquad (3)$$

where POL represents a macroeconomic policy variable. The major behavioural feature of the model outlined above is that increases in oil revenues feed through to higher permanent real income, government consumption, lower import restrictions and a decline in the share of the agricultural sector in non-oil GDP (Nyatepe-Coo, 1994). These factors combine to induce an increase in demand for imports. An increase in domestic prices will also ensue from increased absorption and will result in a real appreciation given a fixed exchange rate and given foreign prices. Income and substitution effects combine to make imports cheaper as a consequence of higher domestic prices relative to foreign prices.

Method of Analysis

A review of the recent literature on Dutch disease revealed that few studies have employed cointegration analysis in the investigation of the non-stationarities that may exist among the time series (Corden, 1984; Saleh-Isfahani, 1989; Fardmanesh, 1991; and Nyatepe-Coo, 1994). Most macroeconomic time series tend to display an upward trend over time leading to the use of differencing to achieve stationarity. The idea of a common trend in time series data motivated the concept of cointegration developed by Engle and Granger (1987). Dickey and Fuller (1981) developed two test statistics - the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) - to test for the order of integration. These along with the cointegrating regression Durbin Watson (CRDW) statistic developed by Sargan and Bhargava (1983), will be used to determine the presence of cointegration among the variables in the reduced form equation. A high R^2 close to unity, a non-zero CRDW and significant Dickey-Fuller and Augmented Dickey-Fuller statistics on the residuals from the static equation are employed as evidence of a cointegrating relationship. The Johansen and Juselius (1990) test for the order of cointegration will also be applied to determine the optimal number of cointegrating vectors holding the import demand system together. The presence of a linear trend will also be evaluated. The Johansen and Juselius (1990) procedure gives rise to three possibilities based on the following error correction model:

$$\Delta X(t) = \alpha_o + \sum_{i=1}^{s-1} \alpha_i D_{it} + \sum_{i=1}^{k-1} \Gamma_i \Delta X(t-i) + \pi X(t-k) + \varepsilon(t)$$

$$\pi = -\left(I - \sum_{i=1}^{k} \pi_i\right)$$

(1) If the rank of $\pi=0$ there is no long run information and the appropriate model is a traditional VAR in differences;

(2) If the rank of π is p (i.e a full rank) X(t) is stationary in levels and a VAR in levels is an appropriate description of the data.

(3) Where the rank of π is r, where $0 < r < p$, this gives rise to cointegration and implies that there are pxr matrices α and β such that $\pi = \alpha\beta'$.

D_{it} denotes seasonal dummy variables.

Estimation of the reduced form regression will be based on the Engle-Granger two step estimator which explores an error correction model of the joint processes among the vector of variables that form a cointegrating relationship. Ordinary least squares regression of past changes in the vector of variables and lags on the residuals from the cointegrating regression is proposed. The following general model is suggested:

$$\Delta X(t) = \sum_{k=1}^{K} A(k)\Delta X(t-k) + \sum_{k=1}^{K} B(k)\Delta Y(t-k) + C(1)ECM(t-1) + \varepsilon(t)$$

where ECM(t-1) is the observed residual from the cointegrating regression of X(t) on Y(t), Δ the difference operator and A(k), B(k) and C(1) are the parameters to be estimated.

In view of the difficulties of choosing among the three alternative models with their associated measures of income, the models are nested using the J-test of their predictive performance. Davidson and McKinnon (1981) proposed the following nested regression:

$$M_t = (1-\alpha_i)X_i B_i + \alpha_i \Phi_i Z_i + \alpha_t ..., \quad i = 1...3$$

where M_t represents aggregate imports, X_i a vector of variables outlined in equation 3 and Z_i a predictive variable after accounting for the impact of the vector X_i. The null hypothesis that $E(M_t) = X_i\beta_i$ obtains if $\alpha_i = 0$ versus the alternative $E(M_t) = \Phi_i Z_i$ when $\alpha_i = 1$. The test is based on either the Likelihood Ratio test or the standard t-test on the parameter α_i. The benchmark model I will be formulated using the measure of permanent income (Y_p) while model II uses oil revenues (GDY), and model III real GDP (RGDP).

Data Issues

Data on real imports, terms of trade, real GDP, net capital flows and private consumption were obtained form the IMF *International Financial Statistics Yearbook.* Quantitative restrictions were obtained from various issues of Trinidad and Tobago *Annual Digest of Statistics.* Quantitative restrictions (QR) were proxied as the ratio of import duties to total government revenues. Imports were deflated using 1985 import prices. The terms of trade (TOT) was defined as a ratio of export to import prices with 1985 as base year. Cyclical real income (Y_c) was measured using agricultural share in non-oil GDP (YAG). Real permanent income (Y_p) was measured as a four year moving average of real income. The other measures of income were defined as real GDP (RGDP) and real non-oil GDP plus oil revenues (GDY). Net capital inflows (CF) and private consumption (PCON) were utilised as ratios to GDP in the estimated equations. Excess supply of domestic credit (XSCRD) which was one of the policy variables used was defined by annual growth in domestic credit less annual growth in GDP less annual foreign inflation. All data were converted to natural logs except net capital flows and excess domestic credit. The annual time series employed in the study covered the period 1965-91.

Empirical Results

All the variables in the reduced form equation were integrated of order one, I(1) and warranted first differencing to achieve stationarity (Table 3.1). Table 3.2 illustrates the results from the static long run equation showing that the models with the three definitions of income indicate the presence of

TABLE 3.1.
STATIONARITY TESTS[1]

Variable	DF(ADF) Statistics
M_t	-1.24(-1.24)
ΔM_t	-12.23(-7.58)
YAG_t	-2.09(-1.84)
ΔYAG_t	-6.21(-5.19)
Y_{pt}	-1.29(-1.23)
ΔY_{pt}	-6.12(-3.03)
GDY_t	-2.19(-2.1)
ΔGDY_t	-5.25(-8.26)
$RGDP_t$	-1.27(-1.49)
$\Delta RGDP_t$	-3.7(-5.29)
QR_t	-1.89(-1.80)
ΔQR_t	-5.38(-5.09)
$PCON_t$	-2.15(-2.11)
$\Delta PCON_t$	-5.24(-4.98)
TOT_t	-1.55(-2.49)
ΔTOT_t	-3.81(-3.07)
CF_t	-1.92(-1.55)
ΔCF_t	-6.08(-2.99)

[1] Tests are based on the following regression:

$$\Delta X(t) = \beta_o + \beta_1 X(t-1) + \sum_{i=1}^{K*} \alpha_i \Delta X(t-i)$$

where Δ is the first difference and K* the optimal lag for the dependent variable.

cointegration on the basis of DF and ADF tests. Further corroboration of the presence of a cointegrating relationship was verified using the Johansen and Juselius procedure (Table 3.3). Johansen (1993) provides a method for sequential testing to jointly decide the rank of the cointegrating vector (r), in addition to whether there is a linear trend in the model. If there is no linear trend hypothesis $H_2(r)^*$ is restricted while if there is a linear trend this hypothesis $H_2(r)$ is unrestricted. On examining Table 3.3 the trace test hypotheses $H_2(0)^*$, $H_2(0)$, $H_2(1)^*$, $H_2(1)$,$H_2(2)^*$ and $H_2(2)$ all suggest rejection of no linear trend and presence of a linear trend. For $H_2(3)^*$ one is unable to

TABLE 3.2
COINTEGRATING REGRESSIONS FOR PERMANENT INCOME (Y), REAL NON-OIL GDP WITH OIL REVENUES ADDED (GDY) AND WITH REAL GDP (RGDP)

Variables	Coefficients		
constant	13.67 (2.81)	7.83 (8.84)	5.04 (1.24)
YAG_t	-0.10 (-0.56)	0.10 (0.53)	-0.14 (-0.91)
Y_{pt}	-0.57 (-1.06)	-	-
GDY_t	-	0.07 (0.82)	-
$RGDP_t$	-	-	0.31 (0.73)
QR_t	-0.04 (-0.17)	0.24 (1.03)	0.13 (0.54)
$PCON_t$	-0.42 (-0.75)	-0.88 (-1.93)	-0.78 (-1.42)
TOT_t	0.93 (2.94)	0.52 (1.72)	0.58 (1.87)
CF_t	4.83 (2.46)	6.88 (3.48)	4.81 (2.17)
R^2	0.74	0.74	0.74
CRDW	1.71	1.64	1.76
DF	-4.43	-4.32	-4.52
ADF	-4.27	-4.30	-4.36

TABLE 3.3
TRACE TEST ON ALTERNATIVE COINTEGRATION SPECIFICATIONS OF AGGREGATE IMPORT DEMAND WITH AND WITHOUT A LINEAR TREND[1]

p-r	r	T^*	$C^*(5\%)$	T	C(5%)
7	0	202.9	131.7	211.62	124.24
6	1	139.0	102.14	147.36	94.15
5	2	83.67	76.07	90.11	68.52
4	3	49.95	53.12	54.27	47.21
3	4	27.02	34.91	28.8	29.68
2	5	11.01	19.96	12.74	15.41
1	6	2.6	9.24	3.26	3.76

[1] C and C* are taken from Table 1 at the 95 percent Quantile of Osterwald-Lenum.
C* is the value with no linear trend.
T* is calculated under the hypothesis of no linear trend.
T is calculated under the hypothesis of a linear trend.
p the number of series, equal to 7.
r is the number of cointegrating vectors.

reject the hypothesis of no linear trend. Therefore on the basis of this finding there are three cointegrating vectors without a linear trend holding the import demand system together. Although these vectors are alternative representations identification of the coefficients of each vector is problematic given the difficulty of identifying valid restrictions that yield meaningful economic interpretations.

We proceeded from the following general model:

$$\Delta M_t = \alpha_0 + \alpha_1 \Delta M_{t-1} + \sum_{i=0}^{k} \beta \Delta X_{t-i} + \lambda ECM_{t-1}$$

where the maximum lag length was chosen on the basis of Akaike's final prediction error criterion (FPE) and the constraint of small sample size. The vector X_t was summarised as follows: X_t=(YAG,Y_p, RGDP, GDY, QR, PCON, TOT, CF, POL). No restrictions were placed on the coefficient of the price variable.

The residuals from all regressions (Tables 3.4 - 3.6) were white noise based on the Lagrange Multiplier test (LM) for serial correlation and the Jarque Bera test for normality (NORM) confirmed that the residuals were normally distributed. The null hypothesis of constant residual variance against the alternative of autoregressive conditional heteroscedasticity could not be rejected on the basis of the ARCH test. Constant residual variance was also corroborated by the WHITE test for heteroscedasticity. Sequential CHOW tests for model stability indicate stable aggregate import demand functions over the period of study. Furthermore, the coefficient of the error correction term (ECM) was significant and of correct sign in all estimated equations. The magnitudes of the coefficient was less than unity therefore suggesting a damped convergence in the long run.

The computed t-statistics for α_1 which evaluated Model I vs II (permanent income vs oil revenues), α_2, I vs III (permanent

TABLE 3.4
DYNAMIC IMPORT EQUATIONS WITH PERMANENT INCOME

Variable	Coefficient
ΔM_{t-1}	-0.07 (-0.91)
ΔYAG_{t-1}	-0.15 (-1.29)
ΔY_p	0.24 (0.28)
ΔQR_t	-0.38 (-2.48)**
$\Delta PCON_t$	0.87 (1.96)*
ΔTOT_t	0.66 (2.27)**
ΔCF_t	4.4 (2.95)***
ECM_{t-1}	-0.68 (-3.07)***
Constant	-0.03 (-0.95)

* significant at the 10 percent level
** significant at the 5 percent level
*** significant at the 1 percent level

Adj. R^2 = .51; D.W. = 1.71; Norm[X^2(2)] = 1.08
L.M. F[1,16] = 1.13; WHITE[X^2(16)]=16.38;
ARCH[X^2(6)] = 1.02; CHOW F[9, 17]=1.45

TABLE 3.5
DYNAMIC IMPORT EQUATIONS WITH OIL REVENUES ADDED TO REAL NON-OIL GDP (GDY)

Variable	Coefficient
ΔM_{t-1}	-0.11(-1.79)*
ΔYAG_{t-1}	-0.27(-2.82)***
ΔGDY	0.19 (2.62)***
ΔQR_t	-0.3(-2.64)***
$\Delta PCON_t$	0.98 (2.74)***
ΔTOT_t	0.47(2.09)**
ΔCF_t	6.51(4.84)***
ECM_{t-1}	-0.72(-4.28)***
Constant	-0.06(-2.12)

* significant at the 10 percent level
** significant at the 5 percent level
*** significant at the 1 percent level

Adj. R^2 = .65; D.W. = 1.61; Norm[X^2(2)] = 0.72
L.M. F[1,16] = 0.42; WHITE[X^2(16)]= 8.96 ;
ARCH[X^2(6)] = 1.02; CHOW F[9,17]=1.23.

TABLE 3.6
DYNAMIC IMPORT EQUATIONS WITH REAL GDP (RGDP)

Variable	Coefficient
ΔM_{t-1}	-0.10 (-1.71)*
ΔYAG_{t-1}	-0.20 (-2.23)**
$\Delta RGDP_t$	1.08 (3.09)***
ΔQR_t	-0.28 (-2.23)**
$\Delta PCON_t$	0.71(1.95)*
ΔTOT_t	0.58 (2.61)**
ΔCF_t	4.99 (3.89)***
ECM_{t-1}	-0.76 (-4.17)***
Constant	-0.03 (-1.16)

* significant at the 10 percent level
** significant at the 5 percent level
*** significant at the 1 percent level

Adj. $R^2 = .64$; D.W. = 1.51; Norm[$X^2(2)$] = 0.85
L.M. F[1,16] = 0.27; WHITE[$X^2(16)$]=16.38;
ARCH[$X^2(6)$] = 1.02; CHOW F[9,17]=1.10.

income vs real GDP), and α_3, II vs III (oil revenues vs real GDP) from the J-test were 2.8, 2.6 and 0.26 respectively. The coefficients α_1 and α_2 were significant at the 1 percent level while α_3 was not significantly different from zero. The results suggest that modeling of income using real non-oil GDP with the addition of oil revenues was a better specification relative to permanent income and real GDP. This finding underscores our proposition that oil revenues were an important determinant of the increases in import demand. The inclusion of oil revenues (GDY) and real GDP measures of income yielded much more robust results (Tables 3.5 and 3.6 respectively). The results from the three specifications were contrasted for both magnitude and sign of the estimated coefficients. Two measures of the macroeconomic variable (POL) defined by (a) the excess of domestic credit and (b) a dummy variable indexing nominal devaluation in 1985 were not significant in any of the estimated import demand equations and resulted in a deterioration of the goodness of fit statistics. This variable was therefore excluded on the basis of this finding and the models were reparameterised.

Some of the results from the equation using permanent income were unsatisfactory in that neither the estimated coefficients of permanent nor cyclical income components proved significant. The estimated income coefficient was of expected sign and we obtained an elasticity of 0.24. However, the relative roles of quantitative restrictions, private consumption, terms of trade and net capital flows were of expected sign and very significant in explaining import behaviour over the period of study. The results show that import demand in Trinidad is inelastic with respect to permanent income and relative prices (Table 3.4). The impact of oil income on import expenditures although inelastic, 0.19 in magnitude, was significant in explaining import demand behaviour. The elasticity associated with real GDP was largest (1.08), suggesting that much of the variation in imports is accounted for by combinations of transitory and permanent components of total income. Our results are not strictly comparable to those of Saleh-Isfahani (1989), nor Nyatepe-Coo (1994), who both examined Dutch Disease and import demand in Nigeria as they did not examine the stationarity properties of the time series data. Nevertheless, the impact of income on imports in Nigeria was much lower compared to Trinidad and Tobago given an elasticity of 0.09. Our results show a much stronger impact of income on import demand and may be partial reflection of the consequences of the GOTT policies of subsidies, tax concessions and increases in personal emoluments.

The results indicate dynamic adjustment of imports which may obtain for reasons of habit persistence and contractual arrangements in the import demand in the equations with oil revenues (GDY) and real GDP. The results also show that a 10 percent decrease in the share of agriculture resulted in an increase in imports that varied between 1.5 to 2.7 percent. This would imply that the decline in food production was offset through increased imports.

Quantitative restrictions were important in all equations; the continuous downward revisions to the tariff structure by GOTT which facilitated the increased importation of goods. A 10 percent decrease in quantitative restrictions resulted in increases of 2.8 and 3.4 percent of imports in the real GDP and GDY equations respectively. The coefficients of the quantitative restrictions variable were on average twice the magnitude of those in the Nyatepe-Coo (1994) study, possibly reflecting the government policy of subsidies and tax relief.

An increase in private consumption had a significant impact on import demand across all estimated equations. The relative importance of this variable in the import relationship is borne out by the magnitudes of the estimated elasticities which ranged from 0.87 to 0.98 and which support the contention of Auty and Gelb (1986), that considerable proportions of both oil windfalls were allocated to consumption. Furthermore this would have been aided by the procyclical policies of the GOTT that fueled consumption.

The impact of the oil shock was also evident through the positive and significant terms of trade effects. The elasticities associated with the terms of trade ranged from 0.47 to 0.66. A 10 percent increase in the terms of trade led to a maximum increase in imports of 6.6%. This finding also supports the prediction associated with 'Dutch Disease' that improvement in the terms of trade as a result of higher oil prices leads to increased levels of consumption which are satisfied through higher levels of imports. The coefficient associated with net capital flows which is a semi-elasticity was significant and of expected sign. The full impact of net capital flows was modified by the degree of Central Bank sterilisation.

Conclusions and Policy Recommendations

It was found that the decline in the agricultural sector, probably due to the oil boom, resulted in increased levels of imports of agricultural products. Private consumption, improving terms of trade and some demand variables all led to increased imports, while possibly in the "bust" period quantitative restrictions resulted in a reduction in import demand. Increased private consumption was fuelled by GOTT policies such as tariff reductions, subsidies and other forms of tax relief.

There are a number of policy issues that emerge from these findings that are relevant to macroeconomic management of windfalls. First, booms in essence should be viewed as a temporary phenomenon and as such long term macroeconomic policies should not be based on such gains. In Trinidad and Tobago's case, using the windfall gains to reduce tariffs and increase subsidies led to higher than normal consumption which was met by increased import demand. Instead, policies aimed at encouraging savings, especially of the temporary income, should be implemented. Second, price and trade policies must be put in place to maintain competitiveness of the other foreign exchange earning sectors. Third, efforts must be made to slow the appreciation of the real exchange rate which will occur through terms of trade effects and excess purchasing power, otherwise productivity may be stymied. The slowdown in the appreciation might be accomplished through the implementation of an incomes policy in conjunction with fiscal and monetary restraint.

NOTES

1. See page 84 of "Accounting for the Petrodollar", Government Printery, Government of Trinidad and Tobago, 1980.

2. ibid.

3. The real exchange rate equation was tested for the presence of a long run relationship based on the trace test reported in Table A1 in the Appendix. One cointegrating vector was found to hold the varibales in the exchange rate equation. The results from the error correction model are reported in Table A2.

4. See pages 46-50 of "Accounting for the Petrodollar".

REFERENCES

Auty, R. and A. Gelb (1986), "Oil Windfalls in a Small Parliamentary Democracy: Their Impact on Trinidad and Tobago," *World Development*, 14: 9, 1161-1175.

Corden, W (1984), "Booming Sector and Dutch Disease Economics: Survey and Consolidation," *Oxford Economic Papers*, 36, 359-80.

Cottani J. A., D. F. Cavallo and M. Shahbaz Khan (1990), "Real Exchange Rate Behavior and Economic Performance in LDCs," *Economic Development and Cultural Change*, 39, 62-76.

Cuddington, J. T (1986), *Commodity Booms, Macroeconomic Stability and Trade Reform in Colombia*, Economic Development Institute, World Bank.

Davidson, R. and J. McKinnon (1981), "Several Tests for Model Specification in the Presence of Alternative Hypotheses," *Econometrica*, 49, 781-793

Dickey, D. and W. Fuller (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root," *Econometrica*, 49, 1057-72.

Edwards, S. (1989), *Exchange Rate Misalignment in Developing Countries*, Cambridge Massachusetts, MIT Press.

Engle, R. F., and C. Granger (1987), "Cointegration and Error Correction: Representation, Estimation and Testing," *Econometrica*, 55, 251-276.

Farmanesh, M (1991), "Dutch Disease and the Oil Syndrome: An Empirical Study," *World Development*, 19: 6, 711-717.

Government of the Republic Trinidad and Tobago (1980), *Accounting for the Petrodollar*, Government Printery.

Hilaire, A. (1992), "The Effects of Trinidad and Tobago's Oil Boom on Relative Prices, Wages and Labour Flows," *Social and Economic Studies*, 41:2, 45-82.

Hill, C. B. and D. N. Mokgethi (1989), "Botswana: Macroeconomic Management of Commodity Booms 1975-86," in *Successful Development in Africa*, Economic Development Institute, World Bank.

International Monetary Fund (1979), "Trinidad and Tobago Staff Report for 1979 Article IV Consultation", IMF, Washington D.C.

Khan, M.S. (1974), "Import and Export Demand in Developing Countries," *International Monetary Fund Staff Papers*, 21, 678-93.

Khan, M.S. and K. Ross (1975), "Cyclical and Secular Income Elasticities of the Demand for Imports," *Review of Economics and Statistics*, 57, 357-61.

Johansen, S. (1993), "Determination of Cointegration Rank in the Presence of a Linear Trend," mimeo, University of Copenhagen, Institute of Mathematical Statistics.

Johansen, S. and K. Juselius (1990), "Maximum Likelihood Estimation and Inference on Cointegration with applications to the Demand for Money," *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

Neary, P. and S. van Wijnbergen (1986), *Natural Resources and the Macroeconomy*, MIT Press, Cambridge, MA.

Nyatepe-Coo, A (1994), "Dutch Disease, Government Policy and Import Demand in Nigeria," *Applied Economics*, 26, 327-336.

Osterwald-Lenum, M (1992), "A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics: Four Cases," *Oxford Bulletin of Economics and Statistics*, 54: 3, 461-473.

Saleh-Isfahani, D (1989), "Oil Exports, Real Exchange Rate Appreciation and Demand for Imports in Nigeria," *Economic Development and Cultural Change*, 37, 496-511.

Sargan, J. D. and A. Bhargava (1983), "Testing Residuals from Least Squares Regression for Being Generated by the Gaussian Random Walk," *Econometrica*, 51, 153-174

APPENDICES 3.A1, 3.A2

TABLE 3.A1
TRACE TEST ON ALTERNATIVE COINTEGRATION SPECIFICATIONS OF THE REAL EXCHANGE RATE WITH AND WITHOUT A LINEAR TREND[1]

p-r	r	T*	C*(5%)	T	C(5%)
6	0	139.54	131.7	138.56	124.24
5	1	77.34	102.14	88.66	94.15
4	2	44.84	76.07	51.86	68.52
3	3	23.17	53.12	29.97	47.21
2	4	6.19	34.91	11.30	29.68
1	5	2.16	19.96	3.74	15.41

[1] See Notes to Table 3.3. The total number of series in this table is 6.

TABLE 3.A2
REAL EXCHANGE RATE EQUATION

Variable	Coefficient
ΔRER_{t-1}	0.13 (0.69)
ΔQR_t	-0.08 (-2.37)**
ΔQR_{t-1}	0.10 (2.35)**
ΔTOT_t	-0.002 (-0.02)
ΔTOT_{t-1}	0.23 (1.92)*
$\Delta PCON_{t-1}$	0.04 (0.32)
ΔCF_t	0.21 (0.36)
$XSCRD_t$	-0.03 (-2.98)***
$XSCRD_{t-1}$	0.03 (2.93)***
ECM_{t-1}	-0.43 (2.93)***
Constant	0.01(0.88)

* significant at the 10 percent level
** significant at the 5 percent level
*** significant at the 1 percent level

Adj. R^2 =0.69; D.W. = 1.91; Norm[$X^2(2)$] = 1.01
L.M. F[1,16] = 1.45; WHITE[$X^2(20)$]=17.25;
ARCH[$X^2(6)$] = 1.07; CHOW F[9,17]=1.60.

CHAPTER 4

MONETARY DYNAMICS IN BARBADOS: THE EVIDENCE FROM COINTEGRATION ANALYSIS AND ERROR-CORRECTION MODELLING

Wendell A. McClean

MONETARY DYNAMICS IN BARBADOS: THE EVIDENCE FROM COINTEGRATION ANALYSIS AND ERROR-CORRECTION MODELLING

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INTRODUCTION

Theoretical work on money in the Barbadian economy suggests that there is a one-way causal relationship between money and the arguments of the money demand function (see McClean, 1994). Prices are hypothesized to be determined predominantly by the price of imports, taxation and other supply-side factors such as pricing practices in the distributive sector. The money market is considered to be demand centred, in the sense that the process of money market adjustment reflects an over-riding tendency for the supply of money to adjust to the demand for money, through a process that entails accommodative balance of payments adjustment.

In the short-run, the rate of interest is regarded as the only argument of the money demand function with significant potential to be proximately responsive to money market disequilibrium. However, during the last two decades, Central Bank control of interest rates would have attenuated the responsiveness of interest rates to money-market disequilibrium and other economic conditions. Hence, during this period, the rate of interest in Barbados may have been largely policy determined rather than market determined.

The foregoing propositions have not previously been subjected to adequate econometric testing. Earlier empirical studies on money in Barbados focussed on the specification of the money demand function. Howard (1981) provided inconclusive evidence regarding the existence of a well defined functional relation for the demand for money in Barbados. McClean (1982) estimated long-run models using annual data and reported results that were indicative of the existence of a transactions money-demand function. Coppin (1991), using both annual and quarterly data, reported results that confirmed McClean's central finding.[1] However, these studies were not designed to investigate monetary dynamics, and they did not investigate the possibility of spurious correlation.

In this study, we use cointegration analysis and error-correction modelling to examine the hypotheses stated above and to further explicate short-run inter-relationships among the money stock and the arguments of the money demand function, in Barbados. The paper is organised as follows: In section 2, we present an aggregative, fixed-exchange-rate, labour-surplus model of a small open economy, that is expressive of the propositions stated above. The econometric analysis is presented in section 3. This is followed, in section 4, by some concluding remarks.

The Model

The Barbadian economy has been characterised by a fixed exchange-rate regime, chronic unemployment, an integrated labour market, institutionalized bargaining arrangements for the fixing of wages, largely unrestricted access to foreign goods and foreign exchange, and levels of factor mobility and product substitutability that validate an aggregative approach to modelling the economy. The following fixed-exchange-rate, short-run, labour-surplus, small-open-economy model, with two goods and an overlay of distributive services, is proposed as an adequate representation of the Barbadian economy:

$$P_a = \left[1 + \phi(i, \bar{t}_c, \bar{t}_e)\right]\left[\alpha(1 + \bar{t}_d)\overline{E}\overline{P}_d^* + (1-\alpha)(1 + \bar{t}_m)\overline{E}\overline{P}_m^*\right]; \quad \phi_i, \phi_{t_c}, \phi_{t_e} > 0;\ 0 < \alpha < 1 \tag{1}$$

$$y = \frac{(1 + t_d)\overline{E}\overline{P}_d^*}{P_a} q \tag{2}$$

$$W_G = (1 + \bar{t}_e)W \tag{3}$$

$$q = F(N, \overline{K}); \qquad F_N, F_K > 0 \tag{4}$$

$$W = W(\overline{E}\overline{P}_d^*, P_a, i, \bar{t}_e, \bar{t}_w); \qquad W_{P_d}, W_{P_a}, W_{t_w} > 0;\ W_i, W_{t_e} < 0 \tag{5}$$

$$\frac{W_G}{\overline{E}\overline{P}_d^*} = F_N(N, \overline{K});\ F_{NN} < 0;\ F_{NK} > 0 \tag{6}$$

$$y - s\left[y(1-\bar{\tau}), \frac{\varepsilon}{P_a}, i - P_a^e\right] - \bar{g} + \frac{1}{P_a}\eta\left[i, \bar{i}_f, \varepsilon, E^e\right] = \frac{dNFA}{P_a} \quad S_y, \eta_\varepsilon, \eta_i > 0;\ S_\varepsilon, S_i, \eta_{E^e}, \eta_{i_f} < 0 \tag{7}$$

$$mH - l(P_a, y, i) = \varepsilon;\ l_p, l_y > 0;\ l_i < 0;\ m > 1 \tag{8}$$

$$dH = dN\overline{L}A + dNFA \tag{9}$$

Where:

E	is the nominal domestic/foreign exchange rate;
E^e	is the expected change in the nominal exchange rate;
H	is the nominal stock of high-powered money;
g	is real government expenditure;
i	is the nominal rate of interest;
i_f	is the nominal foreign interest rate;
K	is the stock of capital;
m	is a portfolio-balance coefficient, linking demand/supply of money to demand/supply of high-powered money;
N	is the level of employment;
NLA	is the local assets of the Central Bank, net of local liabilities other than high-powered money;
NFA	is the net foreign assets of the Central Bank;
P_a	is the absorption price level measured at market prices and denominated in domestic currency;
P_d^*	is the foreign-currency price of the domestic good, measured at factor cost;
P_m^*	is the foreign-currency price of the foreign good;
P_a^e	is the expected rate of inflation of the absorption price level, assumed to be exogenously determined;
q	is real output;
t_c	is the corporation tax rate;
t_e & t_w	are payroll tax rates imposed on the employer and the worker, respectively;[2]
t_d & t_m	are the "ad valorem" indirect tax rates on the domestic and the foreign good, respectively;

W is the nominal contractual wage rate;

W_G is the nominal gross wage rate paid by the employer, inclusive of payroll taxes;

y is real income;

α is the proportion of the domestic good in the absorption mix;

ε is excess money supply as defined by equation 8;

τ is a vector of direct tax rates, including payroll taxes rebased to relate to income;

$\sigma(\,)$ is the private expenditure function;

$\eta(\,)$ is the net nominal capital inflow function;

$\phi(\,)$ is the distributors' mark-up function;

(-) denotes an exogenous variable.

Equation 1 depicts the absorption price level as determined by international market forces, indirect taxation and a set of factors that influence distributors' markup.[3] Equation 2 models the oft ignored relationship between real income and real output. It highlights the fact that these two variables can experience significantly different rates of change.

The notion of the short-run to which our model relates, is a period sufficiently short to preclude current investment expenditure from changing the capital stock, but sufficiently long to allow the capital stock to be influenced by prior-period investment expenditure. Hence, in equation 4, the capital stock is treated as an exogenous variable. That is, our model abstracts from the effect of the rate of interest on the capital stock.

The theoretical underpinnings of equation 5, a wage function, have been presented in Downes and McClean (1982). The wage function has been deduced from a bargaining model of wages, in which the wage rate is postulated to be negatively related to *employers' resistance to wage increases* and positively related to *trade-union pushfulness for wage increases.* Any variable that impacts negatively (positively) on the profitability of firms will increase (reduce) the resistance of employers to wage increases and impact negatively (positively) on the wage rate. Any variable that impacts negatively (positively) on the absolute or relative standard of living of workers will increase (reduce) trade-union pushfulness and impact positively (negatively) on the wage rate.

Equation 6 is an indirect representation of the demand for labour. It depicts the relevant marginal productivity condition for the optimum of the firm.[4] Equations 7-9 have been presented in a manner that highlights the implicit dynamics of the model, in regard to money and the balance of payments. Equation 7, which models the balance-of-payments process (i.e. the foreign-exchange market) indicates that, in an equilibrium context, the money supply is not a determinant of private expenditure or net capital flows. It also suggests that the emergence of monetary disequilibrium induces changes in private expenditure and net capital flows that disequilibrate the balance of payments. Equation 9 is the differential form of the Central Bank's balance sheet constraint.

The product market equilibrium condition is notably absent from the foregoing set of structural equations. In an aggregative SOE model, infinite elasticity of foreign demand for exports, ipso facto, means that demand for the domestic product is permanently larger than supply. Hence, there is no possibility of product market equilibrium as conventionally portrayed. In the SOE case, the "ex post" income expenditure identity may be reformulated as an "ex ante" relation in any of the following three ways: as an excess-supply relation for exports, as an excess demand relation for imports, or with distinct export-supply and import-demand functional relations. The last of these constitutes a modified equilibrium condition pertaining to planned domestic production for the domestic market. We consider the first of these options as most plausible in a Barbadian context. However, such an equation has not been included in our model because a solution for the value of exports is not required for the solution to any other variable in the model.[5]

The balance-of-payments and money-market equations may be reformulated in equilibrium terms by setting $\varepsilon, \dot{E}^e, \dot{P}_a^E$, dNFA and dH equal to zero. In its static equilibrium aspect, the model is slightly decomposable. Equations 1-7 constitute a sub-system that simultaneously determines P_a, W, W_G, N, q, y and i.[6] Given solution values for P_a, y and i, a solution for H may be found from equation 8. Hence, our model implies that, in an equilibrium context, P_a, y and i enter the money demand function as predetermined variables. To solve for NFA, equation 9 may be reformulated in levels of the variables.

The model also implies that, in the transitional period between equilibria, there is a dynamic process of mutual adjustment linking the money market (equation 8) and the foreign exchange market (equation 7), that is conditioned by the Central Bank's balance-sheet identity (equation 9) and by equations 1-6. Hence, the model embraces, but does not necessitate, cyclical responsiveness of the rate of interest, prices and income to monetary disequilibrium. In other words, the model indicates that the role played by these variables in relation to short-run monetary dynamics should be regarded as an empirical issue. In the next section we use cointegration analysis and error-correction modelling to investigate the demand for money and short-run monetary dynamics in Barbados.

ECONOMETRIC ANALYSIS

Before we can investigate these matters, we must select the empirical counterparts to the theoretical constructs in the money demand function In a Barbadian context, we consider a transaction oriented approach to money demand analysis to be most appropriate. Hence a narrow measure of the money supply (M1) was adopted. The Retail Price Index (Consumer Price Index) is the only available quarterly series on aggregate prices in Barbados. It, therefore, selects itself as the price variable. Nominal GDP deflated by the Consumer Price Index was used as a proxy for real income.[7] In Barbados, commercial-bank three-month time deposits are the predominant alternative to holding money. We, therefore, modelled the interest-rate effect around interest rates on three-month deposits. We were confronted with a choice between the minimum and maximum interest rates on three-month deposits, or some combination thereof. We chose the minimum interest rate on three-month deposits and a spread variable (S) defined as the ratio of the maximum to the minimum interest rate on three-month deposits.[8]

We then tested for the order of integration of the logarithms of the nominal money stock, the real money stock, real income, the price level and the two interest rate variables, using quarterly data for the period 1974:1 to 1994:4. The results obtained from Dickey-Fuller (DF) test and Augmented Dickey-Fuller (ADF) tests, the latter with four lags, are reported in Table 4.1.[9] All four tests rejected the null hypothesis that the spread variable was non-stationary. The DF test without trend was the only test that rejected the null hypothesis of non-stationarity of lnP. However, the residuals for this DF test showed evidence of serial correlation and the corresponding ADF tests did not. Every test failed to reject non-stationarity of the levels of lnM, lnr and lny. All four tests rejected the null hypothesis of non-stationarity of the first difference of every variable.

TABLE 4.1
TESTS FOR UNIT ROOTS: 1974:1 - 1994:4

Variables	DF		ADF(4)	
	Without Trend	With Trend	Without Trend	With Trend
lnM	-2.1911	-1.5974	-2.3912	-1.1382
ΔnM	-9.4375	-9.7735	-3.8182	-4.4613
lnP	-5.9445	-2.4540	-1.9813	-.38064
ΔlnP	-6.3843	-7.2667	-3.5576	-4.1212
lny	-1.7147	-2.8345	-2.3742	-2.0470
Δlny	-11.0960	-11.0249	-3.0823	-3.3897
lnr	-2.6084	-2.5230	-2.4162	-2.4582
Δlnr	-8.1696	-8.1504	-4.2963	-4.2609
lnS	-3.6777	-3.6503	-3.5138	-3.6411
95% c.v.	-2.8963	-3.4639	-2.8981	-3.4666

These results indicate that, for the five variables in our hypothesized long-run nominal money demand model to be cointegrated, the sub-set of four I(1) variables must be cointegrated. Hence, cointegration of lnM, lnP_a, lnr and lny constitute necessary assurance against the prospect of spurious regression. If time-series variables are cointegrated, their secular trends adjust in accordance with an equilibrium constraint and the cyclical components of the series fit into a dynamic error-correction process (see Engle and Granger (1987), Granger (1986) and Hendry (1986)). To check for cointegration among the four I(1) variables, we estimated the associated co-integrating regression equation using ordinary least squares, and performed Engle-Granger (Dickey-Fuller) tests on the residuals. The results are presented as equation 10.

$$\ln M_t = -2.2860 + 1.0330 \ln P_t + 1.2106 \ln y_t - .10094 \ln r_t$$

$$\bar{R}^2 = .98924 \quad F(3,80) = 2544.9 \quad DW = 1.2947 \tag{10}$$

$$DF = -6.3695(-4.2326) \quad ADF(4) = -4.2473(-4.2395)$$

The DF and ADF tests both reject the hypothesis of non-stationarity of the residuals, at the five percent level. Hence, cointegration among the four variables is indicated. The relatively high value of the Durbin-Watson statistic is also indicative of cointegration. If the four I(1) variables are cointegrated, then the five arguments of the nominal money-demand function are cointegrated.

We then applied the Johansen maximum likelihood procedure with three lags, with lnS and its three lags included in the VAR as additional I(0) terms (see Johansen (1988)).[10] We used this procedure to identify the number of cointegrating vectors, investigate the issue of simultaneity and obtain the residuals of the appropriate cointegrating vector, for use as an error-correction mechanism (ECM) in the short-run money demand model. The results of the cointegration LR test based on the maximal Eigenvalue are reported in Table 4.2.

Table 4.2
Johansen Maximum Likelihood Procedure (Trended Case, no trend in DGP) Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix 78 observations from 75Q3 to 94Q4. Maximum lag in VAR = 3

List of variables included in the cointegrating vector:

lnM	lnP	lny	lnr

List of additional I(0) variable included in the VAR:

lnS	lnS(-1)	lnS(-2)	lnS(-3)

List of eigenvalues:

35382	.34123	.16958	.064180

Null	Alternative	Statistic	95% C. V
r = 0	r = 1	34.0609	27.1360
r<= 1	r = 2	32.5559	21.0740
r<= 2	r = 3	14.4941	14.9000
r<= 3	r = 4	5.1739	8.1760

The test rejected, at the 5% level, the null hypothesis of at most one cointegrating vector against the alternative of two, but did not reject at most two against the alternative of three cointegrating vectors. The two cointegrating vectors and the associated estimated adjustment matrix are presented in Tables 4.3 and 4.4 respectively. In regard to the cointegrating vectors, only Vector 1 has the expected sign for the interest rate variable in a money-demand function, the normalized value for the coefficient of lnP is closer to the conventionally hypothesized value of unity and the coefficient of lny also has a more plausible value. Hence, it is indicated that Vector 1 pertains to the demand for money.

TABLE 4.3
ESTIMATED COINTEGRATED VECTORS IN JOHANSEN ESTIMATION
(NORMALIZED IN BRACKETS)
78 OBSERVATIONS FROM 75Q3 TO 94Q4. MAXIMUM LAG IN VAR = 3

Variables	Vector 1	Vector 2
lnM	3.3386 (-1.0000)	-.97375 (-1.0000)
lnP	-3.4341 (1.0286)	.79370 (.81510)
lny	-4.3625 (1.3067)	1.7045 (1.7505)
lnr	.60336 (-.18072)	.44440 (.45638

Additional I(0) variable included in the VAR: lnS lnS(-1) lnS(-2) lnS(-3)

The adjustment matrix also provides persuasive evidence in support of this interpretation. Vector 1 of the adjustment matrix indicates that there is significant negative feed-back between monetary disequilibrium and the money stock. This accords with the hypothesized endogeneity of the money stock and with our theory of demand-centred money-market adjustment. The relatively small values of the other elements in Vector 1 of the adjustment matrix indicate that the first cointegrating vector does not enter the equations pertaining to these variables. When an ECM enters more than one equation, the parameters are cross-linked between the equations and weak exogeneity is violated. In such circumstances, OLS estimates of the parameters of the model would be inefficient (see Phillips and Loretan, 1991).

Table 4.4
Estimated Adjustment Matrix in Johansen Estimation
78 observations from 75Q3 to 94Q4. Maximum lag in VAR = 3

Variables	Vector 1	Vector 2
lnM	-.18485	-.046542
lnP	.013028	.0073871
lny	.062352	-.11696
lnr	-.034084	-.47715

We based the dynamic structure of our short-run equation on an error-correction model with contemporaneous and lagged conditioning variables (see Hendry, Pagan and Sargan (1984) and Miller, 1991). The ECM lagged one period and three lags of all other variables were included in the general error-correction model. All I(1) variables were entered as first differences and the I(0) variables were entered as levels.

Table 4.5 reports these estimates, together with Wald tests on the overall relevance of each variable, χ^2_W; and Lagrange Multiplier test statistics pertaining to residual serial correlation, χ^2_{SC}; Ramsay's RESET test of functional form, χ^2_{FF}; a test for normality, χ^2_N; and a test for heteroscedasticity, χ^2_H. The bracketed terms under the coefficients are standard errors. The square-bracketed terms next to test statistics are P-values. The Wald tests of zero restrictions on each variable's lag coefficients rejected the null hypothesis in every case except that of the lagged dependent variable. The Lagrangean multiplier tests accepted the null hypotheses of uncorrelated residuals, correct functional form, normality and homoscedastic errors. Hence, the model is an acceptable over-parameterised model of short-run money demand. The indicated overall insignificance of the lagged dependent variable is consistent with a demand-centred money market.

TABLE 4.5
GENERALIZED ERROR-CORRECTION MODEL: ORDINARY LEAST SQUARES ESTIMATION
DEPENDENT VARIABLE: ΔLNM
77 OBSERVATIONS USED FOR ESTIMATION FROM 75Q4 TO 94Q4

Lag	1	ECM	ΔlnM	ΔlnP	Δlny	Δlnr	ΔlnS
0	-3.2624			1.3089	.92509	.13807	-.13934
	(.62372)			(.41422)	(.16127)	(.047167)	(.057261)
1		-1.0328	.36496	-.20467	-.61280	.078380	-.0011922
		(.19746)	(.16401)	(.42080)	(.24746)	(.052359)	(.074484)
2			.21142	.20923	-.51232	-.063866	-.094058
			(.14214)	(.40545)	(.22385)	(.048749)	(.071812)
3			.20989	.57590	.21325	-.009380	.092666
			(.12112)	(.38589)	(.17917)	(.030626)	(.053423)
χ^2_w	27.3575	27.3575	5.4118	17.5132	56.6595	13.7201	17.5860
	[.000]	[.000]	[.144]	[.002]	[.000]	[.008]	[.001]

R^2= .64431 F(20, 56)= 5.0721[.000] DW= 2.1235

$\chi^2_{SC}(4) = 6.8735[.143]$ $\chi^2_{FF}(1) = .25394[.614]$ $\chi^2_N(2) = .2876E-3[1.00]$ $\chi^2_H(1) = .94336[.331]$

The next step in our analysis was the reduction of the model, by systematically eliminating redundant regressors. Our elimination procedure entailed the sequential exclusion of regressors, until all regressors were significant at about the one percent level. The results of the model so obtained are reported in equation 11.

$$\underset{}{\Delta \ln M} = \underset{(.33423)}{-2.0315} - \underset{(.10611)}{.64745ECM(-1)} + \underset{(.37719)}{1.2718\Delta \ln P} + \underset{(.13693)}{1.0900\Delta \ln y} + \underset{(.11030)}{.48572\Delta \ln y(-3)}$$
$$- \underset{(.031604)}{.13084\Delta \ln r} - \underset{(.02811)}{.09538 \ln S} \qquad (11)$$

$R^2 = .52843$ $F(6,70) = 13.0736[.000]$ $DW = 1.9329$

$\chi^2_{SC}(4) = 2.6107[.625]$ $\chi^2_{FF}(1) = 2.4325[.119]$ $\chi^2_N(2) = .49645[.780]$ $\chi^2_H(1) = .34327[.558]$

The model performs well on all tests. There is no indication of serial correlation, heteroscedasticity, skewness or kurtosis and the functional form has been well accepted. The coefficient of the error-correction mechanism indicates a high speed of adjustment of the actual to the desired money stock. We then conducted stability and predictive failure tests, using 1986:4 and 1990:4 as break points. Table 4.6 presents regression estimates and diagnostic statistics for the sub-period ending 1986:4 and 1990:4. For ease of comparison, estimates for the entire sample period are also included in the table.

TABLE 4.6
SUB-SAMPLE ESTIMATES OF REDUCED MODEL DEPENDENT VARIABLE: ΔLNM

Regressors	75Q4-86Q4	75Q4-90Q4	75Q4-94Q4
1	-1.8703 (.48055)	-1.9123 (.42023)	-2.0315 (.33423)
ECM(-1)	-.59703 (.1517)	-.61093 (.13289)	-.64745 (.10611)
ΔlnP	.94971 (.5584)	1.2595 (.49029)	1.2718 (.37719)
Δlny	1.0324 (.16792)	1.0630 (.15957)	1.0900 (.13693)
Δlny(-3)	.47277 (.13119)	.46747 (.12463)	.48572 (.11030)
Δlnr	-.053966 (.080887)	-.16675 (.056333)	-.13084 (.031604)
lnS	-.062187 (.06181)	-.10523 (.052802)	-.095380 (.02811)

75Q4-86Q4 R^2=.55819 F(6, 38)= 8.0016[.000] DW=1.9682

χ^2_{SC}(4)=3.9939[.407] χ^2_{FF} (1)=2.2608[.133] χ^2_{N}(2)=3.1818[.204]

χ^2_{H}(1)=.20025[.655]

F_{PF}(32, 38)=.86825[.656] F_{SS}(7, 63)=.28878[.956]

75Q4-90Q4 R^2= .49913 F(6, 54)=8.9687[.000] DW=2.0086

χ^2_{SC}((4)=3.0714[.546] χ^2_{FF}(1)=1.4899[.222] χ^2_{N}(2)=1.4243[.491]

χ^2_{H}(1)=.16854[681]

F_{PF}(16, 54)= .48063[.946] F_{SS}(7, 63)= .33735[.934]

The sub-samples produced results similar to the full-sample, with the exception of the interest rate variables in the shorter sub-sample. The two Chow tests provided no evidence of predictive failure or structural instability. Hence, we conclude that the reduced model is an acceptable specification of short-run money demand in Barbados.

As a further check on the validity of the model, we reformulated the model using the level of the money stock as the dependent variable and its lag as an additional regressor with no restrictions on its coefficient. The regression results for the modified error-correction model are presented in equation 12. The close correspondence between the results in equations 11 and 12 is indicative of the adequacy of the model's specification.

$$\begin{aligned} \ln M = & -1.9875 - .64345ECM(-1) + .99464\ln M(-1) + 1.2027D\ln P + 1.0726D\ln y \\ & (.34976) \quad (.10708) \quad (.011756) \quad (.40854) \quad (.14290) \\ & + .47691D\ln y(-3) - .12829D\ln r - .094256\ln S \\ & (.11261) \quad (.032274) \quad (.028379) \end{aligned} \tag{12}$$

$R^2 = .99188$ $F(7,69) = 1203.5[.000]$ Durbin's h-statistic $= .86855[.385]$

$\chi^2_{SC}(4) = 2.6235[.623]$ $\chi^2_{FF}(1) = 1.9237[.165]$ $\chi^2_{N}(2) = .47876[.787]$ $\chi^2_{H}(1) = .69925[.403]$

Satisfied as to the existence of a stable error-correction mechanism, we relaxed the restriction imposed by the ECM, by replacing it with the logarithms of the money stock (otherwise included in equation 12) and the arguments of the money demand function lagged one period. The results for this unrestricted error-correction model, with three lags in the VAR, are shown in Table 4.7. A Wald test accepted a zero restriction on the coefficient of lnM(-1). In the context of a generalized unrestricted error-correction model, this result implies virtually complete adjustment of the actual to the desired money stock within one quarter. However, our earlier findings indicated that the over-parameterised model had overestimated the speed of monetary adjustment. This has proven to be so in this case, because lnM(-1) became significantly positive, during the process of eliminating redundant variables from the model.

TABLE 4.7
GENERALIZED UNRESTRICTED MODELDEPENDENT VARIABLE: LNM
80 OBSERVATIONS USED FOR ESTIMATION FROM 75Q1 TO 94Q4

	0	(-1)	(-2)	(-3)	χ^2_W
1	-3.6242(.9658)				14.0 [.000]
lnP		1.1908(.22598)			27.77[.000]
lny		1.5389(.3041)			25.62[.000]
lnr		-.1503(.04628)			10.54[.001]
lnM		-.1666(.21595)			.5953[.440]
ΔlnM		.4815(.1825)	.2946(.1557)	.2721(.1327)	7.381 [.061]
ΔlnP	1.1164(.4389)	-.01175 (.4468)	.1033 (.4419)	.5248 (.4113)	9.472 [.050]
Δlny	1.0458(.2153)	-.5228 (.2698)	-.4549 (.2457)	.2798 (.2082)	43.33 [.000]
Δlnr	-.0967(.053615)	.06288 (.0564)	-.06598 (.0527)	.0081 (.0335)	7.089 [.131]
lnS	-.0859(.06744)	.00132(.0772)	-.0968(.07501)	1284(.0608)	8.401 [.078]

$\overline{R}^2$=.99196 F(23,56)=424.5576[.000] DW=2.2680

χ^2_{SC}(4)=10.0072[.040] χ^2_{FF}(1)=2.0321[.154] χ^2_N(2)=.10244[.950] χ^2_H(1)=.72668[.394]

Equation 13 reports estimates and diagnostic statistics pertaining to the fully data accepted model, together with the results of predictive failure and stability tests for a 1990:4 break-point.

$$\begin{aligned} lnM= &-1.1113+.44091lnM(-1)+.56964lnP(-1)+.65369lny(-1)-.051698lnr(-1) \\ &(.67225) \quad (.11410) \quad (.11822) \quad (.17516) \quad (.01789) \\ &+1.0590\Delta lnP+.95036\Delta lny+.38141\Delta lny(-3) \\ &(.43593) \quad (.15017) \quad (.11764) \end{aligned} \qquad (13)$$

$\overline{R}^2$=.99049 F(7,72)=1176.5[.000] DW=1.9274

χ^2_{SC}(4)=4.6626[.324] χ^2_{FF}(1)=.13797[.710 χ^2_N(2)=.16366[.921] χ^2_H(1)=.082813[.774]

F_{PF} (16,56)=.64636[.832] F_{SS} (8,64)=.62827[.751]

The results reported in equation 13 for the unrestricted ECM are consistent with and complementary to the restricted ECM estimates in equations 11 and 12. The latter provide explicit information on the speed of adjustment of the actual money stock to the desired money stock, and the former provides similar short-run information, together with information on the long-run money-demand coefficients.

Concluding Remarks

In general, our econometric findings accord fully with the theory of money in the Barbadian economy, outlined in Sections 1 and 2. The evidence supports the view that, in an equilibrium context, the arguments of the money demand function enter the money market as predetermined variables. In particular, the evidence accords with our hypothesis that money is not a determinant of the price level. Our results are consistent with an argument that the rate of interest and prices were not significantly influenced by monetary disequilibrium, during the period of our analysis. That is, the data supports the hypothesis that the Barbados money market is demand centred, with a high speed of adjustment of the actual to the desired money stock.

Hence, the policy inferences of our theoretical model are not contradicted by the evidence. We suggest that monetary policy should be dedicated to balance-of-payments management and should not be targeted at any of the arguments of the money-demand function. In particular, expansionary monetary measures should always be avoided, because disequilibrium in the Barbados money-market is corrected through a process in which the actual money stock gravitates towards the desired level with rapidity and without any significant money-demand response. Hence, the process of adjustment to excess money entails a balance of payments deficit.

Our specification of the money-demand function has been well accepted by the data. However, the focus of the study was not about choosing between fundamentally different formulation of the money-demand function. McClean (1982) hypothesized and found evidence for a second and positive interest rate effect on the demand for money, linked to the cost of illiquidity. This issue has not been addressed in this study. Our study may, therefore, be regarded as providing a point of departure for further investigation of the specification of the money demand function. It also points the way for research into price formation and interest rate determination.

Notes

1. GDP data for Barbados is published on an annual basis only. Coppin's quarterly series was obtained by applying one quarter of annual GDP to every quarter.

2. In the context of this model, income tax payable on the earned income is considered to be equivalent to a payroll tax on workers.

3. For a discussion of pricing policy in the distributive sector in Barbados, see McClean (1981).

4. For a similar approach to the modelling of the demand side of the labour market, see Sargeant (1979).

5. For similar reasons, a net-wage equation corresponding to equation 3 has not been included in our model.. Our purpose is to explicate monetary processes. The export and net-wage equations are not essential to this exercise. In the context of our model, the export equation may be stated as:

$$\frac{P_d}{P_a}x = y - s\left[y(1-\bar{\tau}),\frac{\varepsilon}{P_a},i-P_a^e\right]-\bar{g}+\frac{P_m}{P_a}m\left[y,\frac{\overline{P_d^*}}{\overline{P_m^*}}\right]$$

$$s_y, m_y, m_p > 0; s_\varepsilon, s_i < 0$$

6. Exogenous interest rates would convert the model into a fully recursive system. Whether interest rates in Barbados have been sufficiently regulated to render interest rates exogenous is an empirical issue.

7. Quarterly data on GDP are not available for Barbados. We, therefore, distributed annual, nominal GDP equally across the four quarters of the year. Given an almost monotonic increase in the price level, this procedure would generally result in higher levels of real income in the earlier quarters of the year. This accords fairly well with the Barbadian experience. Hence

we do not anticipate that errors in the measurement of quarterly GDP would have biased our regression estimates, significantly. However this is a matter that warrants further investigation.

8. The ratio was chosen in preference to the difference because the reported maximum and minimum interest rate on three-months deposits have occasionally been the same, and this would create problems for a model based on the logarithm of all variables. Since the focus of this study was not the identification of the best specification of the money-demand function, we did not investigate alternative specifications.

9. All computations in this study were done using Microfit. The critical values of various statistics reported in the study are those supplied by Microfit.

10. We started with a lag length of eight in the VAR and reduced the number until the last lag was accepted by the error-correction model.

BIBLIOGRAPHY

Coppin, A. (1991), "Another Look at the Demand For Money in Barbados," *Social and Economic Studies*, 40, 1-40.

Downes, A. S. and A. W. A. McClean (1982), "The Wage Determination Process in a Small Open Economy", (Department of Economics Discussion Paper) University of the West Indies, Cave Hill Campus, Barbados.

Engle, R. F. and C. W. J. Granger (1987), "Co-Integration and Error-Correction: Representation, Estimation and Testing," *Econometrica*, 55, 251-76.

Granger, C. W. J. (1986), "Developments in the Study of Cointegrated Economic Variables," *Oxford Bulletin of Economics and Statistics*, 48, 213-28.

Hendry, D.F. (ed.) (1986), "Econometric Modelling with Cointegrated Variables," Oxford Bulletin of Economics and Statistics, 48, (special issue).

Hendry, D.F., Pagan, A. R. and J. D. Sargan (1984), "Dynamic Specification,"Chapter 18 in Griliches, Z and M. D. Intriligator (eds.), *Handbook of Econometrics, Volume II.*, Amsterdam: North-Holland, 1023-1100.

Howard, M (1981), "The Demand for Money in the Trade-Oriented Economy of Barbados," *CSO Research Papers*, No. 11.

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control*, 12, 231-54.

McClean, A. W. A. (1981), "Pricing Policy in the Distributive Sector in Barbados," *Social and Economic Studies*, 20, 63-75.

McClean, A. W. A. (1982), " Some Evidence on the Demand for Money in a Small, Open Economy: Barbados," *Social and Economic Studies*, 31, 155-170.

McClean, A. W. A. (1994), "An Aggregative Market-Clearing Model of Small Open Economy", (Department of Economics Discussion Paper) University of the West Indies, Cave Hill Campus, Barbados.

Miller, S. M. (1991), "Monetary Dynamics: An Application of Cointegration and Error-correction Modelling," *Journal of Money, Banking and Credit*, 23, pp 139-54.

Phillips P. C. B and M. Loretan (1991), "Estimating Long-Run Economic Equilibria," *Review of Economic Studies*, 58, 407-36.

Sargent, T. S. (1979), *Macroeconomic Theory*, New York, Academic Press.

CHAPTER 5

A MODEL OF INFLATION IN BARBADOS

Cheryl Ann N. Cumberbatch

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The author would like to thank Dr. DeLisle Worrell for his stimulating comments

INTRODUCTION

Inflation may be defined as a sustained rise in the general level of the prices of goods and services in the economy. It is a dynamic phenomenon and is commonly measured by percentage changes in the retail price index (rpi).

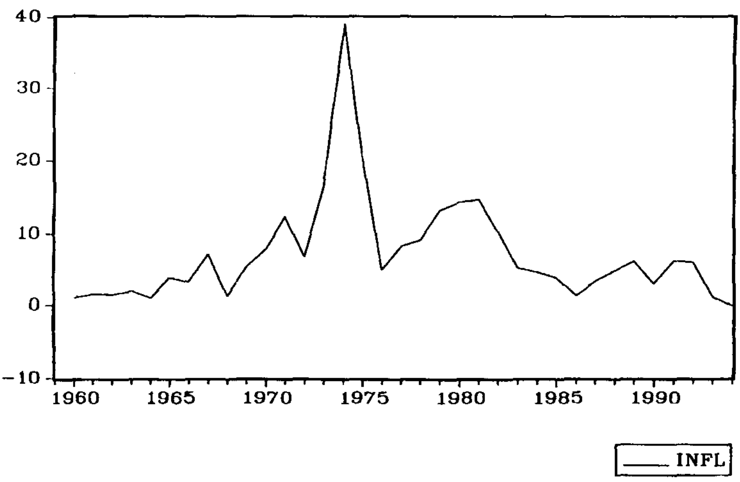
The main purpose of this paper is to empirically investigate the inflationary process in Barbados over the period 1961-1993 with a view to identifying a reliable model of inflation for this small open economy (SOE). It draws on recent thinking (with respect to inflation and econometric theory) and on insights from previous studies in order to identify variables which explain Barbados' historical inflation experience, and offer stability in terms of their predictive capability. The results should prove useful in improving forecasts of inflation in Barbados.

The paper comprises five main sections. Section 1 contains a brief descriptive history of inflation in Barbados, followed by a summary of the methodology and results of previous studies of inflation in Barbados and the Caribbean. Section 2 looks at the state of the art in the theory of inflation in open economies. Based on the insights gleaned from this section, the process of modelling inflation in Barbados is conducted in Section 3, with two alternative models being derived. Section 4 discusses the specification of the econometric test and of the data. Section 5 describes the empirical results in light of theoretical expectations as well as the satisfaction of statistical and econometric criteria.

BACKGROUND AND PREVIOUS STUDIES

Chart 5.1 plots the time path of the percentage change in the rpi from year to year (i.e. the annual inflation rate as represented by the variable infl) over the period 1960-1994. Inflation was recorded at a relatively steady rate of close to 1% during the early 1960s; from the mid-1960s the rate began to fluctuate; it rose to more than 10% in 1971 and by 1974, the annual inflation rate had reached a record high of almost 40%, shooting up sharply from a rate of less than 10% in 1972. Although this abated rapidly (and at a constant rate over the next two years) to a rate of approximately 5% in 1976, by 1981 the rate had increased again to just under 15%. Following this, the annual inflation rate declined and by 1986, for

CHART 5.1
CHANGES IN RETAIL PRICE INDEX



the first time since 1969, it fell below the 1% level. However, this rate was not maintained: it began to rise again with some fluctuation up until 1991, when the rate was just over 6%. Since then the rate of inflation in Barbados declined and, after only seven years, once again fell below 1% in 1994.

Over the last three decades or so, several well-documented studies have been conducted on the inflation and/or price formation process in the small open economies of the Caribbean. This sub-section summarizes the methodology and results of the more recent studies, particularly those for Barbados. This may enlighten us about possible explanatory variables for the purpose at hand.

The earliest studies for Barbados indicate that the main determinant of inflation is rising import prices, with other factors such as wage rate, interest rate and tax rate increases also contributing to the inflationary process. Downes (1985) conducted the first econometric investigation into the causes of inflation in Barbados. Operating on the premise that in a SOE excess aggregate demand tends to affect the balance of payments (BOP), rather than inflation, Downes (on p. 524) said that Barbados' inflationary process "...is fueled by cost-push and institutional factors more than by demand-pull factors" (such as increases in the money supply or credit expansion). He contended that although demand-pull factors may have some effect on inflation, where the ratio of non-tradables to tradables is high and in the absence of excess capacity, neither of these conditions holds for Barbados.

Downes divided the commodity market into transactions for tradables and for non-tradables. Treating the overall domestic price index as a weighted average of its components, he presented the following "cost-push" inflation model:

$$p_t = (pm_t, r_t, w_{t-i}, T_t, Q_t)$$
$$\quad\quad + \quad + \quad + \quad\quad + \quad +/-$$

where the percentage change of the variables at time t is given as p_t, domestic price level; pm_t, import price index; r_t, cost of credit; T_t, tax rates vector; Q_t, vector of other factors; and finally, w_{t-i}, wage rate (at time t-i, t =0,1...), since he believed that "... if wage increases have any impact on the inflation rate, this will occur with a lag that varies with the length of the contractual period" (p. 524).

Downes assumed that T_t and Q_t both exert positive influences on the inflation rate, so that "...their mean effect can be captured in a positive constant term" (p. 525) and specification error would be negligible. He undertook ordinary least squares (OLS) regression analysis for the period 1960-1977 to determine the quantitative effects of import price, interest rate, and current wage rate changes on the domestic inflation rate.

The current wage rate proved to be an insignificant variable at the 5% level with the wrong a priori sign. This result was consistent with Downes' belief that changes in the current wage rate do not significantly affect current price changes. However, introducing a lagged wage rate variable (w_{t-1}) did not change the results significantly, leading him to conclude that wage rate increases were not a critical factor in the inflationary process.

Even after removing the effects of wages, there were noticeable divergences between actual and predicted values of inflation for the periods 1965-68 and 1972-73. Therefore he used dummy variables to capture the events of these two periods - high inflation and devaluation in the first period , and drastic increases in oil and other commodity prices in the second - and obtained the following:

$$P_t = 1.06 + 0.64pm_t + 0.30r_t + 6.25D_t$$
$$(1.42) \quad (11.12) \quad (5.29) \quad (5.27)$$
$$\bar{R}^2 = 0.96 \quad DW = 1.88 \quad SEE = 2.19 \quad F = 95.14 \quad RMSE = 3.33 \quad U = 0.134$$

where D_t is a dummy variable set to 1 for 1967 (the year of the devaluation) and 1972-1974 (the years of increased oil and other commodity prices) and set to 0 for all other years in the study period.

The results indicate that, over the period 1960-1977, the main determinants of inflation in Barbados were increases in import prices and the prime lending rate, with some influence being exerted by institutional factors during 1967 and 1972-74. Therefore, both external and internal factors were found to affect inflation.

A little later the same year, Holder and Worrell (1985) presented a simultaneous equation model of price formation for SOEs which was used to analyze the relative impact of domestic factors on the price formation process in three Caribbean countries - Barbados, Jamaica and Trinidad and Tobago. This model was grounded in the division of the economy into tradable and non-tradable sectors, with the non-tradable sector forming the core (since it is here that domestic influences interact with external factors to determine domestic prices). The model consists of seven equations (and some identities). The first three equations form a simultaneous system and consist of two output equations (for the tradable and non-tradable sectors, respectively) and a price equation for the non-tradable sector. The remaining equations model the wage-determination process as well as the impact of disturbances to the banking system on interest costs (and by extension on prices).

Using annual data for 1963 to 1980, least squares regressions were run on a log-linear specification of the model, for each country. The simultaneous system of the output and price equations were run together using the two-stage least squares technique (2SLS), whilst the remaining recursive equations were estimated using OLS, and the Cochrane-Orcutt procedure in situations where serial correlation was not ruled out by the Durbin-Watson test.

Specifically for the case of Barbados the estimated price equation was given by:

$$LP_n = -0.72 - 0.6LQ_n + 1.55P_t - 0.03LS + 0.59Lr$$
$$(-0.98)\ (-0.54)\quad (8.05)\quad (-0.11)\quad (3.26)$$

$$\bar{R}^2 = 0.96 \quad DW = 1.07 \quad SEE = 0.16 \quad F(4, 16) = 92.03$$

P_n is the price of nontradables; Q_n is the output of nontradables; P_t is the (exogenous) price of tradables; S is the unit labour cost and r is the nominal interest rate

As expected, Holder and Worrell found that "foreign prices play a large direct role in domestic price formation ... contributing about one-third to domestic price formation in each of the three countries tested" (p. 420). Further, the cost of imported raw materials was found to be very significant in the determination of production costs in Barbados and Trinidad and Tobago. Exchange rate changes, trade protection and other domestic policies which influence the local price of traded goods were found to have a similar influence to that of foreign prices. But wages were found to be important only in Jamaica, whilst it was only in Barbados that increases in the interest rate were inflationary. Finally, exogenous increases in real income were not inflationary in any of the three countries.

Downes, Holder and Leon (DHL,1987b) extended the analysis of Downes (1985). Augmenting the set of explanatory variables considered, they utilized cointegration theory and the Error Correction Mechanism (in the form of Granger's Representation Theorem) to model an inflation relationship for Barbados. Their proposed 'long-run' theoretical relationship hypothesized that domestic prices, wages, labour productivity, unemployment and external prices define an 'equilibrium' sub-space. This relationship is consistent with previous studies [e.g. Downes (1985), Holder and Worrell (1985)], "*albeit* in a piecemeal context". However, DHL also argued that high levels of unemployment can weaken unions' bargaining power whilst supporting employers' resistance in the wage-determination process, so that the unemployment variable is representative of conditions in the labour market.

The 'long-run' results of Downes, Holder and Leon (1987a) and Holder, Leon and Wood (1987) indicated that the five series are integrable of order one with the possibility of drift terms. Based on these results, and noting that "the identified vector of variables will be co-integrated if the error term of a suitably normalized static regression is stationary" (p. 174), they assumed normalization on prices. Using annual Barbados data for the period 1958-1984, the 'long-run' static results were as follows:

$$\underset{}{lp} = \underset{(1.66)}{0.23} + \underset{(14.58)}{0.821w} - \underset{(7.94)}{0.58lprod} + \underset{(8.12)}{0.481pt} + \underset{(2.09)}{0.006ur}$$

$\bar{R}^2 = 0.998$ $SE = 0.034$ $DW = 1.094$ $DF(t) = -4.85$

(ACF)LAG 1-10: 0.027, -0.25, -0.158, -0.261, 0.062, 0.1, 0.032, -0.022, 0.105 *SE* = 0.192

where lp is the log of the retail price index; lw is the log of wages; lprod is the log of productivity, defined as the real GDP per person employed; lpt is the log of the price of the tradables (i.e.sugar, other agriculture, tourism and manufacturing); and ur is the unemployment rate.

These results confirmed that the five variables constitute a co-integrated set and, using instrumental variables to allow for the simultaneity in wages and productivity, an error correction equation was estimated for the period 1960-1984:

$$dp = -0.005 + 0.65dw - 0.52dprod + 0.25dpt + 0.21dpm$$
$$(0.33)\quad (4.81)\quad (5.35)\quad (4.64)\quad (3.05)$$
$$+ 0.04dur + 0.19dp(-1) - 0.83ec(-1)$$
$$(1.74)\quad (2.51)\quad (5.61)$$

$\bar{R}^2 = 0.91$ $SER = 0.22$ $DW = 2.30$ $RMSE = 0.018$
RESET [F(3,21)] = 1.01 *CHOW* [F(2,15)] = 0.17
INVR [$X^2(7)$] = 7.00 *NRM* [$X^2(2)$] = 0.33
SC [$X^2(1)$] = 2.0 *SCNL* [$X^2(1)$] = 0.46

where 'd' represents the first difference of the previously defined variables; dpm is the first difference of the log of import prices; and **ec** is the residual from the long-run estimated equation.

Consistent with Downes, Holder and Leon (1987a) the results indicate that wages, productivity, unemployment, the price of tradables and import prices are significant explanatory variables of the inflationary process in Barbados.

More recently, Downes, Scantlebury-Maynard and Worrell (1992) used co-integration techniques on annual data to conduct an econometric analysis of the inflationary experiences in Barbados, Jamaica and Trinidad and Tobago over the 1970-1991 period. They put forward an "encompassing model" of inflation for the three countries which incorporates most of the variables from previous specifications for Barbados and Jamaica, respectively. This model is as follows:

$$\dot{P} = P(\underset{+}{\dot{ER}}, \underset{+}{\dot{USP}}, \underset{+}{\dot{M}^s}, \underset{+}{\dot{R}}, \underset{+}{\dot{WR}}, \underset{-}{\dot{PROD}}, \underset{+/-}{\dot{S}})$$

where $\dot{p}$ is the rate of domestic inflation, ER is the domestic currency per US exchange rate; USP is US dollar prices; M^s is the actual money supply; R is the cost of holding money; $\dot{WR}$ is the change in the domestic wage rate; $PR\dot{O}D$ is the change in the rate of output per worker or index of productivity; and s is a vector of factors that cause domestic inflation to deviate from purchasing power parity. The change in the price of imports can be taken as the product of ER and USP.

Using the MICROFIT regression package, OLS was used to estimate the static 'long-run' or co-integrating price equations for Barbados, while the 'short-run' dynamic inflation equation was estimated using the generalized instrumental variable estimator (GIVE). The Dickey Fuller (DF) and Augmented Dickey Fuller (ADF) test statistics indicated that narrow money supply (M1), the exchange rate (ER), the USA price level (USP), the nominal wage rate index (WR), labour productivity (PROD), and the retail price index (P), are co-integrated. The estimated 'short-run' equation was:

$$\begin{aligned} dlp = & \underset{(-1.17)}{-0.04} + \underset{(5.73)}{2.84dlxr} + \underset{(1.81)}{0.75dlusp} + \underset{(3.41)}{0.76dlr} - \underset{(-1.82)}{0.50dlprod} \\ & + \underset{(2.02)}{0.23dlp(-1)} - \underset{(-3.40)}{0.84ec(-1)} \end{aligned}$$

$\bar{R}^2 = 0.88$ $F(6, 13) = 23.81$ SER = 0.02 DW = 1.16
$SC(X_1^2) = 0.39$ $SAR(X_1^2) = 3.29$ RMSE = 0.02

This equation was favoured in a model selection exercise over one which included changes in money supply and the lagged error term from a co-integrating equation with LM1, LXR, LUSP, LWR and LPROD; for Barbados, but not for Jamaica or Trinidad & Tobago, the M1 variable could be dropped from the equation without the result changing significantly. The authors concluded that there is a "negligible or non-existent" monetary policy effect in Barbados, consistent with the results of Downes et al (1987). Generally, the results supported those of previous studies, which have indicated that inflation in Barbados is largely a cost-push phenomenon with significant import influences.

Coppin (1993) used quarterly data (something previous studies were unable to do due to incomplete data sets) to examine the determinants of inflation in the "tourism-dependent economy" of Barbados during the 1980s - a period when imported inflation did not seem to be the proximate cause of inflation in Barbados. He suggested that the economic contraction experienced in 1990 (when the vital foreign exchange earning tourism sector contracted by 9.8%) may have contributed to the low inflation observed that year.

Coppin argued *inter alia* that demand-side factors, such as the level of real tourism activity, should be included in the inflation determination equation for the Barbados economy. Although real quarterly GDP statistics do not exist, he argued that to the extent that the tourism sector drives the domestic economy, the available quarterly tourism data may serve as a useful proxy for output in a two-sector Scandanavian Model of inflation (described later). Increased levels of economic activity resulting from increased tourism output exert upward pressure on prices, particularly in the non-traded goods sector. Based on this, he tested several variants of the model due to Downes (1985), augmented by proxied real output as a regressor variable:

$$p = f(\underset{+}{lny}, \underset{+}{p^*}, u, \underset{+}{r}, \underset{+}{t})$$

where p is the percentage (quarterly) change in the consumer price index, lny is the log of output (proxied by the log of real tourism activity), p^* is the percentage (quarterly) change in the index of import prices, u is the rate of unemployment, r is the interest rate (proxied by the average lending rate), and t is the change in tax rate (proxied by the consumption tax rate). By including u in some specifications, he allowed the data to determine the superiority between output and unemployment (alternative variables in the short-run Phillips Curve model). All models tested included quarterly dummy variables to capture seasonality in the rate of price formation, where Q_i is a 0-1 dummy variable for quarter i.

Of the five variants tested, one model outperformed the others:

$$p = -11.69 + 0.041 lny + 0.09p^* + 0.24r + 3.6Q_2 + 2.4Q_3 + 1.40Q_4$$
$$(-4.30) \quad (4.13) \quad (2.33) \quad (2.22) \quad (5.76) \quad (4.87) \quad (2.83)$$

$\bar{R}^2 = 0.60$ DW = 2.22 F = 8.58

According to this model, inflation in Barbados is determined by both demand-side and supply-side factors, with seasonal patterns, suggesting that domestic prices may have been impacted by institutional processes associated with the government's annual budget. Consistent with the results of Downes (1985), the tax rate was found to be statistically insignificant when added.

In summary, despite the varied methodologies and combinations of explanatory variables in the previous studies of inflation conducted in the region, there is some common ground. These studies all point to the significant contribution of rising import prices to inflation in Barbados, with the econometric techniques utilized in the later studies serving to underline the importance of this variable. Although the earlier studies seem to rule out wages, those studies that followed suggest that the wage rate could be a significant explanatory variable of the inflation process in Barbados. Productivity and real output were also credited with some significance. However, the results with respect to interest rates are varied and tax rates have been ruled out in all the quantitative studies where considered.

THEORETICAL BACKGROUND

There is no general theory of inflation which accurately describes the inflationary process in all countries and fully satisfies the needs of policy-makers. The varied choices of explanatory variables and approaches in the previous sub-section bear testimony to the existence of several different schools of thought (including the demand-pull, cost-push and structuralist schools - see Frisch (1977), Gordon (1985), and Laidler and Parkin (1975)). However, we are guided by an interest in theory which addresses the SOE specifically.

The "Theory of Imported Inflation" (a variant of the structuralist explanation) is perhaps the most recent such theory - see Aukrust (1977), Frisch (1977) and Lindbeck (1979). It contends that a high degree of external reliance, either in the form of technology and/or imports, results in external pressures on prices which are reflected in the domestic price level. The 'Scandanavian Model' (see Frisch and Lindbeck) is structured so that inflation is mainly imported. International price increases are said to be transmitted via rising import and export prices in the tradable sector, which then spread to the non-tradable or sheltered side of the economy. The line of causation is as follows: more rapidly rising prices for tradable goods result in higher profits in the tradable sector. This leads to faster rising nominal wage rates in this sector and, through a demonstration effect, in the non-tradable sector as well. Finally, rising marginal and average labour costs for the production of non-tradables result in more rapidly rising prices for non-tradables.

MODELLING INFLATION IN BARBADOS

The Scandanavian Model provides a desirable point of departure for the purpose at hand. Having been developed specifically to address SOEs, it recognizes the special characteristics of such economies, including their high levels of foreign trade, their "price-taking" behaviour in the world market, and their endogenous money stocks. The model captures many of the important features of the Barbadian economy and, unlike other approaches, it specifically addresses the phenomenon of imported inflation which seems so characteristic of Barbados.

The Scandanavian Model recognizes that price impulses from abroad may affect sectors differently, depending on their links with the international market. Consequently, the model starts with a division of the economy into two sectors. Industries in the tradable (exposed) sector produce commodities that compete on the world market whilst industries in the non-tradable (sheltered) sector produce commodities that are not traded internationally.

Output prices of the tradable sector are largely determined on the world market, and this means that the upward adjustment of prices cannot be used to compensate for cost increases - which must therefore be entirely absorbed through reduced profits or reduced production. On the other hand, industries in the non-tradable sector do not face the risk of losing their market share to foreign competitors, and therefore they tend to compensate for increased costs by raising output prices.

Industries in the two sectors also differ in terms of their technological attributes. Productivity (i.e. output per worker) tends to increase more rapidly in the tradable sector, where industries are typically capital-intensive and mass-producing, than within the non-tradable sector, where service industries weigh heavily.

For a fixed exchange rate economy, the model links the tradable sector with the world economy by assuming that the rate of inflation in this sector ($\dot{P}_T$) is equal to the (exogenously) given rate of world inflation ($\dot{P}_W$), so that:

$$\dot{P}_T = \dot{P}_W \tag{1}$$

Constant factor income shares are assumed to prevail in the tradable sector. Increases in the tradable sector money wage are given by the sum of this sector's inflation rate ($\dot{P}_T$) and its rate of labour productivity , ($\dot{\lambda}_T$) so that:

$$\dot{w}_T = \dot{P}_T + \dot{\lambda}_T \tag{2}$$

There is either a homogenous labour market or a 'solidaristic' wage policy by unions between the sectors, so that wages increase at the same rate in both sectors:

$$\dot{w}_N = \dot{w}_T = \dot{w} \tag{3}$$

The model also assumes a higher rate of growth of productivity (λ) in the tradable sector than in the non-tradable sector (with both being exogenously given):

$$\dot{\lambda}_T \succ \dot{\lambda}_N \tag{4}$$

The pricing behaviour of firms in the non-tradable sector differs from that of firms in the tradable sector. They are not price-takers; instead they engage in 'mark-up' pricing to achieve a constant profit mark-up over unit labour costs. Prices in the non-tradable sector increase at the same rate as unit labour costs, that is, a rate equal to the difference between wage increases and increases in labour productivity:

$$\dot{P}_N = \dot{w}_N - \dot{\lambda}_N \tag{5a}$$

and substituting (3) and then (2) into this equation we get:

$$\dot{p}_N = \dot{p}_w + \dot{\lambda}_T - \dot{\lambda}_N \tag{5b}$$

The general level of prices in the economy would be a weighted average of the prices in both sectors. In this model, the price index is assumed to have constant weights that express sector shares for output so that the domestic rate of inflation is given as:

$$\dot{p} = \alpha\dot{p}_T + (1-\alpha)\dot{p}_N \tag{6a}$$

Substituting for $\dot{p}_N$ as in (5a) we obtain:

$$\dot{p} = \alpha\dot{p}_T + (1-\alpha)\left(\dot{w}_N - \dot{\lambda}_N\right)$$

and through a series of further substitutions we get:

$$\dot{p} = \dot{p}_w + (1-\alpha)\left(\dot{\lambda}_T - \dot{\lambda}_N\right) \tag{6b}$$

This equation expresses the main message of the Scandanavian Model i.e. under fixed exchange rates and in the long run, the domestic rate of inflation in a SOE is fully determined by price trends in the world market (through direct and indirect linkages to international trade) and productivity trends in the tradable and non-tradable sectors. This may be summarized as:

$$\dot{p} = f\left(\dot{p}_w, \dot{\lambda}_T, \dot{\lambda}_N\right) \tag{6c}$$

It is important to note that in this model, demand has little direct influence on commodity prices. These are determined by the world market or costs (through mark-up pricing), although demand plays an important role in the labour market and, by affecting wages, influences prices indirectly.

The results of previous studies for Barbados are consistent with the Scandanavian Model. However, equation 5a is an extreme simplification. Prices are not only determined by (unit) labour cost; other supply conditions along with demand conditions also figure in the determination of prices in the non-tradable sector. Holder and Worrell (1985) argued that most activities in the non-traded sector are dominated by a few large firms exercising market leadership and "...the market may best be seen through the eyes of decision-makers in the dominant firms" (p.415). This contrasts with the Scandanavian Model's assumption of competitive firms in both the tradable and non-tradable sectors. The expected demand for their product (q_N*) as perceived by non-tradable suppliers, is based on real national income (y), the relative prices of the tradable sector and non-tradable sector goods (p_T / p_N), and the cost of consumer credit (r). From this we may derive the following demand function for our purposes:

$$\dot{q}_N^* = \alpha_0 + \alpha_1 \dot{y} + \alpha_2 (\dot{p}_T - \dot{p}_N) + \alpha_3 r \tag{7}$$

Supply is then determined by producers. They plan a level of output (q_N) which raises the previous year's production by a proportion of the difference between the current expected demand (q_N*) and last year's output (q_{N-1}). This may be expressed as follows:

$$\dot{q}_N = \dot{q}_{N-1} + v\left(\dot{q}_N^* - \dot{q}_{n-1}\right) \tag{8}$$

The price of this output (p_N) is determined by the producers, who set it on the basis of the cost of producing an amount equal to q_N so that:

$$\dot{p}_N = \beta_0 + \beta_1 \dot{q}_N + \beta_2 \left(\dot{w} - \dot{\lambda}_N\right) + \beta_3 r + \beta_4 \dot{p}_T \quad (9a)$$

This equation is a more realistic version of equation 5b; it includes interest costs and a capacity variable (q_N), in addition to the unit labour cost and the inflation rate in the tradable sector.

Combining the demand and supply of non-tradables (using (7), (8) and (9)) gives:

$$\dot{p}_N = a_0 + a_1 \dot{q}_{N-1} + a_2 \dot{y} + a_3 \dot{p}_T + a_4 r + a_5 \left(\dot{w} - \dot{\lambda}\right) \quad (9b)$$

where

$$a_0 = (\beta_0 + \alpha_0 \beta_1 v)/(1 + \alpha_2 \beta_1 v); a_1 = \beta_1 (1 - v)/(1 + \alpha_2 \beta_1 v); \; a_2 = a_1 \beta_1 v/(1 + \alpha_2 \beta_1 v);$$
$$a_3 = (\alpha_2 \beta_1 v + \beta_3)/(1 + \alpha_2 \beta_1 v); \; a_4 = \alpha_3 \beta_1 v + \beta_4/(1 + \alpha_2 \beta_1 v); \; a_5 = \beta_2 \mu/(1 + \alpha_2 \beta_1 v)$$

Finally, substituting for $\dot{p}_N$ as in (9b) into (6a) and substituting for $\dot{p}_T$ as in (1) we get:

$$\dot{p} = \alpha \dot{p}_W + (1 - \alpha)\left[a_0 + a_1 \dot{q}_{N-1} + a_2 \dot{y} + a_3 \dot{p}_T + a_4 r + a_5 \left(\dot{w} - \dot{\lambda}\right)\right] \quad (10)$$

This gives us our preferred test equation, Model 1:

$$\dot{p} = f\Big(\underset{+}{\dot{p}_W}, \underset{+}{\dot{q}_{N-1}}, \underset{+}{\dot{y}}, \underset{+}{r}, \underset{+}{\dot{w} - \dot{\lambda}}\Big)$$

The model may be carried one step further to incorporate the influence of import duties and other direct taxes into equation 1 such that:

$$\dot{p}_T = \dot{p}_W + \gamma \dot{t}, \quad 0 < \gamma < 1 \quad (1b)$$

and this will give us an extended test equation, Model 2:

$$\dot{p} = f\left(\underset{+}{\dot{p}_W}, \underset{+}{\dot{q}_{N-1}}, \underset{+}{\dot{y}}, \underset{+}{r}, \underset{+}{\dot{w} - \dot{\lambda}}, \underset{+}{\dot{t}}\right)$$

ECONOMETRIC AND DATA SPECIFICATION

This study uses annual figures for the period 1961-1993 obtained from the Central Bank's data base, most of which appears in the Bank's *Annual Statistical Digest.* The change in (first difference of) the log (as denoted by CL) was used as representative of the rate of change for each variable in the two equations, except the cost of consumer credit variable, which enters both equations as its level. The following data specifications have been used: the general level of prices (p) is proxied by the annually averaged retail price index (RPI) based on 1980 prices. The series used was a product of splicing since in October 1979 the Central Bank replaced its old index with a base of October 1965 by a new index with a base of March 1980. Data prior to the time of change were obtained by multiplying all items of the old index by the ratio:

$$\frac{\text{October 1979 (New Index)}}{\text{October 1979 (Old Index)}}$$

The world price level (p_W) is proxied by the CIF import price index for Barbados (BPM). Output in the non-tradable sector in the previous time period (q_{N-1}) is the value of the non-tradables proportion of real gross domestic product (GDP) at factor cost and 1974 prices at that time (denoted by QN1). Real national income (y) is proxied by the annual estimates of real GDP at factor cost and 1974 prices (and is denoted by RY). This is consistent with convention and, though limited, is the best measure available, since data are not collected on income for Barbados. The annual average of quarterly data regarding the commercial bank prime rate on loans (denoted by R) is used to represent the cost of consumer credit (r).

The wage level (w) is the wages index with base year 1980, whilst the level of productivity (λ) has been calculated by dividing real GDP at factor cost and constant 1974 prices (i.e. RY), by the level of employment. These were then combined in a measure of the unit labour cost (as denoted by ULC).

EMPIRICAL RESULTS

Ordinary Least Squares (OLS) was used to estimate all equations in this study and the "general to specific" modelling approach (associated with Hendry, 1980, and others) was adopted. This approach assumes that the unknown data-generating process can be approximated using a finite-dimensional error correction model (ECM), under hypotheses of linearity, conditional normality and time homogeneity.

First, the stationarity properties of the series of interest were tested using the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) Tests (see Table 5.1). The results indicate that all the series may be described as integrated of order 1, i.e. I(1), except for CLTAX, which appears to be I(0).

The next step taken was to test Model 1 for co-integration (see Table 5.2 for the results). There was no need to test Model 2 for co-integration since, based on the results from the tests of integration order, it does not satisfy one of the necessary conditions for co-integration; "if there is more than one explanatory variable, the order of integration of the dependent variable cannot be higher than that of any of the explanatory variables" (see Charemza and Deadman, 1992, p. 149). The results from the ADF test (at the 5% level of significance) indicate that Model 1 contains a set of variables that are co-integrated and therefore form a long-run equilibrium relationship. Thus, despite the fact that none of the respective series in this model is stationary, there exist fundamental eco-

TABLE 5.1
TESTING FOR UNIT ROOTS

Variables	DF Statistics	ADF Statistics
CLRPI	-2.6121 (-3.5562)	-2.8503 (-3.5615)
C2LRPI	-5.4249 (-3.5615)	-6.0536 (-3.5671)
CLBPM	-3.9530 (-3.5562)	-2.9660 (-3.5615)
C2LBPM	-7.6068 (-3.5615)	-7.9818 (-3.5671)
CLULC	-5.9554 (-3.5562)	-3.4455 (-3.5615)
C2LULC	-12.7648 (-3.5615)	-6.1574 (-3.5671)
R	-3.9326 (-3.5562)	-3.5857 (-3.5615)
CR	-6.6811 (-3.5615)	-4.1942 (-3.5671)
CLQN1	-5.6371 (-3.5615)	-2.3921 (-3.5671)
C2LQN1	-12.8538 (-3.5671)	-4.3525 (-3.5731)
CLRY	-4.5291 (-3.5615)	-2.8018 (-3.5671)
C2LRY	-9.0700 (-3.5671)	-4.7657 (-3.5731)
CLTAX	-8.7814 (-3.5615)	-5.1225 (-3.5671)

95% critical values in brackets

Note: C ... The respective variable has been differenced once.
C2 ... The respective variable has been differenced twice.

TABLE 5.2
COINTEGRATING RESULTS

Model	CON	CLBPM	CLULC	R	CLQN1	CLRY	R^2	DW	DF	ADF
(i)	-0.08	0.48	0.45	0.01	0.21	-0.09	0.60	1.85	-5.101	-5.311

Note: 95% critical values

nomic forces which result in the variables moving stochastically over time.

Finally, an unrestricted ECM (consistent with the general model proposed by Engle and Granger, (1987)) was derived from Model 1 and estimated. The model was then re-parameterized by dropping insignificant variables and, in addition to the standard diagnostic tests, its within-sample forecasting performance was tested by ignoring the last two observation years. (See Table 5.3 for the results, Chart 5.2 for the fit of the model, and Chart 5.3 for the forecast fit.)

In terms of the a priori economic expectations the only discrepancy is the fact that the coefficient on CLQN1 appears to be zero. This may be a result of high collinearity between that variable and CLRY. All other variables are significant and the signs are as expected. The adjusted goodness of fit measure (see Table 5.3) is quite good considering that the model is in difference form. The various diagnostic tests indicate no significant serial correlation, non-normality, heteroscedasticity, or non-linearity. In terms of the within-sample analysis of the model, constancy of parameters is indicated and the forecast fit for the model is picking up the movements of the data fairly well.

The restricted ECM (derived from Model 1) succeeded in explaining about 76% of the variance in inflation, with import prices and unit labour costs having roughly equal impact: a 3% hike in the rate of domestic inflation for every 10% increase in the rate of import price inflation. There are also strong influences from one year to the next, consistent with the results of Downes, Scantlebury-Maynard and Worrell (1992), which showed previous inflation rates to be significant (p. 9). Unit labour costs, the consumer credit rate and

Table 5.3
ECM Results

Unrestricted ECM - 1964-1993

$$C2LRPI = \underset{(0.249)}{0.002} + \underset{(3.972)}{0.339}C2LBPM + \underset{(1.691)}{0.286}C2LULC + \underset{(1.951)}{0.009}CR - \underset{(-0.437)}{0.127}C2QN1$$

$$+ \underset{(0.329)}{0.093}C2LRY + \underset{(0.134)}{0.016}C2LBPM(-1) - \underset{(-0.266)}{0.040}C2LULC(-1) + \underset{(0.066)}{0.0004}CR(-1)$$

$$- \underset{(-0.735)}{0.214}C2LQN1(-1) + \underset{(1.490)}{0.452}C2LRY(-1) + \underset{(2.002)}{0.379}C2LRPI(-1) - \underset{(-1.380)}{0.202}C2LRPI(-2)$$

$$- \underset{(-2.497)}{0.715}ERR(-1)$$

$\bar{R}^2 = 0.688$ DW = 1.711 LMSC[$\chi^2(1)$] = 1.456

RESET[$\chi^2(1)$] = 0.493 NORM[$\chi^2(2)$] = 1.754 ARCH[$\chi^2(1)$] = 0.835

Restricted ECM - 1964-1993

$$C2LRPI = \underset{(0.319)}{0.002} + \underset{(5.193)}{0.348}C2LBPM + \underset{(3.178)}{0.277}C2LULC + \underset{(2.447)}{0.008}CR + \underset{(2.322)}{0.338}C2LRY(-1)$$

$$+ \underset{(3.689)}{0.416}C2LRPI(-1) - \underset{(-1.747)}{0.205}C2LRPI(-2) - \underset{(-4.006)}{0.755}ERR(-1)$$

$\bar{R}^2 = 0.761$ DW = 1.733 LMSC[$\chi^2(1)$] = 1.139
RESET[$\chi^2(1)$] = 0.507 NORM[$\chi^2(2)$] = 2.189 ARCH[$\chi^2(1)$] = 1.062

CHOW[$\chi^2(2)$] = 0.090 S.E. = 0.030 RMSE = 0.006

Restricted ECM - 1964-1991

$$C2LRPI = \underset{(0.255)}{0.002} + \underset{(4.963)}{0.349}C2LBPM + \underset{(3.024)}{0.278}C2LULC + \underset{(1.905)}{0.008}CR + \underset{(2.197)}{0.337}C2LRY(-1)$$

$$+ \underset{(3.441)}{0.420}C2LRPI(-1) - \underset{(-1.569)}{0.204}C2LRPI(-2) - \underset{(-3.172)}{0.769}ERR(-1)$$

$\bar{R}^2 = 0.751$ DW = 1.691 LMSC[$\chi^2(1)$] = 1.176

RESET[$\chi^2(1)$] = 0.527 NORM[$\chi^2(2)$] = 1.599 ARCH[$\chi^2(1)$] = 0.876

Notes:
1. $\bar{R}^2$: R bar squared statistic
2. DW : Durbin Watson test statistic for serial correlation
3. LMSC[$\chi^2(1)$] : Lagrange Multiplier test of residual serial correlation
4. RESET[$\chi^2(1)$] : Ramsay's RESET test of general specification error
5. NORM[$\chi^2(2)$] : Jarque-Bera test statistic for normality
6. ARCH[$\chi^2(1)$] : Auto Regressive Conditional Heteroscedasticity test
7. CHOW[$\chi^2(2)$] : Chow's predictive failure test
8. S.E : Standard Error of the regression
9. RMSE : Root Mean Squared Error

CHART 5.2
ACTUAL AND FITTED VALUES OF CHANGES IN INFLATION

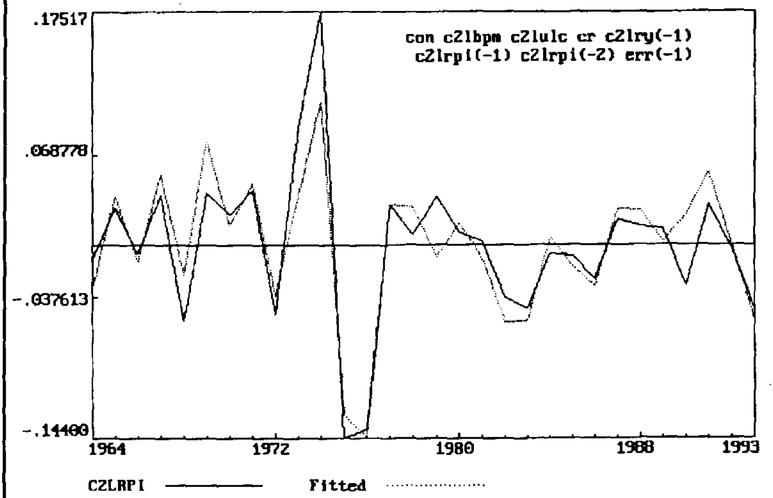
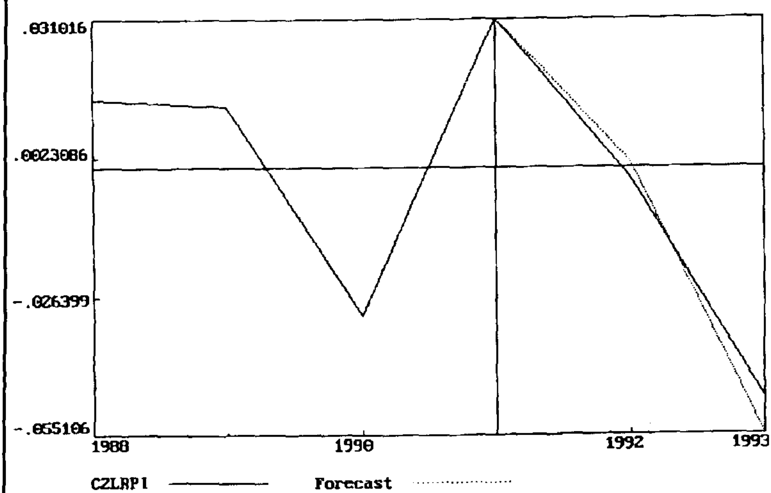


CHART 5.3
ACTUAL AND DYNAMIC FORECASTS OF CHANGES IN INFLATION



real national income prove useful in explaining inflation in Barbados.

CONCLUSION

This study incorporates important structural features of SOEs: the difference in inflation dynamics in the tradable and non-tradable sectors despite the link of a common nominal wage in both sectors. Prices may differ because of productivity differentials and sluggish price adjustments to clear non-tradable markets, among other factors. There are also strong influences from one year to the next. Further, there is some indication that movements in unit labour costs, the consumer credit rate and real national income play a significant role in the determination of inflation in Barbados.

REFERENCES

Aukrust, Odd (1977), "Inflation in the Open Economy: A Norwegian Model", in *Worldwide Inflation: Theory and Recent Experience,"* (Ed.) Krause, L.B. & Salant, W.S., Brookings, 107-166.

Bourne, Compton, ed. (1977), *Inflation in the Caribbean*, Mona, Jamaica: University of the West Indies, Institute of Social and Economic Research.

Charemza, W. and Deadman, D. (1992), *New Directions in Econometric Practice,* University of Leicester.

Coppin, A. (1993), "Recent Evidence on the Determinants of Inflation in a Tourism-Oriented Economy: Barbados," *Social and Economic Studies,* 42: 2 & 3, 65-80.

Craigwell, R. (1991), "Wages and Prices: What Causes What?" *Social and Economic Studies,* 40:1, 93-103.

Downes, A. (1985), "Inflation in Barbados: An Econometric Investigation," *Economic Development and Cultural Change,* 33:3, 521-532.

Downes, A., Holder, C. and Leon, H. (1987a), "A Model of Output, Wages, Prices and Productivity in Barbados," *Central Bank of Barbados Working Papers,* 143-152.

____________________ (1987b), "Inflation in Barbados: A Co-integration Approach," *Central Bank of Barbados Working Papers,* pp. 173-177.

Downes, A., Holder, C. and Leon, H. (1990), "The Wage-Price-Productivity Relationship in a Small Developing Country: The Case of Barbados," *Social and Economic Studies*, 39:2, 49-77.

Downes, A., Scantlebury-Maynard, A. and Worrell, K. (1992), "Macroeconomic Adjustment and the Inflation Experience of CARICOM Countries," presented at the XXIX Meeting of Technicians of Central Banks of the American Continent (CEMLA), Nov. 16-20, 1992.

Engle, Robert F. & Granger, W.J. (1987), "Co-integration and Error Correction: Representation, Estimation and Testing," *Econometrica*, March 1987, 55:2, 251-257.

Frisch, H. (1977), "Inflation Theory 1963-1975: A `Second Generation' Survey," *Journal of Economic Literature*, Dec. 1977, 15:4, 1289-1317.

Gordon, Robert, J. (1985), "Understanding Inflation in the 1980s," *Brookings Papers on Economic Activity* 1: 1987, The Brookings Institution, 263-302.

Hendry, D.F. (1980), "Predictive Failure and Econometric Modelling in Macroeconomics: The Transactions Demand for Money," in *Modelling the Economy* (Ed.) P. Omerod, Heinemann, London.

Holder, C. and Worrell, D. (1985), "A Model of Price Formation for Small Open Economies: Three Caribbean Examples," *Journal of Development Economics*, 18:2-3, 411-428.

Holder, C., Leon, H.L. and Wood, C.J. (1987), "Testing for Non-Stationarities in Macroeconomic Time Series," Central Bank of Barbados (mimeo).

Koutsoyiannis, A. (1977), *Theory of Econometrics: An Introductory Exposition of Econometric Methods*. 2nd Ed., English Language Book Society/Macmillan.

Laidler, D.E.W. & Parkin, J.M. (1975), "Inflation - A Survey," *The Economic Journal*, 85, Dec., 741-809.

Lindbeck, A., ed. (1979), "Inflation and Employment in Open Economies," *Studies in International Economics*, North Holland.

Parkin, Michael and Zis, George, eds. (1976), *Inflation in Open Economies*, Manchester University Press.

Scantlebury-Maynard, A. and Worrell, K. (1994), "An Empirical Note on Inflation in Trinidad and Tobago 1965-1992," Economics and Programming Department, Caribbean Development Bank.

Whitehall, P. (1988), "Inflation in the Open Economy: the Case of Barbados," *Central Bank of Barbados Working Papers*, 252-260.

APPENDIX 5.A1

Derivation of Equation (9b)

The derivation of the coefficients of Equation (**9b**) is as follows:

$$\dot{p}_N = \beta_0 + \beta_1 \dot{q}_N + \beta_2\left(\dot{w} - \dot{\lambda}_N\right) + \beta_3 r + \beta_4 \dot{p}_T \qquad (9a)$$

Substituting for q_N^* as in (7) into (8) we get:

$$\begin{aligned} \dot{q}_N &= \dot{q}_{N-1} + v\left[\alpha_0 + \alpha_1 \dot{y} + \alpha_2\left(\dot{p}_T - \dot{p}_N\right) + \alpha_3 r - \dot{q}_{N-1}\right] \\ &= (1-v)\dot{q}_{N-1} + v\left[\alpha_0 + \alpha_1 \dot{y} + \alpha_2\left(\dot{p}_T - \dot{p}_N\right) + \alpha_3 r\right] \end{aligned} \qquad (8b)$$

Substituting for $\mathbf{q}_N$ as in (**8b**) into (**9a**) we get:

$$\dot{p}_N = \beta_0 + \beta_1\left\{(1-v)\dot{q}_{N-1} + v\left[\alpha_0 + \alpha_1 \dot{y} + \alpha_2\left(\dot{p}_T - \dot{p}_N\right) + \alpha_3 r\right]\right\}$$
$$+\beta_2\left(\dot{w} - \dot{\lambda}_N\right) + \beta_3 r + \beta_4 \dot{p}_T$$

Grouping like terms we get:

$$(1+\alpha_2\beta_1 v)\dot{p}_N = (\beta_0 + \alpha_0\beta_1 v) + \beta_1(1-v)\dot{q}_{N-1} + \alpha_1\beta_1 v\dot{y} + (\alpha_2\beta_1 v + \beta_4)\dot{p}_T$$
$$(\alpha_3\beta_1 v + \beta_3)r + \beta_2\left(\dot{w} - \dot{\lambda}_N\right)$$

and assuming that:

$$\dot{w} - \dot{\lambda}_N = \mu\left(\dot{w} - \dot{\lambda}\right),\ \mu > 1$$

then

$$\dot{p}_N = a_0 + a_1 \dot{q}_{N-1} + a_2 \dot{y} + a_3 \dot{p}_T + a_4 r + a_5\left(\dot{w} - \dot{\lambda}\right) \qquad (9b)$$

where

$a_0 = (\beta_0 + \alpha_0 \beta_1 v) / (1 + \alpha_2 \beta_1 v)$; $\alpha_1 = \beta_1 (1 - v) / (1 + \alpha_2 \beta_1 v)$;
$\alpha_2 = \alpha_1 \beta_1 v / (1 + \alpha_2 \beta_1 v)$;
$a_3 = (\alpha_2 \beta_1 v + \beta_3)/(1 + \alpha_2 \beta_1 v)$; $\alpha_4 = (\alpha_3 \beta_1 v + \beta_4) / (1 + \alpha_2 \beta_1 v)$;
$\alpha_5 = \beta_2 \mu / (1 + \alpha_2 \beta_1 v)$.

CHAPTER 6

THE IMPACT OF GOVERNMENT EXPENDITURE ON ECONOMIC GROWTH IN BARBADOS: A DISAGGREGATED APPROACH

Anton Belgrave
and
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THE IMPACT OF GOVERNMENT EXPENDITURE ON ECONOMIC GROWTH IN BARBADOS: A DISAGGREGATED APPROACH

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INTRODUCTION

Many researchers have examined the effects of aggregate public expenditure on economic growth with mixed results: some support the hypothesis that the share of public spending is negatively associated with economic growth (Landau,1986); others have found that public spending is positively correlated with economic growth (Ram, 1986); and some have found no significant relationship (Kormendi and Meguire, 1985). In general, as noted by Levine and Renelt (1992), studies on the relationship between aggregate public expenditure and economic growth have not yielded robust results. In fact they are very sensitive to small changes in the model specification.

This has led to a number of studies testing the effects of certain public expenditure components on economic growth. These results have also been contradictory. For example, most studies have found a strong positive correlation between education indicators and growth - Barro (1991), Easterly and Rebelo (1993) and Otani and Villanueva (1990). Others have reported a statistically insignificant relationship between economic growth and public investment (Barro, 1991).

This paper uses the analytical framework of Devarajan et al (1994) to determine which components of government expenditure in Barbados are positively or negatively associated with growth. The results indicate that there is a positive and statistically significant relationship between economic growth and expenditure on capital works, agriculture, transport, health and housing. In contrast, the relationship between the current component of public expenditure and economic growth is negative. A similar result is obtained for the share of expenditure devoted to education.

THE EMPIRICAL MODEL

The model expresses the difference between productive and unproductive expenditure by how a shift in the mix of the two alters the economy's long term growth rate. Productive government expenditure is classified as that component of public expenditure, an increase in whose share will raise the trend growth rate of the economy. Likewise, unproductive government expenditure is defined as that component which, if its share is increased, will lead to a lower growth rate. Therefore, these conditions imply that transferring resources from "unproductive" to "productive" expenditures will raise the trend growth rate. The classification of expenditure into productive or unproductive is empirically determined.

The model to be estimated is:

$$DGDP_t = \beta_o + \sum_k \beta_k (G_k/TEXP)_t + \beta_6 SHOCK_T + \beta_7 TEXPGDP_t + \beta_8 DOM_t + \mu_t \qquad (1)$$

Where $DGDP_t$ is the growth rate of real per capital gross domestic product. The term

$$\sum_k \beta_k (G_k/TEXP)_t = \beta_1 AGRTEXP + \beta_2 HOMEXP + \beta_3 HLTMEXP + \beta_4 ROADEXP + \beta_5 EDUCEXP$$

where AGRTEXP is the ratio of agriculture expenditure to total expenditure, HOMEXP is the ratio of housing and community amenities to total expenditure, HLTHEXP is the ratio of health expenditure to total expenditure, ROADEXP is the ratio of roads and other transport expenditure to total expenditure and EDUCEXP is the ratio of education expenditure to total expenditure. We expect that these components of public expenditure will have a positive sign, implying that they are productive expenditures.

The variable $SHOCK_t$ represents external shocks on the economy and is defined as a weighted average of changes in the world real interest rate (R), the export price index (PX) and the import price index (PM). Explicitly we have

$$SHOCK_t=(R_t-R_{t-1})(DEBT/GDP)_t+(PX_t-PX_{t-1})(X/GDP)+(PM_t-PM_{t-1})(M/GDP)$$

where X/GDP is the ratio of exports to nominal GDP, M/GDP is the ratio of imports to nominal GDP and DEBT/GDP is the ratio of debt to nominal GDP. The larger the shock, the more distorted the economy, the worse its growth performance. Hence, the sign on the SHOCK variable is a priori negative. DOM_t is a control variable representing domestic policies. We report the results for the money supply to GDP ratio. The variable $TEXPGDP_t$ is the ratio of total expenditure to nominal GDP and is used to control for level effects and also for the effects of financing government expenditure. This sign is expected to be positive if the productivity of government spending exceeds the deadweight loss associated with the distortionary taxes required to pay for it (see Devarajan et al (1994)). Finally, μ_t is an error term assumed to be identically independently normally distributed with zero mean and constant variance.

In an attempt to isolate the effects of the broad economic expenditure categories on growth we also estimated the following equation:

$$DGDP_t=\beta_o+\beta_1 CAPTEXP_t+\beta_2 TEXPGDP_t+\beta_3 SHOCK_t+DOM_t+\mu_t \quad (2)$$

where CAPTEXP is the ratio of capital expenditure to total expenditure. Public expenditure on capital goods should add to a country's physical capital (mainly infrastructure - roads, bridges, etc.) which could complement private sector productivity and increase growth. The sign of this variable should therefore be positive.

Equation (2) was also re-estimated with current expenditure replacing capital expenditure, that is:

$$DGDP_t = \beta_o + \beta_1 CURTEXP_t + \beta_2 TEXPGDP_t + \beta_3 SHOCK_t + DOM_t + \mu_t$$

where CURTEXP is the ratio of current expenditure (net of interest payments) to total expenditure. Since most current expenditures are for consumption purposes an increase in this ratio should reduce growth (Barro, 1991).

Data, Methodology And Empirical Results

The data used in this study is annual and covers the period 1969-1992. The sources of the data are the Central Bank of Barbados, *Annual Statistical Digest*, the International Monetary Fund, *International Financial Statistics* and the World Bank, *Annual Tables.* The government data employed relates to the central government; expenditures of government owned or controlled public sector enterprises are omitted. Details of the data are given in an appendix available from the authors.

Following Engle and Granger (1987) we first attempt to determine whether the variables are cointegrated, that is, whether a long run relationship exists between the variables. If such a relationship is found then ordinary least squares estimates are consistent. Cointegration implies that the variables cannot move too "far away" from each other. The cointegration method involves checking to see whether the individual series are stationary (I(0)) or not and then testing the residuals from the regression equations for stationarity. The specific method used to test for stationarity is the well known Augmented Dickey Fuller (ADF) method. All computations were done using the TSP computer programme.

Table 6.1 suggests that the series are either I(0) or I(1). Table 6.2 presents the results of the regression of the ratio of capital and current expenditure to GDP (equations 2 and 3 above). These equations are not cointegrated and hence the findings should be interpreted with some caution. Nevertheless, the effect of capital expenditure on economic growth is positive but significant only at the 10% level. This result is in tune with the standard hypothesis that the capital component of public expenditure and per capita growth are positively related. For current expenditure, the level of statistical significance is the same but its sign is negative. Again, this result is in accord with our a priori belief and policy advice from various international institutions.

Moreover, equation 1 of Table 6.2 indicates that the domestic policy proxy (DOM_t) is insignificant along with the shock variable, road expenditure and education expenditure. Omitting DOM_t from the equation not only removed the serial correlation but resulted in the variables having a cointegrating relationship (see Table 6.3). Consequently we focus on the model that excludes the domestic policy variable.

Formal testing of this model for the presence of first order serial correlation results in a rejection of the null hypothesis of serial correlation using the Lagrange Multiplier Test. The ARCH test results in the null hypothesis of homoscedasticity being accepted while the CUSUM test suggests that the parameters of the system are stable. A misspecification test in the form of the Ramsay (RESET) test implied acceptance of the hypothesis that the model is correctly specified in its lin-

TABLE 6.1
UNIT ROOT TEST RESULTS

VARIABLE	AUGMENTED DICKEY FULLER	McKINNON CRITICAL VALUES 5%
DGDP	-2.35	-3.79
D(DGDP)	-3.98	-3.01
AGRTEXP	-2.25	-3.00
D(AGRTEXP)	-5.48	-3.01
HOMEXP	-2.19	-3.00
D(HOMEXP)*	-2.92	-3.01
HLTHEXP	-1.89	-3.00
D(HLTHEXP)	-3.89	-3.01
ROADEXP	-2.37	-3.00
D(ROADEXP)	-3.50	-3.01
EDUCEXP	-3.03	-3.00
SHOCK	-2.08	-3.01
D(SHOCK)	-3.44	-3.02
TEXPGDP	-3.97	-3.00
CURTEXP	-1.38	-3.00
D(CURTEXP)	-3.85	-3.01
CAPTEXP	-1.38	-3.00
D(CAPTEXP)	-3.85	-3.01
MONEY	-0.58	-3.04
D(MONEY)*	-2.75	-3.05
NDA	-0.35	-3.04
D(NDA)	-3.37	-3.05

Notes: * denotes significance at the 10% level and D before the variables represents first differences.

TABLE 6.2
ENGLE-GRANGER COINTEGRATION TEST RESULTS

Equation	1(a)	1(b)	2	3
DGDP	1.000	1.000	1.000	1.000
AGRTEXP	-3.243	-2.837		
	(2.405)	(2.302)		
HOMEXP	-3.265	-3.025		
	(2.201)	(2.456)		
HLTHEXP	-6.050	-6.034		
	(2.583)	(2.907)		
ROADEXP	-0.678	-0.821		
	(1.083)	(1.438)		
EDUCEXP	1.193	0.861		
	(0.689)	(0.719)		
SHOCK	-0.001	0.001	0.006	-0.001
	(0.166)	(0.125)	(1.045)	(1.219)
TEXPGDP	1.724	2.060	2.870	3.130
	(1.985)	(2.535)	(2.959)	(3.284)
CURTEXP				0.895
				(1.685)
CAPTEXP			-1.023	
			(1.909)	
DMONEY		0.001		0.001
		(1.600)		(1.020)
DNDA	0.000		0.000	
	(0.441)		(0.143)	
DICKEY FULLER T	-4.52	5.41	-2.81	-2.59
McKinnon Crit. Val 5%	-5.75	5.75	-5.29	-5.29
D.W statistic	2.49	2.60	1.447	1.554

ear form. These diagnostics are presented in Table 6.3.

Of note is the positive and significant relationship between economic growth and agriculture, housing and community, and health expenditures respectively; road and other transport is positively signed but not significant. As economic infrastructure expenditure generally consists of a high proportion of capital expenditure, the finding that it is positively related to economic growth is consistent with the positive correlation found between capital expenditure and growth discussed above. This result concurs with that of Easterly and Rebelo (1993) who report that public investment in transport and communications in developing countries seems to be consistently positively correlated with growth with a very

TABLE 6.3
A VARIANT OF EQUATION (1) AND DIAGNOSTIC TESTS

Equation	Coefficient	T-Statistics	F Statistics
CONSTANT	-0.0757	-0.236	
AGRTEXP	3.548	2.787	
HOMEXP	3.313	2.722	
HLTHEXP	3.507	2.424	
ROADEXP	0.473	0.798	
EDUCEXP	-0.807	-0.654	
SHOCK	0.006	1.625	
TEXPGDP	-1.683	-2.372	
LM TEST			0.086
ARCH TEST			0.121
RESET TEST (1)			2.686
R-SQUARED	0.77		
D.W.	2.09		
ADF	6.16		

high coefficient. On the other hand, Devarajan et al (1994) found a negative relationship between public infrastructure expenditure and per capita growth.

The finding in the study that education expenditure, though insignificant, carries a negative sign may imply that a finer disaggregation is required for education expenditure. After disaggregating education expenditure Devarajan et al (1994) found that spending on subsidiary services to education (for example, transportation, food, medical and other services to students) and programme units engaged in teaching methods and objectives were positively related with growth while primary and secondary expenditure were negatively signed.

The shock variable has the correct sign but is only significant at the 13% level. Total expenditure to GDP tends to be negative and significant, suggesting that the productivity of government spending does not exceed the deadweight loss associated with the tax used to pay for it.

CONCLUSIONS

This paper develops a simple model to show how the composition of public expenditure affects growth. The cointegration method is employed on data for Barbados over the period 1969-1992. The results indicate that an increase in the share of capital expenditure has a positive relation to growth and so does health, housing, agriculture and road expenditures. By contrast, the relationship between current expenditure and growth is negative. A similar result holds true for education though this relationship is not a significant one.

Directions for further research emerging from this paper include the need for further disaggregation of the data and richer detail as to the mechanism by which government expenditure contributes to growth. Health expenditure needs to be disaggregated to explicitly measure the effects of hospital and polytechnic expenditure on growth. Given the small size of the sample it is also necessary to extend the analysis to cover a wide cross-section of Caribbean economies. Moreover, this paper has not addressed the problem of joint endogeneity of public expenditure and growth, and the possibility of reverse causality.

References

Barro, Robert J. (1991), "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, 106, May, 407-43.

Devarajan, Shantayanan, Vinaya Swaroop and Heng-fu Zhou (1994), "What do Governments Buy? The Composition of Public Expenditure and Economic Performance," *Working Paper*, World Bank, October.

Easterly, William, and Sergio Rebelo (1993), "Fiscal Policy and Economic Growth: An Empirical Investigation," *Journal of Monetary Economics*, 32, December, 417-58.

Engle, Robert and Clive Granger (1987), "Cointegration and Error Correction: Representation, Estimation and Testing," *Econometrica*, 55, 251-76.

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

Landau, Daniel (1986), "Government and Economic Growth in the Less-Developed Countries: An Empirical Study for 1960-80," *Economic Development and Cultural Change*, 35, October, 35-75.

Levine, Ross, and David Renelt (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions," *American Economic Review*, 82, September, 942-63.

Otani, Ichiro, and Delano Villanueva (1990), "Long-Term Growth in Developing Countries and its Determinants: An Empirical Analysis," *World Development*, 18, June, 769-83.

Ram, Rati (1986), "Government Size and Economic Growth: A New Framework and Some Evidence from Cross-Section and Times-Series Data," *American Economic Review*, 76, March, 191-203.

CHAPTER 7

A SURVEY OF SEASONALITY IN CARIBBEAN MACROECONOMIC VARIABLES

Alain Maurin

A Survey of Seasonality in Caribbean Macroeconomic Variables

Alain Maurin

The area of econometric modelling which has undergone the greatest development during this last decade is undoubtedly that of time series econometrics. Initiated by Nelson and Plosser (1982), these developments were first dedicated to the study of the deterministic and stochastic long run properties of economic variables.

In the context of univariate analysis, the main contributions put forward some reliable methods for the tests of a unit root, aiming to characterize trends in series (Dickey and Fuller (1981), Phillips and Perron ((1988), Kwiatkowski, Phillips, Schmidt and Shin (1992)). Until the end of the 1980s, econometricians were principally interested in non-seasonal series. Although Hasza and Fuller suggested the extension of Dickey and Fuller's test to seasonal series as early as 1984, seasonal time series did not attract attention until much later with the works of Osborn, Chui, Smith and Birchenhall (OCSB) (1988), Osborn (1990), and Hylleberg, Engle, Granger and Yoo (HEGY) (1990). In the multivariate context, Frances' recent work (1994) also aims at modelling and studying seasonal variables. The latter relies on the formalization of Johansen (1988) and Johansen and Juselius (1990) to formulate a test of seasonal integration based on the number of relations of cointegration existing between annual series, stemming from the initial quarterly or monthly series.

One might argue that the application of well known methods of deseasonalization avoids resort to tests of seasonal integration. In the same way one could say that such tests are not essential if the weight of the seasonal component is weak in the decomposition of the studied series. But if the former ever turned out to have an unstable seasonal component, and the latter had large amplitude, then the use of these methods of seasonalization could be called into question.

Some economic variables are naturally seasonal and their modelling implies the identification and the modelling of their seasonal component. On this point, Hyllerberg (1994) emphasizes that the seasonal variations explain a large part of the fluctuations of some economic variables, and the seasonal and non-seasonal components are often dependent on one another.

This article offers a review of the literature on tests for unit roots in the presence of seasonality, through numerous applications on Caribbean data. Although econometric work using quarterly or monthly data for Caribbean countries is nearly non existent at the present time, we should witness such development in the years to come. Long series do exist (for currency, prices, etc) for some countries and data bases are becoming richer. The need for empirical verification of some questions of economic analysis and policy gives increasing prominence to econometric work on periodical data. Just to give an example, there is today a vacuum in the area of quarterly models useful for the analysis of fluctuations in Caribbean countries. (See Craigwell et al. (1995) for discussion of macroeconomic forecasts in the English-speaking Caribbean.)

Definitions and Characteristics of the Seasonal Series

When we refer to the traditional statistical methods for the analysis of time series, we usually distinguish four types of movement that can combine with one another: the trend, the cycle, the seasonal component, and the residual component.

The trend represents the average evolution in the long run. The cycle follows a more or less periodic trajectory linked to the booming phase and the recession phase of the economy. The seasonal component comprises the variations which occur repeatedly over the course of time. The residual component, which is uncertain, is composed of many agents responsible for weak amplitudes which also appear in the evolution of the variable, but which cannot be particularized.

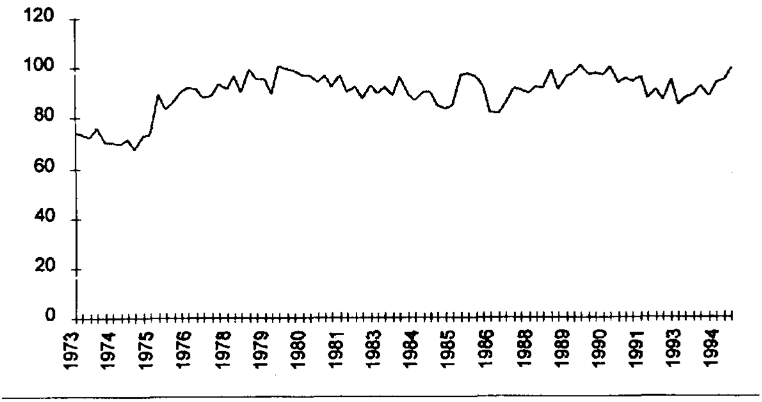
Whether it is a matter of data on socioeconomic variables, or describing natural phenomena, putting together the components (each under the influence of various factors such as annual holidays for the seasonal component) gives rise to more or less complex evolutions, hard to describe in a straightforward way. In order to pass judgement on the basic evolution of background phenomena, it has become a standard procedure to separate the seasonal movements from any other component. Prior to any mathematical transformation aiming at obtaining this decomposition, we always start with a visual analysis using graphics.

To illustrate, we rely on two series which reproduce the evolution of the index of Barbados' industrial production, and the number of tourists visiting the country. The first one uses quarterly data from 1973 to 1994 whereas the second one uses monthly data from January 1992 to April 1995.

In Chart 8.1 we may distinguish two periods. The first, relatively short, is the first two years and the first three quarters of year 1975. We notice some more or less constant values between 67 and 76. The second period also shows observations whose values vary slightly around an average value, but at a higher level, between 82 and 101.

At first sight, we may be inclined to say that the evolution of

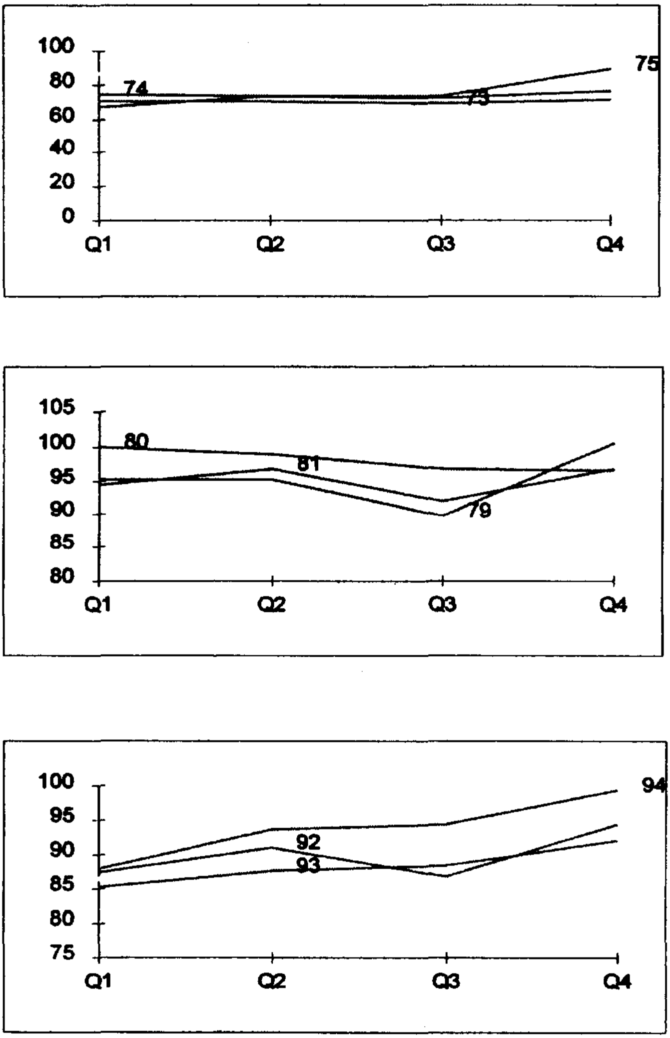
CHART 7.1
INDEX OF INDUSTRIAL PRODUCTION, BARBADOS
(QUARTERLY)



the index of Barbados' industrial production does not seem to be affected by any seasonal variation. But on the contrary, we will accept presence of seasonal movements if we examine carefully the series by depicting a profile of different years on the same graph (Chart 8.2). Indeed, even if movements are not strictly similar from year to year, Chart 8.2 clearly shows that each year, Barbados' industrial production is low during the first quarter, increases in the second quarter, then falls in the third quarter and reaches a high in the fourth quarter.

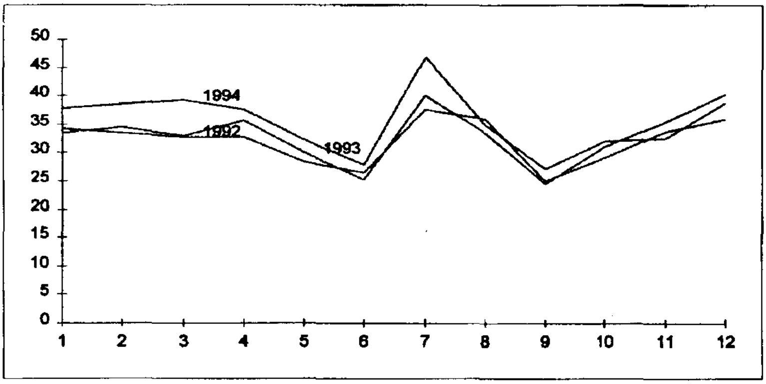
Concerning the number of tourists, Chart 8.3 brings out clearly the presence of more or less regular periodical movements. We notice three phases each year. The first, from January to June, shows a more or less regular drop in the number of tourists. The second from July to September, shows a big increase in July followed by a drop in August and a second much larger one in September; eventually, in the third phase going from October to December, we notice a rather regular increase.

CHART 7.2
INDEX OF INDUSTRIAL PRODUCTION, BARBADOS
(SELECTED YEARS)



Those reports are confirmed when we do graphical analysis of quarterly data for this same variable (see Charts 8.4 and 8.5).

CHART 7.3
NUMBER OF TOURISTS



Although graphs are a convenient approach to examining the trend and the seasonality of a series, they provide insufficient information on statistical properties for econometric

CHART 7.4
NUMBER OF TOURISTS
(QUARTERLY DATA)

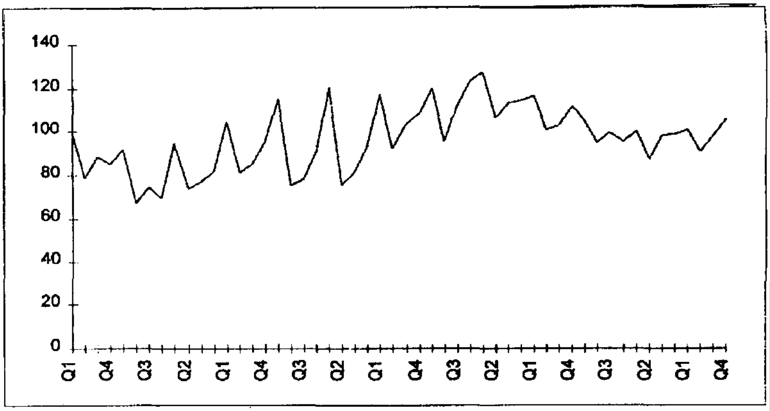
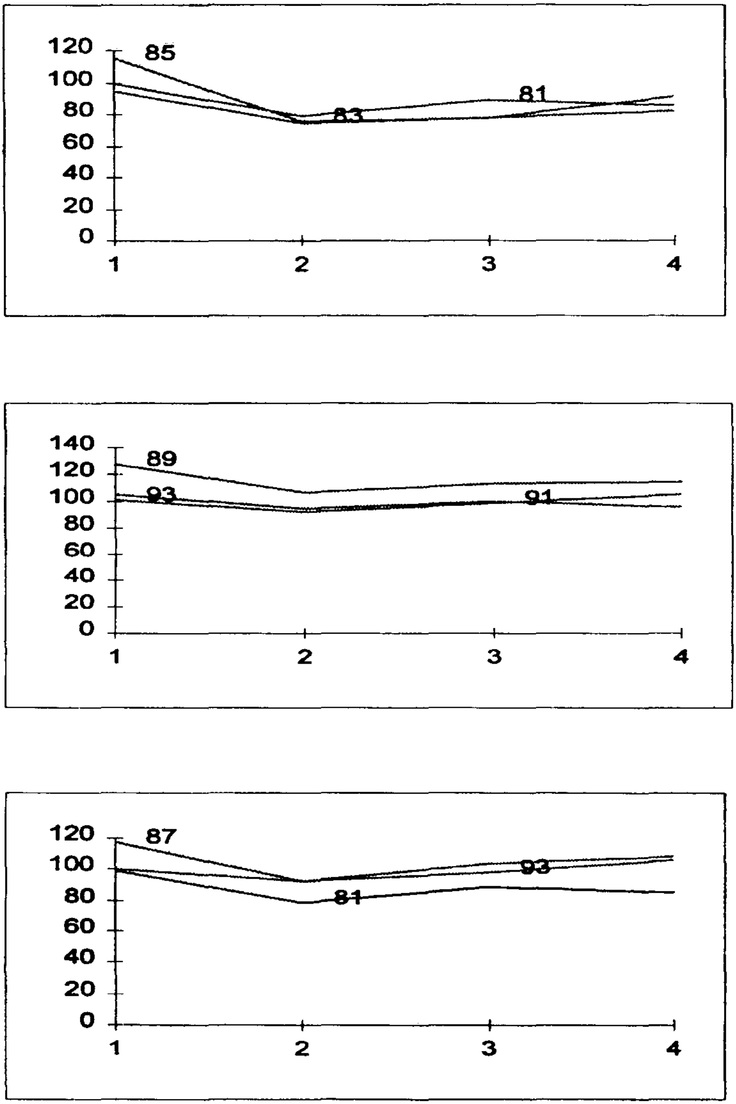


CHART 7.5
NUMBER OF TOURISTS
(QUARTERLY DATA, SELECTED YEARS)



work. Before attempting to model economic variables, it is now established that the origin of trend and seasonality of each series should be determined systematically. The application of econometric methods requires the use of stationary series in the univariate context, and series whose orders of integration are known, in the multivariate context.

Since Nelson's and Plosser's study (1982), a significant amount of work, both empirical and theoretical, has introduced practical procedures to characterize the deterministic or stochastic behaviour that the trend of the series may have. As far as seasonality is concerned, working out of similar procedures has taken much longer.

Although the trend usually dominates in series decomposition, the general profile of those series shows clearly that a good acquaintance with the seasonality is often essential to explain evolution and fluctuations in some variables. It is important to know whether shocks affecting X_t will have a temporary effect only on its seasonal component or, on the contrary, whether they will influence its seasonal profile in the future. These questions lead to questions about the choice of method for achieving stationarity of X_t. Should gross values of X_t be regressed on seasonal dummy variables (deterministic seasonality) or should they be differentiated according to the order of seasonality (stochastic seasonality)?

The definition of seasonal integration that we commonly apply is: a non stationary, stochastic process X_t is integrated in the order (d,D), denoted I(d,D), if X_t is stationary after the application of D seasonal differences followed by the application of d first differences. Thus a quarterly series is said to be I(1,1) if its stationarity requires only one transformation of the initial data X_t by the filter X_t-X_{t-4} followed by a single first differentiation applied to the resulting series.

Compared to the trend, the econometric problems posed in making seasonal series stationary are more complicated. An obvious reason is the fact that the procedures of estimation and testing must take all the unit roots into account. Furthermore, because seasonality is inherent in various economic series, instead of resorting to procedures which eliminate seasonal variations, some authors have stressed the importance of dealing with unadjusted data, working out models to incorporate their seasonality.

On a technical level, Wallis (1992) and Ghysels (1994) have shown that the use of adjusted series may introduce distortions which may lead to misinterpretation of the dynamics of econometric models. For cointegration Hyllerberg (1994) has proved similar results. An empirical example is Osborn's (1988) UK consumption function which incorporates an explicit formulation of seasonality. Using the hypothesis that consumption is often dictated by habits and that households will buy goods according to seasons, Osborn suggested a consumption function including parameters to represent these habits and preferences.

A Review of the Tests on Seasonal Unit Roots

Univariate Approaches

Examination of the dynamic properties of quarterly series is done through tests of seasonal unit roots. Hasza and Fuller (1982) suggested a procedure involving the extension of Dickey and Fuller's method. Testing the presence of unit root at the zero frequency in the model: $X_t = \alpha X_{t-s} + \varepsilon_t$, this procedure gave rise to many criticisms. Afterwards, Osborn, Chui, Smith and Birchenhall (OCSB) (1988) advocated the parameterization (1) below, in order to test the null hypothesis I(1,1) against the alternatives I(0,I) and I(1,0).

$$\Delta_1\Delta_4 X_t = \alpha_1 D_{1t} + \alpha_2 D_{2t} + \alpha_3 D_{3t} + \alpha_4 D_{4t}$$
$$+ \beta_1 \Delta_4 X_{t-1} + \beta_2 \Delta_1 X_{t-4} + \sum_k \Phi_k \Delta_1 \Delta_4 X_{t-k} + \varepsilon_t \qquad (1)$$

where the D_i are seasonal dummy variables.

Note that the variable X is specified in first and fourth differences. Thus, the term $\Delta_4 X_{t-1}$ is used to test for the non-seasonal unit root and $\Delta_4 X_{t-4}$ for the seasonal root. When $\beta_1=0$ and $\beta_2<0$ we conclude that $X_T \sim I(1,0)$ whereas the property I(0,1) is verified when $\beta_2=0$ and $\beta_1<0$. In order to measure the probability distribution of β_1 and β_2, Osborn (1990) provides tables of the critical values of the asymptotic distributions of statistics $t_{\beta 1}$ and $t_{\beta 2}$. Although this procedure is an improvement on Hasza and Fuller's approach, it does not enable one to test for the presence of all unit roots in a seasonal process.

Consider an autoregressive process: $\phi(B)X_t=e_t$. Its evolution is stationary if and only if all the roots of the polynomial $\phi(B)X_t=e_t$ are situated outside the unit circle. Hylleberg, Engle, Granger and Yoo (HEGY) (1990) used the decomposition: $(1-B^4) = (1-B)(1+B)(1-iB)(i+IB) = (1-B^2)(1+B^2)$. In order to apply this to the model $X_t = \alpha X_{t-4} + \varepsilon_t$ for quarterly data use the transformation:

$$X_{1,t} = (1 + B + B^2 + B^3)X_t$$
$$X_{2,t} = (1 - B + B^2 - B^3)X_t$$
$$X_{3,t} = -(1 - B^2)X_t$$
$$X_{4,t} = (1 - B^4)X_t$$

We obtain the model:

$$X_{4,t} = (1 - B^4)X_t = \pi_1 X_{1,t-1} + \pi_2 X_{2,t-1} + \pi_3 X_{3,t-2} + \pi_4 X_{3,t-1} + \sum_k \phi_k X_{4,t-k} + \varepsilon_t \quad (2)$$

which permits a test of the presence of the non seasonal unit root (at frequency 0) and of the seasonal roots -1 (at the semi-annual frequency $^1/_2$), i and -i (at the annual frequency $^1/_4$ and the frequency $^3/_4$).

As Perron (1988) emphasizes, to assure tests of reasonable power, we should begin with the most general model. Then, for the seasonal series, a suitable strategy should rely on regressions including seasonal dummy variables, a constant, and a trend term as regressors:

$$X_{4,t} = \beta_o + \beta_1 t + \alpha_1 D_{1t} + \alpha_{21} D_{2t} + \alpha_3 D_{3t} + \alpha_4 D_{4t} + \pi_1 X_{1,t-1}$$
$$+ \pi_2 X_{2,t-1} + \pi_3 X_{3,t-2} + \pi_4 X_{3,t-1} + \sum_k \phi_k X_{4,t-k} + \varepsilon_t \quad (3)$$

In order to test for the presence of roots at 1 and -1, the nullity of π_1 and π_2 must be evaluated by means of the t-statistics. Thus, we carry out the tests:

$H_0 : \pi_1 = 0 \, against \, H_1 : \pi_1 < 0$
$H_0 : \pi_2 = 0 \, against \, H_1 : \pi_2 < 0$
by using the critical values of Dickey and Fuller (1981).

Concerning the annual unit roots, HEGY suggested some tests based on the t-statistics or on Fisher's statistics. For the t-statistics, we proceed in two stages: first, we carry out the bilateral test $\pi_4 = 0 \, against \, \pi_4 \neq 0$ using HEGY's statistical values. Then , if $\pi_4 = 0$, the presence of the complex roots depends on the test $\pi_3 = 0$ *against* $\pi_3 < 0$ by resorting this time to Dickey, Hasza and Fuller's (1984) critical values.

The F-test of nullity of π_3 or π_4 is estimated from the relations (2) or (3) using the ratio of the regression sum of squares to the sum of squared residuals. If we designate the vector of the residuals by $\hat{e}$, β the vector of estimated coefficients and Z_t the matrix $\left(X_{1,t-1}, X_{2,t-1}, X_{3,t-2}, X_{3,t-1}\right)$, the F are defined as follows (Engle et al. (1993) and Ghysels (1994)):

$$F_{34} = \frac{\left(R\hat{\beta}\right)' \left(\left[R\sum Z_t Z_{t-1} R'\right]^{-1} R\hat{\beta}\right)/2}{\sum \hat{e}_t^2/(T-4)} \quad with\, R = \begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$F_{234} = \frac{\left(R\hat{\beta}\right)' \left(\left[R\sum Z_t Z^{-1} R'\right]^{-1} R\hat{\beta}\right)/3}{\sum \hat{e}_t^2/(T-4)} \quad with\, R = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$F_{1234} = \frac{\hat{\beta}\left[\sum Z_t Z_t'\right]\hat{\beta}/4}{\sum \hat{e}_t^2/(T-4)}$$

By relying on the Brownian motion, we show that these statistics have the same asymptotic distributions as the sum of the squares of the corresponding t-statistics. Their critical values, obtained by simulation have been established by HEGY for F_{34} and Ghysels for F_{234} and F_{1234}.

On the whole, the process X_t will have no unit root if all π_i are different from zero. Similarly X_t will have no seasonal unit root if π_2 and π_3 or π_4 are different from zero. Because of its robustness, this procedure is known as a reference method (see Ghysels (1994)). Note that its field of application remains limited to the test of the null hypothesis I(0,1) against the alternatives I(1,0) and I(0,0).

For a more general test of the hypothesis I(1,1) against I(2,0) and I(1,0), Osborn (1990) suggested a transformation of

HEGY's model (3), using the variant below:

$$\Delta_4\Delta_1\chi_t = \alpha_1(D_{1t} - D_{4t}) + \alpha_2(D_{2t} - D_{4t}) + \alpha_3(D_{3t} - D_{4t}) + \pi_1 Z_{1,t-1}$$
$$+ \pi_2 Z_{3,t-1} + \pi_3 Z_{3,t-2} + \pi_4 Z_{3,t-1} + \sum_k \Phi_k \Delta_4\Delta_1 X_{t-k} + \varepsilon_t \quad (4)$$

where the $Z_{i,t}$ are similar to the $X_{i,t}$ but defined in relation to $\Delta_1 X_1$:

$$Z_{i,t} = (1 + B + B^2 + B^3)\Delta_1 X_t$$
$$Z_{2,t} = (1 - B + B^2 - B^3)\Delta_1 X_t$$
$$Z_{3,t} = -(1 - B^2)\Delta_1 X_t$$
$$Z_{4,t} = -(1 - B^4)\Delta_1 X_t$$

We conclude that $X_t \sim I(2,0)$ and that there is no seasonal unit root when π_2 *and* π_3 *or* π_4 are statistically different from zero and $\pi_1 = 0$. Conversely, we accept the hypothesis I(0,1) when $\pi_2 = \pi_3 = \pi_4 = 0$ *and* $\pi_1 < 0$. For the tests, we use the critical values tabulated by Osborn (1990) for π_2, π_3 *and* π_4 and those of Dickey and Fuller (1981) for π_1.

The procedures which have just been discussed are valid for quarterly series. For monthly data, it is also important to elaborate some tests of seasonal integration, since many economic variables, such as indexes, are measured at the end of each month. The procedure suggested by Beaulieu and Miron (1993) falls within this perspective. It is the analogue of HEGY's procedure and works as follows.

We start from the factorization of the filter $\Delta_{12} = 1\text{-}B^{12}$

$$(1 - B^{12}) = (1 - B)(1 + B)(1 + B^2)(1 + B + B^2)(1 - B + B^2)(1 + \sqrt{3B} + B^2)(1 - \sqrt{3B} + B^2)$$

and try to detect which among the roots of the polynomial $\Delta_{12}X_t$ have a significant influence on the fluctuation of the series. As in the case of quarterly data, the procedure of investigation is based on the linearization of Δ_{12} in the neighbourhood of the unit root and the 11 seasonal roots which are equal to:

$$-1;\pm i;-\frac{1}{2}\left(1\pm\sqrt{3i}\right);\frac{1}{2}\left(1\pm\sqrt{3i}\right);-\frac{1}{2}\left(\sqrt{3}\pm i\right);\frac{1}{2}\left(\sqrt{3}\pm i\right)$$

and are associated with the respective frequencies $\pi;\pm\frac{\pi}{2};\pm\frac{2\pi}{3};\pm\frac{\pi}{3};\pm\frac{5\pi}{6};\pm\frac{\pi}{6}$.

We therefore obtain the analogue of the regression model:

$$X_{13,t}=\left(1-B^{12}\right)X_t=\sum_{k-1}^{12}\pi_k X_{k,t-1}+\sum_k \Phi_k X_{13,t-k}+\varepsilon_t \qquad (5)$$

where each $X_{i,t}$, i=1,...,13 corresponds to a function of the frequency associated with $X_{i,t}$ (see Appendix 8.A2).

In the same way, we obtain the equivalent model to (3) by including a constant, a trend and the seasonal dummies:

$$X_{13,t}=\beta_o+\beta_{1t}+\sum_{k=1}^{12}\alpha_k D_{k,t}+\sum_{k=1}^{12}\pi_k X_{k,t-1}+\sum \Phi_k X_{13,t-k}+\varepsilon_t \qquad (6)$$

For the frequencies 0 and π, we test the respective null hypothesis π_1=0 *and* π_2=0 against the alternative hypotheses $\pi_1<0$ *and* $\pi_2<0$. In the case of other frequencies, we evaluate the significance of the coefficients with the help of Student's and Fisher's statistics for which Beaulieu and Miron have built tables of critical values.

Frances' Multivariate Approach

Starting with Johansen and Juselius' (1990) approach to cointegration, Frances (1994) suggested that we should test for the presence of stochastic seasonality by calculating the number of relations of cointegration between the four series of annual data stemming from the initial series. The stages of his procedure are:

(i) Given a seasonal series of period p, we make up the vector $X_t = (X_{1t}\ X_{2t}...X_{pt})$ where X_{it} is a series of annual data containing the observations of the season i:

(ii) Let the ECM model of order 1 be:
$\Delta X_t = \Pi X_{t-1} + \mu + \varepsilon_t$
We estimate the matrix $\Pi = \alpha\beta'$ under the constraint by applying the maximum likelihood method of Johansen and Juselius (1990).

(iii) We determine the number of cointegration relations r between the X_{it} by using the trace test based on the statistic $Q_1(r) = -N \sum_{k=r+1}^{p} \log(1-\lambda_k)$ and the maximum eigenvalue test based on the statistic: $Q_2(r) = -N\log(1-\lambda_r)$ with the λ_k designating the eigenvalues of β and N=T/p the number of observations of the series X_{it}.

(iv) If r = 4, the initial series X_{it} is stationary, therefore any differentiation is unnecessary.
If r = 0, there is no relation of cointegration between the X_{it}, each of these series being integrated. We conclude that the filter Δ_p (Δ_4 for a quarterly series and Δ_{12} for a monthly series) is suitable to make X_t stationary.

When r is between 1 and 1-p, we test for the presence of the seasonal roots -1, i and -i by imposing different constraints on the matrix .

Applications to Caribbean Macroeconomic Variables

Unit Root Tests of Quarterly Series

The data for our econometric investigations are real and nominal variables for Barbados, Jamaica, Trinidad and Tobago, Guyana and the Dominican Republic. The variables are the total amount of money in circulation m_t, domestic credit cr_t, the index of the industrial production y_t and the consumer price index p_t. They are unadjusted quarterly data for the most part for the period from 1960 to 1994 (see Appendix 8.A1).

Before analysing the nature of seasonality we first attempted to characterize the origin of the trend. For that we relied on Jobert's (1992) sequential procedure for the ADF test (see Appendix 8.A3). Then we carried out tests for seasonal unit roots making use of the strategies previously expounded. Thus, for each variable, we performed the estimation of model (1) for the OCSB procedure and estimation of equations (2), (3) and (4) for the HEGY tests.

The estimations were done on the logrithms of the variables. For each, the selection of the optimal lag was made using the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC) and the Hannan-Quinn Criterion (HQ) (see Appendix 8.A5). For the choice between these criteria, we refer to the result of Lütkepohl (1993); if $\hat{p}$(AIC), $\hat{p}$(BIC) and $\hat{p}$(HQ) represent estimate value of p given by criteria

AIC, BIC and HQ, then:

$\hat{p}(BIC) \leq \hat{p}(AIC) \text{ if } T \geq 8$

$\hat{p}(BIC) \leq \hat{p}(HQ) \forall T$

$\hat{p}(HQ) \leq \hat{p}(AIC) \text{ if } T \geq 16$

with T the length of the series.
For each country, the results are presented in three tables giving results on the ADF test, the OCSB test and the HEGY tests, respectively.

The Results for the ADF Tests

Let us take the example of the series m_t for Barbados to explain the strategy for the ADF test. We start with the estimation of equation (1) in Table 8.1. It shows that the hypothesis of the unit root may be accepted[1] ($\tau = -0.59$). Then, we test the trend term of equation (4), finding the statistic $\tau_t = -1.57$; thus the trend is not significant. Once more we evaluate the unit root in equation (2). The value of τ_μ leads to the rejection of the hypothesis I(1). But since the constant is significant in equation (5) ($\tau_\alpha = 3.26$), we eventually accept the hypothesis I(0).

Thus, in the case of Barbados, Dickey and Fuller sequential tests lead to the rejection of the null hypothesis of unit roots for the series m_t, p_t and y_t (the latter is stationary around a constant) and lead to its acceptance for cr_t.

If we compare the Trinidad and Tobago results to those of Barbados, we notice that the evolution over time of m_t, p_t and y_t shows the same behaviour. In contrast, in Jamaica and Guyana all variables are non-stationary. For the Dominican Republic the stationary variables are m_t and cr_t.

TABLE 7.1
TESTS ADF I(1)/I(0)

	Lag	$\tau_t(1)$	$t_t(4)$	$\tau_\mu(2)$	$t_a(5)$	Conclusion
			Barbados			
m	4	-0.59	-1.57	-1.67	3.26	I(0)
cr	7	-2.56	-2.56			I(1)+T+T²
Y	8	-0.89	-1.66	-4.98		I(0)+C
P	3	-0.84	-1.74	-1.89	2.18	I(0)
			Trinidad and Tobago			
m	7	-1.94	0.16	-0.37	2.02	I(0)
y	0	-4.25				I(0)+T
p	4	-2.49	0.69	0.27	2.51	I(0)
			Jamaica			
m	8	-0.99	2.15			I(1)+T+T²
cr	7	-2.8	0.12	-0.27	2.39	I(1)+T
p	0	-1.21	2.59			I(1)+T+T²
			Guyana			
m	8	-1.23	1.52	0.91	2.05	I(1)+T
cr	7	-2.02	0.72	0.35	2.55	I(1)+T
p	0	-2.21	3.70			I(1)+T+T²
			Dominican Republic			
m	8	-1.58	1.48	0.79	2.05	I(0)
cr	8	-1.52	1.47	1.34	3.77	I(0)
p	7	-1.16	2.01			I(1)+T+T²

To give an economic interpretation, these results seem to indicate that any shock affecting the economies of Barbados and Trinidad and Tobago through the variables considered here will have transitory effects, whereas the effects of similar shocks for Jamaica and Guyana will persist.

The Results of the OCSB Tests

The results in Table 8.2 show very clearly that the null hypothesis I(1,1) at 5% is rejected for all series.[2] More precisely, among the 16 examined series, 8 are I(0,0) (p_t for all the countries, y_t for Barbados and Trinidad and Tobago and m_t for Guyana) and all the other 8 I(1,0). For the latter, the rejection of non-stationary stochastic seasonality is confirmed by the statistics $t_{\beta 2}$. These series are I(1,0) because $\beta_1 = 0$ *and* $\beta_2 < 0$. Likewise, the others are I(0,0) because $\beta_1 \neq 0$ *and* $\beta_2 < 0$.

The Results of HEGY Tests

The results of HEGY tests in Tables 8.3 and 8.4 underline that unit roots at seasonal frequencies are rarely to be found in Caribbean series of high periodicity. If we refer to the t-statistics of the test I(0,1)/I(1,0) and I(0,0) on the 16 series studied here, the coefficients estimated for π_2 are very significant, as are those associated with π_3 and π_4. Similarly, the values F_{34} and F_{234} clearly reject the presence of unit roots at seasonal frequencies.

Every series has a stochastic trend, and none shows stochastic seasonality, which leads us to think that their univariate representation is that of a stationary process in differences around a deterministic seasonal pattern represented by seasonal dummy varibles.

Table 7.2
Tests of OCSB I(1,1)/I(0,1) and I(1,0)

Series	Lag	$t_{\beta 1}$	$t_{\beta 2}$	Conclusion
		Barbados		
m	0	-1.24	-7.72	I(1,0)
cr	0	-1.24	-7.71	I(1,0)
y	0	-2.80	-7.48	I(0,0)
p	1	6.14	-9.65	I(0,0)
		Trinidad and Tobago		
m	7	1.28	-5.61	I(1,0)
y	0	-2.07	-5.81	I(0,0)
p	0	5.35	-9.46	I(0,0)
		Jamaica		
m	0	1.55	-8.77	I(1,0)
cr	1	1.84	-9.48	I(1,0)
p	2	5.92	-8.43	I(0,0)
		Guyana		
m	5	2.05	-5.95	I(0,0)
cr	3	0.99	-8.93	I(1,0)
p	0	4.02	-9.26	I(0,0)
		Dominican Republic		
m	5	1.77	-6.50	I(1,0)
cr	5	-0.61	-7.16	I(1,1)
p	4	3.48	-5.90	I(0,0)

TABLE 7.3
TESTS OF HEGY I(0,1)/I(1,0) AND I(1,0)

Series	Test	k	$t_{\pi1}$	$t_{\pi2}$	$t_{\pi3}$	$t_{\pi4}$	F1234	F234	F34	Concl.
					Barbados					
m	Eq. (2)	1	3.10	-4.43	-3.63	-2.74	57.97	33.70	14.79	
	Eq. (3)	0	-0.29	-5.88	-5.50	-4.51	207.23	78.15	50.71	I(1,0)
cr	Eq. (2)	8	1.59	-3.19	4.19	-3.17	202.38	124.32	87.27	
	Eq. (3)	8	-0.74	-3.05	-4.13	-3.34	2166.76	141.01	104.71	I(1,0)
y	Eq. (2)	0	1.11	-2.54	-5.06	-5.57	31.43	39.99	44.05	
	Eq. (3)	0	-2.87	-3.86	-5.30	-5.11	8203.78	73.01	58.67	I(1,0)
p	Eq. (2)	0	1.59	-7.57	-5.41	-7.13	954.36	617.22	62.54	
	Eq. (3)	0	-0.87	-6.88	-5.48	-7.09	632.07	632.07	70.70	I(1,0)
					Trinidad and Tobago					
m	Eq. (2)	4	1.97	-2.00	-4.52	-1.82	64.91	48.47	47.36	
	Eq. (3)	1	-1.89	-4.62	-4.62	-1.33	2347.41	104.63	77.01	I(1,0)
y	Eq. (2)	3	2.12	-2.11	-4.07	-0.53	17.29	18.57	18.40	
	Eq. (3)	4	-2.14	-2.14	-4.58	-0.22	6923.88	49.12	42.03	I(1,0)
p	Eq. (2)	1	2.24	-4.25	-1.52	-8.15	956.05	292.26	55.86	
	Eq. (3)	1	-2.51	-4.28	-1.79	-8.36	262.84	344.89	65.63	I(1,0)

TABLE 7.3 (CONT'D)
TESTS OF HEGY I(0,1)/I(1,0) AND I(1,0)

Series	Test	k	$t_{\pi1}$	$t_{\pi2}$	$t_{\pi3}$	$t_{\pi4}$	F1234	F234	F34	Concl.
					Jamaica					
m	Eq. (2)	8	3.21	-1.66	-1.02	-2.24	66.01	15.15	7.62	
	Eq. (3)	0	-0.49	-6.94	-5.53	-6.93	167.88	94.83	190.92	I(1,0)
cr	Eq. (2)	6	2.80	-2.48	-1.77	-1.57	60.78	25.05	8.89	
	Eq. (3)	8	-2.81	-5.21	-3.27	-1.43	13077.88	315.09	42.42	I(1,0)
p	Eq. (2)	0	3.52	-8.48	-0.70	-9.72	2077.12	742.08	48.00	
	Eq. (3)	0	-1.35	-7.62	-0.79	-10.55	1573.13	828.52	65.17	I(1,0)
					Guyana					
m	Eq. (2)	5	2.12	-1.56	-1.59	-1.25	22.06	6.37	4.77	
	Eq. (3)	1	-1.88	-3.74	-4.78	-4.45	360.76	126.77	104.27	I(1,0)
cr	Eq. (2)	4	2.57	-5.27	-3.20	-3.62	246.66	108.62	43.51	
	Eq. (3)	4	-2.01	-5.22	-3.39	-3.56	2746.76	117.00	49.36	I(1,0)
p	Eq. (2)	2	2.24	-4.25	-1.52	-8.15	956.05	292.26	55.86	
	Eq. (3)	0	-2.51	-4.28	-1.79	-8.36	262.84	344.89	65.63	I(1,0)
					Dominican Republic					
m	Eq. (2)	5	2.12	-1.31	-2.54	-1.34	26.33	9.14	9.51	
	Eq. (3)	4	-1.50	-4.69	-5.26	-3.17	1050.63	170.55	115.62	I(1,0)
cr	Eq. (2)	6	4.93	-2.55	-3.38	-3.43	364.49	73.19	40.04	
	Eq. (3)	8	-1.76	-5.87	-4.47	-3.44	30446.04	205.74	122.96	I(1,0)
p	Eq. (2)	4	2.39	-5.44	-0.02	-5.05	743.16	416.17	22.89	
	Eq. (3)	5	-1.52	-4.49	-0.12	-6.12	646.09	530.70	45.61	I(1,0)

TABLE 7.4
TESTS OF HEGY I(1,1)/I(2,0) AND I(1,0)

Series	k	$t_{\pi 1}$	$t_{\pi 2}$	$t_{\pi 3}$	$t_{\pi 4}$	F1234	F234	F34	Concl.
					Barbados				
m	0	-5.18	-4.87	-6.15	0.69	31826.13	40.35	31.69	I(1,0)
cr	8	-3.37	-3.19	-5.72	1.08	32179.72	73.03	58.50	I(1,0)
y	0	-5.84	-3.75	-6.29	-0.78	147.77	53.22	36.48	I(1,0)
p	0	-2.85	-4.17	-7.15	-0.10	1578.53	159.53	38.56	I(1,0)
					Trinidad and Tobago				
m	0	-3.27	-4.74	-6.85	4.37	12287.03	37.59	35.53	I(1,0)
cr	3	-3.12	-3.26	-3.38	2.98	321.67	33.67	15.88	I(1,0)
p	0	-3.18	-3.65	-5.04	-3.16	5531.91	84.33	24.60	I(1,0)
					Jamaica				
m	0	-4.63	-5.83	-7.37	-0.63	60728.79	74.98	60.24	I(1,0)
cr	2	-3.78	-6.96	-4.19	-0.79	42141.65	58.24	47.96	I(1,0)
p	0	-3.62	-6.62	-6.76	-5.63	2458.16	258.14	40.02	I(1,0)
					Guyana				
m	2	-2.78	-3.24	-6.35	-0.24	23405.81	37.59	35.53	I(1,0)
cr	3	-2.95	-5.27	-5.29	-0.28	48016.95	33.67	15.88	I(1,0)
p	0	-3.09	-5.41	-7.53	0.88	826.60	84.33	24.60	I(1,0)
					Dominican Republic				
m	3	-2.75	-4.91	-6.75	1.26	27069.63	63.82	69.18	I(1,0)
cr	5	-4.92	-3.25	-6.31	-0.02	321605.8	92.72	57.77	I(1,0)
p	4	-2.45	-4.51	-3.76	-4.29	727.20	42.77	160.53	I(1,0)

An Illustration of Unit Roots Tests of Monthly Series

Monthly data are not available for most of the variables we considered in this study. However, it is interesting to see how the Beaulieu and Miron procedures work on an example, the "number of tourists" series.

To test for unit roots in this series we apply ordinary least squares to equations (5) and (6). The presence of seasonal unit roots must be accepted if π_2 through π_{12} are significantly equal to zero.

Table 7.5
Tests of Seasonal Unit Roots in the "Number of Tourist" Series[1]

	π_1	π_2	π_3	π_4	π_5	π_6	π_7	π_8	π_9	π_{10}	π_{11}	π_{12}
Eq (5)	-0.89	-3.48	-1.11	0.18	-1.32	-0.5	-1.47	-1.07	-2.09	0.19	-2.09	-2.48
Eq (6)	-2.57	-2.73	-3.66	-0.64	-2.87	-0.54	-2.88	-2.25	-4.16	0.83	-0.89	-2.34

1 Critical values at 5% for equation (5) are: -1.89 for π_1; -1.87 for π_2; -1.88 for π_{odd} and -1.63 for π_{even}.
For equation (6): -3.28 for π_1; -2.75 for π_2; -3.24 for π_{odd} and -1.85 for π_{even}.
Critical values at 10% for equation (5) are: -1.58 for π_1; -1.57 for π_2; -1.55 for π_{odd} and -1.27 for π_{even}.
For equation (6): -2.99 for π_1; -2.47 for π_2; -2.95 for π_{odd} and -1.45 for π_{even}.

Results of the estimation of the natural logarithms of the series which cover the period 1986:1 to 1994:12 are reported in Table 8.5. They reject seasonal unit roots at the 5% or 10% level at all the seasonal frequencies. Therefore, it seems that a deterministic seasonal pattern may be used appropriately to describe the seasonality of the series.

Conclusion

The results of the unit root tests on Caribbean seasonal variables are interesting on several accounts. Firstly, the conclusions are very similar to those reported on the origin of trends and seasonality in industrialised countries (Nelson and Plosser (1982), Perron (1988), Osborn (1990), etc.). Most Caribbean economic variables have a unit root at the long run frequency but not at the seasonal frequencies. Secondly, there is apparently no specificity about the properties of the process generating observations of the economic variables in these small open economies, although some Caribbean series do not have a profile corresponding to that observed for similar series in industrialized countries.

Lastly, from a technical point of view, the results of the tests show that the differentiations $\Delta_1\Delta_4$ *or* $\Delta_1\Delta_{12}$ which are usually made according to the Box and Jenkins methodology are often excessive. In a general way, this fact underlines how important it is to carefully examine the statistical properties of Caribbean macroeconomic series, in order to trace the fundamental evolution connected with the economic tendencies in these countries. This is particularly true for studies of economic fluctuations and short term forecasting which are becoming an increasingly common practice, as more reliable statistical measures are now available in these countries.

NOTES

1. The test statistics are respectively τ_t, t_μ and τ and their corresponding critical values - 3.45; -2.89 and -1.95 for a sample of 100 observations (Dickey and Fuller (1981)).

2. For a sample of 100, the critical values for $\tau_{\beta 1}$ and $\tau_{\beta 2}$ are respectively, -1.94 and 1.93.

References

Beaulieu, J.J. and Miron, J.A. (1993), "Seasonal Unit Roots in Aggregate US Data," *Journal of Econometrics*, 55, 305-328.

Craigwell, R., Leon, H., Christopher-Nicholls, J., Nicholls, S., Walker, A. and Watson, K.P. (1995), "Reflections on Macroeconomic Forecasting in the English-speaking Caribbean," Paper presented at the Central Bank of Barbados Research Review Seminar, July 6,7.

Dickey, D.A., and Fuller, W.A. (1981), "Likelihood Ratio Tests for Autoregressive Time Series with a Unit Root," *Econometrica*, 49, 1057-1072.

Dickey, D.A., D.P. Hasza and W.A. Fuller (1984), "Testing for Unit Roots in Seasonal Time Series," *Journal of the American Statistical Association*, 79:336, June, 335-67

Doan T.A. (1992), RATS, User's Manual, Version 4, Fatima.

Engle, R.F., Granger, C.W.J., Hylleberg, S., Lee, H.S. (1993), "Seasonal Cointegration. The Japanese Consumption Function," *Journal of Econometrics*, 55, 275-298.

Frances, P.H. (1994), "A Multivariate Approach to Modeling Univariate Seasonal Time Series," *Journal of Econometrics*, 63, 133-151.

Ghysels, E. (1994), "On the Economics and Econometrics of Seasonality," *Advances in Econometrics*, 6th World Congress, Edited by Sims, C.A., Cambridge University Press.

Ghysels, E. and Perron, P. (1993), "The Effect of Seasonal Adjustment Filters on Tests for Unit Roots," *Journal of Econometrics*, 62, 415-442.

Harvey, A. and Scott, A. (1994), "Seasonality in Dynamic Regression Models," *The Economic Journal,* 104, 1324-1345.

Hasza, D.P. and Fuller, W.A.(1982), "Testing for Non-Stationarity Parameter Specifications in Seasonal Time Series Models," *The Annals of Statistics,* 10, 1209-1216.

Holder, C., Leon, H. and Wood, C. (1990), "Testing for Non-Stationarities in Macroeconomic Time Series Data," *Social and Economic Studies,* 39: 4, 83-105.

Hyllerberg, S. (1992), *Modelling Seasonality,* Oxford University Press.

Hyllerberg, S. (1994), "Modelling Seasonal Variation," in *NonStationary Time Series Analysis and Cointegration: Advanced Texts in Econometrics,* Edited by Colin P. Hargreaves, Oxford University Press.

Hyllerberg, S. (1995) "Tests for Seasonal Unit Roots. General to Specific or Specific to General?" *Journal of Econometrics,* 69, 5-25.

Hyllerberg, S., Engle, R.F., Granger, W.J. and Yoo, B.S. (1990), "Seasonal Integration and Cointegration," *Journal of Econometrics,* 44, 215-238.

Hyllerberg, S., Jorgensen, C. and Sorensen, N.K. (1993), "Seasonality in Macroeconomic Time Series," *Empirical Economics,* 18, 321-335.

Jobert, T., (1992), "Test de racine unitaire: une strategie et sa mise en oeuvre," *Cahiers EcoMath,* Université de Paris I, n 92-44.

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control,* 44, 231-254.

Johansen, S. and Juselius, K. (1990), "Maximum Likelihood Estimation and Inference on Cointegration," *Oxford Bulletin of Economics and Statistics,* 52, 169-210.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P. and Shin, Y. (1992), "Testing the Null Hypothesis of Stationarity Against the Alternative of A Unit Root," *Journal of Econometrics,* 54, 159-178.

Lee, H.S. (1992), "Maximum Likelihood Inference on Cointegration and Seasonal Cointegration," *Journal of Econometrics,* 54,1-47.

Lütkepohl, H. (1993), *Introduction to Mutiple Time Series Analysis,* Sec. Ed., Springer-Verlag.

Maurin, A. and Montauban, J.G. (1995), "Modélisation et prévision des séries temporelles: l'apport des techniques récentes," L.E.A.D., Université des Antilles et de la Guyane.

Muscatelli, V.A. and Hurn S., (1992), "Cointegration and Dynamic Time Series Models," *Journal of Economic Surveys,* 6:1, 1-43.

Nelson, C.R. and Plosser, C.I. (1982), "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications," *Journal of Monetary Economics,* 10, 139-162.

Osborn, D.R., Chui, A.P.L., Smith, J.P. and Birchenhall, C.R. (1988), "Seasonality and the Order of Integration for Consumption," *Oxford Bulletin of Economics and Statistics,* 50, 361-377.

Osborn, D.R. (1988), "Seasonality and Habit Persistence in a Life Cycle Model of Consumption," *Journal of Applied Econometrics*, 3, 255-266.

Osborn, D.R. (1990), " A Survey of Seasonality in UK Macroeconomic Variables," *International Journal of Forecasting*, 6:3, 327-336.

Perron, P. (1988), "Trends and Random Walks in Macroeconomic Time Series: Further Evidence from a New Approach," *Journal of Economic Dynamics and Control*, 12, 297-332.

Phillips, P.C.B. and Perron, P. (1988), "Testing for Unit Roots in Time Series Regression," *Biometrica*, 75, 335-346.

Wallis, K.F.(1992), "Seasonal Adjustment and Relations Between Variables," in *Modelling Seasonality*, Edited by Hyllerberg S., Oxford University Press.

APPENDIX 8.A1

The Data Series by Country

All quarterly series are taken from the World Bank's data base.

Name	Country	Period	Description
CRRD	Rep. Dom.	1960:1-1994:4	domestic credit
MRD	Rep. Dom.	1960:1-1994:4	money
PCRD	Rep. Dom.	1960:1-1994:4	index of consumer prices
CRB	Barbados	1967:1-1994:4	domestic credit
MB	Barbados	1967:1-1994:4	money
IPIB	Barbados	1973:1-1994:4	index of industrial production
PCB	Barbados	1966:1-1994:4	index of consumer prices
CRG	Guyana	1967:1-1994:4	domestic credit
MG	Guyana	1960:1-1994:4	money
PCG	Guyana	1960:1-1992:4	index of consumer prices
CRJ	Jamaica	1963:1-1994:4	domestic credit
MJ	Jamaica	1961:2-1994:4	money
PCJ	Jamaica	1960:1-1994:4	index of consumer prices
CRTT	Trin. & Tob.	1960:1-1994:4	domestic credit
MTT	Trin. & Tob.	1960:1-1994:4	money
IPITT	Trin. & Tob.	1978:1-1994:4	index of industrial production
PCPTT	Trin. & Tob.	1969:1-1994:4	index of consumer prices

Appendix 8.A2

Decomposition of the polynomial $(1-B^{12})X_t$ for the HEGY Test on monthly data

$$X_{1,t} = \left(1 + B + B^2 + B^3 + B^4 + B^5 + B^6 + B^7 + B^8 + B^9 + B^{10} + B^{11}\right)X_t$$

$$X_{2,t} = -\left(1 - B + B^2 - B^3 + B^4 - B^5 + B^6 - B^7 + B^8 - B^9 + B^{10} - B^{11}\right)X_t$$

$$X_{3,t} = -\left(B - B^3 + B^5 - B^7 + B^9 - B^{11}\right)X_t$$

$$X_{4,t} = -\left(1 - B^2 + B^4 - B^6 + B^8 - B^{10}\right)X_t$$

$$X_{5,t} = -\frac{1}{2}\left(1 + B - 2B^2 + B^3 + B^4 - 2B^5 + B^6 + B^7 - 2B^8 + B^9 + B^{10} - 2B^{11}\right)X_t$$

$$X_{6,t} = \frac{\sqrt{3}}{2}\left(1 - B + B^3 - B^4 + B^6 - B^7 + B^9 - B^{10}\right)X_t$$

$$X_{7,t} = \frac{1}{2}\left(1 - B - 2B^2 - B^3 + B^4 + 2B^5 + B^6 - B^7 - 2B^8 - B^9 + B^{10} + 2B^{11}\right)X_t$$

$$X_{8,t} = \frac{\sqrt{3}}{2}\left(1 + B - B^3 + B^4 + B^6 + B^7 - B^9 - B^{10}\right)X_t$$

$$X_{9,t} = \frac{1}{2}\left(\sqrt{3} - B + B^3 - \sqrt{3}B^4 + 2B^5 - \sqrt{3}B^6 + B^7 - B^9 + \sqrt{3}B^{10} - 2B^{11}\right)X_t$$

$$X_{10,t} = \frac{1}{2}\left(\sqrt{3}B + 2B^2 - \sqrt{3}B^3 + B^4 - B^6 + \sqrt{3}B^7 - 2B^8 + \sqrt{3}B^9 - B^{10}\right)X_t$$

$$X_{11,t} = \frac{1}{2}\left(\sqrt{3} + B - B^3 - \sqrt{3}B^4 - 2B^5 - \sqrt{3}B^6 - B^7 + B^9 + \sqrt{3}B^{10} - 2B^{11}\right)X_t$$

$$X_{12,t} = \frac{1}{2}\left(1 + \sqrt{3}B + 2B^2 + \sqrt{3}B^3 + 2B^4 - B^6 - \sqrt{3}B^7 - 2B^8 - \sqrt{B^9} - B^{10}\right)X_t$$

Appendix 8.A3
Henin and Jobert Strategy for the ADF Test

We start from the five following equations;

$$(1)\ \Delta X_t = a + bt + \rho X_{t-1} + \sum_k \gamma_k \Delta X_{t-k} + \varepsilon_t$$

$$(2)\ \Delta X_t = a + \rho X_{t-1} + \sum_k \gamma_k \Delta X_{t-k} + \varepsilon_t$$

$$(3)\ \Delta X_t = \rho X_{t-1} + \sum_k \gamma_k \Delta X_{t-k} + \varepsilon_t$$

$$(4)\ \Delta X_t = a + bt + \sum_k \gamma_k \Delta X_{t-k} + \varepsilon_t$$

$$(5)\ \Delta X_t = a + \sum_k \gamma_k \Delta X_{t-k} + \varepsilon_t$$

We sort out the number of lags in equation (1) with the help of the BIC criterion. Then we apply a downward sequential procedure whose main stages are:

Stage I: We test $\rho = 0$ in equation (1) by using the statistic τ_t. If τ_t is lower than the critical value, we go to stage II, if not we test the coefficient of the deterministic trend with the standard Student-t. If b=0 we go to stage III, if not $X_t \sim I(0) + T + C or X_t \sim I(0) + T$ depending on whether a is different from zero or not.

Stage II: We test b=0 in equation (4) according to the Student-t. If it is significant, we go to stage III, if not, we conclude that $X_t \sim I(0) + T^2$.

Stage III: We consider equation (2). We test the hypothesis of unit root from the statistic τ_u. If $\rho = 0$, we go to stage IV, if not we test the nullity of a according to the Student-t. If a=0 then X_t~*I(0), if not* X_t~*I(0)* +C.

Stage IV: We test once again the nullity of a in equation (5) according to the t of Student. If a=o then we go to stage V, if not X_t~*I(1)+T.*

Stage V: We test r=0 in the equation (3) according to the statistic τ. If ρ =0 then X_t~*I(1), if not* X_t~*I(0)* .

Appendix 8.A4

5% Critical Values for the HEGY and OCSB Tests

Model	n	$t_{\pi 1}$	$t_{\pi 2}$	$t_{\pi 3}$	$t_{\pi 4}$	F_{1234}	F_{234}	F_{34}
	48	-1.95	-1.95	-1.93	-1.76	2.62	2.80	3.26
Eq. 2	100	-1.97	-1.92	-1.90	-1.68	2.55	2.76	3.12
	136	-1.93	-1.94	-1.92	-1.68	2.53	2.72	3.14
	48	-3.71	-3.08	-3.66	-1.91	6.53	6.09	6.55
Eq. (3)	100	-3.53	-2.94	-3.48	-1.94	6.47	5.99	6.60
	136	-3.52	-2.93	-3.44	-1.94	6.33	5.91	6.62

Appendix 8.A5

Lag Length Selection Criteria

AIC :Akaike's Information Criterion

$$AIC(j) = ln(\sigma^2) + \frac{2j}{T}$$

BIC :Bayesian Information Criterion

$$BIC(j) = ln(\sigma^2) + (ln\sigma^2) + j\frac{\ln T}{T}$$

HQ :Hannan-Quinn Criterion

$$HQ(j) = ln(\sigma^2) + cj\frac{\ln T}{T} \text{ with } c > 2$$

The optimal lag $\hat{p}$ is given by the value of j which minimizes these criteria.

CHAPTER 8

"SEMI-OFFICIAL" QUARTERLY NATIONAL ACCOUNTS

Christopher Martin Clarke
and
Michelle Francis

"Semi Official" Quarterly National Accounts

Christopher Martin Clarke
&
Michelle Francis

The authors are both economists at the Central Bank of Trinidad and Tobago. The views expressed are those of the authors and not the Central Bank of Trinidad and Tobago

Introduction

Caribbean econometricans have long identified "data deficiency" as a serious constraint to their work. Watson (1995) notes that the data available for macroeconomic model building not only suffers from the "quality" or measurement problems of the type identified by Griliches (1986) and Hendry (1980) but perhaps more importantly is also deficient from a *quantity* stand point. Watson notes that in many countries the time series covering the key macroeconomic aggregates required for model building are either "non existent, plagued by missing values, too short, or of an inappropriate frequency". These problems are particularly acute in the area of the national income and expenditure accounts which form the core of data requirements for any macroeconomic model.

While the major concern of this paper is the issue of inadequate periodicity, it is worth noting some of the qualitative problems of national accounts data. Most Caricom countries emphasize the output approach to national income accounting and data on expenditure estimates especially in the areas of consumption and investment are particularly weak and estimated at a very aggregated level. Except for Trinidad and Tobago and Jamaica, data are not generally available on expenditure estimates at constant prices and even these data are available only with a significant lag. Forde (1989) noted that for the Trinidad and Tobago data the most serious concern is probably the question of the consistency or reliability of the data over time. Not only are the revisions large, but the dispersion of the revisions is chaotic.

It seems then that the National Statistical Organisations (NSOs) in the Caricom region are barely coping with the challenge of producing an acceptable stream of annual data; and in the medium term they are unlikely to devote significant resources to the production of timely quarterly national accounts. This paper contends that semiofficial statistical agencies - for example Central Banks - should play the leading role in producing such data. After all, it is these institutions which have a compelling need for up-to-date statistics for short-term economic analysis, modelling and forecasting. Indeed, this has been the pattern in the developed countries, as for example, quarterly national accounts for the United States were first produced by the National Bureau of Economic Research in the 1930s. In the Caribbean, the Central Bank of Trinidad and Tobago has been publishing a quarterly real GDP series since 1987. This paper demonstrates that while the compilation of quarterly national accounts is not a trivial exercise, most of the data required is readily available and presented in routine Central Bank publications. The rest of the paper is set out as follows: in the next section, the relationship between quarterly and annual national accounts is established. This is followed by a discussion of the approach that should be adopted for the production of quarterly national accounts for the typical Caricom country. The issue of technical and operational feasibility of such an undertaking is then outlined and then there is a practical example using data for Trinidad and Tobago. The paper concludes with a few remarks on quality assurance.

Quarterly vs Annual National Accounts

The compilation of the full set of national accounts as set out in the System of National Accounts 1993 (SNA 1993) imposes an enormous burden on even the most sophisticated statistical office. As such, no country establishes the full system including the balance sheet on a quarterly basis. In fact, only in a relatively small number of cases are the data on important annual flows (such as, consumption, investment and so on) generated directly from the aggregation of quarterly flows. In most countries, the annual estimates are generated directly from annual surveys and not derived as the sum of quarterly accounts. Quarterly national accounts data are then derived using the *indicator series* methodology. In this methodology, extensive use is made of short term indicator series to establish the quarterly growth path and the annual series are simply moved along this growth path. For example, consider a typical Caricom economy with two sectors - sugar and tourism. One can estimate quarterly real value added for the two sectors using indicators as follows: sugar production and visitor arrivals. The two indicators are available quarterly and with appropriate weights and choice of a base year one can derive a quarterly real GDP Index for this economy. This of course is a simplified example but serves to illustrate the use of the indicator methodology.

An important part of the methodology is the process of reconciling the annual outturn obtained from the indicator based movements with the *true* estimate based on the annual data. Such a process of reconciliation also obtains even where the annual estimates are obtained directly by aggregating the quarterly flows. Indeed it is common practice to revise these estimates in the light of more complete data derived from annual sources such as input-output tables.

Aside from reducing the problem of the estimation burden, there are a number of arguments in favour of the indicator series methodology. Much of the data utilized, for example accounting data, is either available on an annual basis only or when available at higher frequencies, is not reliable and subject to large revisions. Moreover, annual estimates based on quarterly data may differ markedly from those based on annual surveys where establishments and products are better covered. As such, the SNA 1993 warns against too heavy reliance on the analysis of short term indicators since their lack of consistency means that economic interrelationships are not easily understandable through them. Indeed the SNA 1993 notes that the major contribution of quarterly accounts to the development of national accounting methodology lies in providing an understanding of the relationship between the annual indicators and the short-term economic indicators. Thus, SNA 1993 advises that it is better to base the analysis of the longer term on annual data and adopt data derived from quarterly indicators only for the short run or the current period.

In the Caricom region there are several other compelling reasons which suggest that the most efficient course for the potential compiler of quarterly national accounts is to adopt the indicator series methodology. Some of these are as follows:- an institutional environment that is somewhat hostile to the use of business surveys; the need for the quarterly data to be available on a very timely basis; and finally resource constraints especially human and financial. Moreover, the production of quarterly and annual national accounting estimates should always be viewed as complementary activities and the quarterly data should not be seen as a substitute for the annual estimates. Once this position is understood several of the hazards which confront the compiler of quarterly estimates can be addressed in a systematic fashion.

The first of these is the issue of credibility. In an ideal world work of this kind is done in research arms of statistical agencies; unfortunately however, none of the NSOs in the Caricom region have specific research arms. Moreover, these agencies have been unduly affected by some deterioration and loss of resources - human, financial and physical. It is against this background that one can argue that Research Departments of the regional Central Banks should get involved in this type of research[1]. Yet, once such a semiofficial entity begins to compile quarterly national accounts the entity will be regarded as a unwelcome competitor by the NSO which produces the "official data".

The situation is worsened further when the annual movements based on the quarterly estimates differ from the "official" estimates and may even lead to confusion (whether real or imagined) among the user community. This is true even when the quality of the quarterly estimate is acknowledged to be higher than the corresponding annual data, or the variance between the two sets of numbers is insignificant. However, if one adopts the indicator methodology this problem can be eliminated since with this methodology an effort is made to reconcile the annual and quarterly changes. Nevertheless it should be noted that such reconciliation should be done only after a comprehensive review of the reasons for the variance between the two series. Indeed, such a regular quality assurance review, in which the representatives from both agencies participate is likely to improve the quality of the annual estimates.

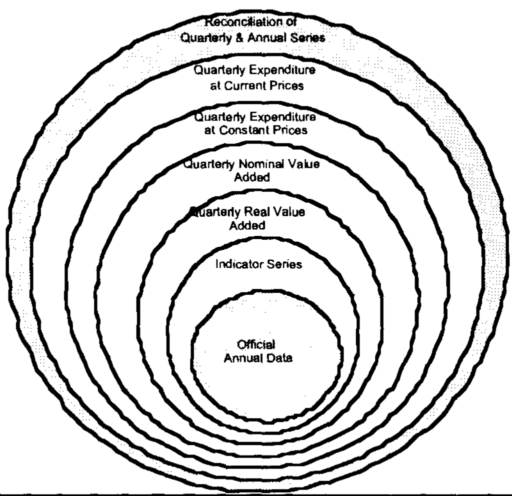
The indicator series methodology also legitimizes the use of less reliable quarterly indicators on the grounds that these are used solely to track short run movements; moreover these estimates are likely to be replaced with higher quality data derived from the annual estimates. Thus armed, the compiler may derive quarterly estimates of GDP even where the quality of the quarterly indicator data is generally so weak that independent estimates would be difficult to defend. Nonetheless in some of the more challenging areas of expenditure estimates (for example inventories) an appropriate indicator series may not be available; in this case it may be legitimate to estimate annual changes which are allocated on a quarterly basis using the popular Lisman-Sandee or the cubic spline techniques.

A General Methodology For Quarterly National Accounts

Chart 10.1 is a ring diagram which illustrates in a conceptual manner the indicator series methodology. The diagram also illustrates the relationship between the data sets used in the estimation of the quarterly data. At the core is the annual data produced by the NSO and this database determines the kind of quarterly estimates that can be produced. For some countries it may be possible to produce value added or expenditure estimates in both constant and current prices. In other cases, the annual data base is more deficient and it is only possible to produce value added estimates at constant and current prices. The indicator series methodology involves the periodic benchmarking of the quarterly indicator series against the annual statistics. This implies that the quality and stability of the quarterly data will be determined by the relevance, accuracy, timeliness and revision performance of the annual estimates. Thus, an essential requirement for the compiler of quarterly national accounts is the need to effectively interface with the NSO and exert a positive influence on the quality of the official data.

The official annual data also determines the potential level of disaggregation that is possible, although this is also determined by the availability of short run indicators which form the second ring in the diagram. Several such indicators are usually readily available from NSOs and include the following: the retail price index, the indices of retail sales and producer prices, data on exports and imports collected for balance of payments purposes, income and outlay data collected in the course of monetary surveys and data on government revenues and expenditure.

CHART 10.1
CIRCLE CHART: INDICATOR SERIES METHODOLOGY



However, other important data such as information on the value and volume of goods and services produced by the industrial sector are often not as readily available from secondary sources. In some of the larger Caricom countries - Trinidad and Tobago, Jamaica and Barbados - production indices are available but closer examination reveals that these indices are often not suitable for use as an indicator series.

For example, in the case of Trinidad and Tobago, the Index of Domestic Production has a base year of 1977 and is released with a lag of one quarter. Moreover, the industrial classification system utilised is the Trinidad and Tobago Industrial Classification System which is incompatible with the Trinidad and Tobago System of National Accounts (TTSNA) utilized for national accounting. Fortunately, these problems can easily be remedied by implementing in-house production surveys. This task is not as burdensome as it may appear as most Caricom countries have 'monocrop' economies and are highly specialized. This implies that value added is generated in a few key sectors such as tourism (Barbados) and oil production (Trinidad). This gives the designers of the in-house surveys the opportunity to concentrate their survey efforts on those sectors where most of the value added is generated. Indeed, much of the raw input is regularly collected, tabulated and presented in the statistical bulletins published by almost every Central Bank in the region. However, the designers of such surveys should also take cognisance of several factors: respondent burden; the reluctance of respondents to disclose financial information; and the difficulty in obtaining information on the pricing of output from certain sectors where price discrimination and discounting are prevalent.

Data availability considerations also play an important role in determining the structure of the outer rings in Chart 10.1, and this essentially follows from the approach adopted by most Caricom NSOs to the calculation of the annual estimates. At Level 3 real value added is estimated using a combination of production indices, the deflation of sales or turnover statistics, physical quantity indicators, employment indicators and in some instances econometric methods.[2] These indicators can then be inflated by appropriate price indices or in cases where available, directly estimated using current price indicators of sales or turnover to obtain quarterly value added at current prices.

In *circle* 5 Gross Domestic Product at current prices is obtained in much the same manner as the value added series (of course the indicator series utilized will differ). The issue of the "independence" of value added and expenditure is not relevant in *circle 5* since the aim is simply to replicate the quarterly growth path of the "official" annual estimate. If the official methodology involves the estimation of components such as consumption or investment then there may be some motivation to utilize this method. However, from a quality assurance point of view it may be valuable to track the growth path of any of the annual "official" series obtained as residuals with short run indicators. The major indicator series utilized include indices of retail sales and government revenue for consumption expenditure and imports and exports for net imports. In *circle* 6 the constant price series are obtained mainly by the deflation of the current expenditure series. In most Caricom countries the retail price index is the only deflator available. However, this index should be used judiciously and the arbitrary use of the "All-Items" index should be avoided.

Finally *circle 7* is concerned with reconciliation of the quarterly series obtained from the lower levels with the annual data at the core of the methodology. Whenever the quarterly flows are based on related quarterly series, there will always be a difference between the sum of the quarters and the annual outturn. At the most basic level these series can be adjusted to the annual level on a prorata basis which will leave the period to period percentage changes unaffected. However the year to year percentage changes are affected since there is a discontinuity between the fourth quarter of the preceding year and the first quarter of the current year. This is sometimes known as the step problem and several methods have been devised to deal with it. The earliest of these is due to Bassie (1958) who obtained quarterly correction factors by hypothesising that the correction factor was a function of time and minimizing this function subject to a number of simple conditions. Other solutions have been suggested by Ginsberg (1973) and more recently Arima models have been proposed. In some cases the problem may be ignored on the ground that the data will be seasonally adjusted and seasonal adjustment packages contain algorithms to deal with such problems. More importantly, however is that there are no reconciliation techniques which can ameliorate the problems caused by choice of a poor indicator series. An indicator series that tracks the quarterly growth path in the annual estimates will need very little reconciliation, while the reconciliation of an indicator based series that is completely orthogonal to the growth path in the annual series will always cause problems. In such cases it may be best to devote attention to the search for better quality indicators, or to identifying the biases in the indicator series and adjusting these series for known biases during the extrapolation period.

A Practical Example With Data From Trinidad and Tobago

To illustrate the simplicity and practicality of the indicator series methodology estimates of quarterly real GDP by industrial sector in both constant and current market prices were calculated for Trinidad and Tobago for the period 1985 to 1989. Appendix 10.A1 details the major data sources used for the estimates although extensive use was made of the production indices which have been compiled at the Central Bank. These data are at the core of the Bank's QGDP Index which is published in the *Quarterly Economic Bulletin*.[3] In what follows there is a brief survey of some of the major issues raised in the estimation of quarterly value added for key sectors of the Trinidad and Tobago economy.

Agriculture

At first glance finding an indicator series for the agriculture sector seems to be straightforward. The annual estimates for gross output are obtained largely from production data, so the logical approach would be to use quarterly production data as an indicator series for the sub-sectors in agriculture. However, in addition consideration must be given to work in progress; indicators based on quarterly production data will tend to understate value added outside the period when the crops are harvested. The bias will increase with the length of the gestation period for each crop but will disappear if the crop is harvested every quarter. For major crops like rice, cocoa, coffee and sugar there are only one or two established reaping periods. The expected annual outturn should be allocated to each quarter on the basis of estimates of work done each period.

Factors used to allocate work in progress each period are obtained via discussions with employers in the major industry groupings (eg. sugar and rice) in the agriculture sector. Forecasts of production for the current year are then allocated to the respective quarters using these factors, which are updated every year. The agriculture index is then derived when the quarterly production data based on work in progress are weighted based on their share in value added. The quarterly constant price GDP estimates for the sector are then simply derived by moving the annual constant price GDP estimates for the previous year by the quarterly changes in the derived agriculture index in each period. Quarterly current price GDP estimates are obtained by inflating the quarterly constant price equivalents by the appropriate sections of the Retail Price Index (RPI). This approach was utilized to obtain the quarterly estimates presented in the paper. However, quarterly data can also be derived by other methods such as trend extrapolation or the application of distribution techniques like Lisman-Sandee. An important point to note here is that the quarterly data obtained by using any of these techniques should **not** be subjected to further seasonal adjustment as this is likely to introduce an element of spurious seasonality into the data.

Manufacturing

Although Trinidad and Tobago has a relatively small manufacturing sector the data requirements for the sector are quite intense. To derive quarterly constant price value added for the manufacturing sector, annual constant price value added in this sector is moved by a quarterly production index. This index is derived by weighting production data obtained from a quarterly sample survey of about sixty major firms according to their share of GDP for a base year. The annual constant price value added for the previous year is moved by the quarterly changes in the production index in order to derive the quarterly constant price series for the current year. The quarterly current price estimates are then obtained by inflating the production index by the relevant sections of the Producers' Price Index (PPI) and applying the changes to the annual current price estimates of the previous year. One disadvantage of the quarterly current price methodology is that the PPI is based on the SITC Revised II Classification, whereas the annual constant price estimates are based on the TTSNA classification. However, since only the major categories of the PPI are used the differences can be ignored for these purposes.

Petroleum

The indicator series used to construct an overall index for the Petroleum sector are crude oil production, refinery throughput, rig months, petrochemical production, and the distribution of petroleum products. Data on these activities are obtained from the Ministry of Energy. The petroleum index is then derived when these indicator series are weighted according to their share in value added for a given base year. Like the manufacturing sector, the annual constant price estimates for the previous year are moved by the quarterly changes in the petroleum index of the current year in order to derive the corresponding quarterly constant price GDP estimates in the current year. To obtain the quarterly current price estimates for this sector, the petroleum index is inflated by the appropriate petroleum price indices and the resulting quarterly changes are applied to the annual current price estimate of the previous year.

Once the quarterly constant and current price GDP estimates have been derived, the next step is to insure that the derived quarterly estimates are consistent with the annual figures. As mentioned earlier in this paper, this is known as benchmarking. Differences arise when the annual estimates are based on sources which are different from their quarterly counterparts. In these circumstances, it is generally necessary to adjust the quarterly estimates to bring them in line with the more accurate annual data.

Quality Assurance

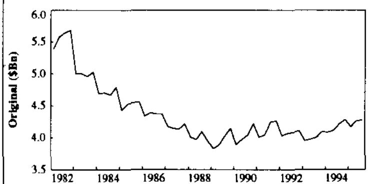
Reliable national accounting information can only be obtained if rigorous quality control measures are implemented. This applies to the production of both quarterly and annual accounts. The most important determinant of data quality, that is, the quality of the "official" annual estimates is outside the control of the compiler of the quarterly accounts. The compiler of the quarterly accounts must ensure that the annual movements are consistent and that the annual data are not subject to unstable revisions. Producers of quarterly national accounting data must make every effort to ensure that the indicator series utilized are relevant, reliable and closely track the official annual estimates. This is complicated by the fact that the quarterly national accounting data has an extremely short "shelf-life" and should be available with as short a lag as possible. Since much of the data utilized in the indicator series is collected from surveys or secondary sources, it is important to have reliable methods to deal with the problem of non-response. Some writers have argued that ARIMA techniques should be used in the information process but unfortunately in the Caricom context the application of such techniques is limited by the short span of the indicator series. While the utility of formal time series methods is limited it is important not to rely solely on judgement for making imputations. In this paper, use is made of a weighted average of the year-on-year growth rates of the latest three periods to impute for non response. (This simple technique can also be used to make simple projections of the annual outturn).

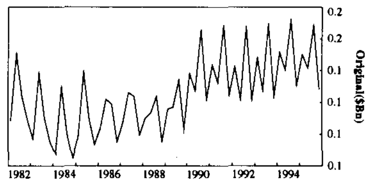
There are a number of other measures that the producers of quarterly accounts can put in place to improve the quality of their estimates. Clearly, the data should be seasonally adjusted as this will serve to distinguish trends from seasonal fluctuations. The data should be reported on a regular basis so that policy makers and analysts can assess its relationship to other short run indicators. Finally, serious consideration should also be given to the development of an input-output model as this would provide compilers with the kind of framework necessary to assess the consistency of the estimates.

TABLE 8.1: G.D.P At Market Prices by Industry

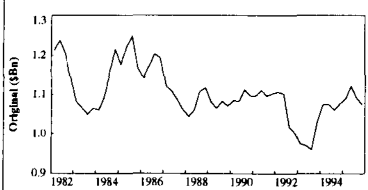
Constant Prices - Millions of 1985 Dollars

Period	Total G.D.P Original Level	Yr/Yr	Adjusted Level	Yr/Yr	Trend-Cycle Level	Yr/Yr	Total Agriculture Original Level	Yr/Yr	Adjusted Level	Yr/Yr	Trend-Cycle Level	Yr/Yr	Period
1991	16,567.3	2.7					568.6	2.8					1991
1992	16,287.2	-1.7					553.3	-2.7					1992
1993	16,023.5	-1.6					568.2	2.7					1993
1994	16,694.4	4.2					593.8	4.5					1994
1995							588.4	-0.9					1995
1990 IV	4,225.1	1.9	4,112.3	1.9	4,070.4	1.8	121.8	20.5	138.4	17.6	140.2	13.1	IV 1990
1991 I	4,006.3	2.9	4,108.4	2.9	4,105.6	2.3	143.6	3.8	145.2	3.7	141.2	9.3	I 1991
II	4,042.7	1.7	4,087.7	1.7	4,137.1	2.8	132.1	3.9	127.9	4.0	141.8	4.5	II
III	4,255.2	5.3	4,220.9	5.3	4,144.9	2.4	168.7	1.7	154.6	1.9	142.0	2.2	III
IV	4,263.1	0.9	4,150.3	0.9	4,150.9	2.0	124.2	2.0	140.8	1.8	140.6	0.3	IV
1992 I	4,031.0	0.6	4,133.1	0.6	4,132.4	0.7	142.6	-0.7	144.1	-0.7	139.2	-1.4	I 1992
II	4,065.5	0.6	4,110.5	0.6	4,091.4	-1.1	121.7	-7.9	117.5	-8.1	138.7	-2.2	II
III	4,084.7	-4.0	4,050.4	-4.0	4,061.8	-2.0	167.9	-0.5	153.9	-0.5	139.0	-2.1	III
IV	4,106.0	-3.7	3,993.2	-3.8	4,040.6	-2.7	121.1	-2.5	137.8	-2.2	140.4	-0.1	IV
1993 I	3,951.1	-2.0	4,053.2	-1.9	4,019.1	-2.7	148.1	3.9	149.7	3.9	141.3	1.5	I 1993
II	3,975.3	-2.2	4,020.4	-2.2	4,007.4	-2.1	127.0	4.4	122.9	4.5	141.8	2.2	II
III	4,003.1	-2.0	3,968.7	-2.0	4,022.3	-1.0	169.6	1.0	155.6	1.1	142.5	2.5	III
IV	4,094.0	-0.3	3,981.2	-0.3	4,055.9	0.4	123.4	1.9	140.1	1.7	144.5	3.0	IV
1994 I	4,082.5	3.3	4,184.6	3.2	4,099.1	2.0	151.6	2.3	153.1	2.3	146.5	3.7	I 1994
II	4,112.6	3.5	4,157.6	3.4	4,149.4	3.5	140.1	10.3	135.9	10.6	147.6	4.1	II
III	4,211.4	5.2	4,177.1	5.3	4,184.7	4.0	171.9	1.3	157.8	1.5	148.3	4.1	III
IV	4,287.9	4.7	4,175.1	4.9	4,214.5	3.9	130.3	5.5	146.9	4.9	148.3	2.6	IV
1995 I	4,171.6	2.2	4,273.7	2.1	4,242.1	3.5	150.3	-0.8	151.9	-0.8	148.1	1.1	I 1995
II	4,261.8	3.6	4,306.8	3.6			141.5	1.0	137.3	1.0	147.4	-0.2	II
III	4,283.1	1.7	4,248.8	1.7			168.5	-2.0	154.4	-2.1			III
IV							128.1	-1.6	144.8	-1.5			IV





Period	Petroleum Original Level	Yr/Yr	Adjusted Level	Yr/Yr	Trend-Cycle Level	Yr/Yr	Manufacturing Original Level	Yr/Yr	Adjusted Level	Yr/Yr	Trend-Cycle Level	Yr/Yr	Period
1991	4,405.7	0.7					1,344.2	4.8					1991
1992	4,228.5	-4.0					1,341.0	-0.2					1992
1993	3,937.2	-6.9					1,296.0	-3.4					1993
1994	4,287.1	8.9					1,341.4	3.5					1994
1995	4,376.8	2.1											1995
1990 IV	1,096.7	2.3	1,092.7	2.3	1,100.5	2.0	335.3	3.4	330.1	3.5	320.8	2.0	IV 1990
1991 I	1,096.2	1.1	1,105.7	1.0	1,102.0	1.6	303.7	0.3	314.3	0.3	326.2	2.8	I 1991
II	1,111.0	2.7	1,110.6	2.7	1,100.7	0.9	329.6	-0.2	325.0	-0.3	333.9	4.6	II
III	1,096.2	-1.5	1,091.2	-1.5	1,102.8	0.7	358.5	14.1	357.7	14.1	342.2	6.7	III
IV	1,102.4	0.5	1,098.3	0.5	1,102.9	0.2	352.4	5.1	347.2	5.2	348.3	8.6	IV
1992 I	1,107.0	1.0	1,116.6	1.0	1,091.9	-0.9	352.8	16.2	363.5	15.6	344.0	5.4	I 1992
II	1,100.7	-0.9	1,100.3	-0.9	1,069.7	-2.8	329.1	-0.2	324.5	-0.2	337.5	1.1	II
III	1,018.6	-7.1	1,013.6	-7.1	1,040.6	-5.6	324.6	-9.5	323.8	-9.5	330.1	-3.5	III
IV	1,002.2	-9.1	998.1	-9.1	1,007.8	-8.6	334.4	-5.1	329.3	-5.2	324.5	-6.8	IV
1993 I	975.1	-11.9	984.6	-11.8	984.1	-9.9	311.8	-11.6	322.4	-11.3	324.0	-5.8	I 1993
II	970.1	-11.9	969.6	-11.9	980.6	-8.3	325.5	-1.1	320.8	-1.1	324.0	-4.0	II
III	959.9	-5.8	954.9	-5.8	996.9	-4.2	324.2	-0.1	323.4	-0.1	325.6	-1.4	III
IV	1,032.1	3.0	1,028.0	3.0	1,022.6	1.5	334.5	0.0	329.3	0.0	331.4	2.1	IV
1994 I	1,075.6	10.3	1,085.1	10.2	1,048.2	6.5	324.7	4.2	335.4	4.0	338.1	4.3	I 1994
II	1,075.6	10.9	1,075.2	10.9	1,066.2	8.7	358.9	10.3	354.2	10.4	338.0	4.3	II
III	1,059.0	10.3	1,054.0	10.4	1,073.5	7.7	344.3	6.2	343.5	6.2	331.5	1.8	III
IV	1,076.9	4.3	1,072.8	4.4	1,081.0	5.7	313.5	-6.3	308.3	-6.4	323.2	-2.5	IV
1995 I	1,089.3	1.3	1,098.8	1.3	1,090.7	4.1	293.8	-9.5	304.4	-9.2	317.2	-6.2	I 1995
II	1,121.8	4.3	1,121.4	4.3	1,094.4	2.6	323.2	-9.9	318.6	-10.1			II
III	1,090.6	3.0	1,085.6	3.0			332.6	-3.4	331.8	-3.4			III
IV	1,075.0	-0.2	1,071.0	-0.2									IV



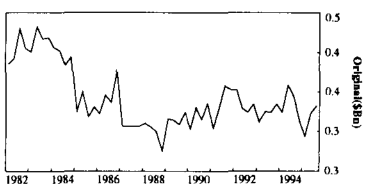


TABLE 8.2: G.D.P At Market Prices by Industry

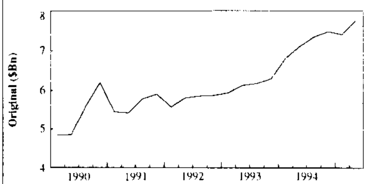
Current Prices - Millions of Dollars

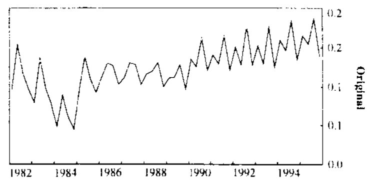
Total G.D.P

Period		Original Level	Original Yr/Yr	Adjusted Level	Adjusted Yr/Yr	Trend-Cycle Level	Trend-Cycle Yr/Yr
1991		22,558.6	4.7				
1992		23,118.8	2.5				
1993		24,519.4	6.1				
1994		28,733.7	17.2				
1995							
1990	*IV*	6,203.3		6,090.4		5,602.5	
1991	*I*	5,454.3	12.2	5,572.6	11.9	5,693.8	
	II	5,427.3	11.5	5,470.8	11.4	5,677.5	
	III	5,776.9	3.1	5,728.0	3.1	5,655.1	3.6
	IV	5,900.1	-4.9	5,787.2	-5.0	5,718.2	2.1
1992	*I*	5,577.7	2.3	5,696.0	2.2	5,775.9	1.4
	II	5,809.0	7.0	5,852.5	7.0	5,782.8	1.9
	III	5,856.4	1.4	5,807.4	1.4	5,825.0	3.0
	IV	5,875.7	-0.4	5,762.8	-0.4	5,909.0	3.3
1993	*I*	5,940.4	6.5	6,058.7	6.4	5,987.1	3.7
	II	6,118.2	5.3	6,161.7	5.3	6,078.2	5.1
	III	6,172.0	5.4	6,123.1	5.4	6,238.0	7.1
	IV	6,288.8	7.0	6,175.9	7.2	6,468.8	9.5
1994	*I*	6,805.3	14.6	6,923.6	14.3	6,737.8	12.5
	II	7,100.1	16.0	7,143.6	15.9	7,033.8	15.7
	III	7,342.1	19.0	7,293.2	19.1	7,259.4	16.4
	IV	7,486.2	19.0	7,373.3	19.4	7,420.7	14.7
1995	*I*	7,413.3	8.9	7,531.6	8.8		
	II	7,782.1	9.6	7,825.7	9.5		
	III						
	IV						

Total Agriculture

Original Level	Original Yr/Yr	Adjusted Level	Adjusted Yr/Yr	Trend-Cycle Level	Trend-Cycle Yr/Yr	Period	
558.8	2.2						*1991*
586.2	4.9						*1992*
583.6	-0.4						*1993*
625.3	7.1						*1994*
645.9	3.3						*1995*
121.2	24.8	139.6	20.8	138.3	14.8	*IV*	*1990*
141.4	3.2	142.7	3.3	139.2	10.0	*I*	*1991*
129.9	3.0	124.9	3.1	139.6	4.4	*II*	
165.6	1.7	151.2	1.9	140.9	2.6	*III*	
121.9	0.6	140.4	0.5	142.0	2.6	*IV*	
151.1	6.9	152.0	6.8	143.4	3.1	*I*	*1992*
128.9	-0.8	123.9	-0.8	145.8	4.4	*II*	
178.0	7.5	163.6	8.2	146.8	4.2	*III*	
128.2	5.2	146.7	4.5	147.1	3.6	*IV*	
153.0	1.3	154.0	1.3	146.9	2.5	*I*	*1993*
129.6	0.6	124.6	0.6	146.3	0.4	*II*	
176.0	-1.2	161.5	-1.3	146.8	-0.0	*III*	
125.1	-2.5	143.5	-2.1	149.7	1.8	*IV*	
160.0	4.6	160.9	4.5	152.9	4.0	*I*	*1994*
146.4	13.0	141.4	13.5	155.1	6.0	*II*	
184.2	4.7	169.8	5.1	157.0	7.0	*III*	
134.7	7.7	153.2	6.7	158.7	6.0	*IV*	
165.2	3.3	166.2	3.2	160.1	4.7	*I*	*1995*
154.8	5.7	149.8	5.9	161.0	3.8	*II*	
187.1	1.5	172.6	1.7			*III*	
138.9	3.1	157.3	2.7			*IV*	



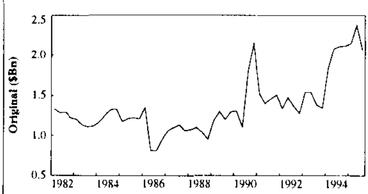


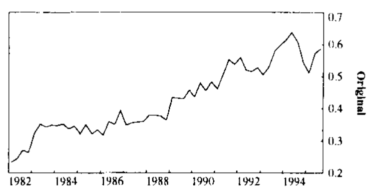
Petroleum

Period		Original Level	Original Yr/Yr	Adjusted Level	Adjusted Yr/Yr	Trend-Cycle Level	Trend-Cycle Yr/Yr
1991		5,903.2	-7.3				
1992		5,464.1	-7.4				
1993		5,825.2	6.6				
1994		8,154.1	40.0				
1995							
1990	*IV*	2,150.9	65.8	2,146.6	66.0	1,683.5	34.3
1991	*I*	1,524.3	16.6	1,508.9	16.8	1,678.1	28.7
	II	1,401.9	26.8	1,422.3	26.3	1,555.8	4.7
	III	1,465.7	-18.8	1,465.1	-18.8	1,452.7	-10.3
	IV	1,511.2	-29.7	1,506.9	-29.8	1,439.2	-14.5
1992	*I*	1,339.7	-12.1	1,324.3	-12.2	1,436.2	-14.4
	II	1,478.1	5.4	1,498.5	5.4	1,394.9	-10.3
	III	1,365.7	-6.8	1,365.1	-6.8	1,391.7	-4.2
	IV	1,280.5	-15.3	1,276.2	-15.3	1,425.9	-0.9
1993	*I*	1,545.3	15.3	1,529.9	15.5	1,437.0	0.1
	II	1,546.4	4.6	1,566.7	4.6	1,447.9	3.8
	III	1,385.6	1.5	1,385.0	1.5	1,492.6	7.2
	IV	1,347.9	5.3	1,343.6	5.3	1,596.3	11.9
1994	*I*	1,835.8	18.8	1,820.4	19.0	1,754.7	22.1
	II	2,084.9	34.8	2,105.2	34.4	1,942.1	34.1
	III	2,114.4	52.6	2,113.8	52.6	2,077.8	39.2
	IV	2,119.0	57.2	2,114.7	57.4	2,153.8	34.9
1995	*I*	2,149.7	17.1	2,134.3	17.2	2,185.2	24.5
	II	2,379.1	14.1	2,399.5	14.0		
	III	2,071.5	-2.0	2,070.9	-2.0		
	IV						

Manufacturing

Original Level	Original Yr/Yr	Adjusted Level	Adjusted Yr/Yr	Trend-Cycle Level	Trend-Cycle Yr/Yr	Period	
2,062.4	10.9						*1991*
2,126.0	3.1						*1992*
2,218.5	4.4						*1993*
2,401.3	8.2						*1994*
							1995
483.5	5.2	484.1	5.2	474.5	6.2	*IV*	*1990*
462.8	5.6	470.0	5.6	489.8	7.5	*I*	*1991*
507.3	5.6	500.0	5.7	508.7	10.1	*II*	
553.4	20.9	552.8	20.9	527.7	12.7	*III*	
538.9	11.5	539.5	11.4	541.4	14.1	*IV*	
559.3	20.8	566.5	20.5	538.5	9.9	*I*	*1992*
520.7	2.6	513.4	2.7	532.7	4.7	*II*	
516.5	-6.7	516.0	-6.7	524.8	-0.5	*III*	
529.5	-1.7	530.1	-1.7	519.6	-4.0	*IV*	
505.9	-9.5	513.1	-9.4	529.0	-1.7	*I*	*1993*
532.3	2.2	525.0	2.2	545.8	2.5	*II*	
580.5	12.4	580.0	12.4	568.0	8.2	*III*	
599.8	13.3	600.4	13.3	594.7	14.5	*IV*	
613.2	21.2	620.4	20.9	611.2	15.5	*I*	*1994*
638.4	19.9	631.1	20.2	607.4	11.3	*II*	
606.2	4.4	605.7	4.4	587.6	3.5	*III*	
543.5	-9.4	544.2	-9.4	566.7	-4.7	*IV*	
511.8	-16.5	519.0	-16.3	555.9	-9.1	*I*	*1995*
572.3	-10.3	565.0	-10.5			*II*	
585.4	-3.4	584.9	-3.4			*III*	
						IV	





Explanatory Notes To Tables 8.1 and 8.2

Table 8.1: GDP at Market Prices by Industry (Millions of 1985 Dollars)

A. The term Yr/Yr refers to year on year percentage changes. For the quarterly data this refers to the percentage change between one quarter and the corresponding quarter a year-earlier, eg. 1995 QI/ 1994 QI.

B. The components of the Tables are explained by drawing reference to the Agriculture Sector:-

(i) The top part of Column 1 in Total Agriculture shows the Central Statistical Office's (CSO) annual value added for the Agriculture sector for the period 1990 to 1995 at constant (1985) dollars.

(ii) At the bottom of Column 1, the quarterly series are obtained by applying the changes in the derived quarterly index (described in Section III) to the constant dollar values.

(iii) The data derived at (ii.) may not sum to the annual totals, therefore an adjustment is done to reconcile the quarterly data to the annual series. This is done using the Bassie's Method as described in Section II and the adjusted quarterly series are found in Column 3 with the corresponding year on year percentage changes shown in Column 4.

(iv) In Column 5, the quarterly series are seasonally adjusted by applying the Census x -11 seasonal adjustment technique, so that the long run trend of the quarterly series can be readily seen and the year on year percentage changes of the seasonally adjusted series are seen in Column 6.

Table 8.2: GDP at Current Market Prices by Industry (Millions of Dollars)

The explanation of Table 10.2. is basically the same as the explanation for Table 10.1 with a few minor changes. Again the Agriculture Sector is used to illustrate.

(i) The annual data shown in the top part of Column 1 in Table 10.2 is the CSO's annual value added in current dollars for the period 1990 to 1995.

(ii) To obtain the quarterly current dollar series, the derived agricultural index, which is a constant price index, is first inflated by the appropriate sections of the Retail Price Index (RPI). The resultant quarterly changes in the inflated Agricultural index are then applied to the annual data in current dollars (see Section III).

(iii) Finally the adjustments performed in iii. and iv. above in Table 10.1 are carried out again to derive the adjusted quarterly series (Bassie's Method) and the seasonally adjusted series (trend cycle).

Note:: The graphs depicted in both Tables 10.1 and 10.2 show the unadjusted quarterly series for the respective sectors for the period 1982Q1 to 1995Q4.

APPENDIX 8.A1

SUMMARY OF INDICATORS USED FOR GDP ESTIMATES

Sector	Annual Indicator	Quarterly Indicator (If different from Annual)
AGRICULTURE	Quantity Index of each sub-sector/sub-group	Quantity Index (Sugar, Citrus, Cocoa, Coffee, Meat, Poultry, Vegetables, Fish)
Export Agriculture		
Domestic Agriculture		
Sugar		
PETROLEUM		
Exploration & Production	Crude Oil Production	
Refinery	Refinery Throughput	
Service Contracting	Cumulative Rig Months	
Bulk Distribution	Stores & Bunkers: Weighted Index of five major items sold	Item not included
Retail Distribtuion	Quantity of Petroleum Products sold at Retail Outlets	
Petrochemicals	Quantity of Petrochemicals Produced	
Natural Asphalt	Quantity of Refined Asphalt Produced	Item not included
MANUFACTURING	Index of Domestic Production	Quantity Index based on a survey of a sub-set of firms in the sector
Food Processing		
Printing		
Textiles		
Wood		
Chemicals		
Assembly		
Miscellaneous		
ELECTRICITY & WATER	Quantity of Electricity Generated; And Quantity of Water Produced	
CONSTRUCTION		Econometric techniques and deflation

APPENDIX 8.A1 (Cont'd)
SUMMARY OF INDICATORS USED FOR GDP ESTIMATES

Sector	Annual Indicator	Quarterly Indicator (If different from Annual)
Quarrying	Deflation Method Using Index of Retail Prices of Building Materials	
Other Construction	Deflation Method Using Weighted Index of Retail Prices of Building Materials and Minimum Wage Rates	
DISTRIBUTION	Deflation Methods Using the All Items Index of the Retail Price Index (RPI)	Index based on the value of a subset of imports adjusted for the change in the exchange rate and deflated by the All Items Section of Retail Price Index (RPI)
HOTEL & GUEST HOUSES	Deflation Methods Using Weighted Index of Hotel Rates and the Drink, Tobacco and Rent Section of the RPI	Quantity Index of Hotel Occupancy Rates
TRANSPORT, STORAGE AND COMMUNICATION		
Bus Service	Number of Passengers Carried	Paying Passengers/Kilometre
Taxi Service & Car Rentals	Index of Hired and Rented Cars	
Trucks (Internal Freight)	Index of Goods Vehicles Licensed	
Shipping	Index of Ships Entering and Clearing Harbour	Item not included
Port Authority	Same as above	Tonnage of Goods Handled by the Port Authority
Airline Services	Index of Passenger Arrivals and Departures	Index of Passenger Arrivals and Departures on the National Airline
Airport Services	Index of Employment	Item not included
Services ancilliary to Transport	Deflation Method (All Items Index of RPI)	Item not included
Storage	Same as above	Item not included
Telecommunications & Telephone Services	Index of the number of Telephones Installed	Number of Telephone Lines in Service
Post Office	Index of Postal Articles Handled	Item not included
Radio and Television Broadcasting	Deflation Method (All Items Index of RPI)	Item not included

APPENDIX 8.A1 (Cont'd)
SUMMARY OF INDICATORS USED FOR GDP ESTIMATES

Sector	Annual Indicator	Quarterly Indicator (If different from Annual)
FINANCE, INSURANCE AND REAL ESTATE	Deflation Methods (All Items Index of RPI)	Index of Employment
GOVERNMENT bill	Index of Employment	Central Government wage deflated by an Index of Wage Rates
EDUCATION & COMMUNITY SERVICES	Extrapolation by Index of Employment and Deflation by Education Section of the RPI	Index of Employment
PERSONAL SERVICES	Deflation Methods using Weighted Index of the Services and Medical Goods and Services Sections of the RPI	Econometric techniques and deflation
CORRECTION FOR IMPUTED SERVICE CHARGE	Deflation Methods	Same indicators as for Finance and Insurance

NOTES

1. Central Banks in the English-speaking Caribbean are "semi-official" statistical agencies in the sense that their legal authority to carry out economic surveys is confined largely to the financial sector which they regulate.

2. This methodology is outlined in some detail in Coker and Forde (1989). See also the discussion in Pariag and Coker (1991).

3. See Coker and Forde (1989) for a discussion of this Index.

References

Bassie, V., *Economic Forecasting*, McGraw-Hill, New York, 1958.

Coker, K. and P. Forde (1989), "The Experience of the Central Bank of Trinidad and Tobago in Estimating a Quarterly Real GDP Series," Paper presented at the Twenty-first General Conference of the International Association for Research in Income and Wealth, West Germany, August 20-26, 1989.

Cope, I. (ed.) (1995), "Data Sources for the Quarterly Account," The United Kingdom National Accounts, CSO Methodological Paper No.3, 1995.

Denton, F.T. (1971), "Adjustment of Monthly or Quarterly Series to Annual Totals: An Approach Based on Quadratic Minimization," *Journal of the American Statistical Association*, Vol. 66, pp 99 - 102, 1971.

Forde, P. (1989), "The Adequacy of the Present Statistical Database to Inform the Planning and Monitoring Mechanism: A User's Perspective," Colloquium on Statistics and New Technologies, UNECLAC, *CSNT/89/04*, 1989.

Ginsburg, V. (1973), "A Further Note on the Derivation of Quarterly Figures Consistent with Annual Data," *Applied Statistics*, Vol. 22, No. 3, 1973.

Griliches, Z. (1986), "Economic Data Issues," in Z.Griliches and M. Intriligator (eds) *Handbook of Econometrics*, Volume III, Amsterdam, North Holland, 1986.

Hendry, D.F. (1980), "Econometrics - Alchemy or Science," *Economica* 47, pp 387 - 406, 1980.

OECD, Quarterly National Accounts - A Report on Sources and Methods in OECD Countries, Organization for Economic Cooperation and Development, Paris 1979.

Pariag, P. and K. Coker (1991), "A Comparison of Constant Price Estimates in Trinidad and Tobago," *Quarterly Economic Bulletin*, Vol.XVI No.3. 1991.

United Nations (1979), *National Accounting Practices in Seventy Countries*, Statistical Office, *Studies in Methods*, Vol.1 United Nations, New York, 1979.

United Nations, *United Nations System of National Accounts (SNA) 1993*, Washington D.C.

Watson, P. (1995) "Data Development for Econometric Models," Paper presented at a Seminar on Data Development and Information Management in Caribbean Economies, Port of Spain, Trinidad, July 10 - 13, 1995.

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