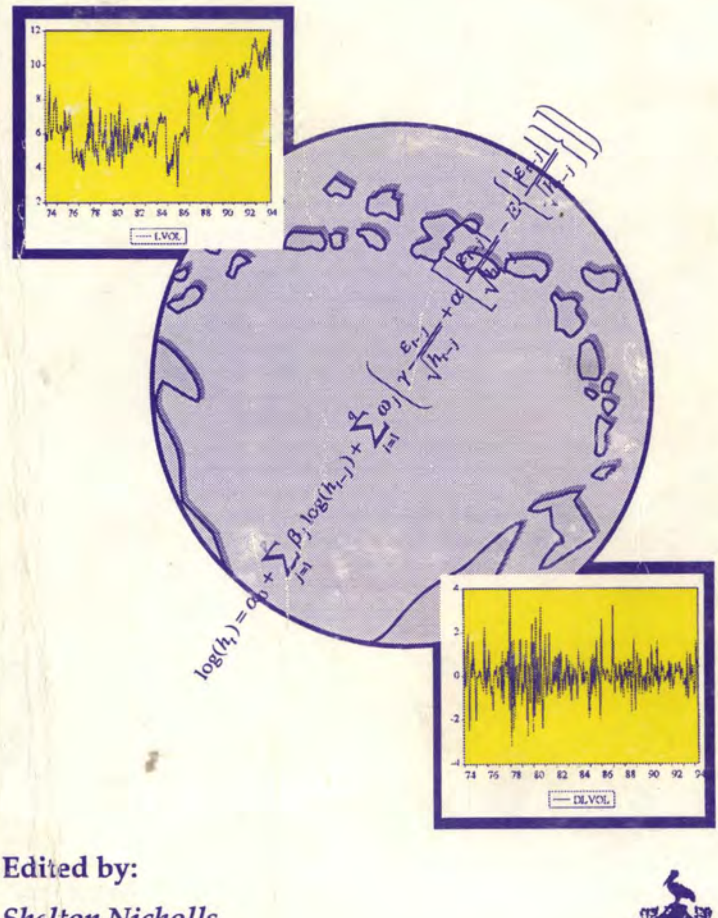
Problems and Challenges in Modelling and Forecasting Caribbean Economies



Edited by:

Shelton Nicholls
Hyginus Leon
Patrick Watson

Problems and Challenges in Modelling and Forecasting Caribbean Economies

The liberalisation of trade and the globalisation of financial markets have brought fundamental and unpredictable changes to the Caribbean environment over the last decade. These events have led to a resurgence in modelling and forecasting efforts as Caribbean economists have tried to satisfy the ever-changing demands of policy makers. The recent genre of politicians and economic decision makers are demanding more tangible predictions about the magnitude and direction of change of major economic variables. This volume of edited papers explores the main challenges confronting macro modelling and forecasting in small open economies. Part 1 provides an indepth account of the history of and problems with macroeconometric modelling in the Caribbean. Parts 2 and 3 explore the use of various modelling strategies to assess important developments in the monetary and financial sector of Caribbean Basin countries. Part 4 provides suggestions on alternative modelling designs and articulates a framework for improving the organisation and analysis of data.

This volume is the only one of its kind which focusses exclusively on the modelling and forecasting efforts of the small island economies of the Caribbean Basin.

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Caribbean Centre for Monetary Studies
Established under the joint auspices of the Central Banks of the Caribbean Community and the University of the West Indies

Michael Craigwell

PROBLEMS AND CHALLENGES IN MODELLING AND FORECASTING CARIBBEAN ECONOMIES

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CARIBBEAN CENTRE FOR MONETARY STUDIES
University of the West Indies, St. Augustine

Published by the Caribbean Centre for Monetary Studies
The University of the West Indies, St. Augustine,
Republic of Trinidad and Tobago.

Printed by Sales Promotion and Advertising Limited,
90 Edward Street, Port of Spain, Trinidad, West Indies.

Problems and Challenges in Modelling and Forecasting Caribbean Economies/ edited by Shelton Michael Anthony Nicholls, Hyginus Lambert Leon and Patrick Kent Watson.

Includes bibliographic references.
British Library Cataloging in Publication Data.
A catalogue record for this book is available from the British Library.

Library of Congress Cataloging in Publication Data.
A catalog record for this book is available from the Library of Congress.

Please note use of Amercian and British Spelling Conventions.

1. Caribbean - Econometric Models
2. Forecasting
3. Time Series Analysis I. Title

ISBN 976-620-065-3 hardback
ISBN 976-620-066-1 paperback

Dedication

To those pioneers of the Regional Programme of Monetary Studies who have left their indelible footprints as guides to the younger generation of scholars

ACKNOWLEDGEMENTS

This volume had its genesis in a series of papers commissioned by the co-ordinator of the Regional Programme of Monetary Studies, Dr. Ramesh Ramsarran. These papers were presented at the Econometric Workshop of the XXVI Annual Conference of the Regional Programme of Monetary Studies, November 23-26, 1994, at the Jamaican Conference Centre, Kingston, Jamaica, West Indies. The editors owe a great debt to Dr. Ramsarran for his encouragement, guidance and confidence in our ability to deliver the manuscript even after we had missed several deadlines. The director of the newly formed Caribbean Centre for Monetary Studies (CCMS), Dr. Laurence Clarke, also has our profound thanks for his support (both administrative and financial) and encouragement as the demands of writing and editing became more burdensome.

As the deadline for the manuscript approached, the geographic spread of the contributors made continuous communication on revisions quite difficult. As editors, we were forced to make editorial decisions for each of the respective contributions. We hope, therefore, that we have captured the spirit, intent and style of the various contributors.

Several individuals at the XXVI Regional Programme of Monetary Studies and from regional and international institutions also made the effort to submit verbal or written comments on papers. Those deserving special mention include: Prof. Compton Bourne (UWI, St. Augustine); Dr. Delisle Worrell (Central Bank of Barbados); Prof. C.Y. Thomas (IDS, University of Guyana); Dr. Roland Craigwell (Central Bank of Barbados); Mr. Carlos Holder (Economist, Caribbean Development Bank); Prof. Simon Jones-Hendrickson (University of the US Virgin Islands); Prof. Chris Milner (University of Nottingham); Dr. Brian Hindley (London School of Economics); Dr. Penelope Forde (Central Bank of Trinidad and Tobago); Mr. Christopher Clarke (Central Bank of Trinidad and Tobago); Mr. Richard Wallach (FAME Incorporated); Dr. Daniel Boamah (Central Bank of Barbados); Mr.

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The manuscript benefitted from the professional editorial assistance of Ms. Brenda Thomas, Mrs. Janice Christopher-Nicholls and Mr. Philip Colthrust. Graduate students of the Economics Department at UWI, St. Augustine, especially Messrs. Earl Boodoo, Michael Henry and Anthony Birchwood, assisted with the verification checks on the various bibliographies.

Special thanks must also be extended to Dr. Penelope Forde of the Research Department, Central Bank of Trinidad and Tobago for granting permission to utilise the powerful desktop publishing facilities of the Central Bank. The completed typescript is the handiwork of Mrs. Maureen David, head of the typing pool, Research Department, Central Bank of Trinidad and Tobago. She was ably assisted by Miss Adonna Gordon who also designed the cover page. Both typists worked into the early hours of the morning over a three week period to ensure that the manuscript was delivered to the publishers on time.

Finally, our families deserve special mention for the tolerance they showed during our periods of prolonged absence.

All remaining errors are the responsibility of the editors.

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LIST OF ABBREVIATIONS AND ACRONYMS

2SLS	Two-Stage Least Squares
ARCH	Auto-Regressive Conditional Heteroscedasticity
AREMOS	Advanced Retrieval and Econometric Modeling System
ARFIMA	Auto-Regressive Fractional Integrated Moving Average
ARIMA	Auto-Regressive Integrated Moving Average
ARMA	Auto-Regressive Moving Average
CARICOM	Caribbean Community
CATS	Cointegration Analysis of Time Series
CBMOD1	Central Bank of Trinidad and Tobago's Econometric Model:Version 1
CBTT	Central Bank of Trinidad and Tobago
CCMS	Caribbean Centre for Monetary Studies
CFES	Central Framework for Economic Statistics
CGE	Computable General Equilibrium
CHISQ	Chi-Square
CMA	Caribbean Monetary Authority
CMCF	Caribbean Multilateral Clearing Facility
CPC	Central Product Classification
CPI	Consumer Price Index
CSO	Central Statistical Office
ECCB	Eastern Caribbean Central Bank
ECM-GARCH	Error Correction Mechanism-Generalized Auto-Regressive Conditional Heteroscedasticity
EGARCH	Exponential Generalized Auto-Regressive Conditional Heteroscedasticity
Eviews	Econometric Views
FAME	Forecasting Analysis Modeling Environment
G7	Group of Seven
GARCH	Generalised Auto-Regressive Conditional Heteroscedasticity

HMSO	Her Majesty's Statistical Office
HS	Harmonised System
IMF	International Monetary Fund
ISIC	International Standard Industrial Classification
L-B	Ljung-Box
LAN	Local Area Network
LDC	Least Developed Countries
LIML	Limited Information Maximum Likelihood
MIS	Management Information Systems
MDC	Most Developed Countries
NLGARCH	Non-linear Asymmetric Generalized Auto-Regressive Conditional Heteroscedasticity
OECD	Organisation for Economic Cooperation and Development
OECS	Organization of Eastern Caribbean States
OLS	Ordinary Least Squares
QGDP	Quarterly Real Gross Domestic Product
RATS	Regression Analysis of Time Series
RMA	Regional Monetary Authority
RPI	Retail Prices Index
RPMS	Regional Programme of Monetary Studies
SABL	Seasonal Adjustment Bell Laboratories
SAM	Social Accounting Matrix
SITC	Standard Industrial Trade Classification
SNA	System of National Accounts
TTSNA	Trinidad and Tobago System of National Accounts
UK	United Kingdom
UNDP	United Nations Development Programme
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
US	United States of America
VEC	Vector Error Correction
WAN	Wide Area Network

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INTRODUCTION

Shelton Nicholls
Hyginus Leon
Patrick Watson

The decade of the 1990s has ushered in major structural change in most of, if not all, the economies of the Caribbean Basin. The world has witnessed the fall of communism, an increase in global tensions and the formation of a new institution - The World Trade Organisation - following the conclusion of the Uruguay round. These developments coincide with a shift in the philosophy of most southern cone countries (Africa, Latin America and the Caribbean) from a protectionist stance towards greater liberalisation both in terms of trade and finance. These new developments worldwide have resulted in greater volatility and uncertainty in economic affairs. If the small island economies of the Caribbean Basin are to survive in this new and uncertain environment, there is an urgent need to develop systems that allow for greater accuracy in predicting the course that Caribbean economies are likely to take in the twenty-first century.

Macroeconomic modelling arose in the Caribbean and elsewhere as a means of providing a framework to allow policy makers to make decisions in an environment of uncertainty. In the decades of the 1950s and 1960s, there was, relatively speaking, a greater degree of stability in the behaviour of economic processes. Indeed, macroeconometric models enjoyed great prominence worldwide because they were able to predict with some degree of success the future course of several important policy variables (i.e. inflation, growth and employment). In the Caribbean however, during the 1950s and 1960s, macroeconometric modelling was very much at an embryonic stage. Naturally, most Caribbean economies in the decade of the 1960s were just becoming independent, with the consequence that there was generally an insufficient number of observations to permit robust econometric estimation.

During the decade of the 1970s, major changes occurred in most of the island economies of the Caribbean Basin. This period witnessed the oil price shock, increased trade union activity and the rise of the structuralist paradigm in both academic and policy circles. This structuralist revolution was heavily influenced by developments in Latin America, and downplayed the importance of formal modelling in the econometric tradition. Econometric modelling in the Caribbean only began in earnest in the decade of the 1980s in the research departments of the various national Central Banks in the region. These modelling developments were facilitated by improvements in the data collection machinery and the availability of a cadre of young economists with strong quantitative orientations.

During the decade of the 1980s, various modelling approaches emerged among the various CARICOM member territories. The 'Trinidad School[1]' which was largely pioneered by the efforts of Patrick Watson (see Watson and Ramkissoon (1986) emphasised structural modelling within the classical econometric tradition. This approach is best illustrated in the Central Bank's model of the economy of Trinidad and Tobago (CBMOD1), (see Hilaire, Nicholls and Henry (1990)), the ILPES Model of the Trinidad and Tobago Economy, Charles and St. Cyr (1992) and the Trinidad Planning Model (Clarke and Watson (1992)). These models were relatively large Block-Recursive systems and emphasised structural detail. The 'Barbadian School' has undergone perhaps the most interesting metamorphosis in the English-speaking Caribbean.

Initially, there was a burst of structural models pioneered mainly by Daniel Boamah, Carlos Holder and Delisle Worrell of the Central Bank of Barbados (see Boamah (1981), Boamah *et al* (1985), Holder and Worrell (1985, 1987)). However, with the introduction of cointegration and the general-to-specific modelling methodology there was a shift in the approach of the 'Barbadian School' towards more parsimonious single equation models (reduced forms) which incorporated these new developments. Although the approach of the 'Jamaican School' started with the same tradition of large scale structural modelling, the modelling attempts that eventually blossomed emphasised, financial programming - in keeping with the various IMF adjustment programmes - the flow of funds approach and, to a lesser extent, input-output analysis. By the end of the 1980s, the predictive ability of the econometric models was cause for much concern. Indeed, most of the Caribbean models were unable to yield useful forecasts in the face of major structural changes. The emergence of these large forecast errors have generally led to a growing disillusionment with macroeconomic modelling. The question which needs to be addressed is whether or not bad forecasts are indicative of bad modelling. Greenaway (1995, p. 972) in a recent editorial note in the Economic Journal reminds us however that *"...Macro-modelling and forecasting are not one and the same, nor should either be regarded as offering an infallible guide to policy makers as to what to do and when. Both are tools and rather useful tools at that."*

This book coincides with the establishment of the Caribbean Centre for Monetary Studies (CCMS) which marks a high point in collaborative efforts between the Central Banks of the region. In essence, the book reflects the current state of the art in Caribbean modelling and forecasting after twenty-seven years of research under the auspices of the Regional

Programme of Monetary Studies. The research agenda of the Monetary Studies Programme was managed by a board comprising Directors of Research of the various Central Banks of the region. However, the researchers who collaborated under the umbrella of the programme did so on a purely voluntary basis. Thus, the Central Bank Governors only influenced the research programme in an indirect way. The establishment of the Centre introduces a new approach in the conduct of the affairs of the Programme. The Board of Central Bank Governors will now intervene directly in the policy research of the Centre.

Given the differences in approaches to modelling and forecasting in the Caribbean, one burning issue which arises relates to which modelling design should be pursued. Should there be a common modelling approach and design for the various countries as a whole, or, should there be different models in the different territories? Whereas the answer to this question is not straightforward, the volume seeks to provide some guidance on how modelling and forecasting in the region should proceed.

Part 1 of the book presents a detailed account of the problems and challenges which confront modelling and forecasting in the Caribbean environment. The main highlight of this section is the paper on *"Reflections on Macroeconometric Modelling and Forecasting in the English-Speaking Caribbean"*. This paper had its genesis in a series of individual reports commissioned by the former co-ordinator of the Programme, Dr. Ramesh Ramsarran, from among the leading forecasters and applied econometricians in the Caribbean environment[2]. These papers were presented at the Econometrics workshop of the XXVI Annual Conference of the RPMS, held at the Jamaica Conference Centre, Kingston, Jamaica in November 1994. The commissioned authors were requested to identify problems in modelling and forecasting at the various Central Banks and to suggest strategies for their resolution. Besides the commissioned papers, several additional papers were presented on various aspects of modelling the economic environment in the Caribbean. The remaining papers that have been included in the volume have been drawn from a selection of those presentations which form a common thread with the issues raised in the reflections submitted by the commissioned authors. These papers highlight concerns relating to inflation and the liberalisation of the monetary and financial sector. The majority of issues which are examined in the various sections of the book can therefore be seen as offsprings of the main concerns raised in the modelling and forecasting deliberations.

One important caveat which needs to be mentioned is that although the present volume focuses on macroeconomic modelling in its broadest sense, the supporting papers to the keynote article on reflections do not deal with the modelling of a broad cross-section of sectors. This may seem, at first blush, to be inappropriate to the reader looking for a wide variety of applications across the full spectrum of economic affairs. We, however, have chosen to focus the volume on topics of more recent concern to policy makers at the Central Banks, namely inflation, reserves and capital markets. Indeed, the choice of topics came about after a lot of debate and discussion at various fora over the direction that modelling and forecasting should take.

It may, therefore, be appropriate at this juncture to summarise the main concerns addressed in the paper on reflections. This paper has three fundamental concerns. First, it seeks to establish a minimum set of requirements to enhance the process of modelling and forecasting both within and between the Central Banks of the Caribbean archipelago. The basic premise of forecasting, in this regard, is to assist decision-makers in the Central Banks to establish meaningful policy priorities. Second, it highlights the various problems which have affected the forecasting and modelling efforts in small open economies. Incidentally, speaker after speaker, reflecting on the experiences in the Caribbean, drew attention, more or less, to the same set of problems. The most important of these relate to:

1. The inability of model-builders to communicate effectively their results to policy makers.

2. The lack of a clear and well-articulated set of policy objectives to circumscribe the responsibilities of the forecasting group.

3. The absence of an appropriate information environment to support the modelling and forecasting function.

4. The lack of an organised body of theory which reflects the realities of the Caribbean environment.

5. The lack of continuity in the model-building and forecasting cycle.

6. The extent to which the theories should be related to the end use of the model.

Third, the paper outlines the rudiments of a strategy for successful forecasting and policy analysis in the Caribbean. The main elements of this strategy involve (i) an 'organised' process analagous to that which is undertaken for the production of the annual reports and the economic bulletins of the various Central Banks; (ii) the development of a co-operative communal spirit; (iii) an integrated information architecture which incorporates a well-developed database system and modern communication facilities and (iv) an appropriate amalgam of skills. The latter should include an economist (theorist) with a strong appreciation of the realities of the Caribbean; a computer specialist (programmer/analyst) with a sound background in economic analysis; an econometrician; a statistician; and a series of sector specialists.

Another important question which needs to be addressed is whether the data and information architecture is capable of supporting the modelling and forecasting efforts. Indeed, one of the explanations for the proliferation of modelling designs in the region relates to the different levels of data availability in the various countries. Traditionally, the more developed countries of CARICOM, in particular, Jamaica and Trinidad and Tobago, with established Statistical Offices, were naturally the first to attempt to utilise and develop macroeconomic models. Of course, there was, no heavy emphasis on quantitative methods in the data scarce territories of the Organisation of Eastern Caribbean States (OECS). To date, the data constraint still remains an important concern in all Caribbean territories[3].

The paper by Forde on "*Challenges and Problems in Forecasting Caribbean Economies: Some Data Issues*" explores the major data deficient issues which frequently arise in economic statistics in Trinidad and Tobago, and by extension in the rest of the Caribbean. This paper identifies six major areas of weakness in economic data: (i) timeliness of current output, (ii) lack of new data series, (iii) inadequate periodicity of recorded data, (iv) insufficient transformations, (v) short data sets and (vi) the absence of forward looking indicators. In addition, it tries to analyse where countries of the Caribbean stand in relation to these deficiences.

The issue of short data sets is one which has been raised, in several fora in the Caribbean, and is one of the major constraints affecting modelling and forecasting. This question of short samples was addressed early on by Manhertz (1971)) and more recently, Watson and Nicholls (1992) have attempted to investigate, via Monte Carlo methods, the difficulties which short samples pose for robust estimation. Whereas this issue of deficient data plagued Caribbean economies in the decades of the fifties, sixties and seventies, its perpetuation into the decade of the nineties reinforces the observation that few initiatives have been successful in alleviating the problem. There is, therefore, need for major improvements in the way in which the Central Statistical Offices and the Central Banks of the Region, collect, collate and publish the type of data that is most meaningful for policy analysis. Fortunately, within recent years, there have been some new initiatives targeted at the re-organisation of the data process. These have come through collaborative efforts between the Canada/UWI Institutional Strengthening Project; the FAME project at the Central Bank of Trinidad and Tobago; the AREMOS projects at the Central Bank of Barbados and the Eastern Caribbean Central Bank, and other efforts mounted by the United Nations Economic Commission for Latin America and the Caribbean (UNECLAC), and the various Central Statistical Offices and Central Banks of the region. These projects have sought to combine the efforts of the MIS departments, with those of the region's economic statisticians and econometricians. These initiatives, however, need to be better focussed if they are to be sustained. Surely, the new information technologies which stress the development of appropriate information architectures could play an indispensable role in improving the availability and quality of data in the Caribbean. An appropriate data architecture is therefore vital to the policy and forecasting function.

Parts 2 and 3 of the book attempt to give a panoramic view of the various modelling approaches which have been undertaken in the Caribbean. Moreover, the papers in these sections apply various approaches to issues of current concern in the monetary and financial sphere. The question of inflation policy is one that has dominated and continues to dominate policy debates throughout the Caribbean. Accurate prediction of inflation is indispensable to future planning as it affects almost all the key macroeconomic aggregates. In fact a low inflation policy may encourage investment and exportation and can indirectly enhance economic growth. The question which needs to be addressed in this context is which of the modelling strategies can lead to a greater understanding of the evolution of inflation in the Caribbean.

Part 2 of the book examines the issues relating to inflation in the economies of the Caribbean Basin. The essay by De Castro develops a game-theoretic evaluation of the conditions under which inflation can be ended abruptly without any major disruption to output. This paper is the first attempt in the English Speaking Caribbean to model inflation using game-theoretic techniques. Although De Castro draws inferences from the Latin American Experience, his findings are equally valid for the Caribbean territories of Jamaica and Guyana which recently have witnessed increasing rates of inflation.

Agbeyegbe's paper seeks to investigate the specific stochastic nature of the inflationary process in three economies of the Caribbean region. He addresses the issue of whether inflation is a fractionally integrated process and concludes that the data for each of the countries does not reject the null hypothesis of fractional integration. Whereas an I(l) process suggests common temporal characteristics of inflation, the finding of different fractional roots is indicative of processes with different temporal characteristics. The implication which this finding suggests for policy is that less emphasis should be placed on a common set of policy instruments since the inflationary process evolves in different ways in the various island economies.

The paper by Leon *et al* on "*Inflation Convergence in Selected CARICOM Countries*" examines the question of monetary integration in CARICOM through the notion of convergence. Indeed, the degree of convergence of inflation is a necessary pre-requisite for the harmonisation of exchange rate policies among participating members. The findings of this study complement the results of Agbeyegbe's work by demonstrating the lack of convergence of inflation rates among the larger economies of the English-Speaking Caribbean. Leon *et al* note that sustainable policy co-ordination is unlikely to be successful among all the CARICOM countries. Rather, the attempts at harmonisation will need to incorporate the effects of significant structural change if meaningful integration is to be achieved.

Part 3 of the book focusses on recent concerns in the monetary and financial sector. The paper by Peter Blair Henry on "*An Iterative Framework for Analysing the Introduction of Money and Capital Markets in Less Developed Countries*" examines the question of liberalisation - an issue that has confronted, recently, all the countries of the Caribbean Basin. Indeed, the latter half of the 1980s has witnessed the development of programmes geared towards privatisation, a reduction in state-led activities and the liberalisation of money and capital markets. Whereas Henry accepts that some liberalisation of the money and capital markets is necessary to engender investment and growth, he questions the use of the sequential approach to develop money and capital markets in the Caribbean. The application of this approach requires the policy-maker to first stabilise the domestic macro-economy and then grant to foreign investors full access to domestic money and capital markets. Henry warns that allowing foreign investors free access to domestic money and capital markets may lead to instability in inflows and outflows of capital and may eventually undermine the development process in the small open economy. The recent experience of Mexico is a case in point. Instead, Henry proposes an iterative procedure which first establishes sound macroeconomic fundamentals and then introduces domestic money and capital markets to increase the rate of investment. Foreign access to money and capital market only becomes necessary if the maximum investment rate attainable falls short of the target level. It must be borne in mind, however, that Henry's analysis is based on the assumption of the fixity of investment and growth targets during the policy horizon. An interesting extension of this study should consider the possibility of changing targets over the life of the sequencing programme.

Leon's paper examines the question of volatility on the Jamaican Stock Exchange (JSE). Following on the heels of the liberalisation policies in the latter half of the 1980s, there was phenomenal growth in the JSE over the period 1991-1992. This increase in activity placed Jamaica as the world's best performer in 1992 in terms of greatest dollar gains. However, by 1993, Jamaica's market capitalisation declined drastically, reducing its rank to 72nd in the world. Indeed, the Jamaican Stock returns data indicate substantial volatility throughout the history of the exchange. The author, building on the paper by Henry, which incidentally was quite guarded about the effects of liberalisation, attempts to gauge the extent of volatility using a Generalised Autoregressive Conditional Heteroskedastic (GARCH) model. The results indicate that returns on the Jamaican Stock Exchange are autocorrelated and exhibit time-varying volatility. The net impact of this increased volatility may include a reduction in the mobilisation of savings among small investors, the financing of low return investments, and inadequate risk reduction through diversification.

Increased volatility in markets that are open can have an adverse effect on the accumulation of foreign reserves. This suggests that liberalisation and the development of efficient money and capital markets ought to be complemented by a reserves policy that can help insulate small open economies from the vagaries of unforseen movements in foreign exchange earnings. This strategy of reserves pooling is developed in the contribution by Nicholls. The author argues that there are overriding benefits to a strategy of reserves pooling, namely: (i) unconditional access to reserves of other member states during times of need; (ii) a reduction in the variability of reserves which arise because of unforeseen variation in the volume of and/or prices of major export earners (and perhaps, as well, a reduction in variability due to capital flight which may follow liberalisation as exemplified in the Mexican experience); (iii) an increase in bargaining power vis-à-vis multinational institutions and (iv) the strengthening of the individual currencies in the region which lead in the final analysis to greater convertibility. The author demonstrates using a coverage statistic that the pooling of reserves can confer meaningful gains to almost all of the member states of CARICOM. In fact, those member countries which enter the pooling arrangement with a relatively low level of reserves and higher variability tend to derive greater overall benefit. The analysis warns however, that there may be a moral hazard problem in terms of illiquidity of the pool if adequate institutional and operational rules are not devised to support the pooling strategy.

Part 4 of the volume focusses on improving the data process through the use of better procedures for classification and adjustment of data. It also brings into focus the use of non-parametric methods which allows statistical inference to be conducted without resort to parametric distributions. Clarke's contribution of (i) a standardised nomenclature; (ii) the identification of relevant domains; and (iii) the establishment of documentation standards to assist in the re-organisation of economic data, is a practical attempt to answer some of the concerns raised in Forde's paper. Indeed, Clarke argues implicitly that the lack of a Central Framework for Economic Statistics is the root cause of much of the data deficient problems that pervade the Caribbean environment. He suggests that the existence of 'islands of information' can create serious disharmonies in the way data is collected, compiled and analysed, and develops an all-embracing nomenclature which can address the specific classification needs of any individual data "outfit", while at the same time allowing for much universality in definition, coding, aggregation and data exchange. A prototype of the new Central Framework for Economic Analysis is currently being developed at the Central Bank of Trinidad and Tobago and is already having a positive impact on data quality, timeliness and availability. To date, some 20,000 time series in the monetary sector are available in a multiplicity of formats (monthly, quarterly, daily, etc.).

Building on the Central Framework for Economic Analysis, Clarke and Francis propose a systemic approach to seasonal adjustment which can guarantee consistent, plausible and reliable seasonal numbers. The issue of seasonal adjustment is only now being actively researched in the Caribbean environment and most of this research is confined to the monetary aggregates and the Index of Quarterly Real Gross Domestic Product in Trinidad and Tobago. The paper by Clarke and Francis attempts to discriminate among six of the

The modelling and forecasting challenges for small open economies are great but they must be addressed in a systematic manner if progress is to be achieved. The Caribbean Centre for Monetary Studies must nurture and direct the forecasting efforts if tangible solutions to important policy questions are to be obtained. We expect that the Centre will rise to the challenge.

ENDNOTES

1. The term 'school' is used rather loosely here to differentiate the approach to modelling that developed in each island of the English-Speaking Caribbean.

2. See in particular Watson (1994), Nicholls and Christopher-Nicholls (1994) and Craigwell and Walker (1994). Dr. Hyginus Leon submitted detailed comments on each of these presentations.

3. The issue of data deficiency was addressed in great detail at a conference on "Data Development and Information Management in Caribbean Economies" held between July 10 - 13, 1995 at the Central Bank of Trinidad and Tobago. This conference was jointly sponsored by the Canada/UWI Institutional Strengthening Project, the Central Bank of Trinidad and Tobago and the Department of Economics, University of the West Indies, St. Augustine.

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PART — 1

Challenges And Problems In Macroeconomic Modelling And Forecasting

REFLECTIONS ON MACROECONOMETRIC MODELLING AND FORECASTING IN THE ENGLISH SPEAKING CARIBBEAN

Roland Craigwell, Janice Christopher-Nicholls, Hyginus Leon, Shelton Nicholls, Audra Walker, Patrick Kent Watson

ABSTRACT

This paper suggests requirements for a successful forecasting effort in the Caribbean. Recommendations include the need for institutional commitment to the modelling effort, an integrated resource approach both within institutional departments and across regional insitutions, and a more concerted effort on developing data and system architectures. It is argued that a structured approach to modelling, and a forecasting environment that fosters collaboration of effort and dissemination of results and skills are necessary. A review and critique of previous macroeconometric models in the region are provided.

Keywords: forecasting environment; information architecture; integrated resource approach.

INTRODUCTION

The set of general equilibrium models, first developed by Léon Walras and later extended by Vilfredo Pareto in the late nineteenth century, provided the foundations of macroeconometric modelling. At its origins, the Walrasian system was conceptual and was not subjected to empirical study by its creators. Empirical testing of macroeconomic models was initiated by Jan Tinbergen on the Netherlands economy.[1] However, major developments took place just after the second World War when Jacob Marschak organised a research team at the Cowles Commission (then at the University of Chicago, now at Yale University in the USA) to study three interrelated themes: economic theory (model specification), statistical inference (model estimation, testing and application), and model construction (including data preparation and numerical calculation). Shortly afterwards similar developments took place in the Netherlands at the Central Planning Bureau, under Professor Tinbergen.[2]

Since the initial work on the Netherlands and the US economies, a great deal of research time and effort by both national and international organisations have gone into the refinement and development of macroeconomic models for these and other developed countries (see Bodkin, Klein and Marwah (1991) and Driehuis, Fase and Den Hartog (1988)). These models, widely used both within and outside the government sector, have been constructed for many purposes: historical analysis, forecasting over a variety of possible horizons, policy formulation and evaluation, the testing of economic theories, and indeed, the elucidation and development of economic theories.

The International Monetary Fund is one international organisation that has encouraged the development of such models in developing countries. Macroeconomic modelling on developing countries at the Fund dates back to the 1950s and 1960s when J.J. Polak and E. Walter Robichek, *inter alia*, presented basic formulations of the monetary approach to the balance of payments. The new generation of models by the Fund represents efforts to specify and estimate models that incorporate many of the key structural and institutional characteristics (for example, lesser developed equity and capital markets, and foreign exchange constraints) that differentiate developing countries from most developed countries (see Khan, Monteil and Haque (1991)).

Aware of the special peculiarities and the importance of macro models for forecasting and policy analysis, Caribbean economists commenced model building in the 1970s. Examples of these early attempts include Harris (1970), Carter (1970) and Manhertz (1971) for Jamaica, and Persad (1975) and Gafar (1977) for Trinidad & Tobago. These efforts at modelling were fairly well rooted in the tradition of the open Keynesian economy (Kennedy (1966)) or, perhaps, more accurately, were examples of open Hicksian type IS-LM models (although some were more IS than LM). This, after all, was the tradition emanating from the metropolitan centres and, in all fairness to these pioneers, the very limited statistical data base that existed at that time clearly favoured the construction of such models. On the odd occasion, and in deference to the "Caribbean reality", one or two "supply side" equations, ostensibly to explain employment or production, were thrown in for good measure.

Whatever the philosophical content of these early models, it is perhaps more worrisome that, from the earliest forays of Caribbean scholars into this domain right up to the present time, models seemed to be constructed more for the intellectual thrill of the exercise than for any other end use to which the model could be put. A cursory glance at the works cited above would reveal that efforts were limited to the specification, estimation and validation of the models. This of course, is not a useless exercise, but modelling counterparts in the developed centres were going, at least, one step further: they were constructing models particularly for the end use of forecasting and, relatedly, policy evaluation. In fact, the market for econometric forecasts grew tremendously in the 70's with actors in both the public and private sectors participating (see, for example, Klein and Young (1980) and U.S. Department of Commerce (1986)).

To be fair, Caribbean modellers always recognised the potential usefulness for forecasting of the models they constructed and, indeed, there was some small attempt to do just that in Harris (1970). But these efforts have never been as sustained nor as systematic as those done by, say, the Wharton School, the Bureau of Economic Analysis, and the Reserve Bank of New Zealand (see Brooks and Gibbs (1991)).

There has been a resurgence of macroeconometric modelling in the English-Speaking Caribbean in recent years, and the efforts are much more sophisticated than those of the previous years. Moreover, these models were specifically developed for forecasting and include Belchere (1988) for the Bahamas, Maraj (1987), Hilaire, Nicholls and Henry (1990), Clarke and Watson (1992) and Charles and St. Cyr (1992) for Trinidad and Tobago; UNDP (1991) for Jamaica; Ganga (1990) for Guyana; and Leon and Samuel (1994) for the ECCB area. Prototype models geared for generating forecasts of Caribbean type economies, such as ILPES (1986) and Holder and Worrell (1987), have also appeared. Still, however, useful output is not forthcoming and, apart from some attempts of the original model builders in one or two of the cases to use the model for forecasting, the efforts have once again been limited to the specification, estimation and validation of the models.

As macroeconomic modelling in the Caribbean region continues to develop, there is need to establish a structure to guide its evolution. The importance of a systematic approach is indicative of the present competitive environment as the region as a whole enters the larger world-wide net. Indeed, policy-makers are now demanding more tangible predictions from economists about major macroeconomic aggregates instead of mere speculations on the direction of movement of economic variables.

This paper[3] attempts to provide some guidelines aimed at improving the development of forecasting in the Caribbean region and provides a critique of past model building efforts. Section I discusses a structured approach to model building. Section II examines the genesis of modelbuilding in the Caribbean and briefly outlines the basic philosophies and approaches which have informed the modelbuilding process. Section III outlines some minimum requirements for successful forecasting in the Caribbean region.

1. A STRUCTURED APPROACH TO MACROECONOMETRIC FORECASTING

A comprehensive approach to designing a forecasting system in the Caribbean should encompass:

1. Clear Delineation of Objectives
2. Database Design and Choice of Appropriate Computing Environment
3. Model Specification
4. Estimation and Testing
5. Forecasting, Simulation and Policy Analysis

In this section, we outline a host of issues that have to be considered in designing a structured macroeconometric forecasting system.

1.1 Delineation of Objectives

It is critical to understand the interplay of these stages if the model building exercise is to proceed smoothly. Perhaps the most difficult task facing the modelbuilder is to obtain a clear set of objectives from policy-makers. On most occasions, policy-makers are often too general about what they require, and the model is expected to explain, forecast, and carry out policy analysis on almost every conceivable policy shift. No model can operate at this very general level and there is need for much clarity in the delineation of objectives. These objectives should clarify the responsibilities of the forecasting group and include statements on the level of detail desired and the frequency of reporting.

On the regional front, there is some evidence that this issue of "targeting" is being actively considered. Quite recently, the CARICOM Council of Ministers emphasised the need for a single market in CARICOM based on trade integration while the Governors of the various Central Bank territories have adopted a two-staged approach to monetary integration, emphasising the need for closer policy co-ordination among the various Caribbean territories. Category A countries (Bahamas, OECS and Belize) are expected to maintain sound macroeconomic policies - a stable exchange rate for 36 months, a sustainable debt-service ratio not exceeding 15% and 3 months import cover in foreign exchange reserves for 12 months. Category B countries (Trinidad and Tobago, Barbados, Guyana and Jamaica) are expected to effect rapid stabilisation and adjustment to cure inflation, restore external payments balances, rebuild foreign exchange reserves and restore growth. Concrete decisions of this type should form the background against which the model building and forecasting exercise in the Caribbean should proceed. These goals emphasise two dimensions. The first dimension relates to how individual countries should effect their stabilisation, while the second underscores the need to synthesise national and regional objectives.

A major challenge that may confront modelbuilders is the likelihood that the objectives outlined may not remain fixed for any specific period of time. As circumstances in the external environment change, policy-makers tend to make radical modifications to the set of goals. Modelbuilders and forecasters need to ensure that the systems devised can quickly adapt to changes in the preference sets of their political leaders. CBMOD1, the Central Bank of Trinidad and Tobago's model, for instance, was designed to answer very specific policy questions, namely, the effect of a devaluation and the implications of increased government expenditure. By the time the model was completed, however, there was a marked shift in emphasis towards debt management. This change in policy could not be accommodated readily without a substantial redesign of the relationships in the model.

1.2 Database Design and the Computing Environment

Quantitative data can be described in a formal sense as the numerical characterisation of some important property of an object (in this case economic variables). Data is useless if it exists in an unstructured manner. The moment it is organised, one can glean useful "bits of information" on specific properties of economic phenomena. Although it is the life blood around which much of forecasting and policy analysis revolves, it has received the least attention among modellers in the region. For a long time, economists in the Caribbean have complained about the problem of deficient data but have taken very few steps to rectify it. Indeed, little by way of organised data collection has occurred among Caribbean forecasters. Griliches (1985 p.196) sums up, quite effectively, the uneasy alliance between data and economists:

> *"We did not observe them [data] directly; we did not design the measurement instruments; and often we know little about what is really going on.......Most of our work is on 'found' data, data that have been collected by somebody else, often for quite different purposes."*

Modelbuilders who have not participated actively in the generation of data tend to be often content with its imperfections and tailor their specifications to reflect the data constraint. In some quarters, there is even a perception that as long as a couple of software packages and powerful microcomputers are acquired, the effects of data constraints on modelling and forecasting can be ignored. Whereas such a position may be tenable for a small "academic" forecasting exercise, it is quite unsound for an organised model building and forecasting programme at any of the region's Central Banks.

In the model building context, the most challenging data problems that arise in the Caribbean relate to missing observations, unrecorded variables, insufficient periodicity of recorded data, measurement errors and short samples.[4] These deficiencies emanate from weaknesses in the data cycle (sourcing, preparation and publication) in the various territories. The logical approach taken by our colleagues in the world of computer data management can yield useful insights for economists and modelbuilders in the resolution of some of these issues.

In the computing sphere, each entity in a specific system is identified with its requisite characteristics (data). These attributes usually exist in an unstructured form but are organised by a process of logical data modelling which defines domains for the attributes and allows a series of relational mappings among entities. Such a process permits easy combinations of attributes for further analysis. This is what computer scientists refer to as a "database". Modelbuilders and forecasters, therefore, need to spend more time with their "data collecting" colleagues identifying relevant entities and attributes which impinge on the forecasting process. It is imperative that the process of data requests, compilation, publication and usage be informed by regular interaction among the users and compilers of economic data. The setting of priorities and foci would naturally be related to ongoing ultimate objectives that the modelbuilders seek to address.

Closely aligned to the issue of the development of an appropriate database environment is the choice of an appropriate information architecture to support the policy analysis and coordination function. Richardson, Jackson and Dickson (1990) have defined the basic elements of this architecture as one which reflects the interrelations among data, hardware, software and communications. The main elements of this type of system include:-

1. Network/communication architecture
2. Office architecture
3. Data architecture

Network architecture refers to the structure of the hardware and communication systems which are required to permit the exchange of information and include the network type (LAN, WAN), the network topology (Star, Ring, Bus), the network model (Peer-to-Peer, Client Server) and network protocols. The data architecture refers to the data elements, global data model and data modelling techniques which permit data combinations and summarisations and permit the construction of databases. The office architecture refers to the physical office design which houses the network, data, personnel and office management systems and defines how information and reports flow within an organisation.

Modelbuilders in our region must become aware of the critical importance of a good information environment to successful policy modelling and coordination. In fact, any attempt at integrating the efforts of individual policy units must consider the elements of an information architecture. In particular, a proper communication architecture would almost automatically guarantee the rapid transmission of data, in a generic sense, among individual units. This communication architecture may take the form of Local Area Networks (LANs) in the satellite nations, which would be linked via gateways to a Wider Regional Area Network (WAN). In addition, some consideration would have to be given to the housing of the network systems and to the identification of the appropriate infrastructure and equipment to support the network/communication and data systems.

1.3 Model Specification

Given the objectives of interest, the model builder attempts to construct a model that will form the basis of decision making. A model is an abstraction of reality, a simplification of the real world. An economic model consists of behavioural relations, technological relations and identities or definitional relations. Behavioural relations are forces thought to determine the behaviour of the various groups of economic agents. Technological relations describe the restrictions imposed by the current technology and endowment of the system. Often technological relations, such as the production function, are not explicit in the model, but would have been used to derive behavioural relations such as the demand function for labour. Identities or definitional relations are self-explanatory.

Econometric models are economic models in an empirically testable form. This generally means augmenting the deterministic component of the behavioural equations with stochastic disturbances to capture observed variations in the data that are unaccounted for by the approximation to the complex process generating the data. These disturbances can be viewed as "catch all" terms representing all the variables considered irrelevant for the purpose of the model, as well as errors due to inaccurate functional form specifications, and measurement errors in the variables being explained. In order to make a probability statement or inference about the wider population parameters of interest from the specific sample being described, classical theory requires a specification of the probability distribution of the disturbances. The most general form of a simultaneous equation macroeconometric forecasting model may be represented as:

$$F\left(y_t, y_{t-1}, \cdots, y_{t-m}, x_t, x_{t-1}, \cdots, x_{t-n}; \beta\right) = \mu_t \qquad (1)$$

where $y_{t-i}, i = 0,1,\cdots,m,$
are vectors of current and lagged values of endogenous variables, respectively and $x_{t-j}, j = 0,1,\cdots,n,$ are vectors of exogenous variables. β is a matrix of (generally unknown) coefficients and μ, a vector of random disturbances.

Several considerations arise in the actual formulation of a macroeconometric model. These include:

1. Elaborating the theoretical and *a priori* notions that inform the linkages in the model;

2. Establishing a mapping from possible theoretical latent variables to observable counterparts;

3. Choosing appropriate functional forms;

4. Deciding on the size and composition of the model (number and type of equations).

The model to be estimated should reflect the broad structure of the economy and be informative on policy issues. However, policy analysis and recommendations from the model ought to be informed by simulations and should be tempered by analysis of the implications of model constraints, political sensitivities, and the socioeconomic framework, the gestalt of which cannot be included in the model. The need for documented analysis and a statement of model assumptions facilitates replication and cannot be understated.

The specification of the model is arguably the most difficult part of the exercise. Standard practice has been for the modeller to be guided by economic theory as well as his/her knowledge of economic structures and institutions in giving a specific structure to the general model defined by equation (1) above. Given the statistical database available, it is at this stage that questions about the size of the model (the level of disaggregation) and the dynamic structure of the equations should be addressed.

All this, of course, is easier said than done. First, it is not clear how the "relevant theory" ought to be defined. Should model specifications reflect standard Keynesian, Monetarist, or Structuralist notions, or what the great economists coming out of the Caribbean tradition tell us? Or is it what our own training as economists lead us to understand about the structure and functioning of Caribbean type economies? Are theoretical constructs of the "demand side" like consumption and investment analytically useful in the Caribbean context and what should be the appropriate modelling framework (multiplier-accelerator theory)? To what extent should our theorising be related to the end use to which the model is to be put and, in this case, shouldn't the approach to specification be more eclectic, using whatever theoretical notions might serve the purpose? Further, should we embrace Sims' (1980) "atheoretical" approach which uses Vector Autoregressive (VAR) models that require no greater knowledge or understanding of economic structure than "everything depends on everything else?"

This lack of an organized body of theory to allow appropriate specifications of the realities in Caribbean economies is one problem that has affected consistent theoretical specifications. We need specifications that are acceptable relative to some theoretical notions and perform adequately according to statistical criteria. The underlying assumptions should be clearly stated for internal model consistency checks and for post-estimation validation. Ultimately, the specification design will depend on the aims of policy makers. The major issue, therefore, relates to the question of what is the best theoretical framework and operational functional specifications to address the objectives of the policy makers. These aims should, in the context of CARICOM, reflect targets for employment, growth in real GDP, foreign exchange accumulation and the rate of inflation. If there is a genuine interest in building models that can guide the Council of Central Bank Governors, then a decision has to be made on how best to use the individual country models to attain that objective.

National models provide very specific guidance on within-country policy effects without providing a mechanism for gauging how activities are affected by policy decisions taken in other nation states. Although not discussed in this paper, a regional model has the distinct advantage of allowing feedback among the various national sub-models;[5] the overwhelming logistics for implementing a regional model would make it difficult however to recommend such an option at this time. Abstracting from those inter-country linkages, each national model should contain a specific general equilibrium design with the following broad structure:

1. National Product and Income
   - Sectoral Output
   - Consumption and Investment Behaviour

2. Labour Market
   - Labour Demand and Supply
   - Wages

3. Monetary Sector
   - Money Demand
   - Domestic Credit
   - Inflation
   - Non-bank Financial Intermediation

4. Government Sector
   - Direct and Indirect taxes
   - Current and Capital expenditure
   - External and Internal Debt

5. External Sector
   - Exports and Imports
   - Capital flows
   - Reserves
   - Exchange rate

Data may not permit the construction of a model with all sectors fully accounted for. In fact, it would be desirable to proceed in a modular form with different sectors or subsectors having different degrees of disaggregation and completeness to reflect individual country structures and their main policy concerns. For example, a Trinidad and Tobago model may include production and trade equations for petroleum products and natural gas whereas an OECS model may wish to focus disaggegation efforts in the production and trade modules on tourism and bananas.[6]

1.3.1 *Exogeneity and Causality*

A premise of the Cowles Foundation Approach postulates that the classification of variables into "endogenous" and "exogenous" and the causal structure of the model are given *a priori* and are therefore untestable. This approach has, in recent years, been criticized on several grounds: (i) classification of variables into endogenous and exogenous is sometimes arbitrary; (ii) there are variables which should be included in the equation but are excluded so as to achieve identification (the Liu (1960) critique) and (iii) at times the coefficients in a simultaneous equations model cannot be assumed to be independent of changes in the exogenous variable (Lucas (1976) critique). For example, if the exogenous variables are changed and agents anticipate the change, they would modify their behaviour accordingly.

Thus, there is a need to formally classify variables into exogenous and endogenous variables to remedy these criticisms. One solution, at least to the Lucas critique, is to make the coefficients of the simultaneous equation system dependent on the exogenous policy variables (Maddala (1992)). This makes the model a varying parameter model (see Maddala (1977)). Leamer (1985) and Engle, Hendry and Richard (1983) suggest redefining the concept of exogeneity to make it testable.[7] Engle *et al* (1983) provide three testable definitions of exogeneity: weak, strong and super. A variable x_t is said to be weakly exogenous for estimating a set of parameters β, if inference on β, conditional on x_t involves no loss of information. Super-exogeneity relates to the Lucas critique and requires x_t to be weakly exogenous and the parameters in the joint probability distribution of y_t and x_t to remain invariant to changes in the marginal distribution of x_t. If x_t is weakly exogenous and x_t is not preceded or Granger caused by any of the endogenous variables in the system, x_t is defined as strongly exogenous. Granger's (1969) definition of causality is based on the notion that the future cannot cause the past but the past can cause the future, and relates to dynamic stochastic systems in terms of a predictability criterion. Methods exist for testing both Granger causality and exogeneity. Granger causality from x_t to y_t generally translates into a regression of y_t on its own lags and lags of x and testing whether the coefficients of the lags of x are jointly zero. Tests for exogeneity depend on the availability of extra instrumental variables and involve adding these constructed variables to the original equations and testing that the coefficients of these added variables are jointly zero (see Maddala (1992)).

1.3.2 Identification

The identification problem is concerned with estimating the parameters of the model. It appears when more than one theory is consistent with the same "data". In other words the theories are observationally equivalent or the structure of the model is unidentified (see Hsiao (1983) for a useful survey). The classic example given follows from Working (1927) in which there is no knowledge of conditions of supply and demand beyond our belief that the data represent equilibria. With only the data, there is no way of determining which of the theories (supply or demand) is correct. Thus, the structure underlying the data is unidentified.

Identification can be established if the structural parameters can be derived from the known reduced form parameters.[8] If the reduced form coefficients imply two or more distinct values for a single structural parameter, the model is said to be over-identified. If unique numerical values of the structural parameters of an equation can be obtained, the equation is called exactly identified. Under-identification, the last category, refers to the case discussed earlier where it is not possible to determine the structural parameters from the reduced form coefficients.

In linear simultaneous equations models, a necessary condition for the identification of an equation is the order condition which states that the number of variables missing from the equation but included in the system should be greater than or equal to (according to whether the model is over or exactly identified) the number of endogenous variables in the equation minus one. To this counting rule, one must also check the rank (sufficient) condition which is based on the structure of missing variables in the other equations.

1.3.3 Functional Form

Usually there are several ways of formulating the econometric model from the economic model. One reason for this is that there may be several functional forms which are consistent with the theory. Although economic theory may sometimes indicate the nature of a function, we often rely on statistical methods to determine the functional form consistent with the observed data. Models can be linear or non-linear, static or dynamic, and structured in levels or differences.

Most model builders are likely to favour linear models because they are easy to estimate. However, such functions may not always fit the data very well, thus resulting in large estimation and forecasting errors. Non-linear models, on the other hand, are generally difficult to estimate and manipulate (see Greene (1991) for a lucid discussion on tests for functional form).

Earlier modellers (see Boamah (1980)) suggested that whether a model is structured in levels or first differences depends on whether it is to be used for short-term or long-term forecasting. For short-term forecasting, it may be appropriate to analyse the system in rates of change of variables. Recent research suggests that it is necessary to determine the properties of the series over time as this may have implications for estimation and inference. For example, the fact that many economic time series are non-stationary in the sense that the mean and variance depend on time, renders inference on equations estimated in levels misleading. However, a linear combination of these non-stationary variables may be stationary, thus allowing OLS estimation.

Economic theory is generally silent about dynamics. The dynamics has to be determined from the statistical methods employed. In this respect, error correction models, which encompass many static and dynamic structures, are becoming quite popular (see Charemza and Deadman (1992) and Cuthbertson, Hall and Taylor (1992)).

1.3.4 *Simple and Complex Models*

Many scientists (for example, Popper (1959) and Friedman (1957)) have a preference for simple models as they are easier to understand, communicate and test empirically with data. However, as Maddala (1992) notes, "the choice of a simple model to explain complex real world phenomenon leads to two criticisms: (1) the model is oversimplified, and, (2) the assumptions are unrealistic". For example, to say that the demand for money is only a function of the rate of interest is an over-simplication and also an unrealistic assumption. To the criticism of over-simplification, Koopman (1957), for example, argues that it is better to start with a simplified model and progressively construct more complicated models. On the other hand, economists like J.D. Sargan and David Hendry of the London School of Economics tradition favour starting from a very general model and simplifying it progressively based on the data (see Granger (1990)).

Regarding the criticism of "unrealistic assumptions", Friedman (1957) argued that the assumptions of a theory are never descriptively realistic. Therefore, "the relevant question to ask about the assumptions of a theory is whether they are sufficiently good approximations for the purpose at hand. And this question can be answered only by seeing whether the theory works, which means whether it yields sufficiently accurate predictions".

The choice of a simple or complex model must also depend on the intended purpose. The model builders should weigh the benefits against the costs of building and continually updating the model.

1.4 Estimation and Testing

When the model has been specified we can proceed to test the empirical validity of the economic model. Several issues relating to measurement and methods of estimation need to be considered.

1.4.1 Measurement Problems

Economic theory is not limited to the available data. Further, concepts developed in economic theory are not conditional upon being measurable. This often results in economic hypotheses being formulated in terms of unobservable variables. Consider, for example, the following:

$$C_t = \alpha_0 + \alpha_1 Y_t^p + \alpha_2 r_t + \alpha_3 H_t + \alpha_4 P_t^e + \mu_t \qquad (2)$$

where C is consumption, Y^p is permanent income, *r* is the rate of interest, *H* is the ratio of human capital to total wealth and P^e is expected inflation. Measurement of each one of these variables presents problems. In practice, C is usually measured by consumers' expenditure on non-durables, which differs from actual consumption in that it does not allow for the flow of services from durable goods; Y^p is not directly observable and is usually approximated by a weighted average of present and past values of measured income with geometrically declining weights - an *ad hoc* approximation which is far from satisfactory. The choice of the appropriate rate of interest (nominal or real, short-term or long-term) for an aggregate function is in the last instance an empirical matter. Furthermore, data on wealth if available at all, are not reliable (see Arestis and Hadjimatheou (1982)). As a result *H* is measured by proxy variables (such as the ratio of earned income to total income) which do not do justice to the theoretical concept. The final regressor, P^e, is also non-observable; notwithstanding the problems of measuring the actual rate of inflation, the expectation generating functions employed in practice, including adaptive and extrapolative expectations, are mostly *ad hoc* devices which leave the issue open.

Other data considerations include the length and unit of time. In order to ensure consistency of estimation, especially in simultaneous estimation techniques, the number of degrees of freedom, that is the number of unspecified parameters of the joint distribution, must be sufficiently large. The unit of time used would generally be determined by the nature and use of the model. For instance, there would not be much use for an inventory model based on annual data if in reality manufacturers adjust their production and stock quarterly.

Problems of measurement and unobservable variables are widespread in economics and are particularly apparent in developing countries. Whenever they occur, their presence and importance should be admitted and the implications for any of the conclusions from the empirical research spelled out. One case in point is the assumption of subsidiary hypotheses when testing a particular hypothesis. The testing of such subsidiary hypotheses can question the generality and definitiveness of the conclusions of that specific hypothesis. For example, consider the empirical modelling of seasonal data. Until recently, the practice had been either to use seasonal dummy variables as additional regressors or to run regressions using seasonally adjusted data. We now know that the use of dummy variables are tantamount to imposing an *a priori* and *ad hoc* seasonal pattern which may be extraneous to the relationship being estimated. Also, seasonal adjustments distort some data characteristics that are unrelated to seasonality (Wallis (1974) and Prothero and Wallis (1976)). The most recent suggestion is to test for seasonal integration as a means of choosing between deterministic and stochastic seasonality. If a series is seasonally integrated, seasonal differencing would be the appropriate method of de-seasonalisation (see Hylleberg (1986) and Craigwell, Leon and Mascoll (1994)).

1.4.2 Methods of Estimation

In fitting the model to the data, the choice of an appropriate estimating technique is very important. This aspect of modelling received a lot of attention in the 1950s and 1960s through the Cowles Foundation which spent a lot of time devising alternative estimation methods and computer algorithms. Estimation procedures can be classified into limited information methods and full information methods. Limited information methods (for example Ordinary Least Squares (OLS)) estimate one equation at a time while full information methods (for example, Full Information Maximum Likelihood) treat all equations and all parameters jointly. Asymptotic results suggest that all of these structural estimators should be preferred to OLS which, alone among the estimators, is inconsistent (see Greene (1991)). Unfortunately, samples are finite (moreso in developing countries) and in many cases OLS has a smaller variance about its mean than does 2SLS (about its mean), leading to the possibility that OLS might be more precise on a mean squared error criterion. For these reasons OLS is often used (see Watson (1987)). However, the fact remains that OLS standard errors are biased and in all likelihood, not useful for inference purposes. Other limited information approaches like 2SLS are preferred. Intuition would suggest that full information methods are superior to single-equation estimators and should be used, given that the current state of available software has all but eliminated the computational simplicity advantage of single-equation methods. Why then are these methods not used? First, any specification error in the structure of the model will be propagated throughout the system. The limited information methods will, by and large, confine a problem to the particular equation in which it appears. Second, Monte Carlo studies have indicated that the finite sample variance of the full information estimator may be as large as or larger than that of the limited information estimator (see Greene (1991)).

The choice of estimation technique is largely a function of the structure of the model's equations and costs. If there is no simultaneity in the structural relationships, then OLS yields consistent estimates. If, however, simultaneity exists, the appropriate estimator should be taken from the class of systems estimators. The majority of large scale models that have been constructed in the Caribbean, have utilized mainly Two-Staged Least Squares (2SLS) and Ordinary Least Squares (OLS) as the principal estimators.

Recently, the framework for modelling single equations has become more sophisticated largely as a result of the development of the general-to-specific methodology[9] and its link with cointegration (see Engle and Granger (1987), De Marchi and Gilbert (1989)). Leon and Samuel (1994) apply this methodology to a model of St Lucia but it is unclear how successful this approach has been since the model is still at a preliminary stage. Another example of the use of that methodology is the model of the Reserve Bank of New Zealand (Brooks and Gibbs (1991)). In the context of these developments, the Ordinary Least Squares estimator is super consistent in fully recursive systems. That property, however, does not translate to non-recursive systems where complex feedback relationships may introduce multiple orders of integration among a given set of variables. It is therefore conceivable for such systems to have variables which are I(2), I(1) and I(0) and for which no integrable combination yields a set of I(0) variables.

The use of the cointegration approach holds a lot of promise. In the first place, it imposes a framework for a dynamic structure which takes full account of the "equilibrium" or "long run" properties of the model. Second, the approach includes a "built-in specification test" because of the existence properties enunciated in the Granger Representation Theorem. However, there is a cost attached. First, the determination of cointegrating relationships can be a long process of establishing the orders of stationarity of all economic time series to be used in the model, and the tests may yield unsatisfactory results because of the short span of the data. Second, choosing an appropriate VAR structure may be problematic because data shortages may not allow different lag lengths: even when the data are adequate, the economic interpretation of the coefficients are not immediately obvious (see Charemza and Deadman (1992), p.201). Finally, although growing, the availability of software for the new techniques is still sparse: to date, MICROFIT (Pesaran and Pesaran (1991)), EVIEWS (Lilien *et al* (1994)), PCGIVE Professional (Doornik and Hendry (1994)), RATS (CATS procedure (Hansen, Johansen and Juselius (1995))) and GAUSS (COINT (Oularis and Phillips (1995))) allow for estimation using the Johansen procedure.

1.4.3 *Evaluation and Model Selection*

Before the estimated model becomes operational, it should be tested for economic and statistical adequacy. The size and sign of parameters should be investigated to determine if they conform to the expectations of the theory. Tests or measures of the validity of restrictions, the explanatory and predictive power of the regression, the stability of the parameters, the size and pattern of residuals are criteria that can be used to evaluate and choose among rival specifications. The development of more recent tests (see Godfrey (1988)) has rendered the old practice of choosing between relationships entirely on the basis of the size of R^2, the coefficient of multiple determination, obsolete. It is now well known that a high R^2 does not establish causality and in fact can easily be achieved especially when any two variables are trending. In fact, it is not always the case that one can choose a model that fits the data well. If, for instance, the model is designed for forecasting purposes, the researcher may be forced to compromise, accepting some equations which, although less desirable from a statistical point of view, nevertheless help to improve the forecasting performance of the model. Thus, the primary purpose of the model plays a role in shaping its final form.[10] Another criterion for accepting a model is its encompassing ability, that is, its ability to explain relevant findings from other studies (see Mizon (1984)).

1.5 Forecasting, Simulation and Policy Analysis

Forecasting, in the framework of the general model defined by equation (1), is the estimation of the as yet unobserved y_{t+k}, k = 1,2, ... given y_{t-k}, k = 0,1,2, ...m, x_{t-k}, k = 0,1,2, ... n and β. Ironically, it is probably the most misunderstood stage of the whole forecasting cycle and there is a widespread belief that this is a fairly mechanical exercise requiring not much more than interfacing with the computer.

Nothing could be further from the truth: there is a very rigid and disciplined routine to follow which requires, among other things, a lot of expert opinion and judgement about the future path to be taken by the exogenous variables in the model. This path may be known with some certainty in the case of certain variables, especially if the model is being used by some state agency like a Ministry of Planning, but it is likely to be unknown for variables which are of fundamental importance - like the price of oil in the case of Trinidad and Tobago. In the final analysis, the forecast will be as good as the assumptions made about the (usually numerous) exogenous variables in the model.

The aim of forecasting is to predict X_{n+h}, h = 1, 2, ..., given a series of equally spaced observations X_t, t = 1, 2,.....n. In a large scale macroeconometric model, the main challenge is to accurately project values for the endogenous variables in the system given assumptions about how the exogenous variables are likely to behave in the future. Large scale macroeconometric models utilize a relatively strong assumption about replicating the future from adequate knowledge of the past. This assumption of structural and parametric constancy is fine if the processes generating the observed data evolve in a constant and stable manner. Forecasting accuracy, however, is a function of future, post-sample events which may change on account of unforseen circumstances.

The main advantage of a formal forecasting method is not necessarily the prediction made but rather the process involved in arriving at the prediction and in the way it is interpreted and utilised. The accuracy of forecasting is therefore dependent on the judgment of the modelbuilder who may be required, based on his/her understanding of future events, to modify the forecast values within tolerable bands. The pertinent issue now becomes how different the model forecasts are from the expectations of experts and how much adjustment needs to be made to the model.

In a standard set up, the best forecast of the disturbance in an equation is its mean value of zero. However, practical forecasts are not purely model based (zero projection), but are subject to non-zero residual adjustments called "constant adjustments" or "add-factors" (see Wallis (1989)). These adjustments are based on (i) the recent patterns of the residuals, (ii) available current information not yet incorporated in the model, (iii) data revisions, and (iv) information about likely future developments not already incorporated in the model; for example, if labour contracts are due for renegotiation, an adjustment may be necessary in the wage equation. Such adjustments are typically made in lieu of a re-specification and re-estimation of the model's equations, which are often impractical at that stage of the forecasting process. Residual adjustments are also used to "fix" solutions to meet a required data constraint; an example of this is when an add-factor is used to ensure that a forecast matches the value of an endogenous variable which is known before the forecast occurs. Adjustments are not necessarily limited to the endogenous variable of interest; a non-zero residual may also be incorporated in an equation of another endogenous variable which is related to the endogenous variable of interest. This mechanism can also be used to explore new scenarios or structural change that the model cannot account for. It is necessary in each case to trace the implicit extension that is being applied to the model; it aids understanding, ensures replicability and points to structural changes that may need to be incorporated later.

The macroeconometric model building environment should not provide the only guide to the future path of the economy. Indeed, it may often be helpful to combine this approach with a series of other methods which can be weighted depending on the preferences of the forecaster (see Granger and Ramanatham (1984) and Holden and Peel (1986)). Although the Trends, Analysis and Projection exercise of the Central Bank of Trinidad and Tobago generated both econometric and judgmental forecasts, there was no explicit process of weighting the importance of the methods based on the preferences of policy-makers.

In macroeconometric models, when all the diagnostic checks have been carried out on the model, the researcher may conduct experiments to further test the validity of the model and/or to predict the unobserved or future values of the endogenous variables.[11] This is usually done through the process of simulation. In the framework of equation (1) above, simulation involves the determination of the time path of the elements of the y vector given x and β.[12] An initial forecast, called the base forecast, is prepared and then another forecast, called a policy simulation, is re-calculated after altering one or more of the exogenous variables. A comparison of the base and policy simulations shows how, conditional on the estimated model, the economy would be affected by the policy change. The rationale for the use of statistics based on simulation is that equation by equation evaluation does not capture the full richness of the simultaneous system and that, if the model is truly a representation of the process generating the data, then it should produce output that closely resembles the observed data. Intuitively, too, it would seem very plausible that a model purporting to forecast future values should at least be able to satisfactorily explain the past (see Watson (1987)). The issue of validation follows no "hard and fast rules" and more often than not, modelbuilders are forced to trade off alternative criteria in different ways depending on the purpose of the model and the nature of the variables concerned.

This process of simulation is not as straightforward as it may appear since depending on the nature and size of the system convergence may be a slow process. Moreover, there is no correlation between goodness of fit of the individual equations and good simulation and forecast performance (see Klein and Young (1980) and Kmenta and Ramsey (1981)). Thus, emphasis on single equation simulation criteria may be misplaced. One global measure of a model's explanatory power is that provided in Smith (1977).

Ex-post simulation is conducted when the main interest is to test the validity of the model. The model is simulated through the estimation period and a comparison between the original data series and the simulated series of each endogenous variable can be made. Forecasting involves the simulation of the model beyond the estimation period. Two forms are often identified: ex-post and ex-ante forecasting. In ex-post forecasting the simulation begins at the end of the estimation period and extends to the present. Ex-ante forecasting, however, refers to the solution of the model from the current period into the future. Quantitative measures which help to gauge the tracking performance of ex-post simulation and ex-post forecasting include measures such as the root mean square error, the mean simulation/forecast error, the mean absolute simulation/forecast error and Theil's inequality coefficient and variance decomposition. Measures of ex-ante forecast performance are more complex as they require a process of stochastic or Monte Carlo simulation. Other measures used in evaluating models check for (i) the number of turning points the simulation/forecast missed and failed to predict as well as the number of under or over-predictions; (ii) the response of a given endogenous variable (target) to a change in an exogenous policy variable (instrument). Ideally, the response should conform to the theory and empirical observations (see Wallis (1989)); (iii) the sensitivity of the models to factors such as the initial period in which the simulation began and minor perturbations in the coefficients. These changes should have minor effects on the simulation or forecasting results.

What caveats should accompany policy prescription or forecasting? First, the estimated model is based on the available historical data. These are generated as products of the economic structure and can only be used for policy analysis on the assumption that structure does not change. For example, the UNDP (1991) model of the Jamaican economy uses data from 1974 to 1989 while the model of the Trinidad and Tobago economy, designed by Hilaire *et al* (1990), was estimated on data from 1966 to 1986. Since the structure of these economies has undergone such radical changes in the very recent past, policy prescriptions based on these forecasts need to be interpreted with great care as the analytical usefulness of both the equations comprising the models and the estimated coefficients are no longer obvious. Second, forecasts have to be based on the estimated coefficients. Policy forecasts will therefore contain margins of error just as the estimated coefficients do. Further, even if the estimated model is adequate and the coefficients are precise, forecasts can still be wrong for essentially three reasons: (i) they incorporate forecasts of the exogenous variables in the model; (ii) they are subject to changed "external" conditions that could not have been predicted; and (iii) changes in policy may affect the underlying behavioural model parameters (see Leon (1989)).

1.6 A Schematic Representation of the Steps in Model Building

We have discussed model building as if there is no interrelationship between stages 1 - 5 (Figure 1.1). There has, however, been considerable dissatisfaction with this scheme since the 1970s. It is ludicrous to assume that there is no feedback from the econometric testing to the formulation of economic theories (i.e. from box 6 to box 1). Econometricians do not simply take the theories they are given and test them, learning nothing from the testing process. Similarly, the data collecting agencies do not gather whatever data is available and the econometricians use whatever data is given to them. In addition, it has been suggested that in testing hypotheses one assumes that the specification adopted in box 2 is correct in that tests are only made on the original economic model. The modelling process generally follows an up-down, down-up schema with feedback from the diagnostic checks to the original model specification and to the refinement of the econometric model. These new developments suggested are shown figuratively in Figure 1.2.

FIGURE 1.1
SCHEMATIC DESCRIPTION OF THE STEPS INVOLVED IN AN ECONOMETRIC ANALYSIS OF ECONOMIC MODELS

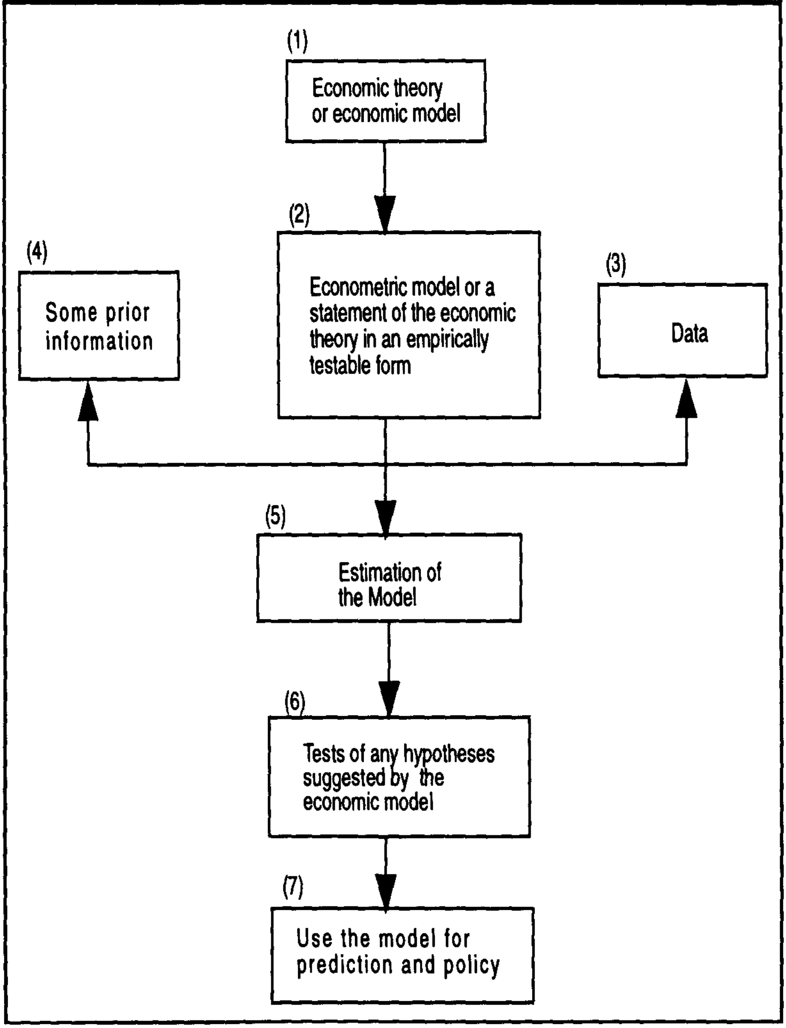
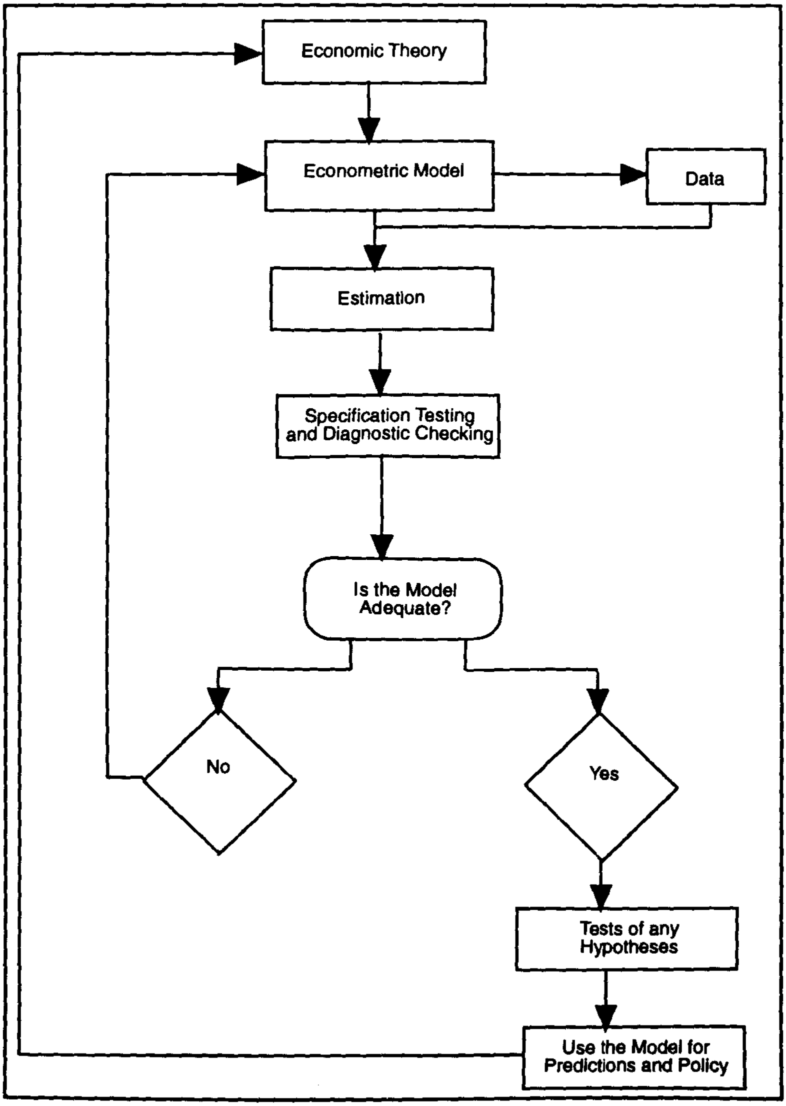


FIGURE 1.2
REVISED SCHEMATIC DESCRIPTION OF THE STEPS INVOLVED IN AN ECONOMETRIC ANALYSIS OF ECONOMIC MODELS



2. A REVIEW OF CARIBBEAN MACROECONOMIC MODELS

There are few formal macroeconomic models for policy use or policy evaluation in the Caribbean, perhaps because the notion of economic management is relatively new to the area. Systems can be divided into three categories: planning models, estimated statistical models and judgemental models. Planning models are based on input-output relationships, using linear programming techniques to establish feasible long-term paths for the economy. The sole Caribbean example of a model of this type is to be found at the Government of Jamaica's National Planning Agency.[13] Judgemental forecasts, as the name implies, suggest that the forecasts are based on the forecaster's judgement. These types of models have been used by the IMF and the Central Bank of Barbados (see Holder and Worrell (1985)). Our main concern is the third class of economic models, that is, statistical econometric models.[14] We do not assess the models under review according to all the design criteria discussed in Section 1; rather, the emphasis is on the sector composition, size and scope of each study, points of similarities and differences with other models of the same economy, their main findings and the way in which each model "hangs together as a whole". A critical evaluation of these models as well as suggestions for improvement are provided.

2.1 Macroeconometric Models for Jamaica

As Table 1 indicates, the earliest efforts on macroeconomic model building in Jamaica used OLS or 2SLS as the estimating method. The frequency of the data was annual and the systems were essentially Keynesian; they incorporated the consumption function and attempted to estimate income multipliers, neglecting monetary effects. These models how-

TABLE 1
MACROECONOMETRIC MODELS IN THE CARIBBEAN
JAMAICA

Authors	Purpose and Type	Nature	Estimation	Results	Critique
Carter (1970)	To assess the impact of government fiscal and monetary policies and to make conditional predictions of values of the main macroeconomic aggregates.	3 blocks 22 behavioural equations 11 identities	1959-1966 Annual data OLS and IV	Data appears to do fairly well in simulation exercises.	No estimation of the labour or financial markets.
Harris (1970)	The projection of the future resource requirements of the economy in terms of potential export-import and saving-investment gaps.	3 blocks 42 behavioural equations 15 identities	1950-1965 Annual data OLS	The trade gap is likely to be more a dominant constraint on growth. Estimation results indicate a good fit and the correlation between observed and predicted values are greater than 0.9.	Neglects the monetary sector. Ignores how foreign exchange gap is financed. No use of simultaneous equation estimation techniques.
Manhertz (1971)	To create a prototype of the economic structure. To observe the multiplier effects and results of policy alternatives.	5 blocks 24 behavioural equations 18 identities	1959-1966 Annual data OLS and 2SLS	With the exception of consumption the data tracks fairly well with R squared values ranging from 0.8 to 0.99.	Failed to discuss the quantitative aspects of his study and how model could be used to observe the various multiplier effects.
Taylor (1972)	Investigates whether a 'real' or monetary mechanism operates in Caribbean type economies.	Monetary model: 3 blocks, 4 behavioural equations and 4 identities. Real model: 3 blocks, 5 behavioural equations and 5 identities	1950-1970 Annual OLS	Either a monetary or 'real' model is capable of explaining income variations in Jamaica.	The 'real' model failed to consider employment and monetary sectors. No use of simultaneous estimation models.
Worrell (1979)	Unearthing the monetary implications of Linder's (1967) trade model and investigating the existence and stability of the money demand function.	3 blocks 6 behavioural equations 6 identities	1962-1971 Annual 2SLS	The Linder model holds in Jamaica and the money demand function is stable.	No consideration of the government and labour markets.
Holder and Worrell (1984)	To analyze economic reactions to changes in international trade and financial markets and official policies.	5 blocks 12 behavioural equations 6 identities	1960-1982 Annual 2SLS	With the exception of the nontradable output and deposits the data tracked fairly well with R squared values between 0.6 and 0.99. Results also indicate that government deficits impact on real output and that monetary policy is irrelevant.	Largely static model.
UNDP (1991)	To develop a model geared to producing forecasts of the Jamaican economy.	4 blocks 9 behavioural equations 104 identities	OLS	Model fits data well but the forecasts give large errors.	No consideration of the monetary block.

TABLE 1
MACROECONOMETRIC MODELS IN THE CARIBBEAN
TRINIDAD AND TOBAGO

Authors	Purpose and Type	Nature	Estimation	Results	Critique
Brewster (1972)	Investigates the relationships between employment and a number of economic variables in an export biased underdeveloped country so as to later develop a simultaneous equation model.	3 blocks 39 behavioural equations	1951-1968 Annual OLS	Research suggests that domestic sector development i.e. changes in wages, consumption and domestic output are important to the formulation of the hypothesis on the growth of employment.	No consideration of other economic blocks e.g. government.
Persad (1975)	To develop a quantitative description of the Trinidad and Tobago economy so as to visualise the likely effects of anticipated monetary and fiscal policies and to project economic growth.	2 blocks 11 behavioural equations 4 identities	1960-1971 Annual OLS & 2SLS	Most of the data tracks well (R squared values greater than 0.8) and the predictive power is adequate.	No discussion of monetary nor employment sectors.
Gafar (1977)	Attempt to construct a simple model of the Trinidad economy.	5 blocks 38 behavioural equations	1951-1968 Annual OLS	The model represents a satisfactory prototype (the R squared values were generally above 0.95).	No use of 2SLS which may be a more appropriate tool of estimating simultaneous equations models.
St Cyr (1978)	To anlayse the responsiveness of policy variables on key macroeconomic variables using an export propelled model.	3 blocks 6 behavioural equations 8 identities	1965-1976 Annual OLS	There is no clear indication as to whether domestic wage cost and prices impinge on the Balance of Payments.	No consideration of labour and government sectors. OLS is not the appropriate tool for modelling norecursive systems.
Joefield-Napier (1979)	Attempts to explain aggregate demand.	6 blocks 8 behavioural equations 3 identities	1970-1978 Quarterly OLS	No policy implications.	Supply side omitted. No use of simultaneous equations techniques.
Holder and Worrell (1984)	As above for Jamaica.	As above for Jamaica	As above for Jamaica	As above for Jamaica.	As above Jamaica.
Charles (1989)	To understand a country's critical relationships and interdependencies through quantitative analysis. Use (a) modified ILPES model and (b) export driven model.	Model (a) 5 blocks 22 behavioural equations 15 identities model (b) 3 blocks 6 behavioural equations 3 identities	1966-1985 Annual OLS	(a) most equations recorded R squared values above 0.9 (b) all estimates were over 0.96. Adequate simulation results.	No use of simultaneous equation estimation methods.
Hilaire, Nicholls and Henry (1990)	Examines implications of policy and non policy shocks as well as to develop a forecasting model	5 blocks 17 behavioural equations 17 identities	1966-1986 Annual 2SLS	Some results contained large forecasting errors. Good historical simulations except for the Monetary Block.	Suffers from use of current versus constant period values. Some of the behavioural equations could be idenities.
Charles and St. Cyr (1992)	To analyze the responsiveness of policy variables on key macroeconomic variables using (a) modified ILPES model and (b) an export propelled model	(a) 5 blocks 22 behavioural equations 15 identities (b) 3 blocks 6 behavioural equations 3 identities	1965-1985 Annual OLS and 2SLS	Both models coefficients were significant and had good tracking ability. Therefore the authors are neutral in choosing the better model.	The export propelled model failed to consider the financial market.
Clarke and Watson (1992)	To simulate and evaluate policy scenarios for the Ministry of Planning, Trinidad and Tobago	5 blocks, 136 equations 25 behavioural equations 111 identities	1970-1990 Annual OLS	Good simulation performance. Captures balance sheet identities in real and financial sector.	Static approach. Incorporates little dynamics.

TABLE 1
MACROECONOMETRIC MODELS IN THE CARIBBEAN
GUYANA

Authors	Purpose and Type	Nature	Estimation	Results	Critique
Jarvis (1990)	To quantify the relationships which govern fluctuations in the Guyanese economy and to present such quantifications in an economic model.	4 blocks 12 behavioural equations 5 identities	1957-1976 Annual OLS and 2SLS	Data explains adequately as it outperforms the naive model.	Neglect of monetary and employment sectors.
Ganga (1990)	To explain the behaviour of key macroeconomic variables and the effects of various policies on them.	5 blocks 7 behavioural equations 10 identities	1966-1985 annual 2SLS	Good tracking and forecasting results. Policy simulations suggest that tight fiscal and monetary policies and exchange devaluation are inimical to growth and ineffective in correcting internal and external imbalances.	No consideration of employment block.

TABLE 1
MACROECONOMETRIC MODELS IN THE CARIBBEAN
OECS

Authors	Purpose and Type	Nature	Estimation	Results	Critique
Leon and Samuel (1994)	To analyse past economic changes in the St Lucian economy. To explore sensitivity to external shocks and to assist policy makers in forecasting and policy formulation.	5 blocks 16 behavioural equations 39 identities	1977-1992 Annual OLS	Results from both the short run and long run equations were encouraging. The signs of ECM terms were negative and less than 2. The t statistics suggest that there are significant short term variations around long run trends.	Use of OLS might not have been the most appropriate tool. Little discussion of simulation results.

TABLE 1
MACROECONOMETRIC MODELS IN THE CARIBBEAN
BARBADOS

Authors	Purpose and Type	Nature	Estimation	Results	Critique
Mac Clean (1979)	-	-	No estimation performed	-	-
Holder and Worrell (1979)	Attempts to describe the economy using a monetary model and, to more importantly, explore central bank policy and its effects.	4 blocks 5 behavioural equations 5 identities	1946-1978 Annual 2SLS	The estimations were statistically acceptable, however, some of the simulations did not tract very well.	Little dynamics.
Boamah (1982)	An attempt to specify an operational model for Barbados.	5 blocks 41 behavioural equations 21 identities	No estimation performed	No estimation performed.	It has been realised that the interrelationship between real and financial sectors is complex and the effect of certain monetary transmissions is uncertain.
Holder abd Worrell (1984)	As above for Jamaica.	As above for Jamaica	As above for Jamaica	As above for Jamaica.	As above for Jamaica.
Mac Clean (1985)	-	-	No estimation performed	No estimation performed.	-
Boamah *et al* (1985)	To analyse the working of the Barbadian economy and to provide forecasts for the medium term.	4 blocks 8 behavioural equations 4 identities	1969-1982 Annual OLS and 2SLS	Good explanatory power however forecasts are poor.	No inclusion of government.
Galawish and Worrell (1988)	Combines econometric and accounting framework to analyse the workings of the Barbadian economy.	5 blocks 5 behavioural equations 8 identities	1958-1986 Annual OLS	Equations fit well but projections were somewhat unrealistic..	No use of 2SLS Static Model.
Craigwell *et al* (1993)	An extension of Galawish and Worrell.	5 blocks	1965-1992 Annual OLS	Although equations performed adequately, the tracking ability was poor.	Did not use 2SLS.
Anyadike Danes (1994)	Framework for assessing the macroeconomic policy options and generate projections for important economic indicators.	4 blocks 7 behavioural equations 7 identities	1965-1992 Annual OLS	Data tracked well. Results suggest that fiscal policy instruments have more permanent effect on the level of national income.	Model ignores the supply side of the model.

ever recognised the importance of international flows to the Caribbean and the authors spent time examining the prominence of trade flows through import and export functions. Later models by Holder and Worrell (1979, 1985) considered not only a prominent tradeable goods sector but also the non-tradeables, banking and government sectors. None of these models has yet been used for forecasting by policymakers.

2.2 Macroeconometric Models in Trinidad and Tobago

The models for Trinidad and Tobago were developed along similar lines and are comparable in scope to those done on Jamaica. There was some discussion on the monetary sector and the supply-side of the economy, aspects lacking in the earlier models. As a result of their highly aggregative nature, these early models on Trinidad and Tobago were however smaller in size than their Jamaican counterparts. The later models of Charles and St. Cyr (1992) and especially Hilaire, Nicholls and Henry (1990) are particularly important as they generated ex-post simulation and forecasting results. The Jamaican models never reached this stage of development. Also important to Caribbean macro-modelling is the fact that the first and only attempt at estimating a quarterly model has been on Trinidad and Tobago although, as Boamah (1981) correctly observed, "even if one were to overlook the use of an inappropriate estimating technique (OLS), most of the results reported are themselves unacceptable from the view point of conventional means of statistical inference". Also, no attempt was made to consider the possible seasonal variation in the data.

2.3 Macroeconometric Models for Barbados

Of the three countries, modelling started last in Barbados. As a result, the theoretical construction of the early Barbadian models was fairly sound. Barbadian model builders seemed to have learnt from the weaknesses inherent in the models of Trinidad and Tobago and Jamaica. As a means of giving their previous judgemental approach a statistical basis, Barbadian model builders have sought to combine econometric, accounting and judgemental frameworks, thereby advancing model building in the region. These models have been used, with limited success, to provide medium term forecasts and ex-post simulations (see Galawish and Worrell (1988) and Craigwell, Haynes, Walker and Worrell (1993)).

2.4 Evaluation and Critique of Caribbean Macromodels

The macroeconometric models reviewed above collectively exhibit a great deal of similarities in both the theoretical structure and methods of estimation. Our purpose in this section is to present a general evaluation of the models from the perspective of:-

1. theoretical underpinnings; and

2. econometric considerations.

Some model specific issues are also addressed.

2.4.1 Theoretical Underpinnings

The discussion above highlights the "incompleteness" of Caribbean macroeconomic theory. As Holder and Worrell (1985) write, nearly "all these models were abandoned by their authors before they had captured sufficient interest to suggest adoption by policymakers and/or their critics ..... the models in general did not yield sufficient insight into policy issues of most vital interest to decision-makers: exchange rates, fiscal policy, interest rates, central bank reserve requirements and exchange controls". Indeed, these models, especially the early models (pre-1980s) were basically of the neo-Keynesian genre, with their emphasis on the demand side of the economy, and little or no discussion of the supply side of the macroeconomic structure. The problems facing developing countries like the Caribbean stem mainly from bottlenecks in production due to limited quantities of certain factors, such as human and physical capital, and relatively inefficient production techniques (Boamah (1985)). This problem, however, is not as great as in the 1960s and 1970s as later Caribbean models have not totally accepted the applicability of the Keynesian theoretical framework. St. Cyr (1991) has recently advanced working hypotheses on some recurring themes central to Caribbean economies. Our view is that where theory models are tentative, statistical techniques should be used to distinguish between exogenous and endogenous variables, to determine whether the models should be estimated in levels or differences, and whether the equations should be static or dynamic.

2.4.2 Econometric Considerations

We focus on two related issues: the data base and the estimation technique. The Caribbean studies mentioned above were typically estimated with 8 - 9 observations and occasionally 15 - 20 observations. Due to the paucity of the data, researchers also omitted several important relations, particularly functions related to the labour and financial markets (Worrell (1973), Boamah (1980)). In many cases, the data employed did not correspond precisely to the theoretical specifications, and some of the key series were at best imperfect, subject to both random and systematic measurement error.

All of the above suggest that the results need careful interpretation, and could have given a distorted picture of the economic structure being estimated. As stated earlier, economists tend not to generate their own data and may be ignorant of the sources and consequences of most of its errors. Indeed, the lack of discussion on the biases transmitted to the estimates by the inadequate data suggest this is the case. Data seems to have been entered uncritically into the computer. Caribbean model building efforts would profit immensely if our trained economists (econometricians) became more involved in compiling data; we should be more concerned with ameliorating our data systems than in estimating what are usually simplistic equations employing rather poor data.

The small data sets also limit us in another area of 'best practice' econometrics. There is some dispute about the exact weight one ought to attribute to prior knowledge and to data evidence; however, there is wide consensus that one should let the data tell part of the story, especially with regard to the dynamics of the model, as macroeconomic theory is often silent in this respect (Malinvaud (1981)). In-depth data analysis may provide insights on causal links and lag patterns; such an approach would undoubtedly enrich our specifications. However, the above macro studies would suggest that Caribbean econometricians pay scant attention to the dynamic properties of their models. This may have been necessary to avoid the familiar degrees of freedom and 'loss of power' problems due to limited data when lagged variables are included in the regressions.

Arriving at an appropriate specification of a model in the Caribbean environment normally involves some iteration between preliminary specifications and data analysis. Given a limited amount of data, the possibilty exists that if enough models are fitted, one can arrive at a good fit without the model being useful for forecasting or policy analysis. As Rock (1984) observes, "due to the lack of a strong macro-theory, model formulation in the Caribbean seems to follow this iterative process: we postulate a (usually parsimonious) representation of our prior beliefs and confront this with the data. Often this preliminary exercise proves unsatisfactory and the model is revised." Such specification searches may converge to the neighbourhood of the "truth" especially when informed by established theory; however, one inherently risks estimating until at some (arbitrary) level of significance one discovers a 'significant' relationship from the sample data. As Johnston (1984) suggests, this significance may simply be a specious contrivance. In addition, such an (iterative) approach, strictly speaking, may well invalidate several of the assumptions underlying the approach to traditional inference (Leamer (1978)). Leamer proposes several appealing - essentially Bayesian - ways whereby the researcher can appropriately discount the final results of such specification searches. We do not discuss these here. In summary, one ought to take careful account of the data mining process since these search procedures imply that the reported standard errors understate the uncertainty associated with the estimated coefficients - the rose may not be as real as it looks!

With respect to the estimating method, OLS is often used as the pragmatic choice. Asymptotically, OLS often gives inferior estimates (biased and inconsistent) relative to other limited information approaches like 2SLS in simultaneous equation models, the exception to the case being block recursive systems. Previous model builders recognised this point but failed to provide more discussion on why this outcome prevailed. The point is that analytical research on the small sample properties of the consistent (simultaneous equations) estimators, such as 2SLS and LIML, indicates that these estimators may possess undesirable finite sample properties; for example, the 2SLS estimators, under several commonly encountered conditions, possess a distribution that has no finite order moments. In addition, certain consistent estimators can have serious finite sample biases and may be outperformed by OLS on a mean square error criterion (Zellner (1979)). Nevertheless, these results do not necessarily imply that OLS is a good choice. There are many situations often encountered in empirical work that challenge the empirical suitability of the OLS estimator. Some of these are: (i) omitted variables; (ii) use of unobservable variables, for example, expectations; (iii) measurement error in the data; (iv) stochastic misspecification; and (v) dynamic misspecification (see Hendry (1980)). Some research has emerged on identifying and dealing with many of these technical problems (Godfrey (1988)) and analysing the properties of estimators in finite samples (Phillips (1977)). An analysis of these problems is indispensable to a correct interpretation of our empirical results (see Watson (1987)).

The more recent studies[15] above show little evidence that many of these considerations were entertained. Further, "casual" modelling which ignores the above situations may even appear sound by the usual regression diagnostics (DW, R^2, 't'- and F- ratios). However, to accept OLS results on the basis of these statistics alone, and without deeper soul-searching, is a process fraught with danger. Granger and Newbold (1974) have clearly shown that when variables are run in levels, inference based on these above mentioned summary statistics may be misleading. In fact, in strict terms, the 'F' and 't' statistics are themselves invalid for inference under several of the above-mentioned conditions. Since the acceptance of the OLS results are conditional on these statistics, the assumptions underlying their validity become important. Godfrey (1988) has outlined several diagnostic tests (for example, exogeneity, parameter constancy, autocorrelation) to check the underlying assumptions of the least squares regression. The objective is to design models that are theory-consistent approximations to the process generating the data, and which mimick elements both of the past, present and future and are the measurement system that generated the observed data.

Another econometric problem which is not peculiar to Caribbean studies is the issue of non-stationarity. Conventional econometric theory has been developed upon the assumption that the underlying data processes are stationary . However, most economic variables do not exhibit constancy over time neither in mean nor variance, implying that classical statistical inference in general is not valid. Recent developments in econometric theory have shown that if a set of non-stationary variables is cointegrated, that is a linear combination of these variables is stationary, valid estimation and inference is possible. This stationary linear combination can be interpreted as a long-run equilibrium relationship. Thus, this econometric methodology[16] (Engle and Granger (1987)) can help ascertain the existence of the theoretical specification.

In addition to the general points raised above, there are practical shortcomings that should be considered in formulating models. For example, in Hilaire *et al* (1990), consumption, income, and imports are estimated using current prices, notwithstanding the fact that the period covers years of moderate to almost no inflation (the 60's) to years when inflation was as high as 22% (the 70's). In addition, some estimated equations did not recognise underlying identities. For example, Hilaire *et al* estimate the function

$$NDAT = -\underset{(0.66)}{115.91} - \underset{(-6.49)}{1.006}\,BUD + \underset{(15.14)}{1.108}\,NDAT(-1) \qquad (3)$$

where *NDAT* = Net Domestic Assets of the Central Bank and BUD = Government's Budget Surplus.[17] The constant term (which should not have been used at all) is not significant while the coefficients of *BUD* and *NDAT*(-1) are not significantly different from -1 and 1 respectively, their correct values derived from the identity *NDAT* = *NDAT*(-1) - *BUD*.

Depending on the objectives of the model and the requisite level of disaggregation, a choice can be made regarding the desirable mix of behavioural equations and identities. Some authors prefer using identities to estimated equations wherever the former are possible. For example, whereas tax revenue functions are generally estimated as:

$$Tax\ Revenue = \alpha + \beta\ Tax\ Base \qquad (4)$$

the identity Tax Revenue = Average Tax Rate * Tax Base could be a preferred alternative; the average tax rate could be deduced from the data.

If the model is to be used for policy making purposes, the use of the identity instead of the equation 4 provides a very powerful policy instrument: the average tax rate. The fixed value for β clearly does not provide for this possibility.

It is particularly important that fundamental accounting identities of the economic system be incorporated into the models. A failure to do this makes it unclear whether sectoral linkages are satisfied. In addition, assumptions implied by data constraints must be fully recognised. For example, we cannot claim that there is no assumption of money market equilibrium when the data does not distinguish between money demand and money supply, and the same money series is used to model both demand and supply functions. Further, where data series, not available in published sources, are compiled for the model building exercise, the procedures used should be clearly stated. Not only is replicability facilitated, but the accuracy and interpretation of the results will depend on the validity of the constructed data.

Simulation results must also be interpreted with great care. In Hilaire *et al* (1990), when the model was simulated to determine the effects of a fall in oil prices, the model predicted that domestic prices would rise. The corollary to this, of course, is that a rise in oil prices would result in a slow down of domestic inflation, a result which, in addition to being counter intuitive, is contrary to all the existing evidence. This result alone, in retrospect, should have been sufficient to prompt further inquiry on the adequacy of the model specification.

Finally, the limited attempts at forecasting have not been very encouraging. In Hilaire *et al* (1990), the model was used to generate forecasts for 1987 and 1988. The actual percentage errors are quite large, especially for the second year of the forecast (1988). For example, in 1988, the forecast errors were 47% for the money supply, 26% for the wage rate and 10% for GDP. The differences between the actual and forecasted growth rates are equally large: an actual growth rate in the money supply of 7.9% is forecasted as 33.9%, a contraction of 2.94% in Gross Domestic Production is forecasted as a 1.8% growth while a 16.6 % increase in the Budget Balance is forecasted as a 6.4% increase. For comparison, the UNDP model of the Jamaican economy forecasts for the growth rates of constant price GDP for the years 1990 to 1991 (the two years adjacent to the historical data used to fit the model) show significant differences between actual and forecast growth rates:

a 5.4% actual growth rate was forecasted at 2.5% in 1990 and a 0.5% growth rate in 1991 was forecasted at 2.6%. The above indicates that the limited forecasting experience of both these models leaves a lot to be desired. This questions the practical validity of macroeconometric models in the Caribbean context and whether other kinds of models may not be more appropriate. One possible alternative is the "accounting" type models such as the one proposed by Bruce (1987) for the more data deficient countries of the Caribbean and which bears a striking resemblance, at least in spirit, to the Revised Minimum Standard Model of the World Bank (Tims and Waelbroeck (1982), chapter 2). Another alternative is to look in the direction of the more elaborate Computable General Equilibrium (CGE) models which, although not requiring a lengthy time series, pre-supposes the existence of a recent Social Accounting Matrix which, at the moment, exists in no English speaking Caribbean country.

In summing up the model building experience to date in the Caribbean, it is not unfair to state that all models were largely built by academics who spent little or no time designing the correct environment for forecasting. The emphasis in most of the modelling attempts was on designing "estimable" systems for testing various hypotheses rather than on designing systems which offered policy analysts the ability to combine simulation and forecast results with their own expert knowledge, in a day-to-day working environment. Indeed, by the beginning of the 1990s, the large scale model attempts which had experienced considerable popularity in the 1980s fell into disuse. Numerous reasons can be cited for this demise, the most important of which include: (i) the lack of continuity in the model building cycle, (ii) the inability of modelbuilders to effectively communicate their results to policy makers, and (iii) the rise of the general-to-specific methodology which emphasised a return to the single equation tradition, with a greater emphasis on testing rather than on structural detail. The Central Bank of Barbados, for instance, shifted to this methodology in the latter half of the 1980s but was unable to effectively combine it with its overall policy and forecasting stance.[18] The detailed attempts at forecasting based on macroeconometric modelling slowed in most of the MDC Central Banks, aggravated, in part, by an exodus of econometric specialists.[19]

The question which needs to be resolved in light of the experiences with model building is how should the process of constructing cost effective models for forecasting and policy analysis proceed in the various Caribbean Central Banks. We envisage two alternatives:

(i) a prototype model taking into account the general features of Caribbean type economies but flexible enough, say, to account for varying oil prices in Trinidad and Tobago and varying banana prices in the Winward Islands. The model, once adapted to the circumstances of a particular country, will become a model of that country alone. This is similar in spirit to the model of Holder and Worrell (1987) but may not at all resemble that particular prototype.

(ii) a single model of the region which will take into account individual differences along the lines of "Pooling Data" methods similar to the IMF type models of Haque *et al* (1990) and Leon and Samuel (1994).

The first alternative takes into account the similarities as well as the very real differences that exist among the various countries making up the English-speaking Caribbean. The second alternative assumes that the similarities are much more noteworthy than the differences, an assumption that was rejected by Watson (1995) in a study involving the countries of the OECS which, on *a priori* grounds, would be the most homogenous grouping in the region.

3. ELEMENTS OF A SUCCESSFUL FORECASTING STRATEGY

In this section we argue that a successful forecasting strategy must be based on a structured forecasting environment. The main elements of that strategy include a structured approach to modelling, a systematic forecasting process, commitment and support across departments and affiliated institutions, and the fostering of a community spirit through a process of dissemination.

As an illustration of the underlying basis for the guidelines, consider the apparently simple question "should an overseas foreign currency deposit be hedged against the risk of currency depreciation?" Stated in prescriptive form, those questions invariably relate to a population of interest. The yes/no initial question becomes "what will be the exchange rate during the forthcoming period of interest?", which in turn asks "what are the factors determining the future exchange rate?" By casual observation or logical deduction we hypothesise a conjecture that the exchange rate is a function of a set of variables. What type of function? What set of variables? We require a body of knowledge and an articulation of a transmission mechanism to guide our specification of the function, and adequate data and statistical analysis to confront the conjecture.

3.1 The Forecasting Process

In an ideal environment, the modelling process has well articulated objectives, there is a body of theory to guide the econometrician in formulating models and establishing mappings from theoretical latent constructs to observational equivalences; the data exist for a sufficiently long period and with appropriate periodicity for the policy questions of interest; appropriate estimation methods are known and used; adequate diagnostic tests are conducted; inference follows sound statistical procedure and the model is interpretable relative to the questions of interest. But there are technical and institutional constraints that ensure that the ideal conditions do not materialise, thereby producing questionable results. By identifying critical junctures in the process we can note the points at which errors can be introduced into the modelling process; we can therefore seek to reduce those errors by judicious choices where possible. The relevant aspects of an appropriate modelling approach have been detailed in Section 1. We can summarise by stating that all models should satisfy certain desirable conditions: (i) be theory consistent; (ii) be data coherent; (iii) must reflect policy sensitivities, realities and constraints; (iv) be capable of accurate historical simulation; and (v) be available for replication of results. It is therefore clear that our needs must include a database that can facilitate, using principles of good model design, individual and comparative analyses of economic processes.

The forecasting process must generate immersion of the relevant constitutents. We will assume without further elaboration that the objectives of the model have been clearly stated and there is a stated commitment to the process by the Central Banks and other relevant institutions. This commitment has to incorporate development, application and refinement time for the model. More importantly, there ought to be a mechanism that integrates the activity maps, resource bases and comparative advantages of various departments of the institution in the development and usage of the model. The model building exercise should not be viewed as the work programme of a sub-group of individuals. The forecasting process must generate a sense of belonging among participants; it must carry the same lofty ideals and generate the same cooperative spirit as exists across all departments in the Central Bank when the annual report (say) is being compiled - information flows from all departments in a timely manner, tone and judgement is exercised by management, and the text is edited for accuracy, style and impact. There must be cognisance of the skills base and current work profiles of computer programmers and analysts, investment officers and bank supervisors and how those skills map into activities that can contribute to and enhance the overall efficiency of the modelling process.

The Central Banks should strive to build quarterly forecasting models with a two to three quarter short horizon and a six to eight quarter long horizon, both of which should be updated as information flows in, bi-monthly for the short and quarterly for the long horizon forecast. Forecasts should be released periodically and a mechanism for updates instituted. Regular updates enhance the accuracy of the final forecast evaluation, ensure the incorporation of revised data and unanticipated events, provide continuity to the modelling and forecasting exercise and utilise available information in an optimal manner. It is more important to incorporate information to refine a forecast than to do a post mortem of a three month old forecast and seek blame. However, care ought to be exercised in ensuring that every "new bit of information" does not change the forecast.

Given the stated goals and tolerance levels for the forecasts, a monitoring process ought to be established and maintained for control purposes. This signalling device is not only informative as a tracking device for the model but may also serve the purpose of monitoring the effects of policy changes or the impact of external shocks. A clear listing of forecast input assumptions and their computational basis (data, judgemental, or anecdotal) are of vital importance in evaluating whether forecast errors are due to factors outside of the control of the forecasters, and helps to develop and maintain the credibility of the forecasts.

Forecasts should be presented in a simple manner with a decided takeaway, and must be technically correct and understandable to policy makers. They should indicate alternative scenarios or a probability weighted forecast with relevant interval ranges. Graphical interfaces ought to be developed to facilitate presentation, scenario demonstration, and model linkages. To encourage exchange and adequate dissemination, it may be necessary to have a common software available at all institutions. Management Information Systems departments should be involved in the development of foreign language interfaces and front end menus.

Since the data collection and publication lags inevitably mean that at any point in time the model is not being solved with current data, a mechanism for constructing imputed data up to the current period (to be subsequently revised) and the incorporation of structured "conjunctural" analysis into forecasts cannot be understated.[20] Where regional forecasts are deemed necessary, it is essential that global or extra-regional assumptions be common to each individual country model. Again the principle of community involvement and cooperative participation can be extended to embrace all the regional Central Banks and RPMS as one regional institution with stated goals .

3.2 An Integrated Information Architecture

This infrastructure should include the appropriate hardware and communication systems to support the forecasting drive. Collaboration requires the participating institutions to disseminate data, a skills database, techniques and models. This would have the obvious benefit of minimising duplication of effort, generating skills enhancement by sharing and ensuring greater uniformity of development across the Central Banks. Exchange visits among staff of various departments of the Central Banks should be regularised, and RPMS meetings - mid-year and annual - should be used to share results, analyses and approaches to various problems. In a supplementary role, the RPMS centre in Trinidad and Tobago can serve as a clearing house, disseminating data and providing a hub for comparative research projects. A minimal requirement for integrating the RPMS with the Central Banks would be a network topology that allowed access to the various Central Banks. Even if this stage of network development is not contemplated now, given different stages of networking topologies and current hardware at the various Central Banks, at the very least, a common transfer protocol should be established with individual routines to interface with software at various institutions. This has the attraction of being low cost and allows the growth of institutional interaction before full blown networking.

A well-developed database system must be flexible enough to allow the modelbuilder to manipulate the data items in the most convenient form. Such a system should contain facilities for:

1. Performing extensive data exchange on electronic media
2. Creating data entry forms with built-in verification checks

3. Sorting, matching and merging records
4. Manipulating data of various periodicities
5. Producing reports with text, tables and high resolution graphics in 2D and 3D.

This database system should also allow for easy interfacing with specialised model building packages; in turn, the chosen statistical packages should contain facilities for addressing external libraries and have an inbuilt programming language to allow coding of new developments in estimation and testing.

In addition, efforts to improve the actual data should be intensified: publication lags need to be shortened, the overall scope widened, and the periodicity of the data increased. The problem of the inadequacy of the statistical data base in Trinidad and Tobago in relation to econometric modelling was addressed more than a decade ago by Watson (1984), and the issues raised then were valid for all English speaking Caribbean countries. Today, the "inadequacy gap" has widened.

In the Caribbean, the practice of generating these data is a fairly well established one although things are far from perfect. Some immediate shortcomings, valid for most (and perhaps all) countries are the following:

1. Data in most categories are available at best on an annual basis. This limits the forecasting exercise to annual models; adjustments that take place from quarter to quarter, for instance, cannot be anticipated in order to allow for corrective measures

2. Inter sector demand (input/output) data are totally absent

3. There is little or no useful disaggregation in certain key

areas like the components of aggregate demand

4. Constant price information and the corresponding price deflators for the trade sector, for example, import demand and exports of tradeables, are very limited.

5. Most of the data are published with an appreciable lag. In 1995, for example, the modelling team may be working with data for which a complete set is available only up to 1992. But in 1995, policy makers are interested in forecasts for 1996 and beyond, and not for 1993 to 1995, which is clumsy given the state of the data. Furthermore, for completeness, data compiled at different sources are frequently related to each other by obvious identities but, more often than not, such coherence is absent from the published data either because of different practices of the various agencies preparing the data or because of the timing of the publications.

3.3 Material and Human Resources

There are many professional economists (including the most highly trained) who believe that all that is required for a good model is a competent econometrician to ply his trade of running regressions and interpreting t-ratios and R^2s. Nothing can be further from the truth and, indeed, the discussion in the previous sections would have already given a hint that the generation of an econometric forecast and, by extension, the maintenance of a macroeconometric model, may require human and material resources that go way beyond this. In fact, it may turn out to be quite expensive![21] In as much as a strong commitment is required, institutions should consider the costs and benefits of engaging in a forecasting exercise. Collaboration, as discussed below, can help reduce costs and increase benefits to individual institutions. This section itemises resources needed for an average institution.

The discussion which follows assumes a model of the size and complexity of the ILPES (1986) model (two of the models cited above, the Charles and St. Cyr (1992) model and the UNDP (1991) model of Jamaica, follow this prototype). This is somewhat larger than the other known Caribbean prototype, the Holder-Worell (1987) model, largely because it is more disaggregated and it takes specific account of the demand side of the economy. Notwithstanding this, it is fairly modest in size (less than 100 equations) and is relatively highly aggregated; therefore, it is not far fetched to assume the size of the ILPES model as an approximate minimum requirement for a typical Caribbean model.

In general, the modelling and forecasting exercise depends on third parties like the Central Statistical Office and the Central Bank to generate most of the data to be used. These include data on national income, prices and wages, balance of payments, stock of money and domestic credit and government's fiscal operations. Given the data deficiencies stated above, it might be asking too much to have all these various agencies, and sometimes even the sub-units within an agency, to so radically alter their practices to suit the modelling unit, even though the latter may be part of the state sector to which the data collecting agencies belong. We believe that it is imperative for the modelling unit to have the services of at least one competent and trained statistician whose principal task would be to acquire an almost perfect knowledge of data collection and compilation practices and data sources in the country or countries concerned. To him/her will fall the (full-time) task of liasing with the various data collection agencies, of filling the inevitable gaps in the data so as to bring the data base up to date, of initiating the compilation of new series, and of marshalling the existing data into a coherent whole (so that, for example, identities required by economic theory are respected). The ideal person should be computer competent (and not simply literate) and should be able to make recommendations about data entry, storage and retrieval in a computer environment.

The statistician should also be a pioneer and be able to use his/her privileged relationship with the data collection agencies to obtain data to satisfy the demands of an increasingly sophisticated model. One immediate area in which this is possible is in the construction of an Input/Output table and, eventually, a Social Accounting Matrix (SAM). A major concern of Caribbean economists is the "demand management" emphasis of macroeconometric models and the consequent inability of these models to forecast supply bottlenecks (Boamah (1981)). With the increasing emphasis on "structural adjustment" and "economic dependence" in Caribbean countries, inter-industry linkages are going to become more and more important and so too therefore must input-output models. These can be used in conjunction with standard econometric models as outlined in Klein (1980).

A successful modelling and forecasting effort requires the (almost) full time attention of a team of very skilled economists headed by a chief economist whose forte should be economic theory, more specifically Caribbean economic theory. The ideal person should have a thorough understanding of the Caribbean reality (including institutions and structures) and should be fully steeped in the knowledge of recent Caribbean economic history. Knowledge of modern and traditional econometric practice would be an asset but it should be more optional than absolutely necessary.

The chief economist would lead a team of sector specialists, each with a thorough knowledge of that branch of economics relating to the sector; for example, a monetary economist would have responsibility for the monetary sector. It is absolutely necessary for such economists to be thoroughly familiar with published economic statistics, especially as it pertains to the data directly related to their specialisation. Once again, a sound knowledge of econometric practice would be useful. The chief economist would have to ensure the unit works as a team, engages in an econometric methodology that is "model-wide consistent" and undertakes inter-sector dialogue.

One of the chief responsibilities of the sector specialist would be the specification (and estimation) of equations purporting to explain the workings of the sector under his/her purview, as well as the identification and the modelling of the linkages with other sectors. The chief economist would be responsible for co-ordinating the overall modelling effort and for ensuring that the linkages between the various sectors are theoretically and technically sound. It is this team, together with the statistician, which would be responsible for formulating the assumptions about the future path of the exogenous variables in the model and to analyse the main consequences of the forecasted scenarios.

The modelling effort, of course, requires the services of an econometrician whose principal intervention would be at the stages of estimation and validation of the model. At the same time, he/she must work closely with the team of economists in the specification exercise and must be in close contact with the statistician in working out the data requirements of the model. The econometrician would also be required to keep *au courant* with current econometric practice; a specifically important duty would be to train (and retrain, if necessary) the economists on the team in the relevant econometric and mathematical methods necessary for the modelling exercise.

Whereas he/she must be more concerned with the mathematical properties of the model (such as its stability), there must also be concern about the economic meaning of the coefficients obtained from the estimation exercise, especially if it involves complicated lag structures like those associated with VAR-Error Correction models. Here, too, he/she will rely heavily on the inputs from the team of economists.

It goes without saying, then, that the econometrician must have a relatively sound knowledge of the underlying economics of the model. Another necessary requirement would be a comprehensive knowledge of state-of-the-art software packages used for estimation and model solution and, ideally, should be able to programme in packages like AREMOS, EVIEWS, GAUSS, RATS and TROLL.

The team of economists should be complemented with a computer specialist. The person sought here is a relatively rare breed in the Caribbean today: he/she will be an economist who is at the same time an expert programmer/analyst (perhaps someone with a good first degree in economics with a post graduate training in computer science). In addition to ensuring the required level of computer competence of the other members of the team, this person would be principally responsible for all major programming exercises, including a user friendly interface for use by the economists whose task it will be to generate the forecasts. He/she must also have or be able to acquire specialist knowledge in hardware and software (including spreadsheets, databases and graphics presentation) and be particularly adept in modern methods of data communication using local and wide area networks.

The technical competence of the team would be incomplete without the services of two or three junior economists who, in addition to serving as apprentices, would be required to function as research assistants to the senior technical personnel. They must of course have a sound training in economics and quantitative methods (including economic statistics and econometrics), and be computer literate.

It is unlikely that each Central Bank would be able to devote the required resources to the modelling exercise. Our suggestion would be to house such a team at the RPMS centre. The first task of the team would be the construction of a new prototype model (which will clearly be influenced by the existing ones) which can be easily adapted for specific use by individual countries. Modelling units at the Central Banks would collaborate with the centre, maintain an in-house version of the prototype and assist in its development. The construction of an adequate data base can be a concurrent activity, eventually feeding into the estimation, validation and forecasting stages for the various countries.

A sustained generation of good forecasts, then, requires the ongoing commitment of a critical minimum level of resources. The need for properly qualified "counterparts" at the Central Banks with almost total modelling responsibilities cannot be understated. The designated users of any model - those who must generate the forecasts - have to play an important part in its construction and development.

4. CONCLUSION

This paper has explored the requirements for a successful forecasting effort in the Caribbean. We recommend the need for institutional commitment to the modelling effort, an integrated resource approach both within institutional departments and across regional institutions, and a more concerted effort on developing data and systems architectures. We argue for a structured approach to modelling, and for a forecasting environment that fosters collaboration of effort and dissemination of results and skills.

The achievement of a relatively successful forecasting system in CARICOM hinges on the expert blending of sound judgement, economic theory and a sohisticated information architecture with a systematic approach to modelbuilding. These requirements, however, are neither necessary nor sufficient to guarantee the occurrence of "accurate forecasts". Indeed, absolute accuracy in forecasting is seldom the pertinent issue, unless, of course, the forecaster is "omnipotent" - a trait which can only be ascribed to the Creator. However, a structured approach to forecasting may often pay useful dividends if model builders are able to anticipate the magnitude and direction of movements in economic variables.

Although Caribbean economists have been involved in the construction of national economic models since 1970, the process of modelling has not contributed as significantly as expected to policy analysis and forecasting. The many models that have been constructed have either not been used consistently or when they have been used, have not been employed with any great degree of success. It is quite likely that this is fundamentally the result of a miscalculation of the resources required to produce good forecasts on an ongoing basis; this would explain both the inadequacy of the models themselves as well the lack of use to which they were put.

It is our opinion that current models should be as simple as possible, although the simplicity assumption should never be taken as a license to strip a model of theory-derived complexities simply to facilitate estimation. The simplicity argument stems from the current shortage of adequate data and of a comprehensive macroeconomic theory of Caribbean economies. However, because of the small samples and the omission of potentially important variables, policy recommendations should be cautious and should attempt to quantify the trade-offs facing the decision makers. In most cases, structured judgement and experience cannot be ignored or understated.

ENDNOTES

1. This model is discussed in detail in Friehuis, Fase and Den Hartog (1988)).

2. See Bodkin, Klein and Marwah (1991) for a detailed description of the history of macroeconometric model building.

3. This is a compiled version of Craigwell and Walker (1994), Leon (1995), Nicholls and Christopher-Nicholls (1994) and Watson (1994).

4. See Bourne (1984) for a discussion of these issues. Watson and Nicholls (1992) have investigated the short sample issues while Nicholls, Coker and Forde (1995) have explored the issue of insufficient periodicity of recorded data.

5. See Nicholls and Christopher-Nicholls (1994) for this argument.

6. The main problem is how to specify the hooks between regional decision variables and national policy parameters. The works of Baird (1983), Bolton ((1980a,b), (1991)), Issaev *et al* (1982), Courbis (1979) and Milne *et al* (1980) may offer useful insights to Caribbean modellers. The standard approach is to build a regional system which includes the national models as satellites in a top-down or bottom-up design. Overall, regional performance can be gauged by some form of aggregation of individual performances. Natural candidate variables for this type of linkage effect include labour supply, the exchange rate, interest rates, imports, exports and prices.

7. The early literature postulates that exogenous variables are predetermined, independent of the error terms in the model.

8. The structural form of a model maybe regarded as a theoretical explantion or hypothesis about the determination of the endogenous variables, conditional on values currently assumed by the exogenous or predetermined. The reduced form of the model expresses a current endogenous variable as a function only of the exogenous and pre-determined variables. Structural and reduced form parameters are derived from the estimated models.

9. This methodology emphasises the notion of parsimony in the construction of models.

10. A choice of model may not be straigtforward since a model's forecast ranking may not be uniform over different forecast horizons.

11. It is helpful to remember the three golden rules of econometric modelling, that is, "test, test and test" (Hendry (1980)).

12. In contrast, for an optimal control exercise, the model is solved for the values of the policy variables (instruments) that will maximise a specified objective function (formulated as a function of policy targets). Typically, a quadratic function is employed with a set of weights that reflect the preferences of the model user.

13. Best and Levitt (1969) developed a detailed input-output model for the Caribbean but it was never implemented because of the extensive data requirements.

14. A recent model by Craigwell, Haynes, Walker and Worrell (1993) attempts to combine statistical and judgemental models.

15. Recent developments in econometric practice post-date the earlier studies.

16. Applications of this methodology in the Caribbean have been mainly in the single equation context (see Craigwell (1991) and Downes, Holder and Leon (1990)).

17. In the paper, BUD is defined as the Budget Balance but it is really the Central Government's Borrowing Requirement (with the sign reversed).

18. Leon (1990) and Downes, Holder and Leon (1990) popularised this notion in the Caribbean but were unable to explicitly encourage the use of the methodology for policy analysis and forecasting.

19. For example, work on CBMOD1 stopped at the Central Bank of Trinidad and Tobago after the model group was disbanded.

20. Bayesian methods may be explored as a means of generating the imputed data.

21. An unwillingness or inability to provide the resources required is a probable reason for the marked absence of forecasts in the region.

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CHALLENGES AND PROBLEMS IN FORECASTING CARIBBEAN ECONOMIES: SOME DATA ISSUES

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ABSTRACT

This paper identifies the main areas of weakness in the economic statistics of Trinidad and Tobago. The major deficiencies considered relate to the timeliness of current; the lack of new data series; inadequate periodicity of recorded data; insufficient transformations; short data sets and the absence of forward looking indicators.

In the absence of reliable and timely data, elegant theoretical models and technically sophisticated computing methods are not likely to contribute significantly to policy formation. Indeed, in the face of major deficiencies in the data cycle, there is a great risk of erring in policy conclusions taken from macroeconometric models.

Keywords: forecasting; deficient data; short data sets; inadequate periodicity.

It is all too possible for someone to activate an econometric software package, of which he has only a dim understanding, to apply it to data of whose nature and provenance he is ignorant, and then to draw conclusions about an economic situation, whose histor.cal and institutional realities he has, perhaps, not studied in any depth. The literature must surely contain more than a few nonsense regressions which have survived the editorial process, and have not yet been consigned to the econometric graveyard.

Johnston (1991)

I don't care about all that complexity, just give me the number.

Anon

INTRODUCTION

Forecasting is as old as time and one can trace some of the earliest recorded examples of forecasting to the Oracle at Delphi. Macroeconomic forecasting however, came into prominence only quite recently. The growth of Keynesianism and national income accounting provided a framework within which large scale macroeconomic models could be built and tested. Macroeconomic model building can be traced back to the work of Tinbergen (1939), Haavelmo (1944), Koopmans (1945), and the Cowles Commission (1952) to mention a few examples. Developments in this early period dictated to a large extent the type of models which were built by the different schools - American, British and Dutch for example. Caribbean model building is of even more recent vintage and its early roots can be traced to the work of Nicholas Carter (1970) and others. Since that period, several macro models with forecasting features have been built within the Caribbean. The work of Persad (1975), Gafar (1977), and Holder and Worrell (1985) all come easily to mind. In the Central Bank of Trinidad and Tobago, Henry, Hilaire, and Nicholls (1990) combined the various existing submodels to produce the Bank's first macroeconomic model of the economy of Trinidad and Tobago. Version I of this model was completed in 1990 but no further progress was made towards Version II.

In the fifty years or so since the work of the Cowles Commission was first presented, great strides have been made in economic and econometric theory as well as in "economic computing". Yet to a large extent, the data used in most econometric models have not kept pace with these developments, especially for developing countries. But even in the case of the more developed economies, some practitioners believe that there are still not enough data available.

Concerns with data are nothing new as is evidenced by the work of Morgenstern (1963) and Griliches (1986). Issues of reliability, measurement bias and comparability have been raised at several different fora. A recent issue of the Journal of Development Economics and in particular the article by Srinivasan (1994) is devoted to concerns about the database used for development analysis and spans an area wider than that of economic statistics. In light of the recent decision by the Regional Programme of Monetary Studies (RPMS) (renamed the Caribbean Centre For Monetary Studies - CCMS in 1995) to initiate macroeconomic forecasting for the CARICOM region, it is important that another look be taken at economic data in the Caribbean. In addition, at a recent meeting of the Council of Central Bank Governors, the commitment was given to monitor on a bi-annual basis movements in selected macroeconomic variables which may be applied in the measurement of economic convergence in the CARICOM region.[2]

This paper examines some of the data deficiencies in the Caribbean with particular reference to Trinidad and Tobago. It is the author's view that data deficiencies pose serious problems for modelbuilding and forecasting in the Caribbean. Economic theory (including Caribbean economic theorising) provides the conceptual framework and usually guides the model builder towards the particular mathematical formulation that he/she may wish to test. Econometric theory provides the appropriate tools, techniques and the inferential procedures to test the validity of such models. Data provide the raw material for testing these models, but if there are major deficiencies, there is a great risk of erring in policy conclusions on the basis of these models.

In the remainder of this paper six major types of deficiencies commonly found in the economic statistics of Trinidad and

Tobago (TT) are described and some suggestions for improvements are provided.[3]

1. SOME MAJOR DEFICIENCIES OF ECONOMIC STATISTICS IN TRINIDAD AND TOBAGO

The two major actors in the preparation of the statistical database in Trinidad and Tobago are the Central Statistical Office (CSO) and the Central Bank of Trinidad and Tobago (CBTT). The Act of Parliament which established the CSO mandated the organization to 'collect, compile, analyse and publish statistical information . . . commercial, industrial . . . economic . . .' In some instances, the CSO has delegated its authority to other public offices such as the Ministry of Agriculture or the Ministry of Energy. The Central Bank by its own enabling legislation has a regulatory function in respect of the financial system and also has a legislative mandate to undertake continuous economic research. To this end, the CBTT has assembled and maintains on a current basis, economic data with a primary focus on monetary, financial, fiscal and real sector variables. Two other important statistical agencies are the Industrial Court and the National Insurance Board. The former collects data on wage contracts and industrial disputes, while the latter has built up an interesting database on employment benefits and social insurance payments.

At first blush, therefore, it may be argued that Trinidad and Tobago is well served in the area of economic statistics. Perhaps ten to twenty years ago, this statement may have indeed been true. However, given the changing economic situation and shorter time horizon of decision makers, one can identify six major areas of weakness in our economic statistics. These may be listed as follows (i) timeliness of current output; (ii) lack of new data series; (iii) inadequate periodicity of recorded data (i.e. annual rather than quarterly data); (iv) insufficient transformations; (v) short data sets; and (vi) absence of forward looking indicators. In outlining these deficiencies, the focus is deliberately not placed on issues of methodology, measurement bias, the classification of economic sectors (e.g. Trinidad and Tobago System of National Accounts versus International Standard Industrial Classification), or even whether the data used bear any relationship to theoretical constructs. Each of these topics may be the subject of separate papers and ought not to be dismissed very lightly.[4] Indeed, if the CCMS intends to build a macroeconomic model for the CARICOM region then these very issues must be confronted at the immediate outset.

1.1 Timeliness of Current Output

Today, decision makers want access to data as well as forecasts of data almost instantaneously so as to inform policy formulation. Thus, for example, in the current liberalised environment in Trinidad and Tobago, any model used to determine open market operations cannot be hampered by long data lags. In the local environment, the timeliness of the CSO's output has deteriorated over the past few years. While data on the monetary and financial system are available from the Central Bank with relatively short lags, there are major problems with the CSO's real sector data.

The CSO's publication of the Index of Retail Prices generally has the shortest time lag (one month); however the situation with respect to external trade data and some production series is cause for much concern. In these circumstances, the lags can be as long as one quarter. In the case of national income data, annual estimates of Gross Domestic Product (GDP) by sector of origin are generally available once a year at budget time.[5] Complete national accounts data seem to be available at five yearly intervals, but sometimes certain sectoral estimates are weak and are subject to constant revision. This is clearly an unsatisfactory position for a country and by implication any serious policy model builder. The situation has deteriorated considerably within recent times as is underscored in the following example. In 1989, the CSO approached the Central Bank to 'delegate' to the Bank responsibility for the balance of payments accounts. At that time, the Central Bank decided to introduce a quarterly balance of payments accounts and to report these statistics with a lag of one quarter. This approach was followed because of several new surveys which were to be introduced, even though at that time the merchandise trade data tended to be current. Over the past twelve to eighteen months, the situation has worsened and now the entire balance of payments is reported with a quarter lag in the Central Bank's Quarterly Bulletin. This situation is even more critical given the nature of the foreign exchange market and the need to have early indications of the changing trends in the demand for imports.

1.2 Lack of New Data Series

A second deficiency is the absence of new data series and this may be examined from two angles. The first is the updating and re-basing of existing data series while the second is the introduction of entirely new series. In the late 1980s, the CSO's series on real GDP was still measured at 1970s prices, and, driven by the need for a more up-to-date series, the Central Bank derived its own real Quarterly GDP Index.[6] It was probably the existence of this index which then provided an impetus for the CSO to revise its own series and currently both series have a 1985 base year.[7]

A second example can be found in the area of the Index of Domestic Production. The base year of the CSO's current Index of Domestic Production, a commodity based index, is 1977. While it may be relatively easy to splice new commodities into the index (e.g. the introduction of methanol and natural gas liquids), the economy has changed dramatically over the past 18 years. In this respect, not only is the individual weighting of the overall Index inappropriate for 1995, but the Index cannot take into account the changing nature of the operations of several manufacturing establishments. One can make similar arguments for the Index of Retail Sales, the base year of which is 1979.

As for the non existence of new series, Forde (1989) identified the following areas in which no data existed for Trinidad and Tobago: concentration ratios, wealth, bankruptcy (personal, corporate), rates of return, capacity utilization, and investment intentions - to mention a few. To date, no progress has been made in the compilation of even one of these series which are all important to decision makers. What is more, house prices, housing starts and satellite accounts might now be added to the previous catalogue. The latter two are important and may be used to determine policy in certain areas. For example, most Central Banks in the region initiate policy changes which directly or indirectly affect the mortgage market; yet there are limited data available to even attempt an econometric model of the housing market in Trinidad and Tobago and the wider region. Satellite accounts can be defined as accounts adjunct to the national income accounts and can be used to present more information on specific activities. There are several countries for which satellite accounts in areas such as tourism, natural resources and the environment might prove useful. Yet, there are currently no major initiatives being developed to introduce these series and some countries may not even be aware of the importance, or the potential usefulness of such accounts.

1.3 Periodicity

Most of the published macroeconomic models in use in the Caribbean are annual models simply because monthly or quarterly series are largely non-existent.[8] For instance Trinidad and Tobago is currently the only CARICOM country which publishes quarterly balance of payments accounts as well as a quarterly real GDP series.[9] The non-existence of data series such as these, particularly real sector data, is a serious limitation, as one is restricted to annual models or the compilation of pseudo quarterly series. The calculation of these pseudo-series is problematic since several of the algorithms used may not be suited to the region. For example, the method of deriving quarterly data introduced by Lisman and Sandee (1964) is appropriate "if nothing is known about the quarterly figures desired, and no assumption can be made about some (seasonal) pattern or actual fluctuations." In reality the pattern of economic activity throughout the year in the Caribbean does not follow a smooth trend, but has discernible peaks and troughs. The choice of the Lisman and Sandee method and its derivatives may not be appropriate in many circumstances. More recently, Nicholls *et al* (1995) investigated the temporal disaggregation of the GDP series for Trinidad and Tobago and concluded that one may be very wrong if one rushes into disaggregation methods that are purely "mathematical" in nature. On a more positive note however, there is a wealth of monetary and financial data which are available at appropriate quarterly and monthly intervals and provide useful input for policymakers.

This state of affairs with respect to periodicity is quite unsatisfactory given rapid economic changes and the need for policy makers to have as much information available to them in a timely fashion. Most recently, decision makers in Trinidad and Tobago have made several demands for 'first flash' quarterly real GDP estimates, about 20-25 days after the end of the relevant quarter. The Research Department of the Central Bank of Trinidad and Tobago has attempted to provide these estimates and at times has had to balance timeliness with accuracy. The Department intends, however, to carry out statistical checks to determine the consistency as well as the robustness of these first flash estimates, as the Central Bank is currently the only institution which provides regular quarterly economic reporting in Trinidad and Tobago.

1.4 Data Transformations

The first type of transformation to be considered concerns the transformation of nominal (current price) series into constant price (real) series. The question of real variables was partially addressed when the problems associated with the revision of base years in the real GDP data were highlighted. However, even when data on real GDP are available at regular intervals the data are generally available by industrial origin rather than by expenditure. Although the industrial origin approach provides useful insights, the behaviour of (real) consumption or (real) investment is sometimes much more relevant. What happens in practice is that some of the regular users (e.g. the multilateral agencies) who are interested in such series will create their own series by employing somewhat arbitrary deflation techniques. These new series are often worse than outdated series and can often lead to the wrong policy prognosis. Some evidence of this occurrence in Trinidad and Tobago is provided by Crichton (1983).

A second type of data transformation is that of seasonal adjustment. The use of seasonally adjusted data is generally accepted in industrialized economies, where the four defined seasons - spring, summer, autumn, winter - impact on certain aspects of economic activity such as construction, agriculture. In developing economies, there are also several seasonal patterns which may be related to climatic and other factors. Nonetheless the existence of seasonal data is something of a '*rara avis*' in the CARICOM region. In the past the Central Bank of Trinidad and Tobago has published seasonally adjusted economic statistics (for example the monetary aggregates), but these have been suspended for technical reasons. Currently the Bank publishes a seasonally adjusted quarterly real gross domestic product (QGDP) series and intends to re-introduce seasonal adjustment of other data series within the near future.[10]

1.5 Short Data Sets

Another area of weakness in the economic statistics is that of short data sets. One can define 'short' in different ways depending on whether one is concerned with annual, quarterly or monthly data. For very many of the annual data sets, the starting date is 1966 so that there are barely 30 observations. For several other techniques - Box Jenkins procedures, for example - there are sometimes less than enough quarterly observations, since the samples are small by any definition. This makes tests of inferences more difficult, although Nicholls (1988, 1990) and Watson and Nicholls (1992) have suggested that under very special circumstances the existence of small samples may not be that problematic. In the case of Trinidad and Tobago the shortness of some of the data sets reflects new areas of activity in the economy, while in other instances they are related to the cessation of an old, and the start of a new series.

1.6 Absence of Forward Looking Indicators

The sixth deficiency relates to the absence of forward looking indicators. Data on the historical past become more and more inadequate to guide us into the future as we move into an era of trade and financial liberalisation. Although the above discussion has focussed implicitly on data for purposes of macroeconomic modelbuilding, one may also wish to consider the leading indicator approach. The study of leading economic indicators was an important part of the initial work on business cycles which was conducted under the auspices of the National Bureau of Economic Research. This approach to forecasting is based on the view that "market oriented economies experience business cycles within which repetitive sequences occur and that these sequences underlie the generation of the business cycle itself".[11] The leading economic indicator approach allows one to find these repetitive sequences, explain them and then use them for forecasting purposes. For the developed economies leading indicators are now the norm, not only for business cycles but for forecasting inflation, turning points in the stock market and in several other areas. Even with the 'rudimentary' data available in the region, it is possible to derive a leading indicator series of inflation for example. The literature on the determinants of inflation in the Caribbean region is particularly rich - wages, imported inflation, money supply, etc. and such a series would not be too difficult to compile.

Relatedly, as more and more countries liberalize their economies, policymakers need to have at their disposal a system which provides 'early warning signals'. These can be derived from the forward looking indicators or be independent of them. These early warning signals must be current - at a minimum they should be be based on quarterly indicators - and be flexible enough to give a short hand indication of trends in the economy. Data collection agencies in the region ought to pay more attention to this issue if the policy advisory function is to be meaningful.

The discussion so far has focussed primarily on time series issues and less so on those associated with cross-section data. The intention was deliberate as all of the macroeconomic models built in the Caribbean to date have used time series and not cross-section/panel data. But if one were to consider the availability of cross-section/panel data some of the problems discussed above will be magnified even further. At present, it is probably only in the sphere of monetary data that one can obtain a consistent set of cross-section data for use in model building.

2. SOME SUGGESTIONS FOR IMPROVEMENT

In the previous section we described several data deficiencies in the economic statistics for Trinidad and Tobago. But while we criticized many of the data series published by the Central Statistical Office, we are mindful of the fact that the agency is operating under tremendous pressures. The Central Statistical Office is subject to several resource constraints - human, physical and financial - and this has had a deleterious effect on its output. However, it is still possible that, despite these constraints, improvements can be made on the basis of information already collected.

Table 1 is reproduced from Forde (1989). Since that time however, there have been some marginal improvements. The Central Bank of Trinidad and Tobago now calculates an effective exchange rate index, but this index is not presently released for publication. Data on rates of return are not readily available for the non-financial sector in Trinidad and Tobago.

However the basic information needed to calculate these rates of return already exists in the annual business surveys which the CSO undertakes. One may take a similar position for other data such as wealth and concentration ratios, that is, that the raw information exists in administrative records at the CSO's disposal. The immediate task is therefore to use these records in as optimal a fashion as possible. The table in the Postscript compares the availability and timeliness of some key macroeconomic variables for three CARICOM countries with that of the United Kingdom. The information contained

TABLE 1
SOME GAPS IN TRINIDAD AND TOBAGO'S DATABASE

Data Series Not Now Published	Information Already Sourced	Additional Surveys Needed	Comments
Concentration ratios	*	-	Business survey
Capacity utilization	-	*	Survey needed
Industry studies	*	-	Business survey
Investment intentions	-	*	Survey needed
Rates of Return	*	-	Business survey
Effective exchange rate indices	*	-	Trade statistics
Bankruptcy (personal; corporate)	-	*	Survey needed
Wealth	*	-	
Poverty	*	-	Household budgetary surveys
Environmental data	-	*	
Leading, Lagging, Coincident Indicators	*	*	Iniatial work needed on appropriate series of indicators

Source: Updated table from Forde (1989).
Note: * means information is available
- means information is not available

therein is instructive and suggests possible goals one would like to achieve.

The Central Bank has done its part in the area of enhancing the country's economic data base by the compilation and publication of series on quarterly real GDP and quarterly balance of payments. The Bank, from time to time, carries out special surveys, the most recent of which has been the survey on business use of bank credit. Interestingly enough, the survey used cross-section data for 1992 which were compared with a previous survey done about ten years earlier. Over the next few years it is the Central Bank's intention to continue such surveys of the financial sector and where necessary to extend these to the real sector.

Finally, the econometric session of the Annual Conference of the Caribbean Centre for Monetary Studies (CCMS) is an important forum which can be used to improve statistical data used in model building. These meetings provide an arena in which research on new methodologies and new statistical techniques can be presented and analysed. Irrespective of the technical sophistication of the computers available and the elegance of the theoretical models, one can do nothing in the absence of data. Finally, if the CCMS intends to forecast Caribbean economies, some of the issues described above must be confronted immediately and solutions found.

ENDNOTES

1. The author is the Chief Economist in the Research Department of the Central Bank of Trinidad and Tobago. The views expressed are those of the author and not necessarily those of the Central Bank of Trinidad and Tobago.

2. See Report by the Chairman of the Council of Central Bank Governors on "Monetary Union and Currency Convertibility in CARICOM", February 1995.

3. In this paper the discussion is focussed on economic statistics in Trinidad and Tobago. Many of our comments on economic statistics however can be extended to the wider CARICOM area. Other commentators may wish to explore problems which are associated with data in the social arena.

4. The decision of the Council of Central Bank Governors to monitor certain macroeconomic indicators which relate to economic convergence raises several methodological issues. Are external debt statistics consistent across the region? Are comparisons of prime interest rates relevant? Are real GDP series appropriate and comparable?

5. See for example *The National Income of Trinidad and Tobago 1966-1985,* Central Statistical Office, 1987 and *The National Income of Trinidad and Tobago, 1981-1991,* Central Statistical Office, 1993. Annual estimates are available in the Review of the Economy, a publication which is issued alongside the budget documents.

6. See Forde *et al* (1987) for example.

7. At present the Central Bank is in the process of revising the base year of its quarterly GDP Index to 1991.

8. One interesting exception is the work of Joefield - Napier (1979) in which a quarterly model is derived for the Trinidad and Tobago economy.

9. There is one other country in the region which has started to compile quarterly BOP accounts and will begin to publish these accounts sometime in 1995.

10. A companion piece in this volume by Michelle Francis and Christopher Clarke of the Central Bank of Trinidad and Tobago describes the Trinidad and Tobago experience with seasonal adjustment.

11. K. Lahiri and G. Moore (1991), "Introduction", in K. Lahiri and G. Moore (eds.), **Leading Economic Indicators** Cambridge: Cambridge University Press.

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POSTSCRIPT

This postscript contains details of subsequent developments which took place after the initial version of the paper was presented in 1994.

Against the background of the increasing globalisation of markets and services and the deregulation of national financial systems, the Mexican crisis erupted in December 1994 and continued into early 1995. The resultant turbulence in foreign exchange markets in some Latin American economies demonstrated the harsh reality of market forces. The response of the international financial community to this crisis was focussed on the record US$17.8 billion financial package provided by the International Monetary Fund (IMF). Less attention however was paid to the position adopted by the IMF that the crisis could have been averted if the surveillance function had been more effective. Since then the strengthening of the surveillance function has been a constant theme adopted by the IMF in several of its publications. On the basis of its April 1995 report on surveillance to the Interim Committee (of the IMF's Board of Governors on the International Monetary System), the IMF's Executive Board established a core set of data which all member countries of the IMF must provide between the regular Article IV consultation missions.

The core data set consists of twelve data categories: (i) exchange rates; (ii) international reserves; (iii) the balance sheet of the Central Bank; (iv) reserve or base money; (v) interest rates; (vi) the consumer price index; (vii) export; (viii) import; (ix) overall fiscal balance; (x) external debt; (xi) debt service; and (xii) GDP. This core represents the absolute minimum which is deemed necessary to maintain continuous surveillance. Early in 1996, the IMF staff is expected to lay down guidelines in respect of the appropriate coverage and periodicity of the data as well as the timeliness of provision of information to the IMF.

It is instructive to note that during 1995, in several of its publications, the IMF has continued to stress the importance of the surveillance function and the provision of timely information in averting future crises. What is clear however, is that the IMF member countries within CARICOM must, in the not too distant future, ensure that these core data exist, are of a sufficiently high quality and are available on a timely basis.

In the absence of the establishment of the norms in respect of coverage, timeliness and periodicity Tables A1 and A2 are instructive. Table A1 is adapted from a larger table in an IMF Staff Report. This table outlines in some detail the timeliness and coverage of the core set of indicators which were endorsed by the IMF's Executive Board. The circles in the table are for those series in which the lag in the published data is equal to or greater than the mean lag plus one standard deviation of the mean for that series. As the table indicates, it is only in two instances - inflation data for Guyana and international reserves for Jamaica - that CARICOM data were found to be extremely tardy.

Table A2 contains some characteristics of three basic economic series for Barbados, Jamaica, Trinidad and Tobago and the United Kingdom. The evidence from the Table suggests that each of the three CARICOM countries must improve in one or more areas to attain the standard set by the United Kingdom. By mid 1996, the IMF will issue guidelines in respect of periodicity, coverage and quality and most CARICOM countries will need a proper headstart to achieve some of these targets.

TABLE A1
COVERAGE AND CURRENTNESS OF DATA IN INTERNATIONAL FINANCIAL STATISTICS

	Barbados	Guyana	Jamaica	Trinidad & Tobago
Exchange Rates	March 95	March 95	February 95	March 95
International Reserves	March 95	February 95	August 93	December 94
Reserve Money	January 95	February 95	January 95	December 94
Broad Money	January 95	February 95	January 95	December 94
Interest Rates	January 95	February 95	February 95	December 94
Consumer Prices	December 94	December 92	December 94	October 94
External Trade	December 94	December 94	November 94	May 94
Current Account Balance	1993	. . .	1993	1993
Overall Government Balance	Q4 94	September 93	. . .	1989
GDP or GNP	1992	1993	1993	1993

Source: Statistical Policy of the IMF, SM 95/115.

TABLE A2
SOME CHARACTERISTICS OF THREE ECONOMIC TIME SERIES

	Base Year	Periodicity	Remarks
A. Gross Domestic Product at Constant Prices			
Barbados*	1974	Annual	Not Seasonally Adjusted
Jamaica	1986	Annual	Not Seasonally Adjusted
Trinidad & Tobago*	1985	Annual	Not Seasonally Adjusted
United Kingdom	1990	Quarterly	Seasonally Adjusted
B. Index of Retail Prices			
Barbados	Mar. 1980	Monthly	Not Seasonally Adjusted
Jamaica	Jan. 1988	Monthly	Not Seasonally Adjusted
Trinidad & Tobago	Sept. 1993	Monthly	Not Seasonally Adjusted
United Kingdom	1985	Monthly	Seasonally Adjusted
C. Balance of Payments			
Barbados		Annual	Not Seasonally Adjusted
Jamaica		Annual	Not Seasonally Adjusted
Trinidad & Tobago		Quarterly	Not Seasonally Adjusted
United Kingdom		Quarterly	Not Seasonally Adjusted

* The Central Banks of Barbados and Trinidad and Tobago provide quarterly estimates of real output.

PART — 2

Modelling Price Convergence And Inflation In The Caribbean

INFLATION CONVERGENCE IN SELECTED CARICOM COUNTRIES

Hyginus Leon
Nathaniel Samuel
Wendell Samuel

ABSTRACT

This paper uses cointegration analysis to test for common trends and convergence in inflation rates among selected CARICOM countries and the US. The results show that four countries in the sample exhibit two common trends and support the hypothesis of weak convergence to the US economy. However, we find that relaxing the invariance property reveals significant structural change in the 1980s.

Keywords: cointegration; convergence; time-varying parameters; monetary union.

INTRODUCTION

Any endeavour at monetary union among a group of countries must take direct account of the issue of convergence, that is, the drawing together of the economic policies and performances of individual countries. An effective union requires a great deal of harmonisation and co-ordination of the economic policies of member countries. However, for such policy co-ordination to be sustainable, some level of convergence must be achieved. This paper investigates the extent to which convergence in inflation rates has been achieved in selected countries in the Caribbean Community (CARICOM).

The paper also explores whether the results are robust to the assumption of an invariant stochastic process.

In July 1992, the CARICOM Heads of Government adopted the recommendations of Central Bank Governors on the mechanisms to be employed in the establishment of a monetary union within the English-speaking Caribbean . Essentially, the procedure entailed a two-tiered, staged approach. Countries were grouped according to their ability to maintain a three month foreign reserves import cover for at least a year, a stable exchange rate for the preceding 3 years and a sustainable debt service ratio. The first stage entailed the conduct of sound macroeconomic policies while the final stage involved the institution of a common currency by the year 2000.

Price stability, one of the most widely used indicators of nominal convergence, reflects the underlying balance of payments and monetary conditions in an economy. Given a sufficient level of integration, the existence of a fixed exchange rate regime should lead to the convergence of price levels for members of the union. Convergence to a low inflation rate may therefore be a requirement for stable economic growth and investment.

The study of convergence is concerned with the relative long-run behavior of economic variables (in one country or region relative to the same variables in other countries or regions). It examines whether there exists a stable, long run equilibrium relationship among these variables. Two issues that have been addressed are the distinction between nominal convergence (exchange rates, inflation, interest rates) and real convergence (real exchange rates, unemployment, real wages), and whether convergence should be a pre-requisite to monetary union. The main issues are how much nominal (and real) convergence is desirable to maximise the success of monetary union, and what policies should be implemented to bring about this convergence. Nominal and Real convergence may not be independent. Hall, Robertson and Wickens (1992) argue that while a single currency may lead to convergence of inflation rates, unless real labor costs also converge, unsustainable unemployment may emerge in high-cost countries, with resultant political pressures to remove economic disparities. Our study, therefore, is limited in that it does not address joint multivariate convergence of relevant economic variables in the context of a systems approach.

Hall *et al* (1992) utilize cointegration and time-varying parameter analysis (Kalman Filter) to measure the degree of convergence of the main economies of the European Community. They find evidence for the convergence of exchange rates but the divergence of interest rates as governments pursued increasingly active interest rate stability. Barro and Sala-i-Martin (1992) use a neo-classical growth model to show income convergence across the 48 contiguous US states; their results indicated that poor states tended to grow faster than rich ones in per capita terms. MacDonald and Taylor (1990) found evidence of convergence of nominal and real exchange rates and money supplies of European Monetary System (EMS) countries, but not for the non-EMS countries.

There is a dearth of studies, however, on convergence among less developed economies. Cardenas and Ponton (1995) examine convergence in per capita income of the different regions in Colombia, while Honohan (1992) examines convergence of inflation and interest rates for the members of two currency unions in Africa namely, the Franc and Rand zones. Utilising a simple error correction framework, Honohan (1992) found that despite short run divergences, the long run trends in inflation and interest rates converged to that in the core country of the union (i.e. France in the case of the franc zone and the Republic of South Africa in the context of the rand zone).

A recent report Eastern Caribbean Central Bank (ECCB (1994)) on economic convergence in CARICOM countries, undertaken by a joint Central Bank research team, found some support for convergence of inflation rates between the CARICOM countries which have maintained fixed exchange rates and the United States (US). These results from the CARICOM region indeed appeal to intuition. The CARICOM countries have practiced some form of economic integration for more than twenty five years, starting with the Caribbean Free Trade Area (CARIFTA) in 1968; some degree of convergence is therefore expected. Furthermore, since all of the member countries have had US dollar pegs and the bulk of their trading relations is with the United States, that country is a potential "core" economy towards which the countries will converge.

In this paper, quarterly data is utilised to test whether the inflation rates in a group of five CARICOM countries have converged. The Johansen test procedure for multivariate cointegration is utilised to test the differences in the rates of inflation between the CARICOM countries and the US. The resulting vector error correction (VEC) framework also enables us to uncover any causal relationships (in the Granger sense) which may exist among the differences in the rates of inflation between CARICOM countries and the US. Furthermore it allows us to inquire about the exogeneity of individual rates of inflation within that structure. In addition, we estimate the long run inflation relationships using the Kalman filter to investigate whether there has been a transition to convergence within similar country groupings.

The paper is divided into three sections. Section 1 discusses the statistical methodology while the empirical results are presented in Section 2. Finally, Section 3 presents concluding remarks.

1. STATISTICAL METHODOLOGY

On an intuitive level, the concept of convergence relates to the notion that the difference between two (or more) series approaches some arbitrarily small constant over time implying that there will be no tendency for the series to drift apart. Given that most economic series are random variables, one can define stochastic convergence as $E\{\lim_{t\to\infty}(X-Y)\}=\alpha$ where the expected value of the difference between the series approaches some arbitrarily small constant over time. If the series are non-stationary a natural definition would require the difference of the two series to be of lower order of integration than the series under consideration. We can further distinguish between strong convergence when every pair of variables in a system has converged, and weak convergence when a subset of the variables has converged, while the time series relationship of the remaining variables does not change. For a vector of variables X, strong convergence requires $E\{\lim_{t\to\infty}(X_k - X_j)\} = \alpha_x$ for all countries k and j, whilst weak convergence requires that the equation holds for some k and j.

Variables X and Y contain a common trend if $E\{\lim_{t\to\infty}(Y_{t+k} - \beta X_{t+k})\} = \alpha$, thus, long term forecasts are proportional. A vector of variables contains a common trend if their long term forecasts are proportional, $E\{\lim_{t\to\infty}(Y_{1,t+k} - \beta' Y^*_{t+k})\} = \alpha$, where Y^* is the vector of remaining variables (Bernard and Durlauf (1995)). In the bivariate case, Y and X have a common trend if they are cointegrated, the cointegrating vector being $[1, -\beta]$.

Cointegration therefore subsumes convergence as a special case when β is equal to minus one. Thus cointegration implies proportionality of the persistent parts of the series while convergence implies equality.

As noted by Hall *et al* (1992), tests for cointegration indicate whether there is convergence over the estimation period, but do not tell whether there is a movement from non-convergence to convergence. If countries are converging from different initial conditions, the assumption that the data is being generated by an invariant stochastic process may be erroneous. Haldane and Hall (1991) argue that not only is the adjustment path of the temporal correlations between the dependent and independent variables more informative, the time-varying models also overcome statistical problems relating to complicated error processes and omitted variables. Our analysis therefore considers both time invariant and time-varying methodologies.

In particular, one seeks estimates of

$$P_{i,t} = \alpha_{i,t} + \sum_{j=1, j\neq i}^{p} \beta_{j,t} P_{j,t} + \varepsilon_t \qquad i = 1, 2, \ldots, p \qquad (1)$$

where p is the number of countries in the group and P_i is the difference in the rate of inflation between country i and the United States (US). If all the $\beta_{j,t} = 0$ then the difference in the rate between the i^{th} country and the US is unaffected by the differences in the rates between the other countries and the US. If, in addition, $\alpha_{i,t} = 0$ then there is inflation convergence between country i and the US. If each $\beta_{j,t} = 1$ then the inflation rates of the countries in the group have converged. Convergence is said to have occurred if the time-varying values of the α and β parameters tend to their expected values of zero and unity, respectively. Inflation convergence is rejected for $\beta_{j,t} \neq 1$, since the difference in the rate of inflation between country *i* and the US is affected by that of the other countries in the group. Even if $\beta_{i,t} = 0$, $\alpha_{i,t} \neq 0$ implies the inflation rate of country *i* is drifting from that of the core country (US), *albeit* without a particular explanation.

2. EMPIRICAL RESULTS

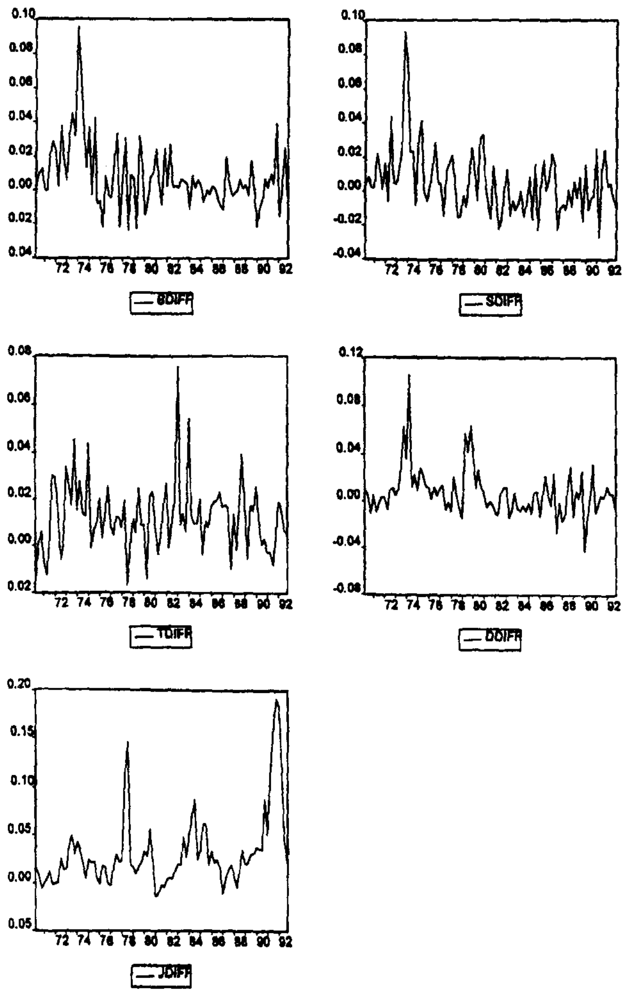
The data set consists of series on the consumer price index (CPI) for the US and selected CARICOM countries spanning the period 1970:1 - 1992:4[3]. All the data were obtained from the International Monetary Fund's statistical database and all computations were doing using RATS and EVIEWS.

Table 1 shows descriptive statistics for the difference in the rate of inflation between Barbados and the US (BDIFF); St. Lucia and the US (SDIFF); Trinidad and Tobago and the US (TDIFF); Dominica and the US (DDIFF) and Jamaica and the US (JDIFF). It is evident that the Jamaica data have different properties relative to those of the other countries, especially since 1988 (see Figure 1). The periods of greatest variability seem to coincide with the two major oil shocks in the mid-

TABLE 1
DESCRIPTIVE STATISTICS FOR INFLATION DIFFERENCES

	BDIFF	SDIFF	TDIFF	DDIFF	JDIFF
Mean	0.008	0.006	0.013	0.008	0.032
Median	0.003	0.003	0.012	0.005	0.021
Maximum	0.096	0.093	0.076	0.106	0.192
Minimum	-0.024	-0.028	-0.018	-0.043	-0.015
Std. Dev.	0.020	0.020	0.015	0.021	0.041
Skewness	1.428	1.523	1.111	1.597	2.186
Kurtosis	6.641	7.374	6.221	8.204	7.916
Jarque-Bera	78.51	104.16	56.16	136.71	158.72

FIGURE 1
INFLATION DIFFERENCES
CARICOM COUNTRIES AND US



1970s and late 1970s - early 1980s. The increased variability in the difference in the rate of inflation between Jamaica and the US in the late 1980s and into the 1990s largely reflect exchange rate movements over that period.

If a set of series is cointegrated, one can test for Granger causality and exogeneity within a vector error correction model. Engle and Granger (1987) showed that when two series are cointegrated there must be causation in at least one direction. For the bivariate model there exists a VEC of the form

$$\Delta P_{I_t} = \alpha_0 + \sum_{j=1}^{k-1} \alpha_j \Delta P_{J_{t-j}} + \sum_{j=1}^{k-1} \beta_j \Delta P_{I_{t-j}} - \rho \pi_{t-k} + \varepsilon_t \qquad (2)$$

$$\Delta P_{J_t} = \delta_0 + \sum_{j=1}^{k-1} \delta_j \Delta P_{J_{t-j}} + \sum_{j=1}^{k-1} \gamma_j \Delta P_{I_{t-j}} - \phi \pi_{t-k} + \eta_t \qquad (3)$$

where $\pi_t = P_{I_t} - \mu P_{J_t}$ is the equilibrium relationship between P_{I_t} and P_{J_t}

The joint significance from zero of the α_j terms in equation (2) and the joint insignificance from zero of the γ_j coefficients in equation (3) would indicate unidirectional dynamic causality from the difference in the rate of inflation between country *j* and the US to that between country *i* and the US. Bidirectional causality would be indicated by the joint significance of the sets of α_j and γ_j coefficients in both equations. Further, a significant coefficient on the lagged equilibrium residual term pt-k in either equation would also imply Granger causality even if the coefficients of the lagged inflation differences were all insignificant (see Toda and Phillips (1994) and Granger and (1995)).

The VEC structure allows us to draw inferences on the exogeneity of the respective variables within our model. Engle, Hendry and Richard (1983) define a variable, X_t, to be weakly exogenous for estimating a set of parameters λ if inference on λ conditional on X_t, involves no loss of information. In other words, given a joint probability density function of two continuous random variables X and Y, $f(Y_t, X_t; \lambda)$, and the conditional distribution of Y_t given X_t $g(Y_t \mid X_t; \lambda_1)$, one may write $f(Y_t, X_t; \lambda_2) = g(Y_t \mid X_t; \lambda_1) h(X_t; \lambda_2)$, with weak exogeneity implying that $h(X_t; \lambda_2)$, the marginal distribution of X_t, does not involve the parameters λ_1 and the conditional distribution depends only on λ_1 (See Urbain (1992)). Under these conditions the parameters of $h(X_t; \lambda_2)$ are merely nuisance parameters. Further, X_t is strongly exogenous if it is weakly exogenous and is not Granger caused by any of the endogenous variables in the system[4]. In the bivariate case, weak exogeneity of the j[th] inflation difference would require that the coefficient ϕ on the lagged residual in equation (3) is zero.

Using the Johansen (1988) procedure, we estimated the rank of the cointegrating matrix for the differences in the rates of inflation between each of the five CARICOM countries and the US. If all p countries in a group have converged, there would be *p-1* cointegrating vectors. The Pantula (1989) principle suggested that there was a maximum of three cointegrating vectors. The hypothesis of strong convergence was therefore rejected. Conditional on that rank, one rejects the null hypothesis that the variables can be considered stationary by themselves. In addition, the multivariate framework permits tests for long-run exclusion and weak exogeneity of the individual variables. The results indicate that Barbados, Dominica, St Lucia and Trinidad and Tobago can constitute a cointegrating group, since one could not reject the hypothesis that Jamaica could be excluded from the

FIGURE 2a
COINTEGRATING VECTOR 1

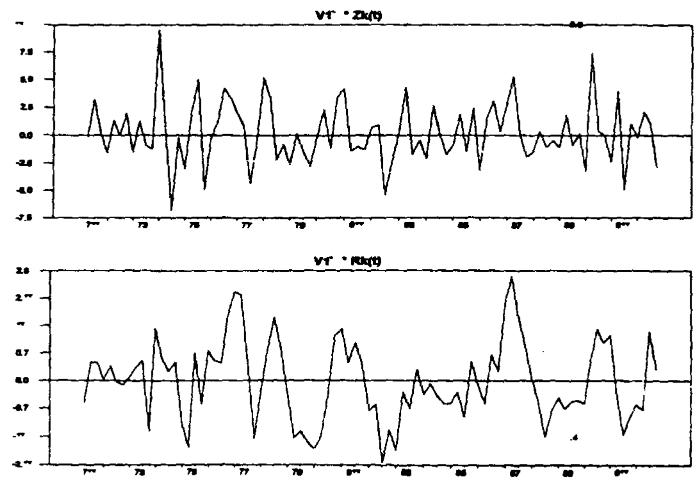
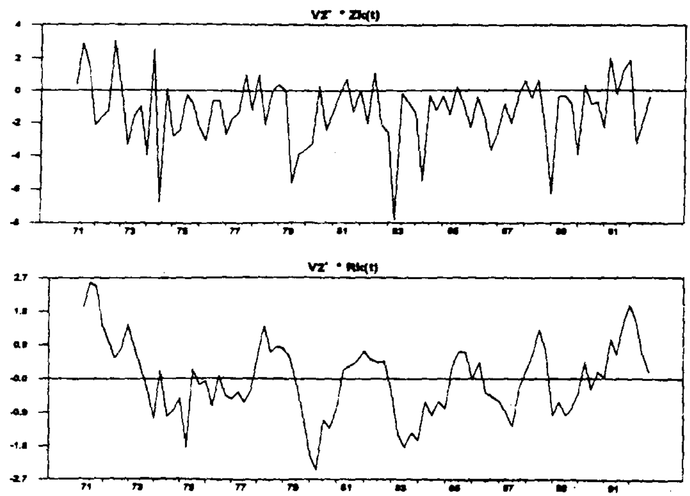


FIGURE 2b
COINTEGRATING VECTOR 2



cointegrating space. Also, Jamaica could be considered weakly exogenous for the long run parameters at ranks two and three. The exclusion of Jamaica and hence its non-convergence is possibly due to the variability generated by exchange rate movements over recent periods.

Analysis of the differences in the rates of inflation between Barbados and the US, Dominica and the US, St. Lucia and the US and Trinidad and Tobago and the US, suggest a rank of two (see Figure 2a, 2b). It is useful to note that the top diagram in each figure refers to the actual disequilibrium while the diagram in the bottom refers to the disequilibrium adjusted for short-run dynamics. At that rank, none of the four variables could be excluded from the cointegrating space or considered to be weakly exogenous or stationary by themselves. A test of the hypotheses that the cointegrating vectors had coefficients of unity indicated that the common trends do map to convergence.

The VEC results (see Table 2) show that the magnitude of the adjustment coefficients for the first cointegrating vector are significant with values of 0.44, 0.63, 0.50 and 0.43 for the Barbados, St Lucia, Trinidad and Tobago and Dominica equations, respectively. The significant coefficients suggest the existence of at least long-run causal influences among the four countries. The second cointegrating vector has significant adjustment coefficients in the Barbados and St Lucia equations with values of 0.42 and 0.41, respectively. The VEC model is deemed adequate in that it satisfies multivariate diagnostic tests for serial independence and normality of the residuals.[5] The univariate statistics show the individual equations to be serially independent, to have insignificant ARCH statistics and, with the exception of St. Lucia which displays some excess kurtosis, to have normal residuals.

TABLE 2
SELECTED RESULTS

Eigenv.	L-max	H0: r	L-max90
0.33	35.77	0	17.15
0.21	20.71	1	13.39
0.11	10.30	2	10.60

	BDIFF	TDIFF	SDIFF	DDIFF
Coint Vector 1	1.000	-0.871	-0.987	0.000
Std. Err		(0.23)	(0.13)	
Coint Vector 2	0.000	-0.903	1.000	-0.914
Std. Err.		(0.31)		(0.16)

Adjustment coefficients and t-values in parentheses

DBDIFF	-0.44 (2.61)	0.42 (2.88)
DTDIFF	0.50 (3.46)	0.19 (1.52)
DSDIFF	0.63 (3.24)	-0.41 (2.42)
DDDIFF	0.43 (2.32)	0.30 (1.91)

Multivariate Statistics:
Test for Autocorrelation:
L-B(21), CHISQ(280) = 271.38, p-val = 0.63
LM(1), CHISQ(16) = 15.85, p-val = 0.46

Test for Normality:
CHISQ(8) = 15.21, p-val = 0.06

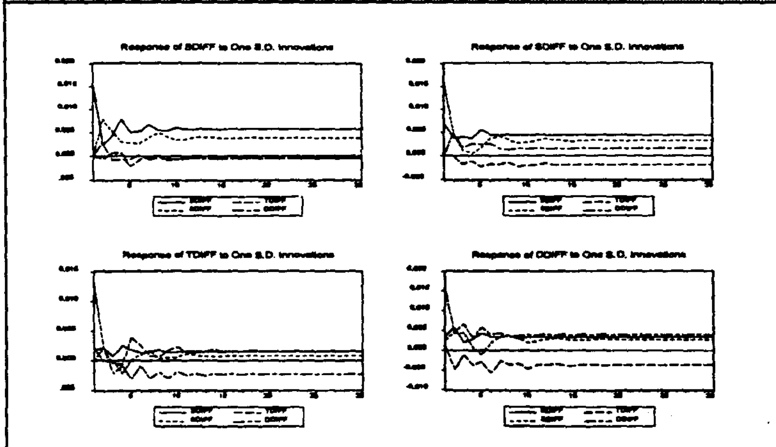
Univariate Statistics:

Variable	Std. Dev.	Skewness	Kurtosis	Normality	ARCH(4)
DBDIFF	1.52	-0.03	2.74	0.02	4.97
DTDIFF	1.30	0.37	3.85	4.79	3.11
DSDIFF	1.74	0.69	4.62	8.89	2.81
DDDIFF	1.65	0.35	3.30	2.30	1.43

Figure 3 graphs the impulse responses of the inflation differences to innovations of one standard deviation. The graph suggests that inflation differences[6] for Barbados and St. Lucia respond to each other and the Dominican difference responds to shocks from both Barbados and St. Lucia. The effects of shocks die out within two years in each case. In terms of the variance decompositions, after twelve periods, 25.7, 1.1, and 1.4 percent of the forecast error variance of Barbados is accounted for by inflation differences of St. Lucia, Trinidad and Tobago and Dominica, respectively. For St. Lucia, Trinidad and Tobago and Dominica, respectively, 49.4, 34.4 and 47.0 percent of the inflation difference variance is not explained by own innovations.

To investigate the possibility of time invariance, a time varying coefficient model was estimated for the group of coun-

FIGURE 3
IMPULSE RESPONSES FOR UNRESTRICTED COINTEGRATING SYSTEMS



tries in the cointegrating space and for the two groups suggested by the cointegrating vectors. Figures 4a, 4b, 4c and 4d show that the slope coefficients (*beta2, beta3 and beta4*) were not constant. For the group making up the cointegrating space, St. Lucia's coefficient (beta3) became significant from 1974 while that of Dominica (beta4) approached significance in the late 1980s. Trinidad and Tobago's coefficient (*beta2*) while significant throughout, clearly has played a less than dominating role from 1980. Similar results emerge for the first cointegrating vector in which the Dominican coefficient is restricted to zero. The second cointegrating vector is normalised on St. Lucia and imposes a zero restriction on Barbados. Again, the Trinidad coefficient (beta2) is significant throughout but has a diminishing influence from 1980. Dominica (*beta3*) grows in importance, becoming significant from 1984. A rather revealing graph is obtained when we estimate the Jamaican inflation difference on Trinidad (*beta2*), St. Lucia (*beta3*) and Barbados (*beta4*). Starting from convergence with Trinidad and Tobago in the 1970s (the coefficients for the constant term (*beta1*), St. Lucia (*beta3*) and Dominica (*beta4*) being zero while that for Trinidad and Tobago (*beta2*) equals unity), the inflation difference began to drift upward from 1978. By1985, the Trinidad and Tobago coefficient was significantly different from unity. That trend has continued since, with the constant series (*beta1*) clearly exhibiting nonstationary behaviour. From 1978, the slowly growing influences from Barbados and St. Lucia petered out. Jamaican inflation has clearly followed a different transitional pattern to that of the other countries in the sample. Our results support the Haldane and Hall (1989) argument that the constant coefficient model may not be an adequate method of modelling convergence, or at least is not as informative about changing correlations. Further, there is ample demonstration in the 1980s of the reversal of the dominating role which the Trinidad and Tobago economy played in the 1970s.

FIGURE 4a
TIME VARYING COEFFICIENTS
INFLATION DIFFERENCES: COINTEGRATING

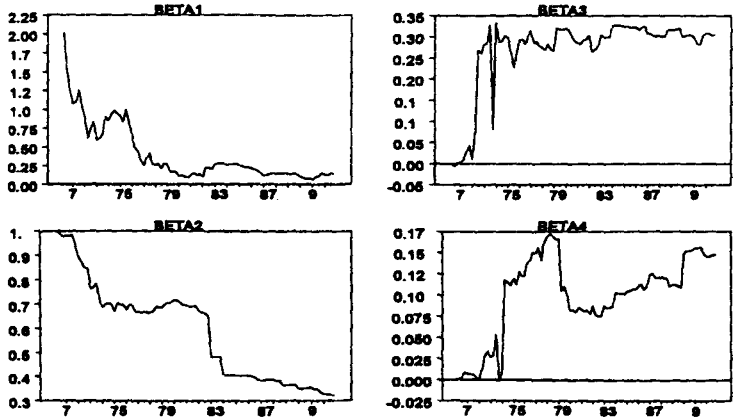


FIGURE 4b
TIME VARYING COEFFICIENTS
COINTEGRATING VECTOR ONE

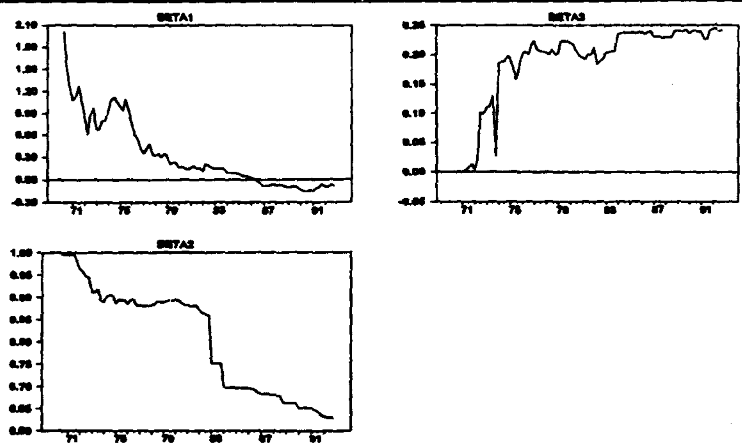


FIGURE 4c
TIME VARYING COEFFICIENTS
INFLATION DIFFERENCES: COINTEGRATING

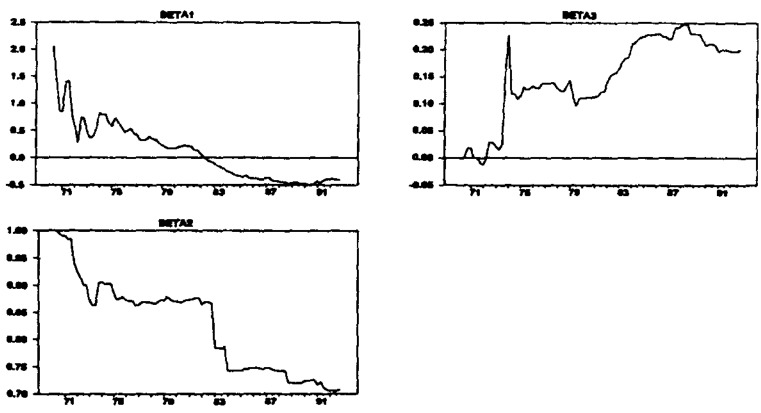
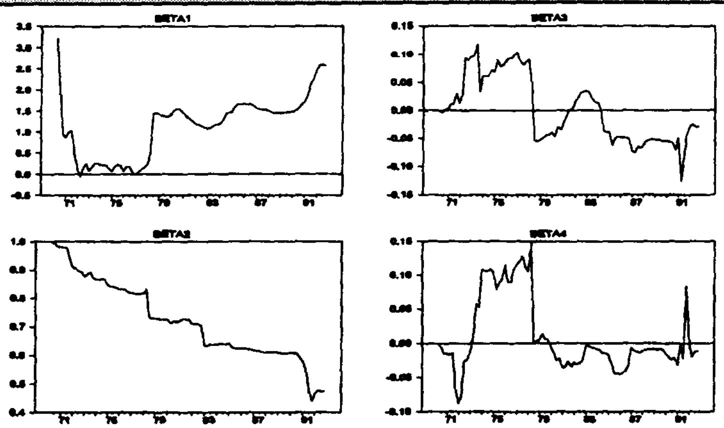


FIGURE 4d
TIME VARYING COEFFICIENTS
JAMAICA INFLATION DIFFERENCE MODEL



3. CONCLUSION

This paper utilised quarterly data spanning the period 1970:1 - 1992:4 to test whether inflation rates have converged in five CARICOM countries. Specifically, the study utilised the Johansen procedure to test for cointegration among the differences of inflation rates between the CARICOM countries and the United States. The resulting vector error correction model was used to inquire about the causal influence and the exogeneity of inflation differences of the CARICOM countries.

The data suggest that there are two common trends among the inflation differences of Barbados, Dominica, St. Lucia and Trinidad and Tobago. The hypothesis of convergence among the four CARICOM countries could not be rejected. The Jamaican inflation difference was insignificant in a test for exclusion from the cointegration space. The results support the convergence to a 'core' country hypothesis and demonstrate that economic convergence may not occur in the presence of volatile exchange rates. Further, convergence to a low inflation rate, as a goal of a monetary union, may be achieved under a floating exchange rate regime once exchange rates are relatively stable.

Our second hypothesis was whether the above results were robust to the assumption that the data were generated by an invariant stochastic process. A time-varying parameter model was estimated for Jamaica, the grouping that indicated a cointegrating space, and for the subgroups implied by the cointegrated vectors. The estimates show that whereas Barbados and Trinidad and Tobago, and St Lucia and Trinidad and Tobago had converged in the 1970s, during the decade cantly correlated with that of Barbados. Similarly, St Lucia and Trinidad and Tobago had converged in the 1970s but during the 1980s the Dominican inflation difference was significantly correlated with that of St Lucia. Our results mirror the influences of the oil boom years of the 1970s in Trinidad and Tobago and the subsequent decline in trade betweenTrinidad and Tobago and its CARICOM partners during the 1980s[7]. A model for the Jamaican inflation difference shows a non-stationary series of constant coefficients and deviation from convergence with Trinidad and Tobago from about 1985.

In conclusion, our results suggest that sustainable policy coordination is unlikely to be successful among all the CARICOM countries. Further, any attempts at harmonisation will need to incorporate the effects of the significant structural change that has occurred since 1980. Further research on the time-varying nature of fundamental economic relationships is clearly an imperative.

ENDNOTES

1. The CARICOM Agreement as enacted in the Treaty of Chaguaramas in July 1973 provides a Common Market and Free Trade Area for its member countries. The countries which make up the CARICOM region are: Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Monsterrat, St. Kitts and Nevis, St. Lucia and St. Vincent and the Grenadines, and Trinidad and Tobago.

2. See "The Report on Study of Economic Convergence in the CARICOM Countries", May 1994.

3. This represents the maximum span common to the set of countries.

4. A third concept that of superexogenity, is also defined. X_t is said to be super-exogenous if it is weakly exogenous and the parameters of the conditional distribution are invariant to a change in the marginal distribution of X_t. This concept is related to the Lucas critique which argues that the parameters of a model may be modified by the impact of expectations concerning changes in the policy (exogenous) variables (Lucas (1976)). See also Leamer (1985) whose definition of super-exogeneity does not require weak exogeneity.

5. In Table 2, L-B is a multivariate Ljung-Box test, LM is a Lagrange Multiplier Test for first order serial correlations and the test for normality is a multivariate version of the univariate Shenton-Bowman test (available in CATS in Rats).

6. The term inflation difference is used here to refer to the difference in the rate of inflation between a given country and the United States.

7. See Chapter 5 of Nicholls (1995) for a fuller discussion of the trade patterns in CARICOM.

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THEORETICAL NOTES ON ENDING BIG INFLATIONS ABRUPTLY, WITHOUT LOSS OF OUTPUT[1]

Steve De Castro

ABSTRACT

Historical hyperinflations were terminated abruptly, sometimes by new governments with no anti-inflation reputation. The theoretical mechanisms which achieved the outcome are not well understood. Recently, Latin American governments have used the intuition to launch many instantaneous stabilisation attempts ("pacotes", "planos") with variable success. A simple model is presented which achieves the result by way of a one-shot, Cournot-Nash equilibrium in a macroeconomic game of conflict among private agents. The supply curve for money plays the same role here as the demand curve of consumers in the original Cournot model. There is no need for social pacts - a co-operative game solution concept. Generalised judicial price freezes are an example of the latter. These fail because each agent has an incentive to defect, a problem which is avoided by Cournot-Nash. Suggestions for new work are given.

Keywords: Inflation; Coumot-Nash Equilibrium, Fraga-Werlang Game

INTRODUCTION

Among both sets of survivors of the recent macroeconomic debates - new classicals and new Keynesians - there are many who accept that it is possible for a government to rapidly reduce high rates of inflation without loss of output. The surprise deflation generates no "reverse-direction" Phillips curve. However, the exact manner by which this could be achieved has not been well specified in the literature. Indeed, several competing approaches have surfaced. These include credibility, strategic behaviour by governments and their central banks to build reputation, strategic behaviour by private citizens as players - with government performing the role of a passive agent reacting mechanically in a macroeconomic game. At the practical level, some interesting suggestions have been made which include (i) an independent central bank; (ii) a fixed rule for the money supply; (iii) a zero fiscal deficit, and (iv) tying the currency to another at fixed parity and allowing the balance of payments to determine the money supply (i.e. a version of the colonial currency board).

One fruitful line of work using game theory, started by Fraga and Werlang (F-W) (1983) and Simonsen (1988,1989), was extended by De Castro (1991). De Castro's point of departure is that inflation can be removed from the non-co-operative equilibrium of the macroeconomic game first formulated by Fraga and Werlang, without having to resort to a social pact - a co-operative solution concept. De Castro demonstrated how government's behaviour, even when it is not a strategic agent (not a "player"), could change the Cournot-Nash non-co-operative outcome. Inflation disappears with no loss of output in the first period after the government announces its supply curve for money. This finding is, however, subject to the government providing the correct value for the money supply.

Although this result may appear to be unduly optimistic, it fits one of the basic facts about how hyper-inflations terminate. Dornbusch (1991), for instance, has used this fact, recently, to criticise the theoretical work on multi-stage games which use reputation, on the grounds that historically, even new governments with no time to build reputation, were able to bring hyperinflations to a halt. He cited, in particular, the Poincaré episode in France in 1926. However, he proceeded to build a model with a completely passive set of private agents - passive with respect to whatever policy is chosen by the government. It is instructive to note here that the Lucas critique is ignored in this analysis.

Our point of departure will be the model by Fraga and Werlang (1983) which links a one-shot, Cournot-Nash inflationary equilibrium to the neo-structuralist theory. This theory treats inflation as the result of a conflict among private agents over the distribution of income (see Canavese (1982)). The co-operative, non-inflationary solution can only be reached by means of a social pact since each party has an incentive to defect. Unlike the game in Barro and Gordon (1983a,b), the government is not a player and acts only to passively supply, any quantity of money the public may require.

Section 2 demonstrates in the original Fraga-Werlang game that each agent's reaction curve in the strategy space of the money demands is independent of the strategies chosen by others. The non-co-operative response, in the form of money demand, is a constant, and, in the example given, doubles the value of the co-operative solution which has no inflation and no loss of output.

Suppose that a slightly more active government is introduced. This government is assumed not to be a player. In short, while it does not act strategically, it can vary the money supply with the price level using a fixed rule. Its new role is analagous to the consumers in the Cournot duopoly. In this situation, the two firms can decide quantities strategically while the consumers react mechanically, in a manner represented by the demand curve, to determine the price. They are not players but they are not entirely passive. The government's fixed rule, a supply curve for money, plays the same role here as the demand curve in Cournot.

The result is a one-shot game in which the reaction curves become dependent on the money demands of other agents, through a parameter, *b*, which appears in the fixed rule. By varying this parameter, it can be shown how the government can choose its value such that the non-co-operative, Cournot-Nash, inflationary equilibrium can be made coincident with the co-operative solution. This co-operative solution results in maximum output and is non-inflationary. It should be stated that our analysis makes no attempt to consider whether the fixed rule can be dynamically inconsistent as suggested by Kydland and Prescott (KP) (1977). Unlike the KP study, our government, in keeping with Fraga and Werlang, does not act strategically. Our rule is therefore credible to the extent that it allows maximum output when the government is doing the right thing.

Simonsen (1989) modified the Fraga-Werlang game in order to remove the rather unorthodox type of Phillips curve effect which ensured the attainment of bounded solutions. However, the non-co-operative equilibrium remained inflationary because of the assumption of a passive monetary policy stance.

Franco (1989) has modelled a context where, despite the implicit existence of a social pact in the form of a government actively attempting to remove inflation by generalised price freezes, the result is "inertial" inflation caused by free riders who gain by getting around the controls. However, this is precisely the situation which the Cournot-Nash theory was invented to avoid. That is, the theory finds an equilibrium where no agent acting alone, can do better for himself.

In this model, Simonsen (1988) explained that inertial inflation results because each private agent is reluctant to play the non-inflationary Cournot-Nash strategy because the agent is not certain whether the others will play theirs. He claimed that this led agents to adopt "conservative", max-min strategies. This claim relies on more profound game-theoretic criticisms of Cournot-Nash equilibria which we hope to address in another paper. It is also related to the role of expectations (beliefs) in strategic behaviour (See Guesnerie (1992,1993)).

In this paper Cournot-Nash equilibrium is adopted but the problem is treated as one of mechanism design. The government is still not a player, just as in Simonsen and Fraga and Werlang. Yet, a case can be shown in which inflation can be removed without the need for co-operative behaviour by the strategic agents. Since our analysis studies neither the dynamics nor other alternatives to the rule, we cannot claim that an independent central bank, which can implement the fixed rule, provides the correct institutional setting. However, if there were such a bank, our argument would lead obviously, to one with no discretionary powers, at least in the static case. The final section, section 3, contains suggestions for new work.

1. THE ORIGINAL FRAGA-WERLANG (F-W) GAME

The Fraga-Werlang game consists of two (2) private agents who demand money (M^D_i) in such a way that each would maximize his share (c_i) of real output, y, which in turn is affected by the level of inflation, (p/po). When there is no inflation, the level of output is a maximum. The government is entirely passive, supplying any amount of money which agents may require. Although agents demand money based on their expectations of the price level (pe_i), their expectations are assumed always to be correct. The equations of the model can be written as follows:-

$$pe_i.c_i = M_i^D; M_i^D = M_i^S \equiv M_i \qquad (i = 1,2) \tag{1}$$

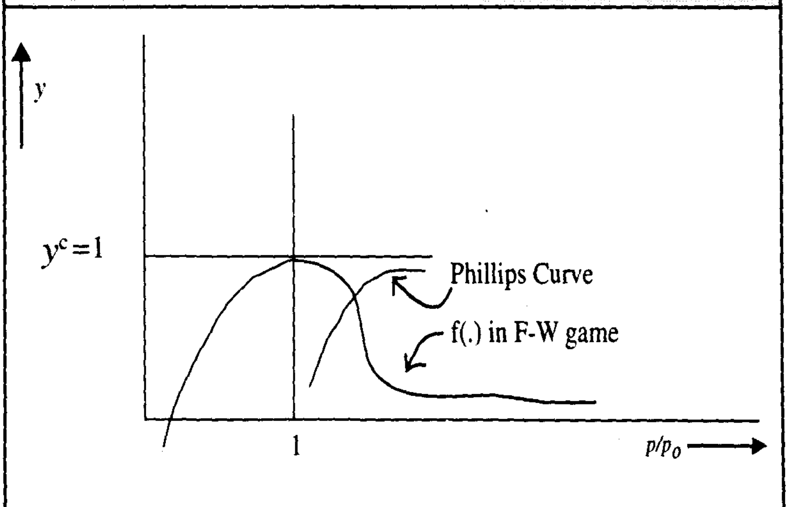
$$c_1 + c_2 = y \text{ ; equilibrium in the goods market} \tag{2}$$

$$pe_i = p \text{ ; perfect foresight by all agents} \tag{3}$$

$$y = f\left(\frac{p}{p_0}\right); \begin{cases} f' < 0 \text{ if } p > p_0 \\ f' > 0 \text{ if } p < p_0 \end{cases} \tag{4}$$

Equation (4) links real output with the level of inflation in a way that is very different to that of an old fashioned Phillips curve. When the price level is stable, that is ($p/p_o = 1$), real output is at a maximium. Any deviation from stability is penalized by a loss of output. The economic interpretation is that inflation causes inefficiencies by inducing wrong production decisions. In the original Phillips curve, the rate of inflation explodes if output approaches capacity level, y^c. In this case, it tends to zero since ($p/p_o = 1$). Figure 1 illustrates the two different assumptions.

FIGURE 1



Although equation (4) appears to be a parable of the good central banker (i.e. price stability is always good for everyone), Fraga and Werlang had a technical reason for replacing the Phillips curve. In their macroeconomic game, each (private) strategic agent's optimisation was unbounded since more money in the hands of each agent resulted in greater inflation and consequently, an increase in output.

The co-operative solution to the F-W game was obtained by the maximization of total joint (real) product:

$$Max\ Z = c_1 + c_2 = {}^{M_1}\!/_{p} + {}^{M_2}\!/_{p}$$

$$Subject\ to\ M_1 + M_2 = p.y \equiv p.f\left({}^{p}\!/_{p_0}\right)$$

Here, the maximization of joint product requires zero inflation if output (y) is to be a maximum $(f(.) = 0)$. This yields $(p/p_o = 1)$. In the example given by Fraga and Werlang, $f(.)$ had the log form:-

$$y = \frac{\left(1 + \ln\left({}^{p}\!/_{p_0}\right)\right)}{p/p_0}$$

which has the maximum value of y, y^c, when $(p/p_o = 1)$. The co-operative solution has total money demand, $M_1 + M_2 = p_0$ and thus maximum output, $y = y^c = 1$.

In the non-co-operative, Cournot-Nash solution, each agent, for example agent 1, demands money (M_1) in such a way as to maximize his share, c_1, of real output, treating the other agent's money demand (M_2) parametrically:

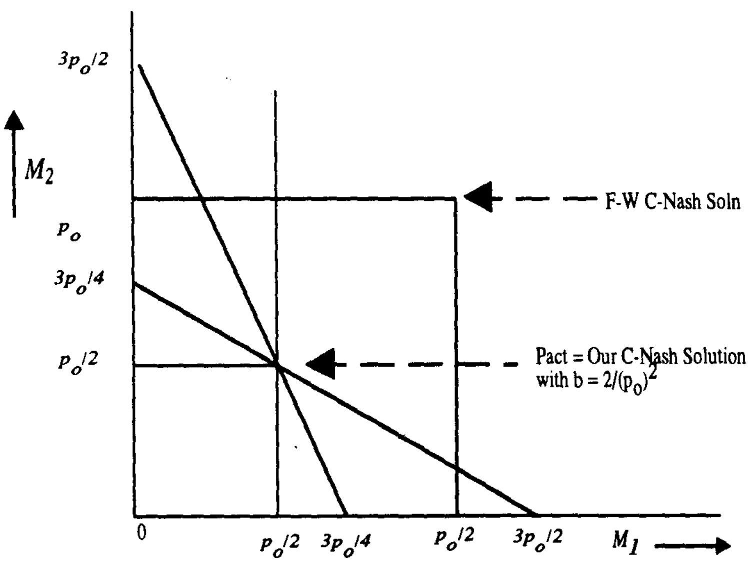
For agent 1, for given M_2 :

$$Max\ Z_1 = c_1 = {M_1}/{p}$$

$$Subject\ to\ M_1 + M_2 = p.y \equiv p.f\left({p}/{p_0}\right)$$

In the log form example for $f(.)$, the F-W result is $M_1 = p_0$ which by symmetry, is also the result for agent 2, so that the total money demand is $2p_0$, twice that of the co-operative solution, generating a level of inflation, $(p/p_0) = e > 1$, and output, $y = (2/e) < y^c = 1$. The two solutions are compared in the strategy space of money demands, (M_1, M_2), in Figure 2.

FIGURE 2



2. A MORE ACTIVE GOVERNMENT

Suppose a slightly more active government is introduced into the game. To do so, one needs to specify a rule which the government can use to decide on the quantity of money that it will supply to the economy, given the level of money demand of private agents. As a preliminary example, consider:

$$p = \left[1/p_0 - b\left(M_1 + M_2 - p_0\right)\right]^{-1}; b > 0 \qquad (5)$$

Two properties of this rule should be noted. The first is that the government always offers an increase in the money supply when the price level increases in the economy. This means that although there is an upper limit to the money supply, M^u, it is only reached asymptotically:

$$M^u = p_o + \left(1/bp_0\right)$$

The second is that the money supply is equal to p_o. The price level is also p_o and yields maximum output because there is no inflation. This is the co-operative solution in the F-W game.

These properties are illustrated in Figure 3. A more general set of money supply curves which yield the same outcome may be obtained from Cournot-Nash theory. Our curve is unlikely to be unique.

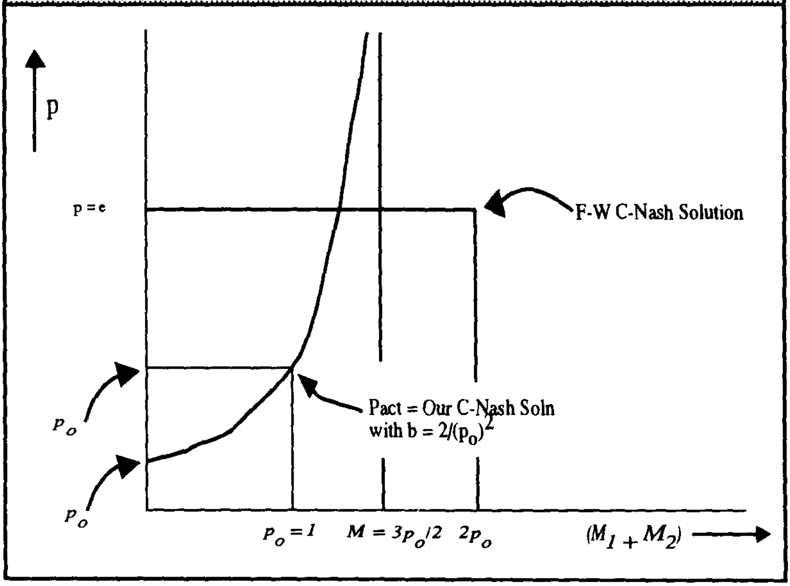
The non-co-operative, Cournot-Nash solution can now be obtained by solving for each agent's curve in this new situation:

For agent 1, for given M_2:

$$Max\ Z = {}^{c_1}\!/_{p} = {}^{M_1}\!/_{p}$$

$$Subject\ to\ p = \left[1/p_0 - b\left(M_1 + M_2 - p_0\right)\right]^{-1}; b > 0$$

FIGURE 3



The resulting reaction curve for agent 1 is:

$$M_2 = p_o + (1/bp_0) - 2M_1$$

Using symmetry, one can easily obtain the other curve and solve for the Cournot-Nash equilibrium

$$M_1 = \frac{1}{3}\left(p_o + (1/bp_0)\right) = M_2$$

and the resulting price level:

$$p = 3\left(bp_0 + 1/p_0\right)^{-1}$$

which is seen to vary with the choice of parameter, *b*.

The question which needs to be answered is what value of *b* makes the total money supply induced by the non-co-operative solution, equal to the co-operative level, p_o. That is:

$$p_0 = \frac{2}{3}(p_0 + 1/bp_0)$$

which yields:

$$b = \left(2/(p_0)^2\right) \textit{ and } M_1 = M_2 = p_0/2$$

This result is illustrated in Figures 2 and 3 which show the Cournot-Nash solution coincident with that given by the social pact in the F-W game, when *b* has the correct value.

In the more general case of *n* agents, the effect of *n* on the resulting inflation rate is the same as in the F-W game. For given *b*, the inflation rate increases with the number of agents. However, for given *n*, one can find a value for *b* such that the inflation rate is zero. This is obtained from the simple relation:

$$b = \left(n/(p_0)^2\right)$$

By introducing the supply curve for money into the F-W game, it would appear as if we have replaced a conflict over real goods by a conflict over money. This is not the case. Indeed, both games have the following common features: (i) agents need money to buy goods; (ii) there is no other reason for holding money; (iii) too much money causes inflation and loss of output; and (iv) government is the only source of money. The only change that has been introduced relates to the manner in which government guarantees supplies of money to the economy. The issue then, is one of credibility of that commitment.

3. SUGGESTIONS FOR FURTHER WORK

The main argument of the paper is that there is at least one middle road between those economists who do not accept the notion that the government's behaviour should be modelled as a strategic player in a game against its citizens, and those who leave it completely passive. There are many reasons, both philosophical and behavioural, why the first is an unacceptable procedure. One can see this clearly in the more recent literature of the Barro-Gordon research programme where, in a context of incomplete information, the optimal behaviour required of the government is for it to choose whether or not it should inflate the economy by a completely random process. Some models (e.g. Vickers (1986), Driffill (1989)) have been able to remove this requirement. Nevertheless, this fundamental issue is a fruitful line for future research.

Another line of work using games has been to try to link the behaviour of the government to its political base. However, this literature was not mentioned in Simonsen's survey. Alesina's model (1987) is probably the best known. However, the search for what we may call ideal social mechanisms would still be valid, if only as measures of the relative inefficiency of representative democracy as a political system.

Using these insights, one can outline a progressive research agenda. The fundamental idea is to maintain the basic result, but in a richer and thus more realistic macroeconomic environment. The major extension in this direction must be to seek ways of incorporating fiscal behaviour, since the basic model treats with only monetary policy. Two clarifications are necessary. The first is that our analysis speaks of behaviour and not policy even though the two concepts may be difficult to separate in economics - a discipline which contains no theory of government. With no such theory, policy would seem the correct term. The phrase is used nevertheless to indicate that the research should make no *a priori* commitment to the effectiveness of fiscal policy. The latter should be a result not a premise. The second is that one tractable way to deal with fiscal behaviour may be to develop decomposability theorems which can show the conditions under which it can be dealt with separately from monetary behaviour.

One approach to examine the fiscal dimension could involve an examination of how the basic model links nominal behaviour in the economy to real output. The criticism that was made of the unorthodox Phillips curve is, of course, not an argument for a return to the orthodox one, as this relation is precisely the one being questioned in this field. For example, one can continue to accept the Fraga-Werlang parable (equation 4) and still introduce a government incentive to issue money beyond the pure need for transactions, by allowing government spending to cause an upward productivity shift in the F-W function, through perhaps expenditure on infrastructure maintenance. The government would then have a separate motive to inflate the economy, but there would be an interesting trade-off from the loss of output that this inflation would cause.

Contrary to our basic model, most of the mainstream work using games have modelled the government as a strategic player in a situation, effectively, of confrontation with its citizens (see, for example, Andersen (1989)). In short, therefore, no account has been taken of the fact that, in a real sense, the government represents the interests of a coalition of at least some of its electors who are the other strategic players. It may be possible to mount a general model for which both types of games - that is, government as player, and government as rule maker or arbiter - can be seen to be special cases. This may very well be a difficult enterprise but it should be considered.

Finally, the research should try to remove from the basic model, the rather trivial incorporation of the rational-expectations hypothesis (See Guesnerie (1992,1993)). This may be a rather tall order as the literature in this area has exploded in recent years. It may appear to be irrelevant to our particular problem, in the sense that expectations are formed by agents using information accumulated from past behaviour of both government and themselves. Since our basic premise is the possibility that a government, perhaps with some new set of institutions, can induce a zero inflation outcome almost immediately, this accumulation process would seem to be taken as exogenous.

However, one can think of the ending of big inflations as a kind of optimal stopping rule problem in which by some change of regime, most agents, despite their accumulated stocks of information about the past, can be induced simultaneously to find it optimal (each in his own private interest) to cease to increase his nominal prices. Some form of expectation formation at that point may need to be specified, perhaps something like what Dornbusch calls credibility.

By thinking of the issue in this dynamic way, the government's new required behaviour may be conceived as a mechanism which can influence the intertemporal constraints in the dynamic optimisation problem of each private agent, such that the optimal time to stop nominal price increases for each agent, is the same for all agents. One extreme case can be the solution in which agents reach their optimal times to stop, even before government intervenes. These dynamics are also a way of thinking about how hyper-inflations are caused rather than ended since hyper-inflations occur when each agent's decision to quit the currency coincides with the decisions of all other agents or at least a significant number of them.

It is hoped that this research will enable us to establish results which can lead to a specification of the social mechanism required for this highly desirable macroeconomic outcome - the almost instantaneous reduction of massive inflation without significant falls in aggregate output. It appears to be pie in the sky, but this is what every stabilisation scheme in Brazil, Latin America and the Caribbean in recent years has promised and sought. This research may help to deliver. And even if the correct one is found by intuitive means, the research may still indicate how big inflations can be avoided in the future.

ENDNOTE

1. This paper was prepared for the XXVI Annual Conference of the Regional Programme of Monetary Studies, November 23-26, 1994, Kingston, Jamaica, West Indies. The assistance of CAPES, the Brazilian Federal Government a gency attached to the Ministry of Education and Sport is gratefuuly acknowledged. This revision benefitted from discussions with Paulo Coutinho and Joao Ricardo Farias. Incisive comments from Shelton Nicholls, Roland Craigwell and Mary Zephirin are gratefully acknowledged.

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THE STOCHASTIC NATURE OF INFLATION: THREE CARIBBEAN EXAMPLES

Terence Agbeyegbe[1]

ABSTRACT

Several studies have examined the issue of unit root non-stationarity in inflation data for selected Caribbean countries. These studies failed to find any strong evidence against the null hypothesis of difference stationarity. This question is addressed in light of recent developments in the time series literature. Two tests are adopted in the paper. The first, takes stationarity as the null and examines whether the variance of the random walk component is zero. The second, examines the fractional integration parameter of a long memory process. The tests were applied to monthly inflation data covering the period January 1970 to December 1993 for Barbados, Jamaica and Trinidad and Tobago. The results are unambiguous and suggest stationarity of the data. The study also suggests that the nature of inflation in Trinidad and Tobago is different from that in Barbados and Jamaica.

Keywords: inflation; unit roots; stationarity; ARFIMA GARCH processes

INTRODUCTION

The oil shocks of the 1970s and the structural adjustment policies of the late 1970s and the 1980s have created substantial interest in modelling the inflation process in the Caribbean. The majority of studies that have addressed this issue in the Caribbean have utilised a wide array of explanatory variables and have made a number of assumptions concerning the behaviour of labour and foreign exchange markets. Examples are to be found in the papers by Holder and Worrell (1985), Downes (1985), Downes, Holder and Leon (1990, 1991), Samuel and Leon (1994) and Thomas (1994). In spite of the differing approaches, a common methodological theme that recurs in recent papers involves the use of unit root tests and cointegration analysis. The unit root tests adopted have been mainly those of the Dickey-Fuller (Fuller (1976), Dickey and Fuller (1979) and Said and Dickey (1984)) and Bhargava (1986) genre.[2]

The standard conclusion drawn from the many empirical studies is that the inflation series contain a unit root (i.e., inflation is an I(1) process). However, theoretical and simulation evidence presented in DeJong *et al.* (1992), Diebold and Rudesbusch (1991a) and Kwiatkowsi, Phillips, Schmidt and Shin (KPSS) (1992) suggest that, in trying to decide by classical methods whether economic data are stationary or contain a unit root, it would be useful to perform tests of the null hypothesis of stationarity as well as tests of the null hypothesis of a unit root. It is important to note that where Dickey-Fuller type tests are used, the null hyphothesis is formulated in terms of a unit root. Indeed, the very manner in which classical hypothesis testing is implemented ensures that the null hypothesis is accepted unless there is strong evidence against it.

This paper considers whether the failure to reject a unit root in the inflation series in selected Caribbean countries, namely, Barbados, Jamaica, Trinidad and Tobago, is due to the fact that the inflation series are not very informative about whether or not a unit root exists. The analysis compares several different tests of unit root and stationarity and explores the possibility that inflation can be modelled as a long memory process.

Although several different models of long memory processes can be used to characterise inflationary processes, the one that is adopted in this paper fits the purpose best, mainly because it does not require the specification of a complex model and illustrates the point that the inflation series are covariance stationary.

A stationary process x_t is said to have long memory if the covariance between x_t and x_{t+j} declines slowly as j increases. The autocorrelations between observations far away from one another in time, while small, are not negligible. More specifically, the autocorrelation function $p(j)$ of a long memory can be approximated as follows:-

$$p(j) \sim M_j^{2d-1} \text{ as } j \rightarrow \infty$$

for some non-zero constant M and a positive d. In other words, the autocorrelation function decreases at a slow hyperbolic rate and the sum of the autocorrelations is infinite. The autoregressive moving average (ARMA) models are by contrast short memory processes. For these, the autocorrelations decay exponentially and the sum of the autocorrelations is finite.

Considerable motivation exists for the assumption of a long memory process. First, economic data have been fit to a variety of long memory processes (e.g., Diebold and Rudebusch (1989, 1991b) and Sowell (1992a, 1992b)). Second, Baillie, Chung and Tieslau (1995) on analysing monthly post World War II inflation rates, using the Consumer Price Index (CPI) for ten different countries, found strong evidence of long memory but also mean reverting behaviour, for all countries except Japan which appeared stationary.

The plan of the paper is as follows. Section 1 describes the KPSS test as an alternative to the Dickey-Fuller while in Section 2, Phillips-Perron type tests ((Phillips (1987) and Phillips and Perron (1988)) for a unit root and the KPSS tests of stationarity are applied to CPI inflation series from three Caribbean countries. Section 3 describes processes which are fractionally integrated and presents maximum likelihood estimates of fractional integration parameters for the inflation series of the three Caribbean countries. Section 4 contains concluding remarks. An apendix on autoregressive fractionally integrated processes is also provided.

1. THE KWIATKOWSKI, PHILLIPS, SCHMIDT AND SHIN TEST

As noted earlier, most of the standard tests for the existence of unit roots involve the null hypothesis of a unit root. If one wishes to test stationarity as the null and one has strong priors in its favour, then it is not clear that the usual Dickey-Fuller parametrisation is the most appropriate method. The KPSS test was developed as an alternative approach to testing for unit roots and it takes stationarity as the null.

Let x_T be a sample of T observations for which one wishes to test the null hypothesis of stationarity. KPSS assume that the series can be decomposed into the sum of a deterministic trend, a random walk and a stationary I(0) disturbance. In short, the series can be decomposed as follows:-

$$X_t = \delta_t + r_t + \varepsilon_t \tag{1}$$

where the random walk r_t can be written as

$$r_t = r_{t-1} + u_t \tag{2}$$

and (u_t) is an independently and identically distributed sequence with mean zero and variance σ_u^2. The initial value r_0 is asumed to be fixed. Kwiatkowski *et al* (1992) show that a score test of the null of stationarity can be based on the statistic

$$\hat{\eta}_\tau = T^{-2}\sum_{t=1}^{T} S_t^2 \Big/ s^2(l) \tag{3}$$

where $S_t = \sum_{i=1}^{t} e_i$, is the partial sum of the residuals, e_i, when the series has been regressed on an intercept and possibly also a time trend; T is the sample size; $s(l)$ is a consistent non-parametric estimate of the "long run variance",

$$\sigma^2 = \lim_{T\to\infty} T^{-1}E\left(S_T^2\right) \tag{4}$$

and is of the form

$$s^2(l) = T^{-1}\sum_{t=1}^{T} e_t^2 + 2T^{-1}\sum_{s=1}^{l} w(s,l)\sum_{t=s+1}^{T} e_t e_{t-s} \tag{5}$$

where $w(s,l)$ is an optimal lag window that corresponds to the choice of a spectral window. In their study, Kwiatkowski *et al* use the Bartlett window[3] adjustment based on the first sample l autocovariances. More specifically, $w(s,l) = 1 = s/(l+1)$, guarantees the non-negativity of $s^2(l)$. The lag parameter l is set to specific integers to correct for residual serial correlation. A choice of $l=0$ would be appropriate if the residual series were independently and identically distributed.

When the residuals are computed from an equation with only an intercept, the test statistic is denoted by $\hat{\eta}_\mu$ and when a time trend is included in the initial regression as in equation 1, the test statistic is denoted by $\hat{\eta}_\tau$. Kwiatkowski *et al*. show that both $\hat{\eta}_\mu$ and $\hat{\eta}_\tau$ are asymptotically functions of a Brownian bridge (see Ross (1983)) and in their work have produced a table of upper tail critical values for $\hat{\eta}_\mu$ and $\hat{\eta}_\tau$. The critical values for $\hat{\eta}_\mu$ and $\hat{\eta}_\tau$ are 0.739 and 0.216 at the 0.01 level and 0.463 and 0.146 at the 0.05 level, respectively.

2. TESTING FOR STATIONARITY IN CARIBBEAN CPI INFLATION SERIES

The time series plots of CPI inflation series for Barbados, Jamaica and Trinidad and Tobago are presented in Figures 1A, 2A and 3A. The data are monthly, spanning the period January 1970 to December 1993 and are not seasonally adjusted.[4] Figure 1A shows that the inflation series in Barbados was generally more volatile in the period before the 1980s than in the post 1980 period. Much of this variability can be attributed to the fact that Barbados is a small open economy and that the increases in world commodity prices in the pre-1980 period caused import prices to rise, and precipated an acceleration in domestic prices (see, for example, Bourne (1977)).

FIGURES 1A, 2A,3A

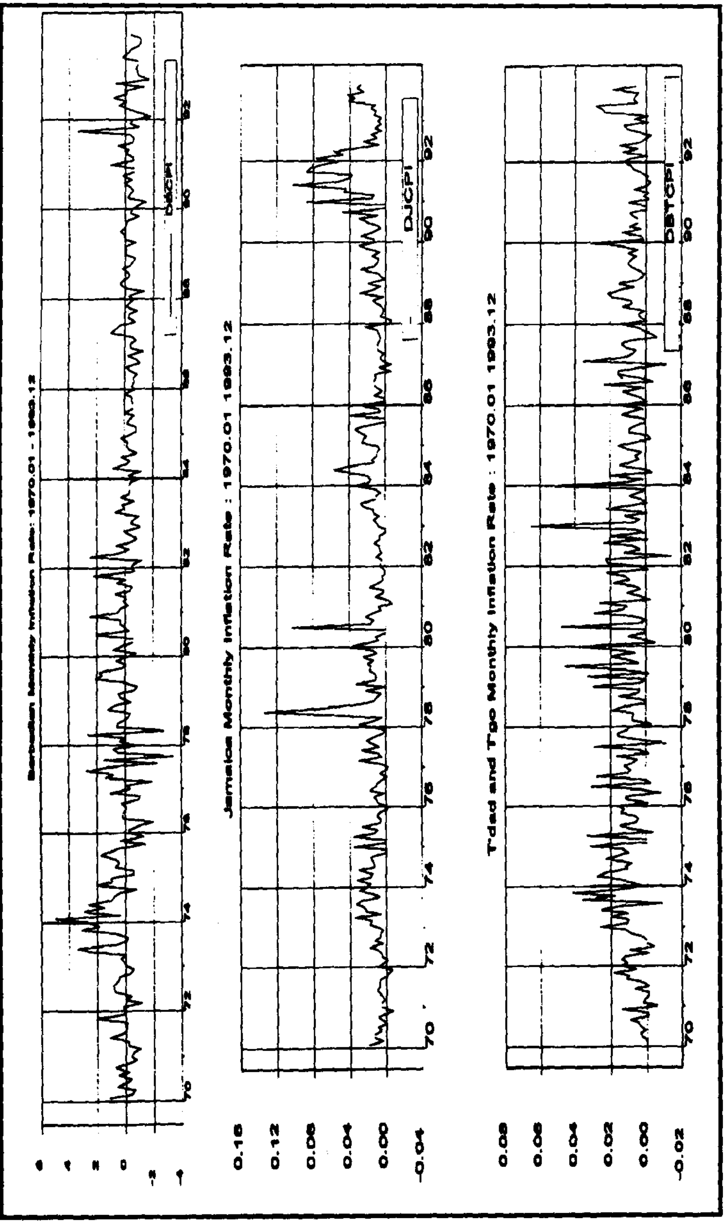

Figure 1B
Barbadian Monthly Inflation Rate: 1970.01—1993.12

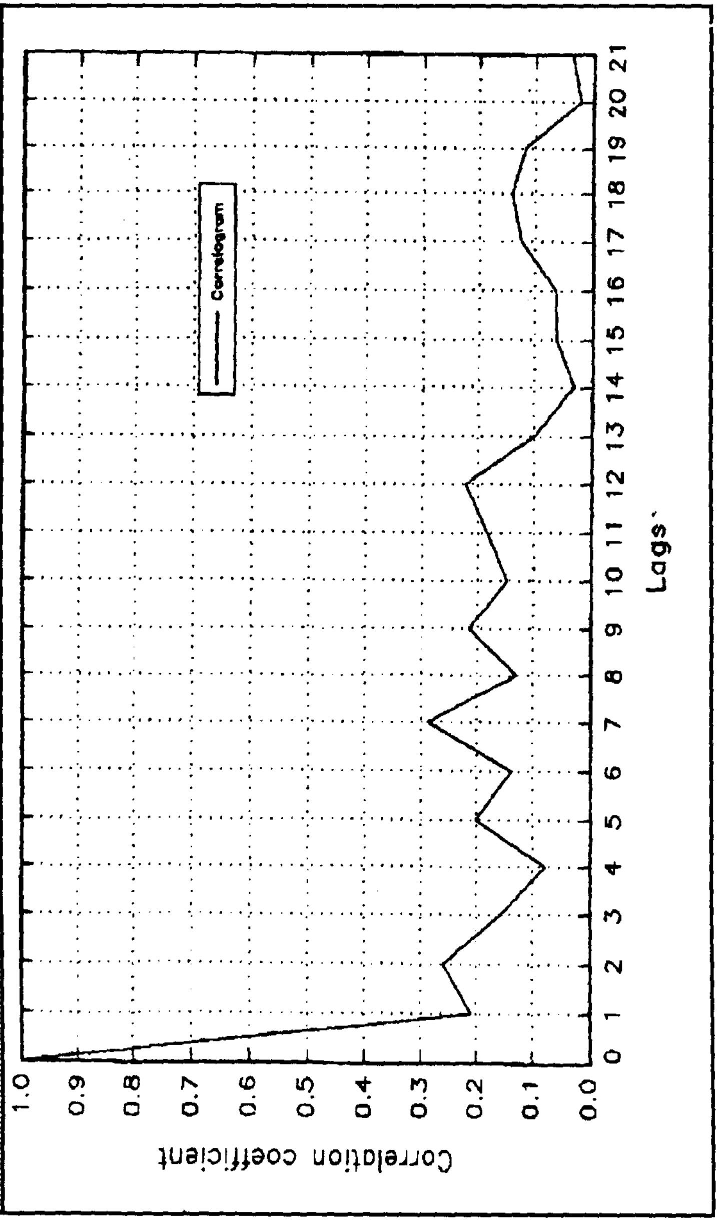

Figure 2A indicates that the rate of inflation in Jamaica was highest in the 1978/1979 period. This corresponds to the period, beginning May 1978, when Jamaica was forced by the International Monetary Fund to implement a structural adjustment programme that included measures such as the abolition of the dual exchange rate and a devaluation of the currency. Another period of high inflation occurred in 1991. Economic policy during this period was effectively directed at moving Jamaica towards a liberalised, market-led economy. Some of the major policies and programmes implemented during 1991 included:- (i) exchange rate measues, in particular the devaluation of the Jamaican dollar; (ii) fiscal measures directed at reducing the fiscal deficit; (iii) monetary policies which increased the rate of growth of the money supply and affected interest rates; (iv) the abolition of subsidies and prices controls; (v) income policies which included the removal of wage guidelines. These policy measures were largely responsible for fuelling inflation during the 1978/1979 period.

Figure 3A presents a graphical plot of monthly inflation rates for Trinidad and Tobago over the period 1970 to 1994. It is evident from the graph that the rate of inflation in Trinidad and Tobago was highest in the 1983/1984 period. This could be attributed to the rapid growth of the money supply which came about largely as a result of the financing of the fiscal deficits of 1982, 1983 and 1984 using foreign exchange earned in the oil sector (see Ramsaran (1988)).

The autocorrelation functions for the CPI inflation series for Barbados, Jamaica and Trinidad and Tobago are presented in Figures 1B, 2B and 3B. Unlike those series for Barbados and Jamaica, the inflation series for Trinidad and Tobago do not show a clear pattern of decay. Indeed, these data indicate the existence of seasonality. Although not reported, the

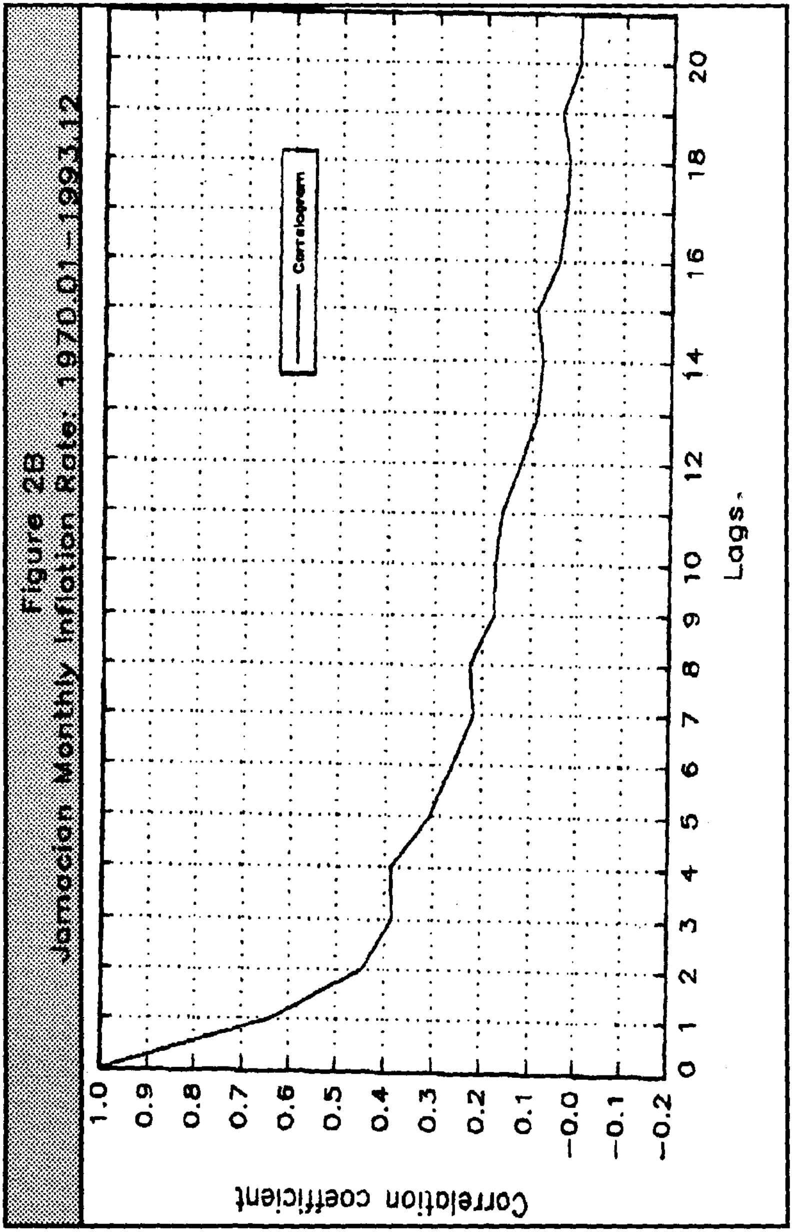
Figure 2B
Jamacian Monthly Inflation Rate: 1970.01 — 1993.12
Correlogram
Correlation coefficient
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
-0.0
-0.1
-0.2
0 1 2 3 4 5 6 7 8 9 10 12 14 16 18 20
Lags

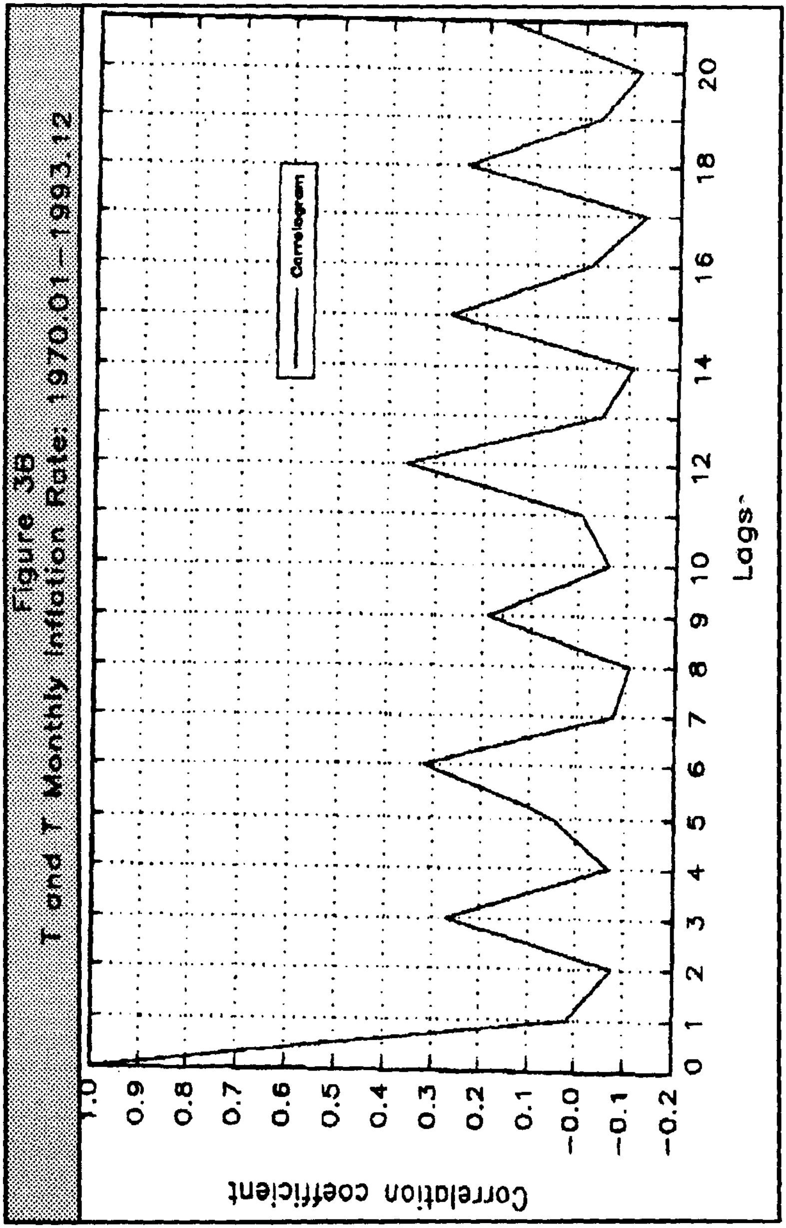

Figure 3B
T and T Monthly Inflation Rate: 1970.01—1993.12

autocorrelations of the first difference of the inflation series for both Barbados and Jamaica appear with large negative autocorrelations at lag one and relatively little other autocorrelation. These patterns suggests that the inflation series for Barbados and Jamaica are stationary and that of Trinidad and Tobago is border-line stationary. To confirm this result, both the null of a unit root and stationarity are tested using the Phillips and Perron (PP) (1988) test statistic for a unit root and the KPSS test statistic for stationarity.

The combined use of the PP and KPSS test statistics gives rise to four possible outcomes:

(i) Rejection by the PP statistic and failure to reject by the KPSS statistic is viewed as strong evidence of covariance stationarity (i.e. an I(0) stochastic process);

(ii) Failure to reject by the PP and rejection by the KPSS statistic appears to be strongly indicative of a unit root (i.e. an I(1) process);

(ii) Failure to reject by both the PP and the KPSS statistics is probably due to the data being insufficiently informative on the long run characteristics of the process;

(iv) Rejection by both the PP and the KPSS statistics indicates evidence of some process that is neither well described by an I(1) or I(0) process.

Table 1 presents the results of applying the PP and KPSS tests to the three inflation series. For all the countries, both the PP and the KPSS test statistics are indicative of inflation being I(0). It is useful to compare these results to those of Baille,

TABLE 1
TESTS FOR THE PRESENCE OF UNIT ROOTS AND STATIONARITY, 1970.1 - 1993.12

Inflation Series	Barbados	Jamaica	Trinidad and Tobago
	H_0: I(1)		
t_α^*	-14.71**	-8.179**	-16.83**
t_α	-15.39**	-8.567**	-16.88**
	H_0: I(0)		
η_μ	1.005**	0.435	0.290
η_τ	0.069	0.015	0.150*

Key:

t_α^* and t_α are the Phillips and Perron adjusted t-statistics of lagged dependent variable in a regression with intercept only, and intercept and time trend included respectively. The 0.05 critical values for (t_α^*) and (t_α) are - 2.870 and -3.431 while the 0.01 critical values are -3.440 and -3.954, respectively.

η_μ and η_τ are the KPSS test statistics and are based on residuals from regressions with an intercept and intercept only and time trend, respectively.

The 0.05 critical tables for $\hat{\eta}_\mu$ and $\hat{\eta}_\tau$ are 0.463 and 0.146, respectively while the 0.01 critical values are 0.739 and 0.126, respectively. All the test statistics reported in this table were based on the Newey-West (1987) adjustments using 10 lags. Two asterisks denote calculated test statistics which are significant at the 0.01 level, while one asterisk denotes significance at the 0.05 level.

Chung and Tieslau (1995) who considered modelling post-war monthly inflation rates for the G7 low inflation economies as well as for three high inflation economies, namely, Argentina, Brazil and Israel. These authors found evidence in support of case (iv) above for Argentina, Brazil, Canada, France, Italy, Israel, UK and US; that is, there is evidence that inflation may not be generated by an I(0) or I(1) process. In a later part of the paper, they argued that for all but one country, Japan, the inflation series can be modelled as an Autoregressive Fractionally Integrated Moving Average Process with Generalised Autoregressive Conditionally Heteroskedastic (ARFIMA-GARCH) effects. See the appendix for a description of ARFIMA(p,d,q)-GARCH(P,Q).

3. A FRACTIONALLY INTEGRATED PROCESS FOR CARIBBEAN CPI INFLATION SERIES

The simplest discrete time long memory process is the fractionally integrated FI(d) process x_t which is defined by:

$$(1-L)^d X_t = \varepsilon_t \qquad (6)$$

for $0 < d < 1/2$, where L denotes the lag operator, and ε_t white noise. The autocorrelations of an $FI(d)$ process can be approximated by:-

$$p(j) \sim \left(\Gamma(1-d/\Gamma(d))\right) j^{2d-1} j \to \infty$$

which implies a hyperbolic and monotone decay in the autocorrelations, when $d \neq 0$. This stationary model reduces to the usual short memory ARMA model when $d = 0$. The $FI(d)$ process can be viewed as an extension of the ordinary integrated process *I(d)* with the parameter *d* being fractionized. An I(*d*) process is a non-stationary *AR(d)* process with *d* integer unit roots.

The *FI(d)* process was first proposed by Granger (1980, 1981), Granger and Joyeux (1980), and Hosking (1981). For its application to economic data, see, for example, Diebold and Rudebusch (1989,1991b), Sowell (1992a, 1992b), and Baillie, Chung and Tieslau (1995).

Several alternative estimation procedures, such as semi-parametric, approximate maximum likelihood estimation (MLE) and full MLE procedures, have been proposed by numerous authors to estimate the parameters of an ARFIMA process. Of special interest is the observation that maximum likelihood estimation can be used to estimate the parameter *d* of the stationary long memory process defined by equation 6 with $\varepsilon_t \sim N(0, \sigma^2)$.

Geweke and Porter-Hudak (1983) suggested a semi-parametric estimator that allowed *d* to be estimated from a regression of ordinates of the periodogram of x_t on a trignometric function. While this estimator is simple to apply and is potentially robust to non-normality, Agiakoglou, Newbold and Wohar (1992) have shown the estimator to be severely biased in the presence of strong autocorrelation in the ε_t process. For this reason, interest has shifted towards maximum likelihood estimation.

Fox and Taqqu (1986) and Chung and Baillie (1993) propose approximate MLE under normality. While Fox and Taqqu (1986) considered a frequency domain approximate MLE based on numerically minimising a weighted sum of the periodogram of x_t, Chung and Baillie (1993) considered a time domain approximate MLE based on minimizing a conditional sum of squares (CSS) derived from a more general process than that given in equation 6. Diebold and Rudebusch (1991a) have applied the Fox and Taqqu estimator and they report that the estimator performs well. Some results concerning the small sample performance of the CSS estimator are reported in Chung and Baillie (1993). The CSS estimator performs well when estimating ARFIMA (p, d, q) models with p and q being 0,1 or 2; $-1/2 < d < 1/2$ and for samples greater than 100. For samples under 100, the CSS estimator can produce substantial biases.

Haslett and Raferty (1989) and Sowell (1992b) proposed full MLE procedures. Sowell (1992b) derived the full MLE for the ARFIMA (p, d, q) process with normally distributed disturbances. Under normality, the log-likelihood is given as :-

$$L(\mu, d, \phi, \theta, \sigma^2) = (T/2)\log(2\pi) - (1/2)\log|\Sigma| - (1/2)(x_T - \mu)' \Sigma^{-1}(x_T - \mu) \quad (7)$$

where $\sum$ is the $T \times T$ variance-co-variance matrix of the process, x_T , and its elements are non-linear functions of hypergeometric functions. The parameter estimates are obtained by maximising this function with respect to the unknown parameters of the model. While this full MLE procedure does not suffer from mis-specification bias inherent in approximate MLE procedures, it is nevertheless computationally demanding, since at every iteration of the likelihood, it requires the inversion of a T-dimensional variance-co-variance matrix. It is for this reason that consideration was given to the prediction error decomposition procedure of Haslett and Raferty (1989).

The estimate of the parameter of the process, defined by equation 6, was based on the the full MLE provided by Haslett and Raftery (1989). This is the estimation method provided in S-PLUS data analysis software. The S-PLUS function *arima, fracdiff* estimates the parameters of a given fractionally differenced ARFIMA (*p, d, q*) model and returns exact or approximate maximum likelihood estimators, standard errors, the covariance and correlation matrices of the parameter estimates and the log-likelihood. By noticing that the *FI (d)* model is the ARFIMA(*0,d,0*), the S-PLUS function arima, fracdiff was used to estimate *d* on the assumption that the density of the error process in equation 6 is normal. The log-likelihood for the model is computed exactly using the prediction error decomposition (see, Harvey (1981)) given by equation 8 below:-

$$-2\log L(x_1,\cdots,x_T) = T\log\left(2\pi\sigma^2\right) + \sum_{t=1}^{T}\log f_t + \sum_{t=1}^{T} e_t^2/\sigma^2 f_t \qquad (8)$$

where $L(x_1,\ldots,x_T)$ denotes the likelihood; σ^2 is the variance of the innovation process, ε_t; $\sigma^2 f_t$ is the conditional variance of $\hat{x}_t^{t-1}$; the conditional mean one-step-ahead prediction of x_t based on data $x_1,\ldots,x_{t-1}$; $e_t = x_t - \hat{x}_t^{t-1}$ $(t = 1,\ldots,T)$ is the prediction error and T is the sample size.

Table 2 reports the estimated values of d for the different countries. For all three countries, the estimated values are below 0.5 and significantly different from zero. In all cases, the estimated standard errors are very tight. These results imply covariance stationarity of the inflation process. Interestingly enough, the estimated value of d for Trinidad and Tobago is considerably smaller than the values of the other two countries.[5] These results are in support of the PP and KPSS tests that suggest that inflation is I(0) and are interesting for several reasons. First, they suggest tht greater care should be undertaken when specifying the stochastic process generating infaltion. This is relevant when the issue at hand is investigating the existence of common stochastic trends among relevant economic variables in the Caribbean Community (CARICOM). Second, although a formal statistical test was not performed, the nature of inflation in Barbados and Jamaica appears significantly different statistically from that in Trinidad and Tobago when judged by the sizes of the estimated values of *d*. One can conjecture that the difference is statistically significant.[6]

Under this scenario the above result suggests that policies designed to fight inflation in Trinidad and Tobago might not be appropriate in Barbados and Jamaica. In effect, this result appears not to support the view of a need for a common regional monetary policy to combat inflation.

TABLE 2
MAXIMUM LIKELIHOOD ESTIMATES OF FRACTIONAL INTEGRATION PARAMETERS FOR INFLATION SERIES IN SELECTED CARIBBEAN COUNTRIES, 1970.1-1993.12

Inflation Series	Barbados	Jamaica	Trinidad and Tobago
d estimates	0.20**	0.47**	0.06**
Standard Errors	0.00	0.00	0.00
Log-Likelihood	-437.22	-481.03	-406.74

Note: Programming was done using S-PLUS and the matrix programming language GAUSS.

4. CONCLUSION

The question of unit root non-stationarity in inflation data for selected Caribbean countries has been considered in earlier studies. These papers have failed to find any strong evidence against the null hypothesis of difference stationarity. Using monthly data from January 1970 to December 1993 and relatively new time series tools, this study re-examined the evidence that the inflation process in Barbados, Jamaica, and Trinidad and Tobago is non-stationary. The KPSS test which takes stationarity as the null was utilised to examine whether the variance of the random walk component was zero. In addition, estimates of the fractional parameter were computed using the exact MLE procedure of Haslett and Rafferty (1989). The results of our investigation differ significantly from the findings of previous studies. For the countries the results are unambiguous and suggest stationarity of the data. One implication of the results in this paper is that less emphasis should be placed on the agenda of a common regional monetary policy since the structure of inflation is different across the three islands under investigation.

APPENDIX

A more general model that can be applied to modelling the inflation process is the ARFIMA(p,d,q)-GARCH(P,Q) process and is defined by:

$$\rho(\mathrm{L})(1-\mathrm{L})^{d}(x_t - \mu - b'y_{1t} - \delta\sigma_t) = \theta(\mathrm{L})\varepsilon_t \tag{A.1}$$

$$\varepsilon_t \mid \Omega_{t-1} \sim D\left(0,\sigma_t^2\right) \tag{A.2}$$

$$\beta(L)\sigma_t^2 = w + \alpha(L)\varepsilon_t^2 + \gamma' y_{2t} \tag{A.3}$$

where $x_i = 100\Delta \log \mathrm{CPI}$, and CPI inflation, y_{1t} and y_{2t} are vectors of pre-determined variables, μ is the mean of the process,

$$\rho(L) = 1 - \rho_1 L -,\ldots,-\rho_p L^p; \theta(L) = 1 + \theta_1 +,\ldots,+\theta_q L^q;$$

$$\beta(L) = 1 - \beta_1 L -,\cdots,\beta_P L^P; \alpha(L) = 1 - \alpha_1 L -,\cdots,\alpha_P L^P;$$

and all the roots of $\rho(L)$, $\theta(L)$, $\beta(L)$ and $\alpha(L)$ lie outside the unit circle. Under the restriction that $\delta = 0$ and $b = 0$, equations (A.1) and (A.2) describe the Autoregressive-Fractionally Integrated Moving Average (ARFIMA) process introduced by Granger (1980, 1981) and Granger and Joyeux (1980). Under the condition $\delta \neq 0$, the model is extended to allow volatility to influence mean inflation. The errors ε_t are assumed to follow a conditional density D, which could be either Normal of Student's t and the time-dependent heteroskedasticity, σ_t^2 follows the Generalised Autoregressive Conditionally Heteroskedastic, (GARCH(P,Q)) model of Engle (1982) and Bollerslev (1986). Lagged inflation is allowed to possibly enter the conditional variance, equation (A.3), through its inclusion into y_{2t}.

ENDNOTES

1. I am grateful to Hyginus Leon, Shelton Nicholls and the participants at the XXVI Annual Conference of the Regional Programme of Monetary Studies, Kingston, Jamaica, for helpful comments.

2. I do note, however, that some of the tests have involved data based on different frequencies and seasonal unit roots. In the empirical tests, reported in this paper, I restrict attention to the more common unit root tests mainly because they are widely reported in studies of inflation series.

3. It is important to note that other windowing methods such as that by Parzen are possible.

4. The consumer prices indices were obtained from the International Monetary Fund (International Financial Statistics). The choice of sample period is arbitrary.

5. This is indeed surprising in view of the earlier observation that the autocorrelation patterns in the inflation series for Barbados and Jamaica suggest stationary processes and those of Trinidad and Tobago suggest border-line stationary process. It may be the case that a more general long memory process is warranted.

6. This and other related issues are the subject of another paper.

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PART — 3

MODELLING THE MONETARY AND FINANCIAL SECTOR

AN ITERATIVE FRAMEWORK FOR ANALYSING THE INTRODUCTION OF MONEY AND CAPITAL MARKETS IN LESS DEVELOPED COUNTRIES (LDCs)

Peter Blair Henry

This paper proposes an iterative procedure for analysing the development of money and capital markets as a means of accelerating economic growth. Money and capital markets may augment investment by decreasing the cost of capital, but they should not be treated as a panacea for stagnant investment activity; there are a number of variables other than the lending rate that affect investment. For given target rates of capital formation and growth, policies should focus on creating a sanguine investment climate and establishing efficient domestic money and capital markets before allowing foreigners free access.

INTRODUCTION AND OVERVIEW

The debt crisis of the 1980s focused attention on developing countries and their sources, or lack thereof, of external finance. The 1990s has seen the advent of a new round of capital flows from the industrialised world to the less developed countries. However, the recent flow of capital has been of a much different composition than the 1970s spate of financing which preceded the subsequent crisis. Whereas the decade of the 1970s saw a stream of loans from large commercial banks, the new round of financing has a much higher content of portfolio equity, bonds and foreign direct investment. As emerging markets continue to attract attention, developing countries are seeking to modernise their financial sectors in an effort to take advantage of the continuing demand by investors in the developed world, for new and profitable sources of investment. Decisions on these matters will have far reaching implications for the development process.

Much of the debate on financial liberalisation has used the sequencing literature (see Dornbusch (1983), Edwards (1984) and (1987), McKinnon (1991) as a basis for analysis). While the sequencing literature provides a useful frame of reference for discussions concerning money and capital market development in LDCs, it has potentially damaging implications for small developing economies if it is used as a basis for macro-financial policy. Applying a sequential approach to the development of money and capital markets would lead the policy-maker in a developing country to first stabilise the domestic macroeconomy and then, on grounds of efficiency, to open money and capital markets— immediately allowing foreign investors full access to the domestic economy. While the first part of the prescription is wise, the latter does not necessarily constitute an optimal development strategy.

This paper analyzes the macroeconomic implications of introducing money and capital markets in developing countries as a means of promoting increased investment, and proposes an iterative decision-making procedure as an alternative to the sequencing approach. While money and capital markets may facilitate higher rates of investment by increasing overall savings, they will not perform their desired function in the absence of sound macroeconomic policy.

Furthermore, money and capital markets may promote investment by decreasing the cost of capital, but they should not be looked to as a panacea for stagnant investment. Great emphasis should be placed on macroeconomic fundamentals and other structural and institutional details that affect investment. For a given target rate of investment, policy options should seek to attain efficient domestic money and capital markets as a means of encouraging investment before allowing free access to foreign investors, because unstable international capital flows can undermine the development process.

Section 1 begins by outlining the benefits of introducing money and capital markets. Section 2 outlines a model of a small open economy considering the introduction of money and capital markets as a means of increasing real investment. Section 3 enumerates the macroeconomic pre-requisites for the effective introduction of money and capital markets. Section 4 discusses the order in which these markets should be introduced and develops a general approach for analyzing money and capital market development. Section 5 looks at the implications of money and capital market development for international capital flows, while some concluding remarks are presented in Section 6.

1. POTENTIAL BENEFITS OF ASSET MARKETS

1.1 The Cost of Capital

The introduction of money and capital markets can directly increase investment by augmenting the overall supply of savings and indirectly by creating competition for banks. Both the direct and indirect effect may lead to a lower cost of capital. Indeed the theoretical details of how money and capital markets lead to lower lending rates is explored in greater detail by McKinnon (1973) and Shaw (1973).

If investment is a driving factor in growth and investment is responsive to the interest rate, then lowering lending rates is one means of promoting economic development. Therefore, if the ultimate goal of economic policy is to achieve satisfactory growth and income distribution, the vital question the developing country policy-maker must ask when thinking about introducing money and capital markets is the following. Will development of money and capital markets increase the supply of capital and thus lead to a lower cost of capital?

Encouraging investment as a means of spurring economic growth requires a sound understanding of what drives investment activity. The fact that there are a number of variables other than the interest rate which affect investment, has crucial implications for the strategy of using capital and money markets as an engine of growth. Acting as though interest rates exclusively drive investment when there are a number of other variables involved, may lead to egregious policy conclusions.

To the myopic policy-maker stagnant investment may be viewed as an ailment requiring only lower lending rates. Let us for a moment suppose that interest rates are successfully lowered by opening domestic money and capital markets, but investment activity remains unsatisfactory. The policy-maker will think that investment is weak because lending rates are still too high, while in actuality, poor consumer confidence, a prohibitive tax regime, or credit rationing by banks may be the cause. Clearly, there are any number of institutional and macroeconomic factors other than the interest rate which could be hindering investment activity.

Nonetheless, the policy-maker concludes that lending rates are too high because there is an insufficient pool of savings in the economy. Therefore, he decides to internationalise money and capital markets while ignoring the possible structural obstacles to investment. Real investment activity may or may not increase as a result of foreign capital inflows. This will largely depend on the aforementioned institutional factors. Regardless of whether or not real investment activity grows, the economy is now increasingly exposed to the volatility of international capital flows. Admittedly, exposure to capital flows and the concomitant loss of policy autonomy are somewhat inevitable for any open economy, but the argument is not that small developing countries should pursue autarkic policies; the operative word is prudence.

While a small open economy must have a fairly liberalised capital account to facilitate trade, it is not clear that increasing the volume and variability of capital flows by opening domestic asset markets to international investors is necessarily a first-best development strategy. In fact, in the case that the pool of savings in the domestic economy prior to opening markets internationally was actually sufficient to fund a satisfactory level of investment activity, one has unnecessarily reduced policy autonomy.

Before increasing the exposure of the domestic economy to the potentially destabilizing forces of international capital flows, one needs to be reasonably certain that there is potential real investment in the economy that is not happening because of insufficient savings. It may, for example, be the case that sufficient domestic funds exist, but the channels necessary for transferring them to deficit units are not in place.

Alternatively, when both the funds and the channels are in place but investment is still sluggish, further lowering lending rates will have only marginal effects on investment activity. This was more or less the scenario in the United States during the early 1990s; interest rates fell substantially but credit markets were largely unresponsive. There is no need to open up financial markets internationally in this case. What is needed is not lower interest rates, but a better understanding of the macroeconomic variables that are contributing to a weak investment climate.

2. ANALYTICAL AND THEORETICAL FRAMEWORK

In this section, the outline of a model of a small developing economy considering the introduction of capital and money markets is presented. It is argued that within the context of such an economy, the basic macroeconomic prerequisites for the introduction of capital and money markets are fiscal soundness, price stability and a sound domestic financial system. It is illustrated that the introduction of money and capital markets in the absence of sound macroeconomic fundamentals leads to systemic instability in the macroeconomy. Having shown the importance of macroeconomic fundamentals, the implications of introducing money and capital markets from two perspectives are considered. First, the sequencing approach is reviewed and this is followed by a discussion of an alternative iterative decision-making procedure. Second, the two approaches are compared, and it is shown that the iterative procedure is a more suitable approach for analyzing macro-financial policy in small developing economies.

2.1 The Model

The economy exists for $t = 0,1,...,T$ periods. The economy begins with an initial endowment of capital and labor, K_0 and L_0 respectively. Output for a given period is determined by a production function that is homogeneous of degree one.

$$Y_t = F(K_t, L_t) \quad (1)$$

It is also assumed that a fraction of national income is saved each year.

$$\delta_t = \delta_t\,(r(D_t), A_t) \quad (2)$$

D_t is a vector of variables indexing the extent of financial deepening in the economy; A_t is a vector of variables indexing the available range of financial instruments and r is the domestic interest rate. Investment demand is given by

$$I_t = I_t\,(r(D_t), V_t) \quad (3)$$

where V_t is a vector of variables other than the interest rate which affect investment.

Capital accumulation can be funded through domestic savings, attracting foreign savings or both. The savings available for capital accumulation at time t is given by $S_t = S^h_t + S^f_t$. Using (1) and (2) we see that

$$S_t = \delta_t Y_t + S_t^f\left(r\left(D_t\right), r^*, A_t, V_t\right) \quad (4)$$

where the $S^{(i)}$ are home savings and foreign savings inflows respectively and r^* is the world interest rate. The labor supply is constant.

Given that national income is Y_0 *(at $t = 0$)*, the policy-maker's problem is to achieve optimal income level Y^* by time T using the available policy tools $P = \{A_t, V_t\}$. In addition, the following assumptions are made:-

1. The hypothetical country being considered is a small economy; changes in its macroeconomic conditions have

negligible spillover effects on the rest of the world.

2. The economy is open with respect to the trade of goods and services.

3. The economy has capital account restrictions and a fixed exchange rate.

4. The economy has no secondary markets for equity or money.

5. If domestic money and capital markets are introduced all capital restrictions remain unchanged and the exchange rate stays fixed.

6. If money and capital markets are opened externally, all capital restrictions are lifted and the exchange rate is allowed to float.

By a restricted capital account we mean that the government is able to exercise effective controls over the allocation and use of foreign exchange. That is, all foreign exchange sales and purchases must be cleared by the Central Bank, and purchases and sales for speculative purposes are not permitted. Furthermore, we make the heroic assumption that the Central Bank is able to police the use of these funds in such a way that no false invoicing or other deceptions take place. While there is ample evidence that capital controls have limited effectiveness, we make this assumption here only to isolate the effects of certain macroeconomic variables on the analysis. It is important to emphasise that the paper is not arguing for a closed capital account. Any open economy maintaining ties with world goods markets must maintain some degree of capital account openness.

Assumption 3 is made in order to disaggregate those capital movements that inevitably take place because of a fully open current account, and those that will occur if domestic asset markets are opened to international investors. Stating that the capital account is closed in the first instance ensures that capital movements which occur while domestic asset markets are closed to foreigners are due to real transactions. Therefore, when markets are opened internationally, one can safely assume that any additional capital movements are a result of financial transactions. Relaxing the capital account assumption only makes the analysis more complicated but does not change its primary thrust.

Thus, in our model the financial options initially available to a given agent in the economy are bank deposits and one-time purchases of shares offered by firms. Since there is no secondary market, these shares are quite illiquid. Keeping this simple framework in mind, the macroeconomic prerequisites for successful introduction of money and capital markets in this economy will now be outlined.

3. MACROECONOMIC PRE-REQUISITES

3.1 Fiscal Stability

The continual inability of a government to maintain a stable fiscal position is generally due to one, or a combination of two factors. A general lack of fiscal discipline - populist policies in pre-election years, corrupt use of funds or generally poor and inefficient planning - is one cause of persistent deficits. Another possibility is deficits that are induced by exogenous shocks to the economy - inclement weather conditions that result in poor harvests and decreased tax revenue, terms of trade shocks and the like. In these instances, especially in developing countries where the effects of reductions in legitimate social spending can be particularly acute, governments may be reluctant to curb spending and are therefore more likely to incur budget deficits. In either case, the deficit problem is unlikely to be self-correcting.

The introduction of money and capital markets in the face of fiscal imprudence can increase the likelihood of persistence of the deficit. Rather than finding ways of disciplining its spending to reduce the deficit with the introduction of new financial instruments, the government may simply choose to finance the deficit by issuing public debt (i.e. bonds and treasury bills). However, there is nothing inherently unsound about financing spending through the issuance of debt, assuming that the debt issue is sustainable.

Consider now the following scenario. The government introduces money and capital markets in the face of a considerable debt and capitalizing on the initial euphoria surrounding the new development, the government puts together a campaign promoting the sale of debt instruments by promising fiscal reform, renewed prosperity, etc. Given the initial level of investor excitement, the government is able to find takers for the entire amount of the debt.

If the government makes no fundamental change in its fiscal policy so that there is no visible demonstration to investors of the government's ability to meet its long-term payment obligations, as time unfolds, people will lose confidence in the government. Consequently, in order to get individuals to continue to hold the debt, the government will have to offer a higher rate of return. As more time elapses and the government still has not redeemed its ways, it will have to offer even higher rates. Clearly, such a policy is unsustainable. With increased arrears, and an inability to finance through the issuance of debt, the government may be inclined to use the inflation tax as a means of deficit reduction, but seigniorage will tend to reduce real balances.

By assumption, once our small open economy internationalises money and capital markets, it also completely liberalises all capital controls. Therefore, if the money and capital markets introduced are international, then agents will increasingly be able to escape the inflation tax by holding less domestic currency. As this occurs, in order to finance the deficit, the government will have to print money at an accelerating rate; this too is unsustainable since monetising the debt will eventually lead to hyperinflation. If money and capital markets are domestic, then agents will not be able to flee the tax via currency substitution. In this case, individuals will try to maintain the value of their earnings by increasing purchases of durable and consumption goods; the introduction of money and capital markets will not increase saving.

3.2 Price Stability

Stability of the price level is an essential prerequisite for the introduction of money and capital markets. Since we have assumed that our small open economy has a liberalised domestic price system, we do not address in this section the need to remove distortions to the pricing mechanism prior to opening capital and money markets.

If price instability defined as the situation where the amount by which domestic inflation exceeds world inflation is an increasing function of time, then the introduction of money and capital markets in the face of price instability will be destabilising. Given prices and the nominal exchange rate, suppose our country decides to introduce international money and capital markets in the face of domestic price instability. Since the domestic price level is increasing faster than the world price level, taking the nominal exchange rate as given, there will be secular appreciation of the real exchange rate. Without a policy change to bring domestic inflation in line with world inflation, there will be a tendency for the current account to deteriorate and the traded goods sector will be hurt by the loss in competitiveness.

Rectifying price instability once international capital and money markets have been introduced will be problematic. An attempt to squeeze out inflation through a monetary contraction will push up interest rates and tend to make domestic money instruments such as time deposits more attractive to foreign investors. As the demand for domestic currency rises- foreign investors need domestic currency to buy the instruments, the nominal exchange rate will tend to appreciate, thus worsening the real exchange rate predicament. There will be a further loss in competitiveness and the current account position will worsen as well.

One might argue that as long as foreign capital is flowing in to finance the current account deficit there is no problem. But, while such an argument may hold in the short-run, we will see in Section 6 that this strategy is dynamically infeasible. The scenario just outlined is not unlike what happened in the Southern Cone countries, particularly Chile, during their attempt at liberalisation during the 1970s and early 1980s (see Diaz-Alejandro (1985), The Economist (1993)).

3.3 Domestic Financial Stability

The domestic financial system is like the central nervous system of the economy. While it is important that goods markets be undistorted so that individual agents can make decisions that allocate resources in an efficient manner, financial markets apportion those funds which will allow agents to act upon their economic decisions. A distortion in one sector of the goods market may or may not affect other sectors, but a malfunctioning financial system necessarily permeates the entire goods market (see Stiglitz (1993) for a detailed argument).

Therefore, it is especially important that distortions not be present in the financial system and that investment decisions reflect the true cost of capital. Such reasoning might seem to imply that complete deregulation of the financial system is a desirable aim. This is not the case, however, as unbridled deregulation is potentially destabilising. In the face of deregulation and the introduction of more sophisticated money market instruments, domestic banks may be tempted to raise interest rates on deposits to imprudent levels in an attempt to woo depositors away from their competitors. With a completely liberal capital account this may attract foreign funds. Excessive capital inflows could have deleterious effects on the real exchange rate and the financial sector. Implications for the financial sector is discussed in the section of the paper that covers the order of liberalisation (see Edwards (1993), and World Bank (1993)). We turn now to the effects of foreign capital surges on the real exchange rate.

High interest rate differentials between domestic and foreign time deposits can generate arbitrage opportunities for foreign investors. Since domestic and foreign assets are not perfect substitutes, these arbitrage opportunities may persist and foreign funds will flow into the economy with resultant upward pressure on the nominal exchange rate. This will, taking prices as given, result in a real exchange rate appreciation with implications for the current account balance and the traded goods sector.

The issues surrounding capital flows are addressed later in the paper, but it should be noted that if growth in the real sector is desired, an import surge financed by foreign capital inflows is probably not an optimal strategy. An argument can be made that the real appreciation could be used as an opportunity to increase imports of capital equipment needed for production in the traded goods sector, but we will say more about this in Section 5.

4. THE ORDER OF INTRODUCTION OF MONEY AND CAPITAL MARKETS

Once the macroeconomy is stabilised, a number of important decisions regarding the order of introduction of money and capital markets must be made. Do we introduce money or capital markets first? How many and what types of instruments should be made available? Given that new financial instruments would be introduced in a stable domestic economy, is the current set of macroeconomic policies appropriate to the new environment? Should the new instruments be available to domestic residents only or should they be available to the international investor?

In answering all of these questions it is essential to keep in mind that the ultimate aim of developing money and capital markets is to increase growth by augmenting real investment. The order in which money and capital markets are introduced will have implications for growth, income distribution, the possibility for maturity of the institutional and legal framework, and, in the event that markets are opened internationally, the credibility of maintenance of an open capital account.

Before looking at these issues in detail, it will be helpful to review what the sequencing literature has to say about the order of liberalisation.

4.1 The Sequencing Literature

The sequencing literature (see Dornbusch (1983), Edwards (1984), McKinnon (1991)) is concerned with the order in which a "repressed" economy should be liberalised. By a repressed economy we mean one in which domestic and external goods and financial markets are not allowed to operate freely. The general conclusion from this literature is that liberalisation should proceed in the following order:

> First, remove distortions in domestic goods and capital markets, attain fiscal order, and remove dependence on inflationary finance.
>
> Second, forge links with the rest of the world by liberalising the current account before the capital account.

The key distinction between sectors in determining the order of sequencing is the basic assumption that goods markets clear slowly, while asset markets adjust quickly. Asset markets are more sensitive to future expectations; new information that alters expectations is reflected in asset prices much faster than in the prices of goods and services. Opening the current account first allows policy makers to observe the reaction of markets and correct any errors. Opening the capital account does not allow a grace period. Indeed, reactions to capital account opening will be quick and huge.

Opening the current account first is also desirable because it is easier and less costly to society to reverse wrong portfolio decisions than it is to do so in the case of real investment.

One should remove distortions in domestic commodity and financial markets, then open up the trade account so that real investment decisions can be made in a distortion free environment. Therefore, once the capital account is opened, capital flow will be more consistent with long run patterns of real investment (see Dornbusch (1983)).

The sequencing literature provides valuable insight into some of the issues concerning liberalisation, and is thus a useful departure point for posing the theoretical implications of introducing money and capital markets in our small open economy model. However, as will soon be argued, there is a fundamental aspect of the sequential approach that is patently flawed. This deficiency is corrected through the iterative procedure outlined below.

4.2 The Algorithm

The iterative approach to opening markets can be summarised as follows. Investment demand is a function of the lending rate and a vector of investment variables. If the current rate of investment is sufficient to generate the desired growth rate then nothing else needs to be done for the time being. If the rate of investment is insufficient for generating the desired growth rate then introduce measures to change the investment variables. If these measures are sufficient, do nothing; if not, develop domestic money and capital markets and see whether investment responds as desired. If domestic money and capital markets are sufficient to achieve a desired level of investment, then let the markets run and simply monitor and regulate as needed. If not, change the investment variables. Given that we now have a deeper financial system, these changes may lift the economy onto the desired growth path. If changing the investment variables is sufficient for generating the desired level of investment activity, then there is no need to open money and capital markets internationally. However, if the introduction of domestic money and capital markets along with other policy changes is still not sufficient to generate the desired rate of investment, then the policy-maker may consider opening domestic financial markets to the rest of the world.

Suppose the developing country policy-maker wants to achieve a target rate of investment. He should first establish sound macroeconomic fundamentals and then introduce domestic money and capital markets as a means of increasing the rate of investment. Opening money and capital markets internationally should only be considered as a policy option if the maximum investment rate attainable falls short of the target level.

4.3 Sequencing vs. Iteration

By taking a sequential approach to the subject of money and capital market development, one is implicitly led to the conclusion that external financial opening is necessarily desirable. The sequencing literature maintains that it is desirable at some stage to have a fully open capital account but that capital account opening should take place in proper order, that is, after an appropriate sequence of previous reforms.

Within the simple framework of sub-section 1.1, opening domestic money and capital markets would mean that the capital account is open only for the purposes of real transactions, while opening international money and capital markets would mean that the capital account is open for both real and financial transactions. Since we have already argued that domestic money and capital markets should be introduced only after the real and financial sectors of the economy have been stabilised, in the context of our model, a sequencing analysis would imply that money and capital markets should immediately be opened internationally.

The crucial flaw in the sequential logic is the failure to distinguish between "fundamental" and "speculative" capital account transactions. Fundamental capital transactions can be of two types: (i) transactions to finance real activity such as the exchange of goods and services; and (ii) transactions to finance the purchase and sale of assets due to changes in expectations of their profitability. Such changes in expectations may occur because of changes in monetary and fiscal policy, the state of technology and private real investment. By construction, all non-fundamental capital transactions are speculative. The magnitude of capital flows relative to the size of the economy being the relevant factor, an inordinate amount of speculation is not needed for the resulting capital flows to have harmful effects on a small developing economy. It is now clear why the model assumes that the capital account remains closed if money and capital market development is domestic only. Although the model does not distinguish between fundamental and speculative domestic financial transactions, this is a separate issue and, as will be argued later in the paper, financial speculation is not as vexing a problem if the resulting capital gains remain in the domestic economy.

The argument is not that small developing countries should have closed capital accounts, but because behaviour in financial markets tends to be more speculative then fundamental, it may be best to limit such behaviour by keeping markets closed to international investors. The primary purpose of introducing a stock market in developing countries should be to enhance real investment activity by lowering lending rates and providing firms and entrepreneurs with alternative sources of financing. While some speculation is inevitable, the volume of speculative activity will only increase if markets are opened internationally. If caution is not employed, stock markets in small developing countries could easily become financial playgrounds for international speculators. "Speculators do no harm as bubbles on a steady stream of enterprise. But the position is serious when enterprise becomes the bubble on a whirlpool of speculation" (Keynes (1936)). The sequencing approach says because external financial market liberalisation can increase volatility in the real economy it should be done last; the iterative procedure says external financial liberalisation may or may not be desirable for that very reason. This lacuna in the sequencing logic is the critical departure point between applying a sequential approach to the analysis of money and capital market development and using the iterative method.

Given that the ultimate goal of macro-financial policy is to create an environment that promotes robust and sustainable growth, ascertaining the role that new financial markets will play in fostering this growth and development is paramount. Specifically, it is questionable whether opening of money and capital markets to international investors necessarily constitutes an optimal strategy.

Like any other decision under uncertainty, external opening has potential pitfalls as well as benefits. Therefore, at any point in time the policy-maker must solve a dynamic programming problem, choosing the strategy that, conditional on current information, maximises expected future welfare. The control variables (recall the set-up in sub-section 2.1) available to the policy-maker at each point in time are essentially (i) keep financial markets closed to foreign investors and try to promote growth using domestic financial reforms (ii) open financial markets externally

(iii) some combination of (i) and (ii).

Assuming that once markets are opened externally they remain forever open, a salient issue arises. Choosing variables (ii) or (iii) reduces the policy-maker's autonomy by exposing the country to the volatility of bi-directional capital flows. Within the decision theoretic framework of this problem, one should only open externally if opening maximises expected future welfare from that moment onward.

This point is fundamental. The policy-maker holds an option: he may exercise the right to open financial markets externally or not. Since external opening has an irreversible cost — permanent exposure to unstable capital flows — there is value in waiting to exercise this option. The sequencing approach misses this critical point. Having argued that the inherent instability of international capital movements makes the iterative framework more appropriate than sequencing, the paper now turns to the topic of international capital flows.

5. INTERNATIONAL CAPITAL FLOWS

This section of the paper explores how speculative international capital flows can destabilise the domestic economy. This topic is analysed in two contexts, namely the introduction of an international stock market and the opening of money markets to foreign investors. By extending the simple open economy model developed earlier, it is shown how allowing international investors access to the domestic stock market can actually reduce the overall level of savings in the economy. Following this analysis is a discussion of the possibility of large and unsustainable capital inflows due to the introduction of international money markets.

As regards the market for equities, particular emphasis is placed on the distinction between speculative capital flows, and capital flows that are aimed at reaping the long-term benefits of investing in the domestic economy. It will emerge from the analysis that the potential for depletion of domestic savings by international investors depends crucially on asymmetric opportunities for speculation and the nature of the capital flows. This conclusion is closely linked with the need for macroeconomic stability. In general, the more unstable the macroeconomy, the more likely are capital flows to be speculative in nature and thus the greater the potential pitfalls for the domestic economy if money and capital markets are opened up internationally in the face of macroeconomic instability.

The economic rationale for the internationalisation of money and capital markets is simply a cross-border generalisation of the argument for domestic money and capital markets. Allowing capital to flow unrestricted from country to country allows investors to send funds to areas where the rates of return are highest. In its simplest form the argument can be presented as follows. For each country in the world, assume an aggregate production function $F(K,L)$ that is homogeneous of degree one. Let the world interest rate be r^*. Taking the state of technology as given, the efficient use of capital in the production process is characterised by the use of a quantity of capital such that the marginal product of capital evaluated at that level of capital and labor usage is equal to r^*.

Assuming that labor is immobile between countries, if the marginal product of capital evaluated at the current level of capital and labor employed is less than r^*, capital will tend to flow out of that country, and if the marginal product of capital is greater than r^*, capital will tend to flow in. Given that their level of capital employment is in general quite low relative to the rest of the world, opening their financial markets internationally will cause capital to flow into developing countries.

This line of analysis may be correct when international capital movements are generated by long-term investment opportunities, but the fact that the volume of international capital flows regularly outpaces the volume of international trade is evidence to the contrary (see Akyuz (1990)). It is not clear that international capital flows are in response to macroeconomic fundamentals. If capital flows are speculative in nature, then ascertaining their stability could prove to be quite difficult.

Speculation is by definition volatile and unpredictable; it is not always clear what drives speculative behaviour and in what direction it will be driven. It may be unclear as to why capital flows in and why it flows out if it is not driven by economic fundamentals. In this case it may be difficult and unadvisable to center long-term development strategies around investment funded by foreign capital.

5.1 Asymmetric Investment in International Equity Markets

We now recall the small open economy model from Section 2 and use it to analyse the potential pitfalls of opening equity markets to the international investor. A highly simplified partial equilibrium is employed to illustrate the main points. Imagine that the economy consists of three classes- capitalists, rentiers and workers. There is one firm that is owned entirely by the capitalist which produces both traded and non-traded goods through the use of domestic labor and capital equipment imported from abroad. The production process is defined by a standard Cobb-Douglas production function $F(K,L)$.

The rentier owns land which the capitalist rents so that he can operate his factory. The rentier also owns and operates a commercial bank which the capitalist uses to deposit his profits and borrow money to finance the purchase of new machinery from abroad.

The workers in the economy work for the capitalist who pays them a wage. They use part of their wage income for consumption and whatever they save, they deposit with the rentier.

As in the previous model, a government exists for the purpose of introducing policy changes, but in the present analysis, we assume the government does not tax, save, invest or consume.

Suppose the government wants to promote investment, and attempts to do so by establishing a primary and secondary domestic market for shares of the capitalist's firm. The government believes that the increased avenues for financing will encourage the firm to build up a greater capital stock. Before the introduction of capital markets, the capitalist had to finance all his investment activity by going to the rentier and getting loans. Now that he can sell equity in his firm, he has another financing option; the firm may now finance its activity by issuing shares on the primary market.

Let total domestic saving prior to introduction of the equity market be $150. After the introduction of the equity market, the rentier reduces his present consumption. Given the opportunity to own a portion of the means of production and lay claim to a fraction of the firm's future earnings, the rentier is willing to save an additional $100 out of his rental income. We assume here that the rentier continues to place the same amount of his rental income in his bank deposit.

Initially, the workers do not reduce their consumption. During the first period of analysis, the workers are unwilling to invest in the equity market because they are leery about using a fraction of their wages to directly help the capitalist finance his investment. They may be wary about giving their money to a new and unfamiliar source. Thus, even if equity investment has an extremely high expected rate of return relative to commercial bank deposits, in period one, the workers do not buy any shares.

Suppose the capitalist offers ten shares of his company for sale on the primary market in period one, and that for a price of \$10 per share the rentier is willing to buy all ten shares of stock. The price the rentier is willing to pay is based upon his expectation about both the future price of the company's stock and the value of its dividend stream, given that the company is going to use the \$100 primary issue to buy a new piece of machinery. We may summarise the rentier's expectations as follows. The rentier believes that in time the workers will follow his lead and reduce their consumption in order to purchase equity in a later period; once they understand the potential hazards and benefits of purchasing the firm's stock, the workers will want to enter the secondary market. Given that there is a fixed amount of stock, there will be excess demand for the shares at the time the workers decide they want to purchase equity. Thus, the price of equity will be bid up and the rentier will realise a capital gain on his investment. Furthermore, with an increase in the capital stock, the firm's output will rise and its profitability will increase. Higher profits may induce the firm to pay out greater dividends. The combination of expected future price and dividend increases is what convinces the rentier to purchase all of the primary issue.

There was no need for the government to open up the market to international investors in period one, because the firm's initial issue was fully subscribed. If the firm had been unable to fill the issue because of insufficient domestic demand then a case might have been made that foreign investors were needed to help fund real domestic investment. However, one can imagine a scenario where the government gives foreigners access to the market because of political pressure from abroad or cajoling by international financial institutions, or, the government might believe that demand for domestic stocks by international investors will give their developing economy a much needed boost. While it is true that a buoyant stock market can still be propped up by an inflow of foreign capital which may in turn boost the economy in the short run, we will see, by way of a simple numerical example, that this may not constitute a sustainable development strategy.

Suppose the government opens the stock market internationally in period two and that the total demand by foreign investors is five shares. Since there are only ten shares available, at the current price there will be excess demand for the stock. The rentier will require a higher price than $10 a share to relinquish 5 shares of his stock. If the foreign investor bids up the price to $15 per share, the rentier subsequently sells him five shares and then places the $75 into his bank account; the domestic economy has attracted $75 of foreign savings. Thus, as a result of capital market introduction, domestic savings has increased to $175 - the $100 that was initially spent by the rentier on the primary offering plus the $75 spent on shares by the foreigner.

The potential danger in this scenario is that with the opening of an international equity market there is no guarantee that the capital which flows into the country will stay. Thus the $75 inflow may be available to fund investment ex-ante, but it may disappear ex-post, because the foreign capital is free to leave at any time. In fact, speculation may do more than just withdraw the quantity of money which came into the country; it may actually reduce domestic savings.

Suppose that in period three, workers are aware of the occurrences in the equity market and get over their mistrust of the system so that they now demand to hold shares of the company. Assuming that there is no new issue, when workers demand to hold shares in the company, there is excess demand and the price of equity must rise. Suppose demand is sufficient to boost the price of equity to $40 per share, and that at this price workers demand a total of 5 shares. The foreign investor is willing to sell five shares, and the rentier continues to hold his five shares. The foreign investor receives $200 of revenue which we assume he withdraws from the economy and takes home.

Thus the foreign investor effectively induces $200 worth of domestic dis-saving that more than offsets the initial $175 increase in savings brought about by introducing an equity market. The net result of introducing an international equity market has been to draw down domestic savings by $25. Although some of the dis-saving induced by the speculator will be tempered by the increase in profits and wages so that the net effect on domestic savings may be ambiguous, the potential danger to the economy is clear. Although the firm was able to carry out its initial investment plan since the original $100 of savings from the rentier went toward this end, there may be less savings in the economy to help fund future real investment than there was at the outset. Looking only for a quick return, the foreign investor pulled his money out as soon as there was the possibility of a capital gain; the result is a possible net outflow of savings. While the capital gain need not be so large that the outflow of capital to foreign speculators completely erodes any gain in savings due to the introduction of money and capital markets, any capital gain on the part of foreigners that is completely withdrawn will reduce domestic savings.

It is important to realise that the potential depletion of domestic savings by foreign investors is not limited to speculation in the secondary market for stocks. A common argument for opening equity markets to international investors is that developing markets are thin. There is not sufficient domestic demand for a stock market to be a viable means for companies to finance their investment activities. If markets were opened internationally, this would increase liquidity.

While this may be true, one can imagine a slight alteration in the previous scenario where the market is open to foreign investors from the outset, and initially the only demand for equity is from the foreign investor. In this case the entire purchase of new machinery by the firm would be financed by the foreign investor. If at some future date domestic residents desire to hold the stock and bid up the price so that foreign investors sell all ten shares to domestic residents, then if the foreigners withdraw the capital gains, effective domestic dis-saving will again have been induced. The initial inflow of foreign capital will have successfully financed the firm's activity, but the subsequent capital outflow reduces the amount of potential investment ex-post.

The question of sustainable development inevitably comes to mind. What is desired in developing countries is not simply a one-time burst in investment and growth. The goal of policy-makers is to achieve a higher but stable path of investment and growth. If international capital flows place the economy on a higher investment path today, but tomorrow render it on a lower path than it was on to begin with, then financing growth with foreign capital may not be optimal, especially if international capital is not really needed to finance investment.

The two implicit assumptions that drive this story are the asymmetry of investment flows (that is the fact that capital gains made by foreign speculators in the home economy are not tempered by capital gains made by domestic speculators abroad), and the speculative nature of the foreign capital inflow. First we address the asymmetry of the financial investment and follow it with a discussion of speculative capital flows.

Whenever foreign investors withdraw their original investment funds and capital gains, there is no reciprocal inflow to buffer the effects of foreign profit-taking in the domestic market. There is a unilateral movement of capital away from the home economy. As long as there is asymmetry in the holdings of equity, the possibility of massive outflows exists. The likelihood of such an asymmetry existing is high in the developing country context.

In a small LDC, the potential pool of resources for investment in foreign equities markets will surely be smaller than the potential pool of foreign resources for investment in the domestic equities market. Furthermore, there are institutional rigidities - a general lack of awareness as to how equity markets function and thus a reluctance to invest in them, and high information costs and limited funds that would make it difficult to invest abroad.

In the scenario we sketched, the decision by the foreign investor to exit the domestic equity market was not motivated by a change in expectations concerning the company's future profitability. The decision to exit was merely speculative; the investor was not interested in the prospects for healthy long-term returns. He merely capitalised on the euphoric investment climate and got out, drawing down domestic savings in the process. The lesson to be learned from this story is not that development strategies should avoid foreign capital entirely. Had the investor held on to his domestic stocks or deposited his money in a domestic bank, then the funds would have been available as a future source of investment funding. The emphasis here is on caution.

Similar reasoning applies in the case where the foreign investor is the only purchaser of primary equity and then sells some or all of his shares in the secondary market. If the investor repatriates his earnings that are deposited at domestic financial institutions, then the economy has in fact benefited twofold. In addition to financing the firm's investment outlay the foreign investor is also helping to fund future investment.

The fundamental point emerging from the analysis is that the stability of foreign equity investment is crucial. If foreign investors simply engage in "short-term financial round-trip excursions" (Tobin (1978), then it may be sensible to make stock markets available to domestic residents only. On the other hand, if it can be ascertained that investors are coming for long-term earnings considerations, then foreign capital may be a valuable source of investment funding. Of course, the complication lies in the fact that foreign equity investment does not come with a label marked "real" or "speculative." Therefore, in practice it may be quite difficult to surmise the nature of foreign interest in the domestic stock market.

While it is difficult to determine whether capital flows are real or speculative in nature, it is fairly clear that unsound macroeconomic policy will increase the amount and volatility of both types. In the first instance, unsound policies will increase the volatility of real flows because policies which undermine the fundamentals of the economy (such as price stability, fiscal soundness and domestic financial stability) will, as a rule, change expectations about the future profitability of firms. In the event of imprudent macroeconomic policy, investments that were previously promising may no longer be feasible, and capital that came for long-term purposes may leave because the real investment opportunities that were previously present have been eroded. Furthermore, macroeconomic instability opens up a host of opportunities for speculators. Having examined international equity issues, we now turn to the topic of external monetary instruments.

5.2 Money Markets and Capital Flows

In the event that money markets are opened internationally, proper regulation of the domestic banking system will become vitally important. Imprudently high rates will generate massive and unsustainable capital inflows as investors try to capitalise on arbitrage opportunities. This was largely the Southern Cone countries' experience during the mid and late 1970s. The unsustainability of speculative capital flows is due to moral hazard adverse selection and exchange rate difficulties (see Stiglitz and Weiss (1981) and Diaz-Alejandro (1985) for detailed discussions of these issues). The focus here is on exchange rate difficulties.

If interest rate differentials between domestic and foreign money instruments are sufficiently large, the economy may attract a large inflow of foreign funds. Taking the foreign and domestic price level as fixed, this spate of capital will induce real appreciation. What should a government do in the face of such capital inflows? One possibility is to use both the inflow of funds and the favorable exchange rate position to finance investment in the traded goods sector. If capital goods are needed to enhance the production of traded goods, as is likely to be the case in many LDCs, then the favourable exchange rate position will make the purchase of capital goods from the developed world relatively less expensive. The climate could be quite favourable for capital investment in the traded goods sector. But, as always, there are a couple of caveats. The exchange rate will not go on appreciating forever and there is no guarantee that borrowers will use the newly available funds and favourable exchange rate position to invest.

Consider the following informal argument for why investment cannot be funded forever in this manner. Presumably, capitalists in the traded goods sector increase investment in capital goods so that they can boost production. A desire to increase production on the part of suppliers requires an expectation of the ability to sell the additional output at some point in the future (even inventory is accumulated with the expectation that it will one day be sold). As these capitalists deal in traded goods, a major source of the demand for their goods is the foreign market, and an appreciating real exchange rate will tend to reduce their ability to sell traded goods. Capitalists will only invest heavily in future production if they expect that at some point the exchange rate will depreciate, thus increasing the quantity demanded of their traded goods.

Thus, either the exchange rate is expected to appreciate continuously, in which case entrepreneurs will not invest, or, capitalists in the traded goods sector import machinery to augment production of future output which they expect they will be able to sell when the exchange rate begins to depreciate. These outcomes are mutually exclusive and the probability of the latter is much higher than that of the first. When a large enough quantity of people expect that a depreciation will take place, the currency will in fact depreciate. Depositors will withdraw their money from domestic banks, domestic savings will fall and new means of financing investment will have to be found.

Besides the fact that investment in the traded goods sector cannot be continuously funded by capital flows generated by speculation on interest rate differentials and exchange rate movements, there is an additional problem. Economic actors may not use the favourable liquidity and exchange rate position to invest in the traded goods sector. An equally strong argument can be made that individuals will use the opportunity to increase imports.

If, instead of using the flood of foreign capital to invest in productive activity, agents simply increase consumption, the current account will deteriorate. While there might be a positive short run effect on aggregate demand for non-tradeables, which could stimulate investment in the non-traded goods sector, a surge in consumption financed by foreign capital inflows will not in general enhance domestic economic growth. The foreign-financed consumption boom can not last forever.

Banks will have to make interest payments on their newly acquired deposits which means that borrowers will have to repay their loans. Repayment of loans requires that borrowers either find some source of income that allows them to meet payments on their loans (which may not happen if the consumption boom does not spur any new productive activity), or, they will require new loans to meet their debt obligations. It is not possible to continually satisfy arrears by incurring new debt; this Ponzi-type scheme is unsustainable. In the present context, depositors will come to realise that banks are making questionable loans and will demand their money. As deposits dwindle, so will the source of new loans. Borrowers will begin to default and the stability of the domestic financial system will be threatened.

6. CONCLUSION

Increased capital formation is fundamental to generating higher growth rates, but increased investment cannot take place without increased savings. If the rate of investment is to increase, then either domestic savings must increase or foreign savings must be attracted. The evidence seems to indicate that financial deepening is to some extent an engine of economic growth, so that increasing the level of financial intermediation may be an important first step in increasing the savings rate of developing countries. However, a legitimate concern of developing country policy-makers is that income may simply not be high enough to accommodate higher saving rates or, even with increased saving, income may not be sufficient to generate a substantial level of savings.

Thus, the development of money and capital markets can in theory play a significant role in the development process. In addition to then appeal as a means of increasing domestic saving, money and capital markets are ostensibly promising as a potential means of attracting foreign capital. Using foreign portfolio funds to finance investment is a more appealing way of augmenting domestic savings than relying on loans from foreign banks. In many ways, portfolio financing of development is much more tractable since payments to equity holders will be correlated with economic performance.

However, much care needs to be taken in using finance as a leading variable in development. Looking to money and capital markets as a potential engine of growth requires careful analysis and prudent policy. Equity markets require particularly close attention. Firms must use stock markets as a significant source of financing if they are to play a major role in promoting development.

If the issuing of primary shares is a relatively infrequent phenomenon and the market is mainly used for a secondary instruments, while this may serve the risk-return needs of agents in the economy, it is not clear that a stock market in this case will be particularly helpful in promoting growth. For example, a great deal of financial deepening took place in the so-called high performing Asian economies between 1970 and 1990. However, with the exception of Korea and Taiwan, China, stock markets played a relatively small role in the mobilisation of capital (World Bank (1993). Therefore, in looking to use the market for equities as a means of increasing investment, continued attention needs to be focused on real versus purely financial activity. Furthermore, foreign portfolio investment may be unstable and therefore an unreliable source of investment financing.

All of this discussion presupposes that there is incentive for firms and entrepreneurs to engage in capital formation. Increasing domestic savings and or attracting foreign savings will be of little use in augmenting growth if the funds are not used to finance investment. If regulations are obstructive, tax regimes oppressive, or political climates volatile, then there can be little hope that increased saving will translate into higher investment rates. In an inimical environment investment will remain stagnant; the funds, which are available for increased capital formation ex-ante, will simply be allocated for consumer loans ex-post.

If bank liabilities increase in an environment where firms and entrepreneurs are reluctant to invest, the result will simply be an inter-temporal re-distribution of consumption, from savers to borrowers (as opposed to from savers to investors).

Furthermore, if foreign funds are only used to finance consumption and there is no significant increase in investment (and hence output), then the net result will be a future deterioration in the balance of payments.

Instituting money and capital markets can play a fundamental role in economic development but further work needs to be done on the process of implementation. While the sequencing literature on economic reforms provides a useful starting point for discussion, it is problematic. The sequencing approach to introducing money and capital markets is not well suited to small, developing countries that are particularly vulnerable to unstable capital flows. An iterative approach to opening markets is better from a theoretical and a practical standpoint. Iteration is preferable to sequencing because it highlights the need to be continually aware of the danger of exposing a small developing economy to speculative capital flows and the fact that investment is a function of both the level of financial intermediation in the economy and the general investment climate. Ignoring the non-financial variables which affect investment could lead developing countries to prematurely and unnecessarily open asset markets to the rest of the world.

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TOWARDS A FRAMEWORK FOR RESERVES POOLING IN CARICOM[1]

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ABSTRACT

This paper examines the case for reserves pooling in CARICOM using insights from the theoretical work of Dodsworth (1975) and Ben-Bassat *et al* (1992). The paper employs a coverage statistic to demonstrate the beneficial impact of pooling under various configurations. The analysis demonstrates that a strategy of pooling can confer benefits on the member states of CARICOM provided that it is pursued in the correct institutional setting. Such a setting needs to ensure that operational rules are devised to eliminate situations of moral hazard or other forms of abuse of the reserve fund.

INTRODUCTION

The CARICOM Heads of Government have recently agreed on a two-tiered approach to monetary union. This approach sets the stage for the evolution of a Caribbean Monetary Authority (CMA) with power to issue a common currency.[2] Concrete monetary union in CARICOM, however, not only involves the creation of a CMA and common currency but must consider, in addition, the management of the reserves which are at the disposal of the CMA.[3] On this latter score, the report of the Central Bank Governors (1992) is particularly silent. The issue of a reserve fund for CARICOM is, however, not an entirely new idea and was given some active consideration in the decade of the 1970s by Thomas (1973), the World Bank (1975), Worrell (1976a,b), Bennett (1979, 1982) and Dodsworth (1978). No concerted follow-up was made since one member state of CARICOM (Trinidad and Tobago) amassed a large quantity of reserves (on account of a hike in oil prices), and was able to advance loans and provide aid to less fortunate members, obviating the reserve constraint of other member states.

By the mid-1980s, however, the situation changed drastically as commodity prices collapsed, exposing the fragile base of Caribbean economies. The pooling of reserves is a key strategy which, had it been adopted, may have provided Caribbean member states with a source of funds to continue with their developmental objectives.

This paper provides the rationale for an examination of foreign exchange pooling as a viable strategy in the advancement of Caribbean integration and in the promotion of exchange rate stability. The pooling of reserves, however, raises several important questions. First, why should reserves be pooled in CARICOM? Second, how much reserves should be contributed to a common pool? Third, who should be in charge of managing the reserves of the pool? The ensuing sections of this paper attempt to shed some light on these critical matters. Section 1 essentially deals with the question of why reserves should be pooled in CARICOM and explores the benefits and costs which can result from pooling. The theoretical rationales for and against reserves pooling are presented, drawing from contributions of Dodsworth (1975, 1978), Landell-Mills (1989) and Ben-Bassat *et al* (1992). Section 2 discusses the question of how much reserves should be contributed to a CARICOM pool and examines the benefits which accrue to member states under varying pooling configurations. Section 3 examines the institutional framework which is needed if a strategy based on pooling is to confer benefits to the member states of CARICOM.

1. RESERVES POOLING - RATIONALE AND THEORY

1.1 Benefits and Costs of Reserves Pooling

The reserves of a country in a broad sense, consist of its official holdings of gold and the convertible currency of other states. The International Monetary Fund (IMF) defines reserves as "the resources that are available to the monetary authorities for the purpose of meeting balance of payments deficits". This definition, includes Special Drawing Rights (SDRs) and the reserve position in the Fund. Jager (1979) however, questioned the inclusion of the latter arguing that they fail to satisfy the very definition of reserves. In this paper, the IMF definition will be utilised although a greater weight will be placed on the convertible currency of other states.[4] The pooling of reserves refers simply to the amalgamation of the reserve holdings of a set of co-operating entities.

Countries hold reserves for reasons that arise out of their economic circumstances and policy priorities. These circumstances and priorities include imbalances of a financial, cyclical and seasonal nature; intervention in exchange markets; the smoothing of current consumption and the provision of a buffer to cushion the economy against future exigencies (Landell-Mills (1989)). The opportunity to pool reserves under the umbrella of a monetary union can confer several benefits on the member states of CARICOM. First, by belonging to a reserve pool, each member state can buy itself unconditional access to the reserves of other member states during times of need (Medhora (1992a, b)). Second, pooling may afford member states the possibility of a reduction in their reserve variability thereby granting them protection against unforeseen variations in the volume of and/or prices of their major hard currency earners. This issue, incidentally, is only truly beneficial if the variability in reserves of the entire pool is smaller than the variability in the reserves of the individual member countries. Third, reserve pooling allows an increase in the bargaining strength of individual member countries especially as regards negotiations with multilateral institutions like the IMF and World Bank. Typically in such negotiations, developing countries with limited reserves are forced into a weak bargaining position. Fourth, the existence of a strong regional reserve fund can give a position of strength to regional currencies by lessening the risk of frequent exchange rate depreciations. This leads in the final analysis to fuller convertibility of the respective member currencies. Finally, reserve pooling also confers indirect benefits by fostering an environment in which member states can pool knowledge, information and exchange technology. This can cultivate a better understanding of differences and serve to enhance co-operative efforts between member states (Wadhva (1969)).

It would, of course, be inadequate to focus only on the perceived benefits of pooling since contributing to a regional reserve fund also carries with it certain inherent costs. These opportunity costs involve the loss of income which results if the reserves were deployed in alternative uses. For countries in the Caribbean, reserves have several alternative uses. For a start, they can be monetised and utilised by individual member governments to finance infra-structural development and investment in the economy. Alternatively, they can be utilised for debt repayment or, in the case of excess reserves, invested on the international market in short-term, liquid instruments.

Several well-meaning skeptics in the Caribbean suggest that the pooling of reserves is an uninteresting proposition since arrangements with similar effects (e.g clearing-houses) have been attempted with limited overall success. It is useful to point out, though, that the clearing house arrangement which was undertaken in CARICOM (i.e the CARICOM Multilateral Clearing Facility (CMCF)) occurred in the context of a pseudo-exchange rate union which delivered no fixed commitment on the part of participating members, to discipline defaulters. However, a reserves pooling arrangement under the umbrella of an independent monetary authority with well-defined operational rules can bring benefits to the member countries of CARICOM.

1.2 Theory of Reserves Pooling

1.2.1 The Dodsworth Model applied to CARICOM

In order to analyse the possible contribution of reserves pooling to economic integration, this section draws on the framework of Dodsworth (1975, 1978) and Dodsworth and Diamond (1980). This framework is in actuality a modification of the theory of Clubs developed earlier by Buchanan (1965) and Ng (1965).

The model of Dodsworth assumes that members of a regional group are faced in each time period t with a choice regarding the financing of payments. Payments, D_t, can either be financed from current receipts, C_t, if $D_t < C_t$, or from a reserve pool, R, if $D_t > C_t$. The size of the reserve fund reflects the dispersion of D_t above C_t as well as a risk factor, W, which is the probability that illiquidity will arise after a number of time periods, n.

$$W = Pr\left[\sum_{t=1}^{n} D_t > \left(\sum_{t=1}^{n} C_t + R\right)\right] \qquad (1)$$

If the time horizon, n, is arbitrarily fixed at unity, then a trade off curve, reflecting the distribution of payments, D_t, around receipts, C_t, may be drawn between reserves held and the risk factor, W. These payments reflect, for CARICOM countries, recurrent fiscal expenditure especially on principal and debt payments. Receipts are derived primarily from exportation of one or two major products (e.g oil, bauxite and alumina).

Several interesting and relevant conclusions can be gleaned from an analysis of the Dodsworth model. First, benefits from the reserve pooling arrangement depend not only on reserve economies but also on the differences in the preferences (risk aversion) of member countries. The larger the differences in desired risk factors in a situation of pooling, the more inferior will the pooled state be to the unpooled state. Second, the savings in reserves will be affected by the choice of the common risk factor. If a conservative scheme is adopted that requires no member state's risk factor to be increased, then the reserve saving element will be reduced and, if there are wide differences between factors, may even be negative. This situation is more likely if a wide divergence in risk adversity is combined with greater correlation between member's usage patterns (i.e similarity in seasonal and cyclical reserve behaviour). Third, the size of the reserve saving will be affected by the cost-sharing scheme. Cost sharing schemes should be inclined towards requiring the more risk averse members of the group to contribute more than a proportionate share to the common fund.

The Dodsworth model provides a useful reference frame for analyzing reserve pooling in CARICOM but has some inherent limitations. The analysis focuses almost exclusively on the variability of payments and the risk of illiquidity. These are, however, not the only factors which affect the demand for reserves in the member states of CARICOM although they do play a significant role.[5] Furthermore, the Dodsworth model implicitly assumes that future deficits/surpluses of member states will be unaffected by the existence of the regional reserve pool. This may introduce a problem of moral hazard in which some member countries who are granted unlimited access to the reserve fund adopt a profligate approach in their spending patterns. This signals the need for operating rules which employ some credit rationing devices to force likely "abusers" to exercise a more disciplined stance in their foreign and domestic expenditure decisions. The following sections utilise insights from the Dodsworth model and the work of Medhora (1992a,b) to explore the case for reserves pooling in CARICOM.

2. RESERVES POOLING AND THE RISK OF ILLIQUIDITY

2.1 Potential for Reserves Pooling in CARICOM

The pooling of reserves offers member states in CARICOM the potential to derive two sources of gains. The first of these is access to increased reserve holdings while the second is a possible reduction in reserve variability. Dodsworth (1978) and Medhora (1992a,b) have adopted a notion of coverage which incorporates these two sources of gain. This concept of coverage is defined as the ratio of reserve holdings to their variability. For a single country, coverage in a situation without pooling is :-

$$C_i^u = \frac{R_i}{Varb(R_i)} = \frac{R_i}{\sigma} \tag{2}$$

where R_i is the reserve holdings in a member state and Varb(R_i) is the variability of reserves proxied by the standard deviation of reserves. Suppose that the N member states of CARICOM decide to pool a proportion of their reserves by establishing a reserves fund. Let R_i ($i=1$ *to* N) be random variables which represent foreign exchange earnings of the various member states. R_i is assumed to have mean, μ_i and variance, σ^2_i. The reserve fund, R^p_N, can be expressed as a linear combination of the R_is as follows:-

$$R^p_N = \sum_{i=1}^{N} \phi_i R_i \tag{3}$$

where ϕ_i $(0<\phi_i<1)$, $i= 1,2....N$, are parameters which denote the proportion of reserves that will be committed to the fund by each member state. The mean of the reserve fund can be written as follows:-[6]

$$\mu^p_N = E\left[\sum_{i=1}^{N} \phi_i R_i\right] = \sum_{i=1}^{N} \phi_i E(R_i) = \sum_{i=1}^{N} \phi_i \mu_i \tag{4}$$

The variance of the pool can be written as

$$\sigma^{2p}_N = \sum_{i=1}^{N} \phi_i^2 \sigma_i^2 + 2\sum_i \sum_j \phi_i \phi_j \rho_{ij} \sigma_i \sigma_j \tag{5}$$

while the standard deviation of the pool of reserves is:-

$$\sigma^p_N = \sqrt{\sum_{i=1}^{N} \phi_i^2 \sigma_i^2 + 2\sum_i \sum_j \phi_i \phi_j \rho_{ij} \sigma_i \sigma_j} \tag{6}$$

where

$$\rho_{ij} = \frac{Cov(R_i, R_j)}{\sigma_i \sigma_j} \tag{7}$$

If the R_is are mutually independent so that the Cov $(R_i, R_j)=0$, $(i \neq j)$, the standard deviation of the reserve fund is simply

$\sqrt{\Sigma\phi_i^2\sigma_i^2}$. In any given period the coverage that is available to a member state of CARICOM under partial reserve pooling can be defined as follows:-

$$C_i^p = \frac{\phi_i R_i + (1-\phi_i) R_i + \sum_{j(i\neq j)} \phi_j R_j}{Varb\left[\phi_i R_i + (1-\phi_i) R_i + \sum_{j(i\neq j)} \phi_j R_j\right]} \tag{8}$$

The numerator in the above expression represents the reserves which each member state has at its disposal. This consists of the contribution to the reserve pool, $\phi_i R_i$, plus reserves in hand, $(1-\phi_i)R_i$, plus the sum of the contributions of the remaining member states, $\Sigma\phi_j R_j$. The formulation in equation 8 reduces to the following expression:-

$$C_i^p = \frac{R_i + \sum_{j(i\neq j)} \phi_j R_j}{Varb\left[R_i + \sum_{j(i\neq j)} \phi_j R_j\right]} \tag{9}$$

If reserve pooling is to afford any gains to member states then $C^p_i > C^u_i$. The necessary conditions for this to occur are (1) $\{\Sigma\phi_j R_j\} > 0.0$ and (2) $Varb[R_i+\Sigma\phi_j R_j] < Varb[R_i]$. Coverage under reserve pooling, therefore, will be higher than that in the autonomous state if the variability of the pool is lower than the variability of the reserves of each member state separately, or if increased access to reserves outweighs the higher variability of the pool. It should be emphasised at this juncture that in this formulation each country has unrestricted access to the resources of the pool.[7] As a result, the drawing of reserves from the pool by any single member country will reduce the coverage that any other member of the pool will have at its disposal.

The pattern of reserve holdings and their variability in each member state of CARICOM is indicated in Table 1. The first

TABLE 1
MEAN RESERVES HOLDINGS AND VARIABILITY IN CARICOM

	MEAN US$	STD. DEV	COEFVAR
1975 -1991			
ANTIGUA & BARBUDA	16.17	9.76	0.605
BARBADOS	93.86	42.44	0.452
BAHAMAS	114.42	52.83	0.462
BELIZE	22.40	20.79	0.928
DOMINICA	6.99	5.91	0.845
GRENADA	13.43	5.40	0.402
GUYANA	25.34	33.42	1.319
JAMAICA	100.61	44.20	0.439
ST. KITTS & NEVIS	7.18	5.22	0.727
ST. LUCIA	17.83	14.78	0.829
ST. VINCENT & THE GRENADINES	12.96	8.42	0.650
TRINIDAD AND TOBAGO	1241.02	1009.15	0.813
AVERAGE	**139.35**	**104.36**	**0.71**
1975-1985			
ANTIGUA & BARBUDA	9.54	3.66	0.384
BARBADOS	78.71	43.51	0.553
BAHAMAS	87.33	41.90	0.480
BELIZE	9.00	3.29	0.366
DOMINICA	3.31	2.70	0.816
GRENADA	10.39	3.74	0.360
GUYANA	22.40	26.63	1.189
JAMAICA	82.82	39.74	0.480
ST. KITTS & NEVIS	3.79	1.54	0.406
ST. LUCIA	7.87	2.82	0.358
ST. VINCENT & THE GRENADINES	7.32	3.39	0.463
TRINIDAD AND TOBAGO	1777.26	850.44	0.479
AVERAGE	**174.98**	**85.28**	**0.53**
1986-1991			
ANTIGUA & BARBUDA	28.33	2.28	0.080
BARBADOS	121.62	23.46	0.193
BAHAMAS	164.10	29.05	0.177
BELIZE	46.97	15.53	0.331
DOMINICA	13.74	3.54	0.258
GRENADA	19.01	2.78	0.146
GUYANA	30.73	45.86	1.492
JAMAICA	133.32	33.47	0.251
ST. KITTS & NEVIS	13.39	3.23	0.241
ST. LUCIA	36.09	8.10	0.224
ST. VINCENT & THE GRENADINES	23.29	2.40	0.103
TRINIDAD AND TOBAGO	257.90	140.95	0.547
AVERAGE	**74.03**	**25.89**	**0.34**

column displays average reserve holdings of each member state while the second and third columns display the standard deviation of reserve holdings and the coefficient of variations, respectively. This coefficient is a statistical measure of the degree of variability of reserve holdings. The variations in reserves are analysed for the sub-periods, 1975-1985 and 1986-1991 and the overall period, 1975-1991. For the overall period, 1975-1991, the results indicate wide dispersion in the mean reserve holdings of the various member states. For instance, the mean reserve holdings of Trinidad and Tobago were almost three times that of the combined earnings of the other member states. Moreover, the coefficient of variation reveals that Guyana, Belize, Dominica, St. Lucia and Trinidad and Tobago had comparatively higher levels of variability than the other member states of CARICOM over the period 1975-1991. When the data is disaggregated into sub-periods an interesting contrast emerges in respect of reserve variability. Reserve holdings displayed much greater variability in the first sub-period than in the second for most countries of CARICOM with the exception of Trinidad and Tobago and Guyana.

Coverage ratios for the members states of CARICOM were calculated based on the expressions for C^p_i and C^u_i and are reported in Table 2. The first column displays the coverage ratios (C^u_i) that each member state would have enjoyed had it not belonged to the reserve pool. The remaining columns show coverage ratios under varying pooling configurations. During the first subperiod, 1975-1985, Antigua and Barbuda, Belize, Grenada and St. Lucia would have enjoyed lower coverage under pooling than they would have experienced autonomously. These results demonstrate that even increased access to pooled reserves would have been insufficient to compensate these countries for accepting the higher variability of other countries in the pool. However, the majority of countries would have experienced

TABLE 2
COVERAGE RATIOS UNDER VARYING POOLING CONFIGURATIONS IN CARICOM

	COVERAGE (no pool)	COVERAGE 10%	COVERAGE 50%	COVERAGE 70%
1975-1991				
ANTIGUA & BARBUDA	1.65315	2.14396	1.87923	1.86115
BARBADOS	2.16567	2.69552	1.96163	1.89686
BAHAMAS	2.21116	3.33074	2.02441	1.92299
BELIZE	1.07778	2.28213	1.89517	1.86797
DOMINICA	1.18470	1.97073	1.86125	1.85348
GRENADA	2.48650	2.01030	1.86575	1.85541
GUYANA	0.75813	2.17011	1.89278	1.86719
JAMAICA	2.27616	3.01879	1.99020	1.90870
ST. KITTS & NEVIS	1.37500	1.97564	1.86169	1.85367
ST. LUCIA	1.20581	2.19606	1.88514	1.86368
ST. VINCENT & THE GRENADINES	1.53922	2.07805	1.87257	1.85831
TRINIDAD AND TOBAGO	1.22976	1.28699	1.52635	1.65208
1975-1985				
ANTIGUA & BARBUDA	2.60931	2.58876	2.47690	2.46888
BARBADOS	1.80932	2.66188	2.50776	2.48298
BAHAMAS	2.08401	3.04090	2.55608	2.50363
BELIZE	2.73235	2.52025	2.46944	2.46569
DOMINICA	1.22902	2.47567	2.46439	2.46352
GRENADA	2.77795	2.51143	2.46849	2.46528
GUYANA	0.84114	2.99938	2.52594	2.48990
JAMAICA	2.08384	3.02998	2.55200	2.50179
ST. KITTS & NEVIS	2.45873	2.50184	2.46723	2.46473
ST. LUCIA	2.79168	2.53540	2.47096	2.46634
ST. VINCENT & THE GRENADINES	2.19574	2.54091	2.47169	2.46665
TRINIDAD AND TOBAGO	2.08981	2.12898	2.28186	2.35572
1986-1991				
ANTIGUA & BARBUDA	12.41822	6.45008	5.43949	5.36142
BARBADOS	5.18335	10.51115	6.45238	5.78765
BAHAMAS	5.64908	7.68914	6.21088	5.71502
BELIZE	3.02462	4.85877	5.30273	5.30612
DOMINICA	3.88354	5.72658	5.36043	5.32758
GRENADA	6.83166	7.07524	5.48356	5.37954
GUYANA	0.67010	2.22744	4.68294	5.03708
JAMAICA	3.98000	5.93055	5.92252	5.59872
ST. KITTS& NEVIS	4.03050	5.34635	5.31183	5.30658
ST. LUCIA	4.45630	5.42168	5.33823	5.31878
ST. VINCENT & THE GRENADINES	9.69400	5.99693	5.38792	5.33929
TRINIDAD AND TOBAGO	1.82975	2.24221	3.74522	4.40933

higher ratios if reserves were pooled than if they were left under autonomous control. For the second sub-period, 1986-1991, despite the fact that reserve holdings of most member states displayed relatively little variability, there were still gains to be made from pooling on account of the increased access to additional reserves. Only two countries - Antigua and Barbuda and St. Lucia - displayed coverage ratios under pooling that were lower than in the unpooled state. For the entire period 1975-1991, all countries with the exception of Grenada would have benefited from a reserve pooling scheme. In examining coverage ratios under pooling an attempt was also made to discern the extent to which coverage ratios differed under a full pooling arrangement than under a partial pooling scheme. The results, based on the pooling formula utilised, indicate that a full pool delivers lower reserves gains and coverage for the majority of countries than a partial pooling arrangement. This is not to suggest, however, that a full pool is not beneficial since it does afford countries the potential to realise increased coverage.

To understand the beneficial impact of pooling one need only ascertain the level of reserves each country would have had to hold in an autonomous state to enjoy the level of coverage afforded by pooling reserves. Following Medhora (1992a), this level of reserves can be computed as follows:-

$$R_i^* = C_i^p \, Varb(R_i) \qquad (10)$$

R^*_i is the hypothetical level of reserves that each member state would have to hold to enjoy the pooled level of coverage, C^p_i. Table 3 presents reserve savings computed if a 10% partial pooling scheme had been adopted in CARICOM. In the sub-period, 1975-1985, the reserve gain, as a percentage of unpooled reserves, ranges from 1.87% in Trinidad and Tobago to 256% in Guyana. The large percentage gain figure for Guyana is not surprising since this country had, throughout the period, a very low level of reserves coupled with the highest level of own-reserve

TABLE 3
MEAN RESERVES HOLDINGS AND VARIABILITY IN CARICOM

	MEAN ACTRES. US$MN	POTRES US$MN	GAIN/LOSS US$MN
1975 -1991			
ANTIGUA & BARBUDA	16.17	20.97	4.80
BARBADOS	93.86	114.40	20.54
BAHAMAS	114.42	175.96	61.54
BELIZE	22.40	47.45	25.05
DOMINICA	6.99	11.65	4.66
GRENADA	13.43	10.86	-2.57
GUYANA	25.34	72.53	47.19
JAMAICA	100.61	133.43	32.82
ST. KITTS & NEVIS	7.18	10.31	3.13
ST. LUCIA	17.83	32.46	14.63
ST. VINCENT & THE GRENADINES	12.96	17.50	4.54
TRINIDAD AND TOBAGO	1241.02	1298.77	57.75
1975-1985			
ANTIGUA & BARBUDA	9.54	9.47	-0.07
BARBADOS	78.71	115.82	37.11
BAHAMAS	87.33	127.41	40.08
BELIZE	9.00	8.29	-0.71
DOMINICA	3.31	6.68	3.37
GRENADA	10.39	9.39	-1.00
GUYANA	22.40	79.87	57.47
JAMAICA	82.82	120.41	37.59
ST. KITTS & NEVIS	3.79	3.85	0.06
ST. LUCIA	7.87	7.15	-0.72
ST. VINCENT & THE GRENADINES	7.32	8.61	1.29
TRINIDAD AND TOBAGO	1777.26	1810.57	33.31
1986-1991			
ANTIGUA &BARBUDA	28.33	14.71	-13.62
BARBADOS	121.62	246.59	124.97
BAHAMAS	164.10	223.37	59.27
BELIZE	46.97	75.46	28.49
DOMINICA	13.74	20.27	6.53
GRENADA	19.01	19.67	0.66
GUYANA	30.73	102.15	71.42
JAMAICA	133.32	198.50	65.28
ST. KITTS & NEVIS	13.39	17.27	3.88
ST. LUCIA	36.09	43.92	7.83
ST. VINCENT & THE GRENADINES	23.29	14.39	-8.90
TRINIDAD AND TOBAGO	257.90	316.04	58.14

variability among the member states. Belonging to the pool therefore would have conferred on Guyana the double benefit of increased access to reserves plus a lower level of variability. Dominica, like Guyana, would also have experienced a large gain (101.9%) while Barbados and the Bahamas would have experienced relatively moderate gains of 47.15% and 45.90%, respectively. Trinidad and Tobago and St. Kitts and Nevis would have gained the least from the partial pooling arrangement. In respect of the losses from pooling, these are relatively small ranging from -0.68% in Antigua and Barbuda to 9.6% in Grenada. A similar pattern (i.e. of large gains and small losses) emerges when the entire period 1975-1991 is considered except that only one country, Grenada, experiences a relatively large loss from pooling.

Two important points emerge from the pooling analysis presented above. First, countries that are likely to gain the most are those which display relatively low levels of own reserves availability coupled with high levels of variability. Second, pooling will not deliver equal reserve gains to all the member states: there is likely to be some asymmetry in the distribution of gains but most countries in CARICOM will derive benefits.

2.2 Risk of Illiquidity

An evaluation of risk is critical to the success of a reserves pooling strategy in CARICOM since recent experiences have indicated that large payment imbalances are more than likely to be continuing features of these economies. There is, consequently, a strong likelihood that claims on the reserve pool can be frequent and substantial for the more depressed economies which are unable to access funds from the multilateral institutions. It is useful, therefore, to attempt an evaluation of the risk of illiquidity for various member territories.

Consider, therefore, a reserve pool in CARICOM which is comprised of some proportion of the foreign exchange earnings of the individual member states of CARICOM. The risk of illiquidity of the pool or the probability that the payment deficits of countries will exhaust the holdings of the pool can be expressed as follows:

$$\Pr\left[\tilde{D}_i > R_N^p\right] = \int_{R_N^p}^{\infty} p\left(\tilde{D}_i\right) d\left(\tilde{D}_i\right) \tag{11}$$

where $\tilde{D}_i$ - payment deficit of country i

R_N^p - reserve holding of the pool

or for all member states collectively as :-

$$\Pr\left[D_N^p > R_N^p\right] = \int_{R_N^p}^{\infty} p(D_N^p) d(D_N^p) \tag{12}$$

where D_N^p ~ payment deficits of all members

where $D_N^p = \sum\left(\tilde{D}_i - C_i\right)$, $p\left(D_N^p\right), p\left(\tilde{D}_i\right)$ are probability density functions and C_i represent current receipts. The calculation of the risk of illiquidity hinges, therefore, on appropriate specifications of the probability density functions. For instance, if $p\left(\tilde{D}_i\right)$ is Gaussian then

$$\Pr\left[\tilde{D}_i > R_N^p\right] = \int_{R_N^p}^{\infty} \frac{1}{\sigma\sqrt{(2\pi)}} e \frac{1}{2}\left(\frac{\tilde{D}_i - \mu}{\sigma}\right)^2 d\left(\tilde{D}_i\right) \tag{13}$$

or alternatively,

$$\Pr\left[\tilde{D}_i > R_N^p\right] = 1 - \Pr\left[\tilde{D}_i \leq R_N^p\right] \tag{14}$$

where

$$\Pr\left[\tilde{D}_i \leq R_N^p\right] = \int_{R_N^p}^{\infty} \frac{1}{\sigma\sqrt{(2\pi)}} e \frac{1}{2}\left(\frac{\tilde{D}_i - \mu}{\sigma}\right)^2 d\left(\tilde{D}_i\right) \tag{15}$$

A transformation to standard normal form can be utilised to enable computations of the risk of illiquidity for each member territory. Recourse to the Central Limit theorem would suggest for equation 15 the following inequality:-

$$Pr\left[\ \hat{D}_i \ \leq \ \hat{R}_N^p \right] = 1 - \alpha \tag{16}$$

where

$$\hat{D}_i = \frac{\tilde{D}_i - \mu_{\tilde{D}_i}}{\sigma_{\tilde{D}_i}}, \hat{R}_N^p = \frac{R_N^p - \mu_{R_N^p}}{\sigma_{R_N^p}} \tag{17}$$

$\mu_{\tilde{D}_i}$ - mean of $\tilde{D}_i$

$\mu_{R_N^p}$ - mean of R_N^p

This inequality indicates at a given probability level, the size of the reserve fund that the regional monetary authority must have on hand to meet the net deficit of each member state.

Thus the probability that each member state of CARICOM can make the pool insolvent can be calculated for given values of $\tilde{D}_i$ and $R^p{}_N$. Whereas the normal density may be an appropriate characterisation for the deficits of some member states in CARICOM, it may provide an inadequate representation for other members whose payment deficits exhibit more probability mass in the tails of the density function. For these countries, density functions which allow for longer tails and a greater degree of skewness may be more appropriate. The choice of an appropriate representation of the density must, however, involve an examination of the empirical moments of the main sources of payment imbalances which arise in the member states. Empirical moments utilising these data are reported in Table 4. A cursory look at the data indicates relatively small skewness coefficients for most of the member states of CARICOM with the exception of St. Kitts and

TABLE 4
EMPIRICAL MOMENTS FOR EXTERNAL DEBT DATA OF CARICOM MEMBER COUNTRIES

COUNTRY	MEAN	STD DEV.	SKEWNESS	KURTOSIS
BARBADOS	307.48	265.83	0.261	-1.703
BELIZE	72.66	57.41	0.136	-1.508
DOMINICA	32.48	31.62	0.696	-1.047
GRENADA	0.04	0.03	0.758	-0.633
GUYANA	975.71	648.51	0.190	-1.529
JAMAICA	2748.10	1403.52	0.222	-1.772
ST. KITTS & NEVIS	12.71	12.69	1.335	0.965
ST. LUCIA	22.52	24.39	1.214	0.269
ST. VINCENT & THE GRENADINES	0.03	0.05	3.563	14.424
TRINIDAD & TOBAGO	1052.25	818.81	0.259	-1.432

Nevis, St. Lucia and St. Vincent and the Grenadines. External payments outstanding for these countries display a greater degree of asymmetry with coefficients of 1.33, 1.21 and 3.56, respectively. The coefficients of kurtosis which give a measure peakedness of the data are relatively small for most countries with the exception of St. Vincent where the value of the kurtosis coefficient is 14.424, indicating a greater degree of leptokurtosis. Nevertheless, the empirical moments suggest that the normal distribution may be a relatively good approximation of risk for most of the CARICOM member states with the exception of St. Kitts, St. Lucia and St. Vincent and the Grenadines.

Table 5 presents results of the risk of illiquidity among the various member territories of CARICOM based on the standard normal form. In calculating these probabilities, it was assumed that R_N^P represents the total reserves of all CARICOM countries. Data on External Debt and Reserves

TABLE 5
RISK OF ILLIQUIDITY IN CARICOM
(NORMAL DISTRIBUTION)

COUNTRY	AVGPROB. (73-83)	AVGPROB. (84-91)	AVGPROB. (73-91)
BARBADOS	0.65670	0.93111	0.77224
BELIZE	0.68381	0.94183	0.79245
DOMINICA	0.62442	0.90905	0.74426
GRENADA	-	-	-
GUYANA	0.74164	0.96521	0.83577
JAMAICA	0.83043	0.98759	0.89660
ST. KITTS & NEVIS	0.60678	0.89744	0.72916
ST. LUCIA	0.59760	0.89104	0.72115
ST. VINCENT & THE GRENADINES	-	-	-
TRINIDAD & TOBAGO	0.69327	0.94620	0.79976

were converted to standard normal form and utilised to compute the probability expression in equation 15 for each year over the period 1971-1991. The risk of illiquidity was estimated by simply subtracting these probabilities from unity and averaging across various time periods. The results reveal marked differences in the risk of illiquidity between the various member states of CARICOM during different phases of the integration effort. If a pooling strategy were adopted in the first decade of the integration movement (1973-1983), then the risk of illiquidity would have been substantially higher for Jamaica and Guyana than for most of the other territories. These countries had estimated risk probabilities of 0.830 and 0.742 respectively, compared for instance to values of 0.597 and 0.657 for St. Lucia and Barbados, respectively.

For the period 1984-1991, the risk probabilities are much higher for all the member states while the deviation between the risk estimates is relatively minor. This is indicative of an increase in payment difficulties in all the member territories. The risk probabilities for the overall period 1973-1991 suggest that the larger territories with sizeable external debt pose a greater risk of making the reserve pool insolvent.

These member countries in any pooling arrangement may therefore be required to make proportionately larger reserve contributions to the regional fund.

3. INSTITUTIONAL STRUCTURE FOR RESERVES POOLING

The success of the strategy of pooling will depend critically on the environment under which it is adopted as well as on the rules and regulations which are crafted to govern its operation. In the context of CARICOM it is useful to discuss these considerations under the following headings:

1. Institutional Environment for Pooling;

2. Objectives and Functions of a Regional Monetary Authority; and

3. Operational Rules, Moral Hazard and political constraints of a Pooling Scheme.

3.1 Institutional Environment For Pooling.

The pooling of reserves needs to be undertaken in an environment in which there exists a definite commitment to closer co-ordination of exchange rate, fiscal and monetary policy. These conditions represent the rudiments of a monetary union. Such a union presumes that a Regional Monetary Authority (RMA) will be established to oversee the operations of the reserve pool. This authority should be headed by a board of directors which comprises the governors of the national central banks as well as finance ministers from the participating member territories. The composition of the board is important since it creates an atmosphere in which central bank governors and national governments can work towards the effective co-ordination of policies. It would also serve to partially diffuse some of the antagonisms which can arise between national finance ministers and their governors, since both parties would now have a stake in achieving common objectives. The board of directors should report to the CARICOM Secretariat and should be directly accountable to its Council of Ministers.[8]

Another matter to be decided relates to the method of voting among board members. The issue of weighted versus unweighted voting will have a significant impact on the decisions of the RMA. Depending on the absolute size of the contributions of member states to the pool some countries may wish to exercise a greater degree of influence on the decisions of the RMA. A system of 'one country, one vote' may be needed to ensure a more democratic stance to decision-making which can ultimately be decided by a simple majority voting rule.

To function effectively, the RMA must be an independent entity. It should therefore be reasonably insulated from the political directorate of the various member territories so that it can carry out its task without fear of reprisals. One former governor of the Central Bank of Barbados underscores this point by noting that too often Central Bank governors in the Caribbean and the developing world are confronted with difficult tradeoffs. They must either bow to political pressure or face the prospect of losing their jobs when they pursue a tight monetary policy stance which runs counter to the spending plans of their political bosses.

A major difficulty with the establishment of the RMA revolves around infrastructural provisions for its effective operation. The execution of its function would require administrative staff, equipment, offices and the like. Whereas this issue can only be adequately addressed in the medium term, a short-run solution would involve housing the RMA in one or more of the national central banks until provisions can be made for a permanent site. The financing of the RMA should be drawn from foreign exchange contributions of national central banks although the board of the RMA should be allowed to source funds from multilateral institutions to boost its resource base.

3.2 Objectives and Functions of the Regional Monetary Authority

The overall objectives and functions of the RMA will be dictated by the form of monetary integration being contemplated. In our analysis special emphasis was placed on the importance of the notion of reserves pooling. This is but one activity in a monetary union in which exchange rates bear a fixed relationship with each other and where the national central banks submit exchange rate and reserve management to the RMA. The RMA will therefore have as its broad mandate, (1) to lend assistance to member territories so that they could maintain the value of their respective currencies and (2) to assist members to undertake sound fiscal and monetary policy. To discharge this mandate, a number of specific functions may have to be undertaken. These are listed as follows:-

- *Collect reserve contributions from member territories.*
- *Allocate reserve credit to member states.*
- *Co-ordinate exchange rate and monetary policy.*
- *Manage the external debt of members.*
- *Design methods for fiscal harmonisation.*
- *Collate, analyse and present fiscal, monetary and exchange rate data on the member states.*

In respect of the broad objectives outlined, it will be necessary to ensure that appropriate boundary rules are laid so that no conflict of interest arises between the national central banks and their regional counterpart.

3.3 Moral Hazard, Operational Rules and Political Constraints of a Pooling Scheme

The elimination of situations of moral hazard is of paramount importance if the reserve pool is not to become illiquid. Moral hazard generally refers to situations in which the actions of a fully insured "party" cannot be effectively monitored by the insurer. Thus, a relaxation in "due care and attention" can occur on the part of the insured party after the insurance cover has been granted. In the context of the reserves pool in CARICOM, the fact that some countries are granted access to an additional source of funds may mean that individual member states experiencing payment deficit problems may not see the need to actively pursue corrective policies since they can expect an appropriate level of "insurance cover" from the pool. Indeed, the incentive to pursue "inappropriate inflationary type policies" or to draw down the pool during times of economic stress may rise since the member knows that belonging to the pool will cover some of the effects of its actions. The likely development of situations of moral hazard will depend on the extent to which the Regional Monetary Authority can effectively ensure that countries adopt policies which would moderate the size and frequency of claims on the reserve pool. If this problem is to be effectively addressed then the following policies[9] may have to be actively considered:-

1. The employment of rationing devices to prevent any single member from becoming a drain on the resources of the pool.

2. Imposition of an upper limit on credit extended to any of the given member states.

3. The granting of credit beyond certain prescribed limits on a discretionary basis, conditional on the adoption of sound fiscal and monetary policy in the member state.

4. The use of differential interest charges on varying levels of withdrawals from the pool.

5. Mandating member states to supply information relating to budget deficits, debt accumulation and reserves earnings on a timely basis.

If these suggestions are adopted, then a series of operational rules relating to contributions to the pool, credit allocations and penalties will need to be developed. In respect of contributions, a decision will have to be made on the percentage contribution that each member state should commit to the regional pool. In the hypothetical pooling scenario presented above, a range of possible pooling configurations was examined. The optimal contribution for each country is likely to depend on several factors including the level of reserves earned, existing foreign exchange commitments and the degree of reserve variability of the member state. The member states may therefore elect to contribute varying proportions of their foreign exchange earnings to the pool depending on their individual circumstances.

The allocation of credit by the RMA should be based on the joint needs of the member territories rather than on the single requirements of any individual member. This will ensure that no single country can continuously draw from the pool without gaining the approval of the other members. The RMA will also be required to impose a statutory limit on the level of credit that can be extended to any single member in a given year. In the event that a member country experiences a reserves crisis (i.e. its reserves fall below tolerable limits), the RMA should permit it to draw down its own holdings from the pool and may advance additional credit subject to strict repayment conditions.

The RMA will also need to devote resources to ensure that a body of enforceable penalties is established. These penalties should encompass terms for principal and interest repayments on outstanding debt as well as targets for the size of the trade and budget deficits in each member state. However, even if a body of such penalties is established, it is possible for several member states to experience major payments crises in the same time intervals which may force them to access the reserve fund almost simultaneously. A situation should only be deemed a crisis for the reserves pool if its holdings of reserves fall below a prescribed threshold and not when the reserves of any single member or group of members fall below a prescribed minimum. If the former circumstance develops, the regulations of the RMA should allow it to access additional funding from regional, bilateral, and/or multilateral lending institutions.

Several politico-economic considerations can, however, surface if such strict operating rules are devised to lessen situations of moral hazard. First, some of the more powerful member states of CARICOM may be unwilling to leave the determination of credit limits entirely to an independent Regional Monetary Authority. Indeed, given the existing pattern of debt accumulation in some of the weaker economies, the stronger and more powerful economies may wish to be in a position to lobby for rules to ensure that no large transfers of foreign exchange are made to the weaker members of the group. Second, there is no guarantee that member states will fully accept guidelines on expenditure reducing measures in order to qualify for additional credit from the pool. Third, the use of differential interest rates may convey the wrong signal to members - in particular, that the terms and conditions of their access to resources to the pool is dependent on their economic and political status.

Reserves pooling, therefore, by itself is unlikely to guarantee success. If the pooling scheme is part of a regional monetary union with the attendant institutional structures encompassing an independent Regional Monetary Authority and coordinated fiscal and monetary policy, then it may be easier for member states to accept the ground rules for the successful operation of a pooling arrangement.

CONCLUSION

This paper has sought to demonstrate that a strategy based on the pooling of reserves would have conferred benefits, primarily through reserve savings, to the individual economies of CARICOM. In particular, those members who enter the pooling arrangement with a relatively low supply of reserves and a high degree of reserve variability would tend to derive greater overall benefit. If the creation of a reserve pool for CARICOM is to provide long-term benefit to the region then greater effort should be devoted to setting up the right institutional environment for the pool to operate successfully. Indeed, the failure of the CARICOM Multilateral Clearing Facility (CMCF) was due, in part, to the absence of an appropriate institutional environment. Such an environment requires an institutional structure which encourages monetary and fiscal policy co-ordination as well as well-defined operational regulations for over-seeing the day to day management of the fund.

END NOTES

1 This paper is an excerpt from Chapter 7 of the author's Doctoral Thesis, (See Nicholls (1995)). I wish to thank Professors Victor Bulmer-Thomas, Chris Milner and Brian Hindley for incisive comments on the earlier drafts. Drs. Oli Haltia, Penelope Forde, Delisle Worrell and Professor Compton Bourne also made useful suggestions.

2. See Farrell and Worrell (1994) for a fuller exposition of these issues.

3. See Blackman (1981) and John and Forde (1995) for further discussions on reserves management.

4. In Caribbean economies, the United States (US) dollar is the major reserve currency.

5. Attempts have been made in other empirical studies to analyse the main determinants of the demand for reserves. (See Bahmani-Oskooee (1985) for a useful survey).

6 See Hogg and Craig (1978) and Hogg and Klugman (1983) for details on these derivations.

7. The equation for C^p_i represents a member's full access to the fund and assumes that no two countries can draw reserves from the pool simultaneously.

8. Ideally, this board should be democratically accountable to a regional parliament but such an institution involves closer political union, a matter which has not been placed squarely on the cards given the experience with the federation.

9. See Dodsworth and Diamond (1980) for further elaboration of some of these considerations.

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VOLATILITY PERSISTENCE ON JAMAICAN STOCK RETURNS

Hyginus Leon

ABSTRACT

This paper uses alternative univariate formulations of the GARCH process to model stock returns on the Jamaica Stock Exchange. The results show that the observed stock price returns are autocorrelated and negatively related to changes in the treasury bill rate, and the volatility of the returns is related to traded volume and absolute changes in the treasury bill rate. Further, a measure of volatility persistence is dependent on the model's specification.

Keywords: ECM-GARCH process; volatility persistence

INTRODUCTION

Stock markets in emerging economies play a vital role in constituting markets for the issue of new shares and facilitating the transfer of assets and the sale of state-owned enterprises. The International Finance Corporation (1993) states that, as a group, emerging stock markets had nearly tripled their share of world equity market capitalisation in 1992 from 2.5% to 7%, and provide attractive risk-adjusted returns. Trading volume increased twenty five times 1982 levels and listed companies account for 40 percent of the listed companies worldwide.

These emerging stock markets are typically characterised as fragmented and thin. They generally have high transactions costs (especially high minimum commissions) which tend to deter small investors and leave the market under the operation of a small number of large, dominant operators who can affect market prices substantially. Bourne (1988) argues that these markets tend "to exhibit stock price volatility, stock price manipulation and market inefficiency in that some investors have a systematic tendency to gain from stock price movements". Some of the net effects of market imperfections and inefficiencies include reduced mobilisation of small savings, the financing of low return investments and inadequate risk reduction through diversification.

An ability to predict variations in stock price movements would be important for valuation models which depend on some measure of risk or volatility (Chou (1988)), and for portfolio management (for example, hedging strategies (Baillie and Myers (1991)). Since Mandelbrot (1963) and Fama (1965), researchers have attempted to characterise the stochastic processes that may be consistent with the observations from developed equity markets that asset returns are approximately uncorrelated over time and exhibit volatility clustering. Researchers seeking to explain the observed leptokurtosis in returns have focussed on the appropriate specification of the distribution (stable, student-t, mixed normal - see Blattberg and Gonedes (1974) and Bookstaber and McDonald (1987)) characterising the stochastic properties of stock prices. A more recent development seeks to exploit non-linear dependence in stock returns. The ARCH model (Engle (1982)) and its GARCH generalisations (see Bollerslev (1986), Engle, Lilien, Robins (1987)) specify the temporal dependence of the conditional variance as a linear function of past squared errors; these models do not explain the non-linear dependence as a function of other explanatory variables. Despite the voluminous literature on ARCH models in finance, applications have focussed on developed equity markets (see Bollerslev *et al* (1992); also, Booth *et al* (1992) and Stenius (1991)).

This paper applies the GARCH modelling technique to explain the non-linear dependence in stock returns on a developing country's equity market. It extends the international evidence on the applicability of GARCH models, and complements earlier research investigating market efficiency on the Jamaican Stock Exchange (see Agbeyegbe (1994), Jackson (1986), Kitchen (1986), Koot *et al* (1989)). In addition, the paper provides an initial attempt at modelling the time-varying volatility of returns as a function of economic variables.

The results show that the GARCH technique, which recognises that both conditional means and variances may be time dependent, is capable of predicting stock return volatility on the Jamaica Stock Exchange. The data support the hypotheses that stock returns are correlated and that estimated volatility increased over the estimation period. In addition, the incorporation of the treasury bill rate and traded volume as explanatory variables in the mean return and variance functions helps reduce the estimated persistence of the standard GARCH model and improves predictive ability.

Section 1 provides a brief institutional perspective and the model structure is described in Section 2. The empirical results are discussed in Section 3, with conclusions and directions for further research following in Section 4.

1. INSTITUTIONAL OVERVIEW

The Jamaica Stock Exchange began trading on February 2, 1969. Traded securities include common shares, preference shares and corporate bonds. Trading is undertaken by broker-members. There are twelve brokerage houses qualified to conduct business through the Exchange. The number of listed companies has grown from 34 in 1969 to 50 at the end of 1993. The common stock index is a weighted index of shares listed on the Exchange based on closing prices and firm capitalisation. From a base of 100 in June 1969, the index rose to an all time high of 32,421.71 at the end of January 1993. The all time low of 35.84 was recorded in February 1978.

During the first two decades of stock market operations, the Jamaican economy experienced long periods of both declining and growing investment climates as the administrations' ideological stance shifted from predominantly socialist to predominantly private enterprise regimes. There was a prolonged decline in output growth, general economic uncertainty, high inflation, financial sector regulation and a series of economic stabilisation programs with the International Monetary Fund (see Bank of Jamaica (1985) and Sharpley (1984)). As a result, the market experienced periods of both large and small price changes.

At the end of 1993, the Jamaica Stock Exchange had a market capitalisation of J$41.9 billion. Total trading volume in 1993 was 567.45 million (value J$8.35 billion) compared with 395.61 million (value J$4.69 billion) in 1992. The stock index had plunged from a 1992 year-end high of 25,745 to 13,100, a 49 percent fall compared to the over two hundred percent increases in both 1991 and 1992, and market capitalisation declined 45.6 percent. In terms of greatest dollar gains, Jamaica had moved from the world's best performer in 1992 to a rank of 72nd in 1993. A cursory look at returns on the Jamaican stock market indicates substantial fluctuations throughout the history of the Exchange (see Figure 1).

2. MODEL SPECIFICATION

Let *DLR* be the rate of return on the market portfolio from time t-1 to t for an information set of past realisations up to t-

1. In a general model, the rate of return is modelled as a function of a vector of explanatory variables, X, and a disturbance term μ. The disturbance term is assumed to follow a moving average process, and the innovation, conditional on the information set, follows a specified distribution with variance specified as an augmented GARCH process (see Baillie and DeGennaro (1990).

$$\begin{aligned} DLR_t|\Phi_{t-1} &= g(X;\theta)+\mu_t \\ \mu_t &= \varepsilon_t - \textstyle\sum_{j=1}^{q}\gamma_j\varepsilon_{t-j} \\ \varepsilon_t|\Phi_{t-1} &\sim \Omega(0,h_t) \\ h_t &= f\left(\varepsilon_{t-j},h_{t-j}\right)+\xi' Z \end{aligned} \tag{1}$$

Typically, it is assumed that the mean process is linear and the disturbances are innovations which follow a normal distribution. *Z* is a vector of additional variables explaining the variance of the innovation process. Alternative formulations of *f*, the variance function, exist. Subset restrictions on the parameters of the general structure define special cases and ensure finite variance and stationarity. The above specification shows that critical components in the modelling process include the conditioning sets and the functional forms (*f* and *g*) of the variance and mean functions, and the distribution of the innovation process (see Pagan and Schwert(1990)).

The GARCH model hypothesises that the conditional variance can be modelled as a function of the unexpected returns prior to time *t*. Bollerslev (1986) defines the GARCH(*p*,*q*) process as:

$$h_t = \alpha_0 + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-i}^2 + \sum_{i=1}^{p}\beta_i h_{t-i} \tag{2}$$

where $\alpha_1,\cdots\alpha_q$, $\beta_1,\cdots\beta_p$, and α_0 are constant parameters. The model is well defined if the coefficients of the infinite autoregressive representation are all non-negative, and the roots of the moving average polynomial of squared innovations lie outside the unit circle. In the GARCH(*1,1*) model, the effect of a shock on volatility declines geometrically over time.

Nelson (1991) argues that returns may exhibit asymmetrical conditional variance behaviour in that positive and negative shocks generate an unequal impact on volatility (see also, Black (1976)). He proposed an exponential GARCH or EGARCH(*p,q*) model to capture that asymmetry:

$$\log(h_t) = \alpha_0 + \sum_{j=1}^{p} \beta_j \log(h_{t-j}) + \sum_{i=1}^{q} \omega_j \left(\gamma \frac{\varepsilon_{t-j}}{\sqrt{h_{t-j}}} + \alpha \left[\frac{|\varepsilon_{t-j}|}{\sqrt{h_{t-j}}} - E\left\{ \frac{|\varepsilon_{t-j}|}{\sqrt{h_{t-j}}} \right\} \right] \right) \quad (3)$$

where $\omega_j, \beta_j, \gamma$, and α are constant parameters. The terms in the equation ensure asymmetry through their coefficients. If a coefficient is negative, the variance increases (decreases) when the error innovation is negative (positive). Stationarity requires the roots of the autoregressive polynomial to lie outside the unit circle. Since information flows affect portfolio selection, different models of predictability of market volatility will have different implications for asset pricing or strategic decisions.

The above variance models are augmented to include the effects of both the treasury bill rate and traded volume on the variance of returns. Fischer (1981), Fama and Schwert (1977), Campbell (1987) and Glosten, Jagannathan and Runkle (1993) use nominal interest rates to predict future volatility. Since short-term rates incorporate inflation expectations, they could be good predictors of stock return volatility. Booth *et al* (1992) point out that observed distributional and dependency properties of stock returns can be caused either by a non-linear stochastic process or a mixture of independent distributions. Karpoff (1987) argues price changes are related to traded volume and that the relationship provides not only insight into the structure of financial markets but has implications with respect to discriminating between the stable Paretian and the mixture of distributions explanations of the observed distributional characteristics of speculative prices. The mixture of distributions hypothesis suggests that the conditional variance of returns is proportional to volume, with volume proxying for some notion of information flow (see also Ross (1989)). Lamoureux and Lastrapes (1992) found evidence that trading volume, as a proxy for a stochastic mixing variable, is a significant explanatory variable in the variance equation.

In this case, Peart (1994) has identified structural change (a potential mixing effect) as having occurred in the Jamaican financial sector from the mid-1980s. Financial reform from the mid-1980s accompanied the structural adjustment and macroeconomic (SAM) stabilisation programme initiated by the Government of Jamaica in the early 1980s. During that period, the Government raised the ceiling on Treasury bills from $0.5 bn in 1984 to $7.5 bn in 1993. Further, market participation increased significantly: mean traded volume in the post-1984 period increased to 14.7 million per month from 0.6 million in the pre-1984 period, and the standard deviation in the post-1984 period was 23.1 million compared to 1.0 million in the pre-1984 period.

For the mean process, two models are considered: the base model is a first-order autoregression in the stock returns, and an extended model hypothesises that stock returns follow an error correction process with a GARCH error strucutre (ECM-GARCH), reflecting interaction between the equity and treasury bill markets. Cutler, Poterba, Summers (1991) argue that short term rates are negatively correlated with excess returns on other assets, while Mills (1991) found evidence of interaction between equity prices and gilt yields in the UK. Peart (1994) states that the principal objectives of financial reform in Jamaica from the mid-1980s were "the separation of monetary and fiscal policies, elimination of distortions in the financial market, and the creation of a fiscal and institutional environment which would strengthen the capital market". He argues that the elimination of the secondary reserve ratio (consisting of treasury bills and local registered stock with maturities of 90 days or less) requirement facilitated an increased role for treasury bills as a deficit financing instrument. Treasury bills of different maturities became more widely available and rates were market determined, resulting in an expanded asset base and promoting a competitive interest rate structure.

In an attempt to capture the interaction between the treasury bill rate and equity prices, and between equity prices and traded volume, both the treasury bill rate and traded volume are incorporated in a unified framework that seeks to identify short-run dynamics, long-run tendencies and volatility behaviour. The treasury bill rate and volume are used as proxies for mixing variables in the variance function; in particular, the absolute value of changes in the treasury bill rate is used to indicate that volatility may be influenced by both positive and negative contemporaneous changes in the treasury bill rate. Given the open nature of the Jamaican economy, a more general model could incorporate international influences from world financial and commodity markets by focussing on the expected risk of financial distress, and on the effects of the structural adjustment in the latter part of the estimation period.

This study compares volatility predictions for four standard and four extended models, assuming a linear mean process and uncorrelated normally distributed disturbances. The variance models span non-linear, symmetric and asymmetric variance functions. Differences among the various models can be obtained by comparing their news impact curves. Engle and Ng (1993) define the relation between the lagged unexpected return and the conditional variance as the news impact curve since it measures how past news affect current volatility. The GARCH model is a quadratic function centred at $\varepsilon_{t-1}=0$. The EGARCH has its minimum at $\varepsilon_{t-1}=0$, and

TABLE 1
MEAN AND ALTERNATIVE GARCH PROCESSES (STANDARD MODELS) MEAN PROCESS

MEAN PROCESS

$$DLR_t = \theta_0 + \sum_{j=1}^{p} \theta_j DLR_{t-j} + \mu_t$$

GARCH(1,1)

$$h_t = \alpha_0 + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}$$

EGARCH(1,1)

$$-\log(h_t) = \alpha_0 + \beta \cdot \log(h_{t-1}) + \gamma \cdot \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \alpha\left[\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{2/\pi}\right]$$

VGARCH(1,1)

$$h_t = \omega + \beta h_{t-1} + \alpha\left(\varepsilon_{t-1}/\sqrt{h_{t-1}} + \gamma\right)^2$$

NLGARCH(1,1)

$$h_t = \omega + \beta h_{t-1} + \alpha(\varepsilon_{t-1} + \gamma \cdot \sqrt{h_{t-1}})^2$$

increases exponentially in both directions with good and bad news having differential impacts on volatility. Similarly, the nonlinear asymmetric GARCH model (NLGARCH) and the VGARCH model are symmetric about $\varepsilon_{t-1} = -\gamma \cdot \sqrt{h_{t-1}}$, with $\gamma > 0$ implying an axis of symmetry left of the origin. It is clear that predictions of volatility will be dependent on the model specification chosen. The models (see Table 1) are estimated by maximisation of the log likelihood function, using the Berndt, Hall, Hall and Hausman (1974) algorithm. For the sample period the likelihood function is given by:

$$L(\phi) = \sum_{t=1}^{T} l_t(\phi), \text{ where } l_t(\phi) = -0.5 \log h_t - 0.5 \varepsilon_t^2 h_t^{-1} \qquad (4)$$

3. EMPIRICAL RESULTS

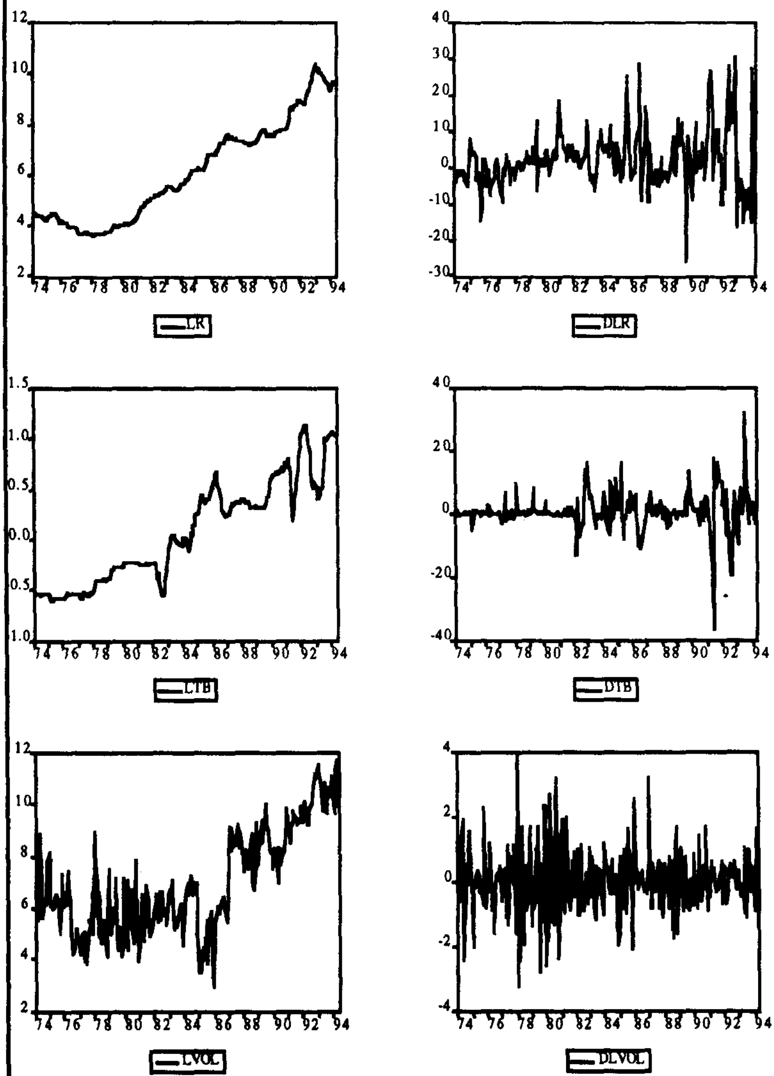
The data are monthly closing indices for the Jamaica stock market index spanning the period 1974:01 to 1994:5. Table 2 provides descriptive statistics and Figure 1 graphs of the logarithm and first difference of the logarithm for the stock price index (*LR*), the treasury bill rate (*LTB*) and traded volume (*LVOL*). The individual series are approximately normal in the levels and non-normal in the first differences. The graph of the logarithm of the composite monthly stock price index suggested non-stationarity, possibly with drift. The distinct cut off after a value of 0.99 for the first sample partial autocorrelation and the smooth and slowly declining autocorrelation function (value of 0.89 at lag 10) suggested first order non-stationarity. The Dickey and Pantula (1987) test indicated that the null hypothesis of two unit roots is rejected for the stock price, the treasury bill rate and traded volume, and conditional on that rejection of two unit roots, each of the series has one unit root.

TABLE 2
DESCRIPTIVE STATISTICS FOR STOCK PRICE INDEX, TREASURY BILL RATE AND TRADED VOLUME

	LR	DLR	LTB	DTB	LVOL	DLVOL
Mean	6.10	2.11	0.07	0.65	7.01	0.02
Median	5.70	1.43	0.02	0.20	6.57	-0.006
Maximum	10.39	30.55	1.14	32.21	11.78	3.96
Minimum	3.61	-26.03	-0.61	-36.96	2.94	-3.24
Std Dev	1.98	7.79	0.50	5.98	1.97	1.04
Skewness	0.42	0.79	0.29	-0.43	0.41	0.24
Kurtosis	1.96	5.58	1.90	12.95	2.26	4.40
Jarque-Bera	18.05	92.91	15.87	1014.84	12.52	22.23

Initial OLS regressions of the stock returns on lagged returns, monthly dummies and a first-order moving average term indicated no significant monthly effects and an insignificant moving average term. The partial autocorrelation function of the log change of the price index indicated a first-order autoregression. The residuals from the first-order autoregression revealed no evidence of serial correlation, but the absolute and squared residuals had significant first partial correlations, suggesting non-linear dependence (see Akgiray (1989)). For a covariance stationary series, the unconditional variance is constant over time. Figure 2A plots the recursive estimates of the unconditional variance of stock returns for the period. It suggests relative constancy up to 1984 and an increasing trend for the post 1984 period; alternatively, the the figure can be interpreted as reflecting a nonlinear trend process for the entire period. Non-normality, mainly due to leptokurtosis, was also evident. The Jarque-Bera normality statistic decomposed to values of 9.10 and 192.45 for skewness and kurtosis, respectively, the 5 percent critical values being 3.84. The linear dependence in the continuously compounded monthly returns indicates that the

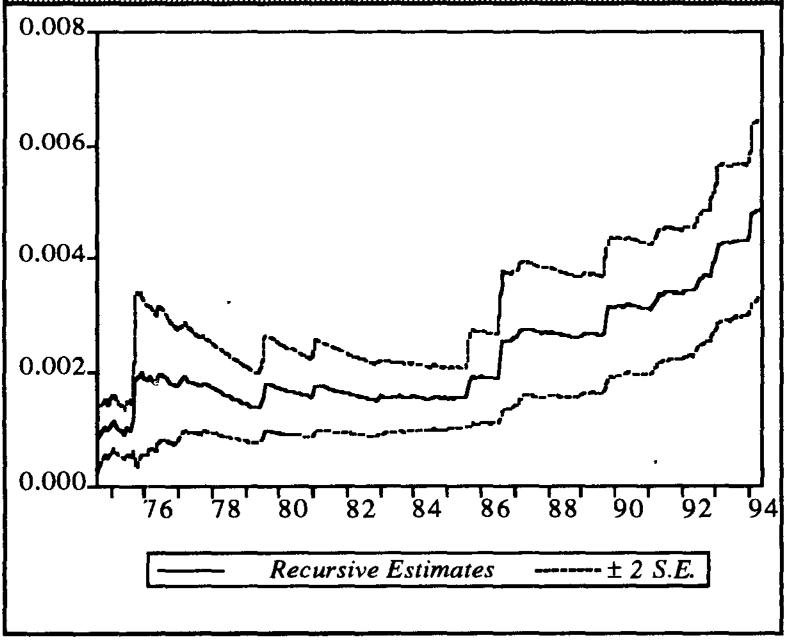
FIGURE 1
LOGARITHM AND FIRST DIFFERENCE OF STOCK PRICE INDEX, TREASURY BILL RATE AND TRADED VOLUME



reaction of share prices to new information is not immediate, and the peakedness in the distribution suggests changing variances, possibly related to uncertainty about future government policy and economic fundamentals, and the current and expected corporate decisions. The above statistics confirm that a model of the observed stock price returns must explain the observed autocorrelation in the returns and the dependence in the squared returns.

Given that the series are integrated of order one, the Johansen (1988) procedure was used to test for cointegration between prices in the equity and treasury bill markets. One cointegrating vector was obtained. The residuals from the

FIGURE 2A
RECURSIVE VARIANCE

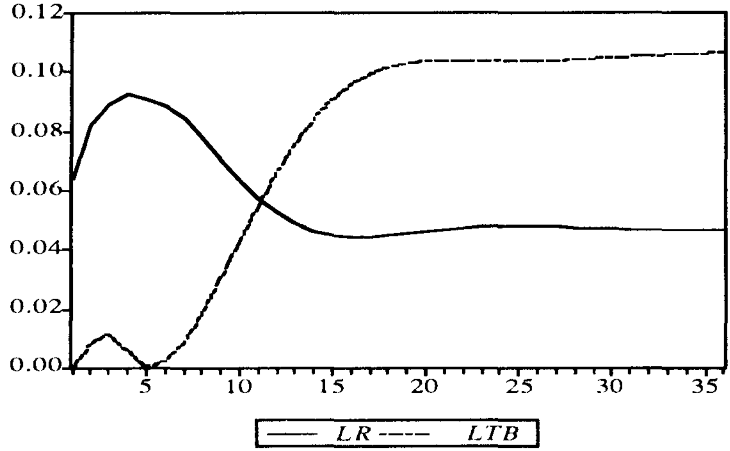


vector error correction model indicate an approximately diagonal covariance matrix, the contemporaneous correlation between the two equation innovations being -0.09. The impulse response functions (see figure 2B) show that shocks to the treasury bill market, reflecting changing economic conditions, have a delayed impact on the equity market and are completed within eighteen months. Adjustments in the treasury bill market are completed in about twelve months. Over a two year period, equity prices are largely determined by the treasury bill rate, and the effects of treasury bill innovations show after the initial interaction between the equity and treasury bill markets have subsided.

The maximum likelihood estimates for the standard (non-augmented) GARCH models for the period 1974:01 to 1994:05 are shown in Table 3. The parameters are well determined and significant at the 5 per cent level. The lagged conditional variance term is significant and positive in every model. The magnitudes indicate stable variance functions. The Ljung-Box test for serial correlation in the standardised residuals and their squares are not significant at the 5 percent level, but the squared residuals indicate some significant 7th and 8th lag autocorrelations. All parameters are positive and the conditional variances are positive. The VGARCH has the highest log likelihood. The positive gamma coefficient in the EGARCH is small and insignificant indicating that shocks have a symmetrical effect on the volatility, but suggests positive return shocks generate more volatility than negative return shocks.

Engle and Ng (1993) suggest tests of the asymmetrical effects of unpredicted errors on volatility. Specifically, the sign bias, negative sign and positive sign tests were used. The sign bias test indicates whether positive and negative innovations affect volatility differently from the models prediction; the nega-

FIGURE 2B
IMPULSE RESPONSE FUNCTIONS FOR VECTOR ERROR CORRECTION



Response of LTB to One S.D. Innovations

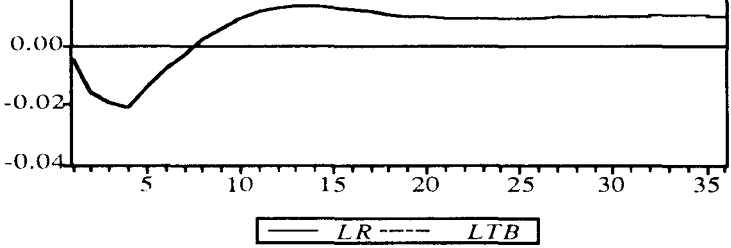


TABLE 3
ESTIMATES OF ALTERNATIVE VOLATILITY MODELS

GARCH(1,1)

$$DLR_t = \underset{(4.51)}{0.19} + \underset{(11.49)}{0.54}\, DLR_{t-1} - \underset{(4.82)}{0.31}\, DTB_{t-3} - \underset{(4.29)}{0.02}\, ECM_{t-1}$$

$$h_t = -\underset{(2.93)}{0.002} + \underset{(0.52)}{0.04}\, h_{t-1} + \underset{(4.74)}{0.56}\,\varepsilon_{t-1}^2 + \underset{(2.59)}{0.02}\left|DTB_t\right| + \underset{(3.70)}{0.0005}\, LVOL_t$$

$L = 368.10$ $S = 0.32$ $K = 1.86$ $Q_1(8) = 0.68$ $Q_2(8) = 0.73$ $Mn = .0003$ $Mx = .071$

$$DLR_t = \underset{(1.69)}{0.005} + \underset{(10.51)}{0.57}\, DLR_{t-1}$$

$$h_t = \underset{(2.84)}{0.0004} + \underset{(6.48)}{0.39}\, h_{t-1} + \underset{(7.09)}{0.81}\,\varepsilon_{t-1}^2$$

$L = 350.95$ $S = 0.36$ $K = 1.49$ $Q_1(8) = 0.65$ $Q_2(8) = 0.49$ $Mn = .0008$ $Mx = .109$

VGARCH(1,1)

$$DLR_t = \underset{(4.38)}{0.17} + \underset{(10.89)}{0.55}\, DLR_{t-1} - \underset{(5.67)}{0.32}\, DTB_{t-3} - \underset{(4.11)}{0.01}\, ECM_{t-1}$$

$$h_t = -\underset{(2.53)}{0.002} + \underset{(1.91)}{0.24}\, h_{t-1} + \underset{(4.45)}{0.0015}\left(\varepsilon_{t-1}\big/\sqrt{h_{t-1}} - \underset{(0.62)}{0.10}\right)^2 + \underset{(2.30)}{0.02}\left|DTB_t\right| + \underset{(2.99)}{0.0004}\, LVOL_t$$

$L = 370.2$ $S = 0.18$ $K = 1.53$ $Q_1(8) = 0.32$ $Q_2(8) = 0.57$ $Mn = .0005$ $Mx = .023$

$$DLR_t = \underset{(2.26)}{0.007} + \underset{(11.46)}{0.59}\, DLR_{t-1}$$

$$h_t = \underset{(0.26)}{0.0001} + \underset{(8.14)}{0.55}\, h_{t-1} + \underset{(6.23)}{0.002}\left(\varepsilon_{t-1}\big/\sqrt{h_{t-1}} + \underset{(2.88)}{0.28}\right)^2$$

$L = 357.18$ $S = 0.28$ $K = 1.28$ $Q_1(8) = 0.47$ $Q_2(8) = 0.18$ $Mn = .0004$ $Mx = .029$

TABLE 3 (CONT'D)
ESTIMATES OF ALTERNATIVE VOLATILITY MODELS

EGARCH(1,1)

$$DLR_t = \underset{(3.62)}{0.13} + \underset{(12.07)}{0.59}\, DLR_{t-1} - \underset{(4.77)}{0.28}\, DTB_{t-3} - \underset{(3.38)}{0.01}\, ECM_{t-1}$$

$$\ln h_t = \underset{(4.47)}{-4.62} + \underset{(3.49)}{0.44} \ln h_{t-1} + \underset{(0.49)}{0.04} \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \underset{(8.89)}{0.94}\left[\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{2/\pi}\right] + \underset{(2.27)}{4.33}|DTB_t| + \underset{(3.43)}{0.17}\, LVOL_t$$

$L = 377.01 \quad S = 0.21 \quad K = 1.48 \quad Q_1(8) = 0.58 \quad Q_2(8) = 0.38 \quad Mn = .0005 \quad Mx = .076$

$$DLR_t = \underset{(2.10)}{0.006} + \underset{(12.11)}{0.60}\, DLR_{t-1}$$

$$\ln h_t = \underset{(3.53)}{-1.30} + \underset{(11.78)}{0.76} \ln h_{t-1} + \underset{(1.21)}{0.09} \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \underset{(12.13)}{1.08}\left[\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{2/\pi}\right]$$

$L = 354.36 \quad S = 0.32 \quad K = 1.37 \quad Q_1(8) = 0.59 \quad Q_2(8) = 0.55 \quad Mn = .0007 \quad Mx = .142$

NGARCH(1,1)

$$DLR_t = \underset{(4.54)}{0.19} + \underset{(11.04)}{0.53}\, DLR_{t-1} - \underset{(4.93)}{0.32}\, DTB_{t-3} - \underset{(4.33)}{0.02}\, ECM_{t-1}$$

$$h_t = \underset{(3.16)}{-0.002} + \underset{(0.19)}{0.02} h_{t-1} + \underset{(4.20)}{0.52}(\varepsilon_{t-1} - \underset{(0.68)}{0.10}\sqrt{h_{t-1}})^2 + \underset{(2.45)}{0.02}|DTB_t| + \underset{(3.87)}{0.0005}\, LVOL_t$$

$L = 368.23 \quad S = 0.33 \quad K = 1.83 \quad Q_1(8) = 0.70 \quad Q_2(8) = 0.76 \quad Mn = .0002 \quad Mx = .062$

$$DLR_t = \underset{(2.34)}{0.007} + \underset{(11.57)}{0.60}\, DLR_{t-1}$$

$$h_t = \underset{(2.72)}{0.0004} + \underset{(5.36)}{0.35} h_{t-1} + \underset{(7.55)}{0.81}(\varepsilon_{t-1} + \underset{(2.78)}{0.23} \cdot \sqrt{h_{t-1}})^2$$

$L = 353.60 \quad S = 0.26 \quad K = 1.42 \quad Q_1(8) = 0.74 \quad Q_2(8) = 0.22 \quad Mn = .0007 \quad Mx = .124$

1. *DLR* is the stock return, *DTB* is the change in the treasury bill rate, and *LVOL* is the traded volume. L is the value of the log-likelihood function and *S* and *K* are skewness and excess kurtosis in the residuals. $Q_1(8)$ and $Q_2(8)$ are the prob-values for the Ljung-Box test statistics applied to the residuals and squared residuals, respectively; they provide tests for the presence of autocorrelation and Arch effects up to eight lags. *Mn* (*Mx*) is the minimum (maximum) value of the conditional variance, and t-statistics are in parentheses. ECM is the residual of the cointegrating regression from the Johansen procedure, *LR* + 5.78 - 4.52**LTB*.

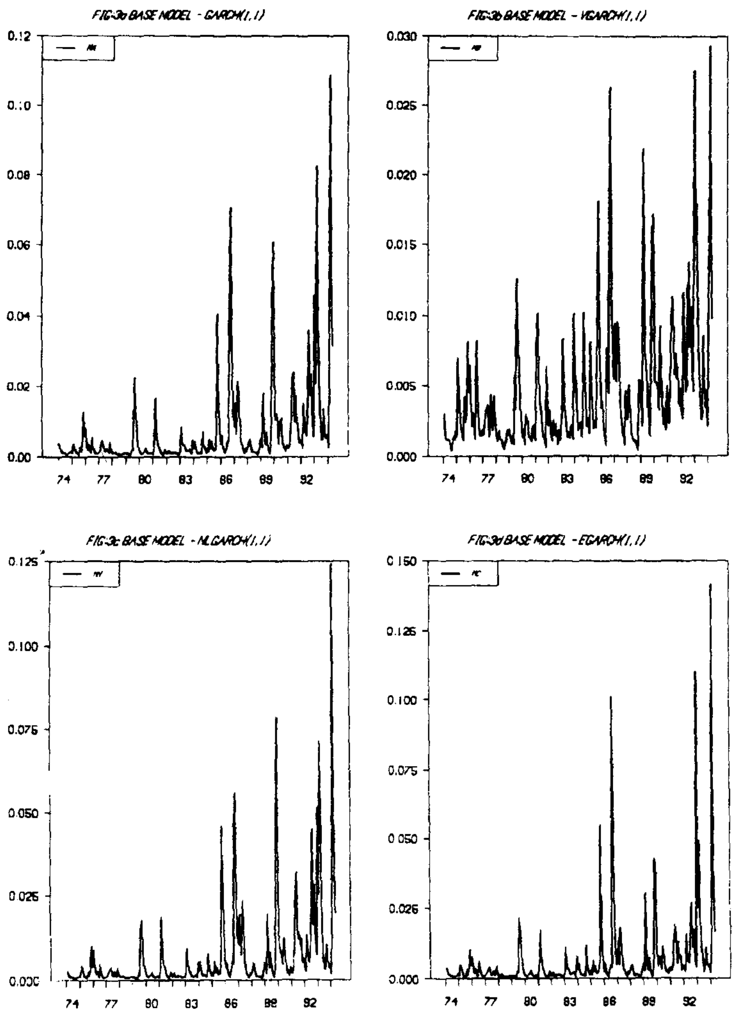
2. The Treasury Bill and ECM coefficients in the mean function are almost equal to coefficients from equivalent OLS models; however, the OLS equation displays significant ARCH heteroscedasticity and excess kurtosis.

3. A first order moving average model for the disturbances was also estimated but had an insignificant coefficient. To facilitate comparisons, the alternative GARCH models were estimated on the same information sets.

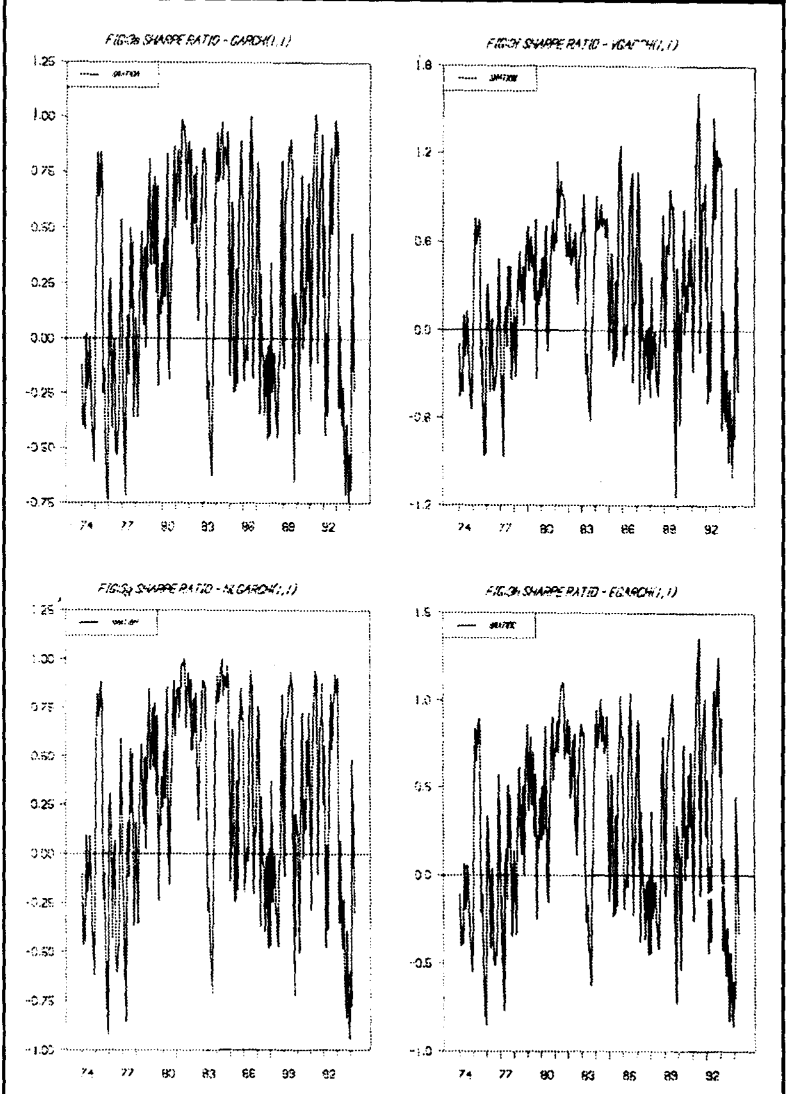
tive (positive) size bias test shows whether large negative (positive) innovations are correlated with large biases in predicted volatility. No evidence was found for bias in any of the models. An encompassing test of the GARCH versus EGARCH was conducted by estimating a conditional variance function that nests both the GARCH(*1,1*) and EGARCH(*1,1*)) models (See Engle and Ng (1993)). The GARCH specification was rejected in favour of the EGARCH model. Further, a likelihood ratio test rejects the GARCH model against the NLGARCH. The news impact curves for both the VGARCH and NLGARCH models attain their minima at negative shocks. Except for the NLGARCH (prob-value 0.5), the standardised residual are skewed; however, the unconditional variance and kurtosis of the conditional variance are significantly lower than the variance and kurtosis of the squared conditional mean for all models. In each case, some excess kurtosis is evident. The standard GARCH and NLGARCH models indicate processes that are integrated in the variance with trend, thus indicating that shocks to the system persist for a long time. The VGARCH and EGARCH models do not indicate persistence.

Table 3 also shows the estimates for the extended models. Maximum likelihood estimates of the cointegrating vector, obtained from the Johansen (1988) procedure, were used to generate the error correction variable . The results show that the lagged change in the monthly treasury bill rate (DTB) is negatively related to the expected mean of the stock return (DLR); also, the absolute value of the change in the treasury bill rate and traded volume both have positive effects on the variance of stock returns for all models. In each case, the extended model cannot be rejected against the more restricted standard model. In contrast to the standard VGARCH and NLGARCH models, which have axes of symmetry to the left of the origin, the corresponding extended models show im-

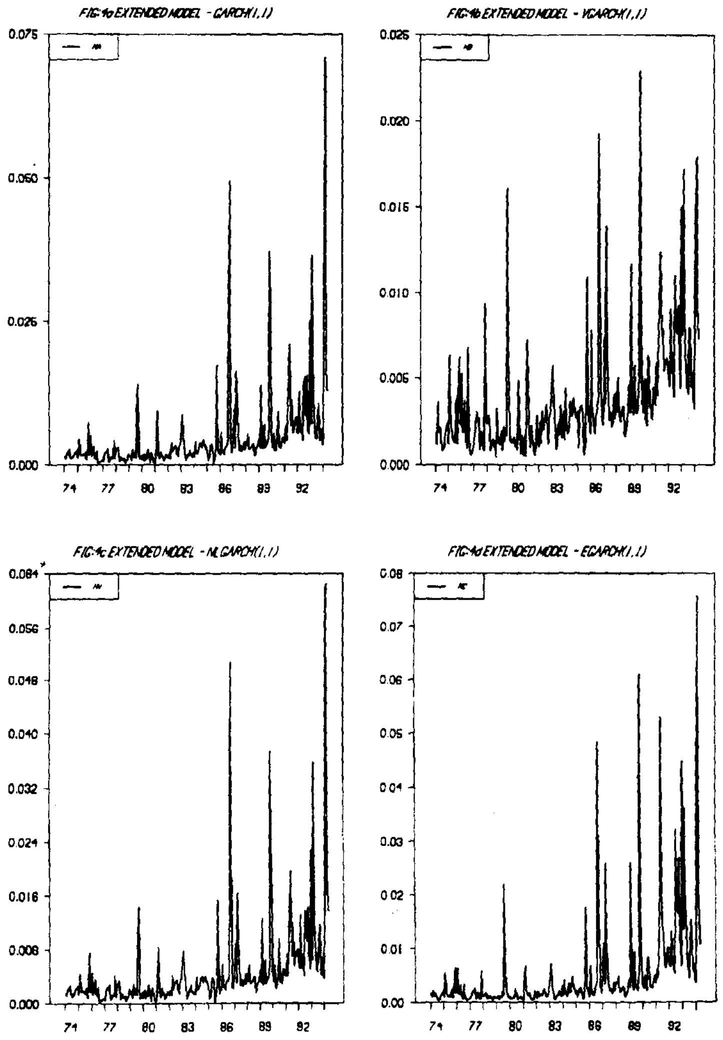
FIGURES 3A - 3D



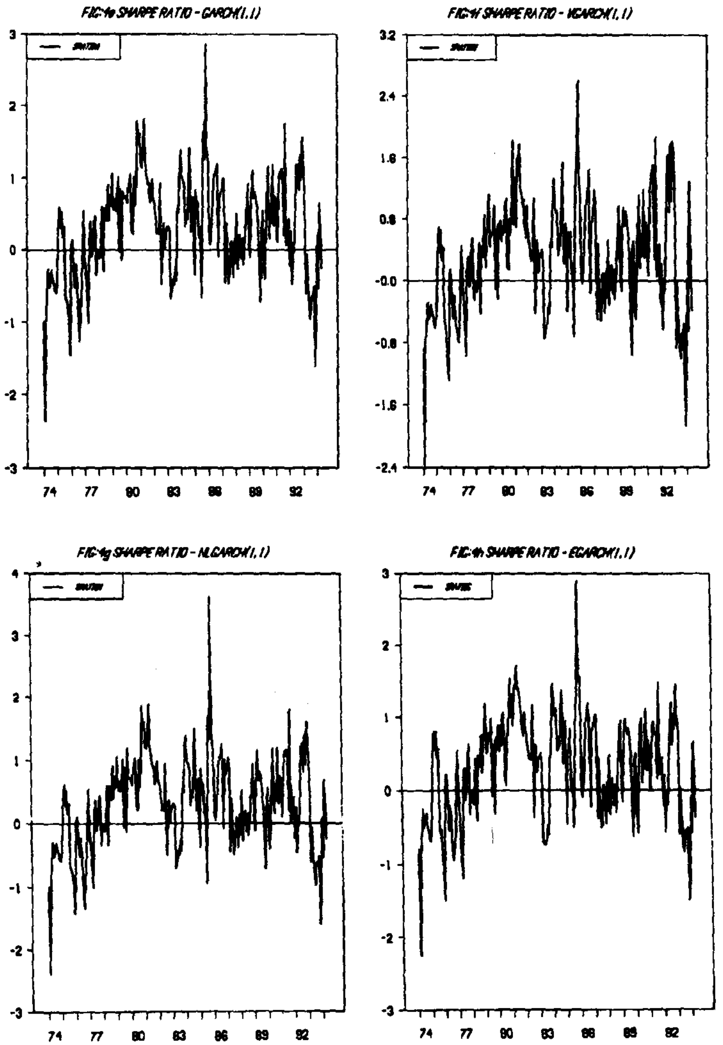
FIGURES 3E - 3H



FIGURES 4A - 4D



FIGURES 4E - 4H



pact curves that have axes of symmetry shifted to the origin. Therefore, the models only differ in their relative impact responses, that is their slopes at the point of interest. In particular, the GARCH model cannot be rejected against the NLGARCH. Further, the persistence factors are reduced significantly so that the pure autoregressive parameterisations of the GARCH models are stable. The reported models show no size or sign bias, and both the standardised residuals and their squares do not depict any serial dependence. Some leptokurtosis remains in each case but at a significantly lower level than that of the corresponding conditional means. The treasury bill rate and error correction terms are significant in the mean function for each model, with the adjustment towards the long run relationship being sluggish. The extended EGARCH model seems to fit well; the residuals are symmetric and have the lowest excess kurtosis. Figures 3a-3d and 4a-4d show the estimated conditional volatility for the standard and extended models, respectively.

The return variance ratio is a statistic commonly used to indicate the amount of return accepted per unit of risk. Since the variance and mean functions are time dependent, the time varying nature of this statistic may be preferable to the more common five year average. Figures 3e-3h and 4e-4h show the ratios for the estimation period. The ratios are on average positive but have varied significantly over the period.

4. CONCLUSION

This paper provides supporting evidence that stock returns on the Jamaica Stock Exchange are autocorrelated and exhibit time varying volatility. The linear dependence of the returns indicates imperfect utilisation of information flows. A first order GARCH process fits the data adequately. It is shown that the predictive content of the models can be improved by the incorporation of the treasury bill rate and traded volume as explanatory variables in the mean and variance specifications . The results suggest that integratedness in the variance of standard GARCH models may be indicative of misspecification in the model structure.

Further research is clearly needed to explore the relationships among the stock returns and other monetary and price aggregates, to estimate alternative distributional assumptions and to question whether international financial and commodity market fluctuations have greater impact than internal monetary and fiscal policies. In conclusion, the results suggest that in the emerging equity market context, a stable macroeconomic environment may help reduce some of the volatility in the equity market.

ENDNOTES

1. This research was supported by a Faculty Development Grant under the auspices of Research Foundation, State University of New York. I am grateful to Wain Iton and the staff of the Jamaica Stock Exchange for allowing access to various worksheets from which some of the data were compiled, and for comments from T. Tabrizichi and particpats at the 26th Regional Programme of Monetary Studies conference held in Jamaica, November 1994.

2. Estimations were done using RATS 4.2 and Econometric Views version 1.1.

3. This two-step double maximum likelihood estimation was preferred since the Johansen estimate of the cointegrating vector utilises the full covariance structure between treasury bill rates and stock returns and easily allows a constant term both in the regression and the cointegrating vector.

4 Estimates using the t-distribution (not reported) were similar to those of the normal distribution; however, the estimated degrees of freedom was between 3 and 4, indicating the non-existence of a population fourth moment.

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PART — 4

ALTERNATIVE METHODS FOR DATA DEVELOPMENT AND ANALYSIS

NOMENCLATURE FOR ECONOMIC STATISTICS

Christopher Martin Clarke[1]

ABSTRACT

This paper develops a standardised nomenclature for the classification of economic statistics in Trinidad and Tobago. It discusses the problems encountered in applying this nomenclature in the data environment in Trinidad and Tobago. The benefits of the FAME environment for managing large sets of time series data are also discussed.

Keywords: Nomenclature for Economic Statistics; Central Framework for Economic Statistics; FAME; Domain Management

INTRODUCTION

The main mission of the Research Department of the Central Bank of Trinidad and Tobago (CBTT) is that of informing the decision making process of the monetary authorities in the areas of monetary and exchange rate policy. To this end, the Research Department performs the various functions:

1. continuously monitors developments in the economy;
2. undertakes basic economic research;
3. produces forecasts, projections and policy simulations; and
4. disseminates a number of statistical publications to the public.

These activities are facilitated by a time series repository which covers traditional areas such as the national accounts, the balance of payments, financial and monetary statistics, international trade, labour market statistics and so on. Additionally, because of the importance of the petrochemicals and petroleum industries in the Trinidad and Tobago economy, the Research Department also maintains a relatively large database of international price and production trends for petroleum, petroleum products and petrochemical commodities such as methanol, urea and ammonia. In some of these areas (balance of payments, financial and monetary statistics) the Research Department is the country's primary compiler of the data and also maintains the micro-data sets associated with compiling statistics in these areas. In other areas (for example, labour force statistics, domestic prices and national accounts), the Central Statistical Office (CSO) of Trinidad and Tobago is the major compiler while the Research Department maintains more aggregate level time series.

The traditional approach to repository management has been to set up and maintain independent production and dissemination environments to support each area of specialisation. These sub-systems were custom built utilising different software tools (for e.g. Dbase IV, Excel/Word) and were distributed across different hardware platforms such as mainframes, minis and personal computers. The practical result was that each domain in the repository functioned as if it were an isolated island of information; there was little co-ordination and considerable duplication of effort.

In an effort to deal with the technological aspects of the problem, the decision was taken to centralise the Department's time series repository in the Forecasting Analysis Modeling Environment (FAME). The new system called the Central Framework for Economic Statistics (CFES) is expected to yield the following benefits:

1. greater coordination among the specialised units in the Research Department;
2. more extensive automation and integration of data capture, processing and reporting activities,
3. an improved quality control regime;
4. greater transparency and accessibility to data by end users; and
5. the integration of routine data processing operations with "value added" activities such as forecasting and econometric modeling

With such a concentration of data there is always the potential for chaos. If the promise of the new environment is to be realised, then data must be properly documented and organised. In this regard, *standard nomenclature, domain formation* (the grouping of related time series) and *documentation standards* have been identified as critical success factors. This paper is primarily concerned with the role of standardised nomenclature as a data organisation tool. It is divided into four main sections. Section 1 outlines the data model which underlies the CFES nomenclature and presents an example of its application. Section 2 examines some of the problems encountered in applying standardised nomenclature to economic statistics in Trinidad and Tobago. The final section of the paper outlines the current status and the future development of the CFES project.

1. A DATA MODEL FOR ECONOMIC TIME SERIES

Standard nomenclature organises time series data by ensuring that while unique names are assigned to each object in the repository, they contain common fragments or dimensions which identify how they are statistically related to the other objects in the repository. A prerequisite for such a nomenclature is the assumption that common elements or properties can be identified in the information being transmitted in time series data.

Traditionally, this was a rather strong assumption to make. However, in recent times, the international statistical agencies (United Nations Statistical Commission, the International Monetary Fund (IMF), EUROSTAT, Organisation for Economic Co-operation and Development (OECD) etc.), have been devoting considerable efforts towards the harmonising of various types of economic statistics. These efforts have resulted in a more unified approach to, and a common view of the objectives of all systems of economic statistics. This unified approach also ensures that specialised systems of economic statistics do not stand by themselves, but rather can be viewed as "satellite" systems, unfolding a given set of interrelationships, while still remaining closely integrated to a common framework

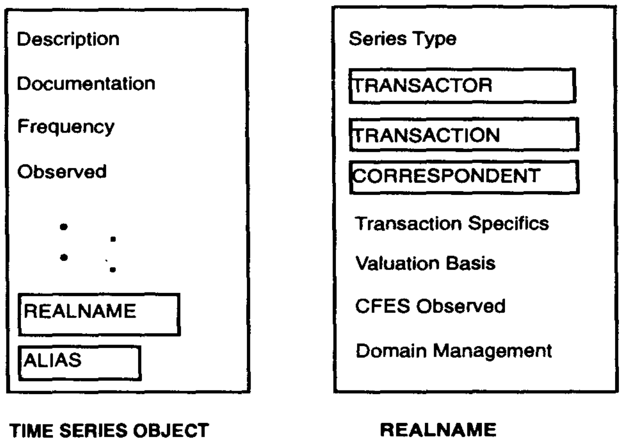
The unified approach starts with a re-examination of the question "What are economic statisticians really trying to measure?". The answer is of course, the effects or results of economic inter-relationships. The effects of economic inter-relationships are observable because they result in the creation, transfer or extinction of economic value. This means that the information carried in an economic time series must represent information about the value, price or quantum of either *flows* (these refer to actions and the effects of events taking place within a given period of time) or *stocks* (these refer to a position at a point in time).

However, the measurement of economic inter-relationships is complicated by the fact that economic life generates an immense array of elementary flows and stocks. Thus, apart from quantifying economic inter-relationships, systems of economic statistics also seek to categorise flows and stocks so that a clearer picture of economic behaviour would emerge. A logical starting point for categorising inter-relationships is the question "Who does what with whom?", where *who* refers to the economic agent performing the action - the TRANSACTOR, *what;* refers to the type of action being undertaken - the TRANSACTION; and *whom* refers to the CORRESPONDENT in the transaction.

This classification allows one to represent any economic time series as an identity or semantic object (see Figure 1). In this representation, the Time Series Object has nine properties, the first seven which are non-object properties are generally standard to the FAME environment while the remains two will be the focus of this discussion. In this model the REALNAME is an object property which uniquely identifies and relates of the Time Series Object to other Time Series Objects in the repository.

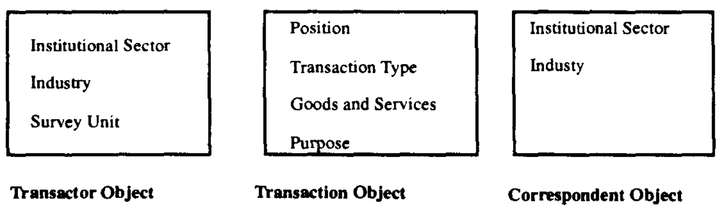
The REALNAME object has eight properties. The first is a non-object property called *Series Type,* which describes whether the time series carries information about stocks or flows. In fact, the domain for the Series Type property includes categories such as stocks, real commodity flows, real non-commodity flows, financial flows, prices and interest rates. This is followed by the TRANSACTOR, TRANSACTION and

FIGURE 1
SEMANTIC OBJECT DIAGRAM: ECONOMIC TIME SERIES OBJECT



CORRESPONDENT object properties. A more detailed view of these three object properties is shown in Figure 2.

FIGURE 2
SEMANTIC OBJECT DIAGRAM TRANSACTOR, TRANSACTION AND CORRESPONDENT OBJECT PROPERTIES



In this model the TRANSACTOR property is defined by three non-object properties. The first of these properties, *Institutional Sector*, characterises TRANSACTORS on the basis of the major functions that they perform in the economic system i.e., consumption, financial intermediation, production, regulation and so on. TRANSACTORS classified by function can then be grouped into major institutional sectors namely households, non-financial corporations, financial corporations and government. The *Industry* property describes the major economic activities that the TRANSACTORS may be engaged in, for example, agriculture, retail sales and manufacturing. Finally, the *Survey Unit* property allows for the identification of entities such as corporations or establishments.

THE TRANSACTION object is defined by the following properties namely:

1. *Position* - This refers to the stock position affected by the flow;

2. *Transaction Type* - This refers to the nature of the flow itself and determines whether the flow involved the production or use of goods and services, was distributive, involved financial instruments or could not be classified in any of these categories;

3. *Goods and Services* - This refers to the goods and services exchanged in the course of transacting, and;

4. *Purpose* - The purpose of the transaction.

Finally, the CORRESPONDENT object essentially has the same properties as the TRANSACTOR object; however, it is important to note that the statistician often does not have as much information about the CORRESPONDENT as he has about the TRANSACTOR. Thus, in Figure 2 the Unit property has been excluded from CORRESPONDENT object.

Whereas the first four properties of the REALNAME are concerned with categorisation, the final four non-object properties in Figure 1 are all concerned with describing how the information recorded in the time series was measured or acquired. These properties allow for the identification of:

1. *Transaction Specifics* - Refers to transaction currencies for flows and stocks;

2. *Valuation Basis* - Specifies whether the flows were valued at market prices or producer prices;

3. *CFES Observed* - Describes how the information in the time series was observed. For example, a base year - 1985 vs. 1990 - distinguishes constant price series, whereas, "high", "low", "median", or "weighted average" can be used to identify interest rates or exchange rates; and

4. *Inter Domain Management* - Refers to time series on the basis of whether they contain *entered data* (raw or unadjusted data from a survey, external publication or another statistical agency) or *derived data* (data that has been aggregated or adjusted or seasonally adjusted).

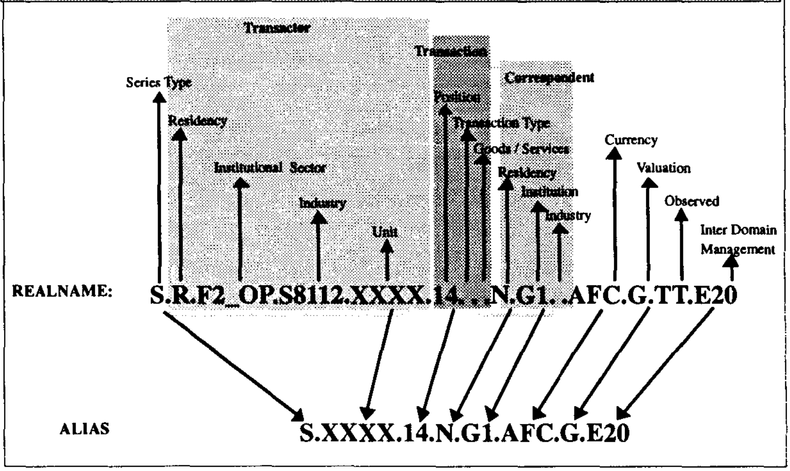
It should be stressed that the full articulation of these properties is not necessary in every area of statistics. For one, the statistician may not have all the required information. However, in other cases the statistical system itself may de-emphasise certain properties. For example, the main accounts of the System of National Accounts (SNA) de-emphasise the CORRESPONDENT. In contrast, the CORRESPONDENT property is critical to the analysis of monetary, financial and Balance of Payments (BOP) statistics.

This gives rise to a discussion of the ALIAS object property. This property may be represented as a 'generalisation' object with sub-types specific to the different domains of specialisation. The relationship between the REALNAME and ALIAS properties is illustrated in Figure 3. The REALNAME has fifteen (15) dimensions each of which represents the properties of economic time series as discussed above. The alpha-numeric characters in each dimension represent a unique coding scheme. As far as possible, the coding system utilised in each dimension is derived or based on a well established coding system. For instance, the institutional sector coding of the system of National Accounts can be utilised for the institutional sector; the International Standard Industrial Classification (ISIC) can be utilised for industry while the Harmonised System (HS) or Standard International Trade Classification (SITC) for Goods and Services.[3]

In Figure 3, the series description is *"All Foreign Currency Loans by a domestic commercial bank to foreign central governments"*. The REALNAME provides a lot more information about the time series. It is a stock series resulting from the actions of financial intermediaries in the commercial banking industry. It records an individual commercial bank's outstanding balance or position in loans. Note that since it is captured in a balance sheet format, the specific transactions and services exchanged in arriving at the position are unknown. The correspondents in the transactions are non-resident central governments and the *Correspondent-Industry* dimension has been left empty on the basis of parsimony. The series covers loans in all foreign currencies without taking into account provisions for loan losses. The outstanding balance has been recorded in the Trinidad and Tobago dollar (TT$) equivalent of the foreign currency. The time series is an "entered" series that comes from a survey instrument called the CB20.[4]

In creating the ALIAS, the domain manager chooses from the REALNAME those properties which are relevant only to the Time

FIGURE 3
CFES REALNAME AND ALIAS



Series Objects in the domain of interest. Thus, in the example, the *Survey Unit* property proves sufficient to represent the TRANSACTOR property because, sector specialists prefer to use a dynamic classification system based on factors such as asset size and legal status rather than one based on institutional sector or industry. In other words, the domain manager is constrained to construct REALNAMES for objects by considering the generalised statistical context. However, in building the ALIAS, the domain manager only considers those properties that allow for the management of objects in the domain. In this context, issues such as facilitating the aggregation of series and sub-series are considered paramount and the ALIAS will be constructed with this goal in mind. This implies that the dimensions chosen for the ALIAS as well as the ordering of these dimensions would change with the different domains.

The typical end user is not expected to work directly with the REALNAMES or ALIASES, or even the dimension coding systems. Special routines will be developed to hide the technical details from the user and present a consistent and logical view of the data in the repository. This will permit users for example, to locate all time series covering particular sectors and transactions, and compare price, volume and value representations of these series. From the perspective of the managers of the repository, the CFES names and ALIASes identify both aggregate and sub-components series. Moreover, the coding systems utilised generally comply with national and international standards. This permits the development of generalised aggregation and reporting procedures that can meet both national and international requirements.

2. NOMENCLATURE IN PRACTICE

The CFES nomenclature relies heavily on the assumption that systems of economic statistics generally have a common view of economic actors, their actions and interactions. Indeed, complete harmonisation requires all systems of economic statistics to define institutional sectors, industries, transactions, etc. in the same way. Furthermore, the same set of accounting rules and valuation standards should underlie all areas of economic statistics. Obviously, taken to its logical conclusion, complete harmonisation would do away with specialised areas of economic statistics altogether. This is unlikely to occur in practice. However, recent guidelines - the System of National Accounts (1993), the Fifth Balance of Payment Manual (1993) and the Manual on Financial and Monetary Statistics *Annotated Outline* 1993) - issued by international statistical agencies go a long way towards establishing a more coherent approach to traditional economic statistics. Even in non-traditional areas such as social, environment and human development indicators, the concepts of social accounting matrices and satellite accounts have allowed for the development of new kinds of data which still remain closely linked to the generalised framework.

While considerable progress has been made in the harmonisation of economic statistics, domain managers are still faced with a number of incompatibilities. In some areas the problems are relatively minor; for example, in the Balance of Payments (BOP) vs. the Central Product Classification (CPC) for service transactions or the SNA vs. IMF treatment of financial assets. In these cases, clear mapping rules have been established which make the task of the domain manager more tractable. In other areas, harmonisation efforts have not gone very far and the task of developing appropriate classification systems, coding and mapping rules must be addressed.

The task of applying standard nomenclature is further complicated by the frequent revisions of standard coding systems which form the basis of the nomenclature. In most areas, the revision process is well documented and major efforts are made to reconcile the "old" and "new" coding systems. Unfortunately, this problem is particularly acute in areas such as tariff statistics. Tariff classifications tend to be arrived at through a process of international negotiations. In many instances, statistical agencies are not privy to these negotiations and may be the last to be informed about changes in tariff schedules. The compiling agency is then faced with an enormous re-coding problem. This situation also limits the capacity of agencies, like the Research Department of the CBTT, to maintain consistent time series on trade and tariffs.

These kinds of problems are considered to be fairly universal. However, in the specific context of statistics Trinidad and Tobago, the application of data management techniques like standardised nomenclature is complicated by data deficiency problems.[5] Forde (1989), noted that there were serious gaps in the country's ability to produce timely, accurate and relevant statistics and attributed these problems to severe resource constraints and, more importantly, to the lack of coherent national policies on information and statistics. The end result of this situation is a high level of disorganisation in the way in which some types of economic statistics are conceived, collected, compiled and disseminated. In some cases, different agencies may be responsible for particular types of statistics. Often, little effort is made to harmonise the definitions for institutional sectors, industries, accounting rules and valuation standards. The problem is most acute when the agency producing the "statistics" is really meeting some statutory requirement to publish administrative data. In other cases, severe resource constraints mean that compilation and dissemination guidelines are often woefully out of date and totally at variance with the concepts underlying the nomenclature.

Even when the agencies concerned are more sophisticated, the existence of "islands of information" can create serious disharmonies between the various production environments. This is best illustrated with a specific example. In the 1970s, the Trinidad and Tobago System of National Accounts (TTSNA) was developed to address concerns that the structure of the domestic economy was not being adequately represented by the System of National Accounts (1968). One of the negative innovations of TTSNA, was the fact that it led to the development of a system of industrial classification which was incompatible (at the four digit level) with ISIC (Revision 2). At the same time, statistics on industrial production continued to be compiled, disseminated and analysed using an ISIC-based classification (see in particular the Trinidad and Tobago System of Industrial Classification -

1985). Thus, in an effort to meet the demands of all end-users, two sets of four digit level industrial production time series have to be set up and maintained. This unfortunate situation has been repeated in many other areas and can only be resolved though more effective co-ordination. In a bid to resolve such problems, the Research Department has entered into dialogue with a number of other agencies.

3. CURRENT STATUS AND FUTURE DEVELOPMENTS

The FAME/CFES project commenced earnestly in January 1995 as a joint undertaking of the Research and Management Information Systems (MIS) Departments of the Central Bank of Trinidad and Tobago. The project group has been able to achieve the following:

1. Migration of over 20,000 monetary time series from the mainframe based Financial Returns System (FRS) to the FAME/CFES environment;

2. Migration of over 3,000 "domestic production" time series from EXCEL;

3. Development of basic data processing systems for the CBTT Monetary Surveys which cover:

   (i) **Data capture** - Both ASCII file data capture and traditional data entry screens are supported. The ASCII file loading programs have been developed using the FAME 4GL while the data entry screens have been developed using FAME Windows;

   (ii) **Editing** - The availability of the time dimension has enhanced the scope of the editing process. Routine consistency (zero sum) and range checks now span the twelve periods instead of a single period in the traditional edit reporting system. Graphical elements have also been added to the reporting of some range edits. This graphical view has greatly added to our ability to spot outliers in the data;

(iii) **Imputation** - The availability of extrapolation and time series forecasting techniques (such as Linear Extrapolation, ARIMA, Leading Indicators, etc.) in the FAME environment means that sophisticated procedures can be easily developed to treat with the problem of non-response;

(iv) **Reporting** - These reports, developed using FAME Postscript reporting, take the form of "workbooks" and are designed to show information at both the industry and institution level.

4. Development of prototype applications that support querying, ad-hoc tabulations and graphing.

The Research Department's medium term plans (to the first quarter of 1996) for the FAME/CFES environment include:

1. The automation of the domain building and multiple dimensional space management;

2. Implementation of solutions to permit multiple users to update FAME databases;

3. Migration of Quarterly Real Gross Domestic Product system from EXCEL to FAME and implementation of FAME - X11- ARIMA link;

4. Production of the Research Department's publications using FAME and FrameMaker. This will allow the

Department to develop and disseminate electronic versions of its publications to meet the needs of its internal readership;

5. Linking of FAME/CFES with econometric modelling.

ENDNOTES

1. The views expressed here are those of the author and not necessarily those of the Central Bank of Trinidad and Tobago.

2. DBase IV is a database developed by Ashton-Tate/ Borland; EXCEL is a spreadsheet program developed by the Microsoft Corporation.

3. In this regard SNA provides a useful set of guidelines for coding system that could be employed in the dimensions.

4. This survey instrument is a reporting form developed by the Central Bank of Trinidad and Tobago

5. These issues are discussed at length in the paper by Forde (1995) on "Challenges and Problems in Forecasting Caribbean Economies: Some Data Issues" which is included in this volume.

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SEASONAL ADJUSTMENT SYSTEMS FOR PRACTITIONERS IN THE CARIBBEAN:
LESSONS FROM THE TRINIDAD AND TOBAGO EXPERIENCE

Christopher M. Clarke
and
Michelle Francis

This paper addresses the critical success factors for seasonal adjustment systems. These success factors include an appropriate data processing environment, a quality control regime and a proper marketing strategy. Several issues relating to the choice of an adequate adjustment method are explored in the Trinidad and Tobago data context. The Census XII and XII-ARIMA methods emerged as the top contenders among a variety of seasonal adjustment techniques.

Keywords: SABL; Census XII; XII-ARIMA; Seasonal Adjustment; Critical Success Factors

INTRODUCTION

Seasonal adjustment is done to simplify data so that they may be easily interpreted by statistically unsophisticated users without significant loss of information. (Bell and Hillmer (1984), p.301).

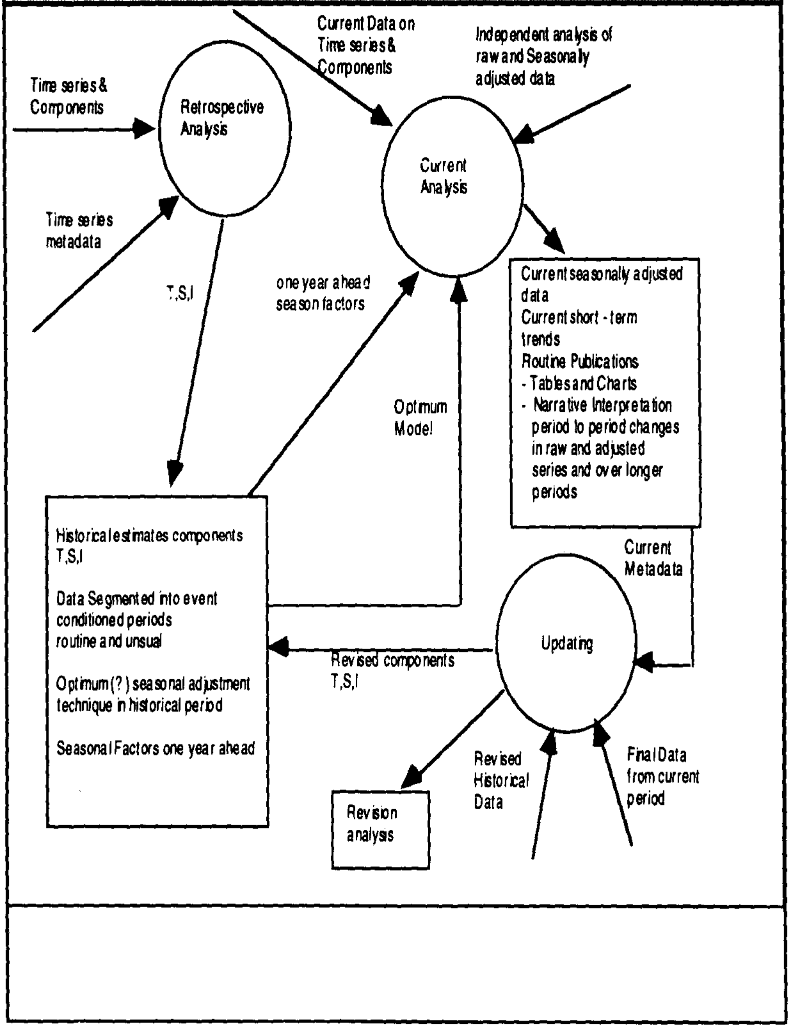
The Central Bank of Trinidad and Tobago's (CBTT) experience with seasonal adjustment dates back to the late seventies. Indeed, the study by Farrell and Soo Ping Chow (1983) is probably the most comprehensive of those on seasonality that have been produced so far in the region. The CBTT was also among the first official statistical agencies in the region to regularly publish seasonally adjusted numbers (over the period 1981 to 1992). Yet, an examination of the CBTT's current economic reporting reveals that systematic use and analysis of seasonally adjusted data are confined exclusively to the reporting of the Bank's Quarterly Real Gross Domestic Product (QGDP).[1] The publication of seasonally adjusted monetary numbers was discontinued in December 1992. Indeed, this was the second time that the CBTT stopped publishing its seasonally adjusted monetary numbers on "technical" grounds. The latest interruption in the CBTT's seasonal adjustment program represents a critical gap in the country's statistical database, given the increased demand for timely short term analysis of economic developments brought about by the requirements of managing structural adjustment and liberalisation programs. In the absence of officially sanctioned seasonal numbers, policy makers have been bridging the gap with ad-hoc methods and techniques. Past experience tends to show that such an approach usually fails to provide very reliable data. Consistent, reliable and plausible seasonal numbers can only be developed within the context of a systemic approach to the issue of seasonal adjustment.

This paper addresses the critical success factors for seasonal adjustment systems. In this context "success" is achieved only if as large a group of interested parties as possible - that is, not only central bank economists or trained statisticians, but also government officials, journalists, students and even politicians - have the confidence in and are able to analyse the numbers intuitively. Thus, Section 1 comments briefly on a number of practical issues which should be addressed in seasonal adjustment systems. These include the basic processes that need to be put in place, the type of data processing environment and quality control regime required and finally the important but often overlooked issue of marketing the seasonally adjusted data. Section 2, examines the issue of choosing an adequate seasonal adjustment technique from among the numerous techniques available. A number of simple tests were applied to six time series drawn from key areas of economic reporting. The final section of the paper presents a summary of the major findings and some suggestions for future research.

1. STRUCTURING SEASONAL ADJUSTMENT SYSTEMS

This section of the paper draws heavily on insights gleaned from an earlier study by Clarke and Francis [1994] which examined why CBTT's seasonal numbers failed to win widespread credibility and acceptance by the user community. Aside from pointing to a number of environmental factors and technical weaknesses in the previously published seasonal numbers, the major finding of this study was that these efforts had failed not because of a lack of technical sophistication, but rather because the statisticians did not appreciate the scope of the seasonal adjustment process. These earlier efforts tended to approach the issue as a "one shot" academic exercise so that while the initial investigations may have been of high quality, the work was usually confined to relatively few time series, and even fewer of these were actually published. This meant that analysts never had the critical mass of seasonally adjusted data required to examine short trends in the economy. Moreover, once the initial studies had been completed, the Bank did not devote sufficient human or computer resources to the seasonal adjustment programme. In addition, no quality control systems were put in place to ensure that the seasonal numbers remained plausible in light of structural changes in the economy. The net result was that the reliability of the seasonal numbers and eventually the rel-

FIGURE 1
CONTEXT DIAGRAM SEASONAL ADJUSTMENT SYSTEM



evance of the whole exercise were called into question. The requirements of a successful seasonal adjustment system essentially flow from this analysis. The basic processes involved in seasonal adjustment are presented in Figure 1.

The most fundamental process in the seasonal adjustment system is retrospective analysis. In this process, the analyst determines the major components and characteristics of the series, chooses the best available adjustment technique or model, and obtains one year ahead seasonal factors to utilise in the current analysis process. The major inputs into this process include:-

1. The time series over a defined time interval including any sub-series;

2. Any related series (such as weather for series covering the production of agricultural commodities) and if available micro time data (i.e. weekly or daily data on the series);

3. Metadata or data about the series itself. Basic time series metadata covers information on sources, units of measurement and so on. In historic analysis, the scope of the metadata set is extended to include information on issues such as special conditions related to the collection, processing and reporting of the economic surveys which underlie the data. Experience has shown that these peculiarities (e.g., changes in methodology or rebasing) tend to cause discontinuities in the data. Additionally, a chronology of the events which may have affected the time series over the period and the analysts' knowledge of the characteristics of the series under investigation should also form part of the metadata set. The net result is that the

reasons for the fluctuations in economic activity over the months of any given year are fully described;

4. An appropriate set of seasonal adjustment techniques or models for testing or experimentation.

The major outputs of this process include estimates of the behaviour of the components - Seasonal (S), Trend (T), Irregular (I) - of the series (and sub-series) over the historical period. In some cases it may prove useful to segment the series into homogeneous intervals to distinguish the effects of unusual events and to examine the characteristics of the components in these periods. Also, the most appropriate adjustment technique and forecasts of seasonal factors for the one year ahead period are obtained. The latter are major inputs into the current analysis process. In Section II, a number of simple tests which may assist in the choice of the most appropriate adjustment technique are presented. However, it should be noted that choosing among the more well-established techniques (such as, Census X11, X11- ARIMA or SABL) is not likely to be a simple matter, because some techniques perform better on some tests than others. It may thus be important to attach weights to the tests that best represent the statistical agency's philosophy on its published statistics and its evaluation of the sophistication of the user community. For official statistical agencies like Central Banks, the relevant questions to ask of any seasonal adjustment method include:-

1. Is the software commercially available? How easy is it to program?

2. Is it easy to explain to non-technicians?

3. Is it widely used by other statistical agencies?

4. Are the estimates of the seasonal components stable when new data is added?

5. Does it work well on a number of series from different areas of the economy without major prior adjustment?

1.1 Current Analysis

This represents the routine aspect of the seasonal adjustment program. Data is continually generated for the series and its components in each month or quarter. These data are seasonally adjusted using either the one year ahead seasonal factors generated from the retrospective process or "concurrent" seasonal factors based on the new data. If the latter method is chosen, then revision analysis must be conducted every reporting period. It is important to analyze both the adjusted and unadjusted series to examine period to period changes or changes over longer periods. Furthermore, the analyst needs to determine whether the behaviour of the series is in line with current events and conditions and also whether any similarities (or differences) to the past exist. This serves as an initial quality control measure designed to trap short term shifts in the seasonal patterns as well as to identify unusual periods, outliers and the like.

1.2 Updating

This builds on the initial quality control checks established in the current analysis by repeating retrospective analysis from time to time, usually after a complete year of data is available. An important aspect of this process is revision analysis which is critical if periodic reporting is chosen. In periodic reporting, the seasonal factors are revised on an annual basis and historic seasonally adjusted data are also revised in light of updated seasonal factors. In such a system revision analysis serves to illuminate the adequacy of the initial model chosen for seasonal adjustment. In the case of concurrent reporting, updating is actually built into the current analysis process as seasonal factors are revised every reporting period (i.e. there is no reliance on year ahead seasonal factors). Concurrent adjustment is only practicable in the context of a highly integrated and flexible environment since the processing cycle is reduced to a single period.

1.3 Data Processing Environment

It should be quite evident from our discussion of processes in a seasonal adjustment system, that such a system would require either a large cadre of analysts or statisticians or, alternatively, a very sophisticated, automated processing environment characterised by a high degree of integration. In such an environment, primary data capture, the aggregation of time series data, seasonal adjustment and routine reporting and analysis are tightly integrated. Ideally, this system should also be linked to time series forecasting or econometric modelling systems. It is only within such a context that the producers of the seasonal numbers can obtain feedback on the plausibility of the results of the seasonal adjustment process, as well as apply it as widely as possible. Moreover, formal quality control systems can be more easily implemented in such an environment. In other words, an integrated production, reporting and analysis environment will involve an optimal level of interaction between the practical and the theoretical and is likely to result in a very responsive program of seasonal adjustment.

1.4 Marketing Seasonal Numbers

The success of the seasonal adjustment program is measured by the degree to which policy makers and other non specialists like journalists and government ministers have the confidence to use the seasonal numbers intuitively. Given the relative lack of statistical sophistication of this client base in the Caribbean context, any statistical agency producing seasonal numbers will have to actively stimulate the demand for these data. In this regard, the following steps should be given active consideration.

First, seasonal adjustment should be applied to key data in as many areas as practicable. The availability of reliable seasonal numbers across all areas of economic statistics will contribute to the improvement of the in-house technical analysis of the economy; also other interested parties (the press, students etc.) will be better informed about the short run movements in the economy.

Second, aside from the choice of an adjustment technique, other technical issues should be given careful consideration such as the timing of revisions (which should be standardised across the system); direct vs indirect adjustment; and the "adding up" problem. With regards to the latter, while additivity is a desirable quality of seasonally adjusted monetary data, this may be less relevant in the analysis of seasonally adjusted retail price data.

Third, statistical agencies should change the way economic data are tabulated or presented. Consideration should be given to the presentation of both seasonally adjusted and unadjusted series in the same table once there are marked seasonal patterns in the data. Such a presentation would serve to clarify the analysis. Additionally, where relevant, annualised growth rates and moving average growth rates based on de-seasonalised data should also be presented, as these measures serve to highlight the trends in the series under investigation. These tables should be supplemented with "indicator" tables which contain movements in the major seasonally adjusted indicators. Clarity may also be improved if charts highlighting the trends in the series are presented along with the statistics. These practices have been successfully adopted by several other leading statistical agencies such as the Bank of Canada, the Federal Reserve Board and Her Majesty's Statistical Office (HMSO) in the United Kingdom.

Finally, an effective regime of quality control is a critical component of a seasonal adjustment system and indeed all statistical processing systems. It is important to note that while the diagnostic assessment performed by seasonal adjustment software is an important quality control tool, experience has shown that more is required. Rizki (1993) notes the reliability of any system of published economic statistics can be assessed by its revision performance. This is so because good statistical systems are continually engaged in updating and revising past data. These revisions arise from a number of causes such as, receipts of more comprehensive data, changes in estimating procedures, revisions due to seasonal updating and so on. Thus, if the statistical data is continually being revised for these reasons and these revisions are relatively small then it can be assumed that the level of quality assurance is high. Indeed, one can argue that the initial estimates of the economic indicators were unbiased. When this is not the case then decision makers will be misled about developments in the recent past and soon lose faith in the seasonal numbers.

2. TESTING SEASONAL ADJUSTMENT METHODS

Over the years several seasonal adjustments programs have been developed for detecting and isolating seasonal variations in economic time series. In this paper six of these methods have been chosen for testing based on the availability of the software and the popularity of the method. The methods examined in this section are :-

1. Fixed Additive Method
2. Fixed Multiplicative Method
3. Census Method 1 (or Ratio - to - Moving Averages Method)
4. Census X11
5. X11-ARIMA
6. SABL (Seasonal Adjustment Bell Laboratories)

With the exception of the X11-ARIMA, all these techniques are mechanical in nature and therefore adjustment of the various series by these methods is carried out in conformity with the same rules, without the specific characteristics of the individual series playing a part. Indeed, most of these methods represent improvements to the simple ratio to moving average method. By contrast, in the X11- ARIMA method, an appropriate ARIMA (p,d,q)x(P,D,Q) serves as a starting point for the analysis. This method is simply an extension of the basic Census X11 framework in which an ARIMA model is used to provide symmetrical weights to the observations at the beginning and at the end of the series. Moreover, when large numbers of time series must be adjusted, it is common to leave the choice of the ARIMA model up to the software package. In other words, X11-ARIMA as applied in practice, has a lot more in common with the mechanical adjustment methods than the model-based or structural approaches. The heuristic nature of the mechanical models means that the statistical properties of the techniques are not fully determined, so that these methods cannot be judged unambiguously by sharply defined formal statistical criteria. In what follows, each method is described briefly and this is followed by a discussion of its application to three actual Trinidad and Tobago macro-economic series.

2.1 Methods of Seasonal Adjustment

2.1.1 Fixed Additive Method

In this method seasonal adjustment is based on the following additive model:-

$$y_{ij} = T_{ij} + S_{ij} + I_{ij}$$

where T_{ij} is the centered 12-month moving average trend cycle component of the series y_{ij}; and i,j represent the year and month, respectively. The means of the difference between the trend-cycle component and the original series is calculated for each month to determine the preliminary seasonal component S_i'. The seasonal components are then derived from the preliminary component as follows:-

$$S_{ij} = S_i' - \frac{1}{12}\sum_{i=1}^{12} S_i'$$

$$\text{where } \sum_{i=j}^{12} S_i = 0$$

The irregular component is then derived as $I_{ij} = y_{ij} - T_{ij} - S_{ij}$ and the seasonally adjusted series y_{ij}^{sc} is calculated as

$$y_{ij}^{sc} = y_{ij} - S_{ij} = T_{ij} + I_{ij}$$

2.1.2 *Fixed Multiplicative Method*

This method assumes the following multiplicative form:-

$$y_{ij} = T_{ij}.s_{ij}.i_{ij}$$

where again T_{ij} (the trend-cycle component) is the 12-month moving average of the series y_{ij}, as it is in the fixed additive method. However in multiplicative adjustment, the size of the seasonal as well as the irregular component is proportional to the trend value of the data. This relationship between the seasonal component and the series is expressed by the seasonal index s_{ij}, where

$$S_{ij} = \left(1 - \frac{1}{s_{ij}}\right) Y_{ij}$$

Like the fixed additive method, for each month i, the preliminary seasonal index is determined as the mean of $s_{ij}.i_{ij} = y_{ij} / T_{ij}$

This seasonal index can be expressed as:-

$$s_{ij} = s_i = \frac{s_i}{\frac{1}{12}\sum_{i=1}^{12} s_i'}, \text{ for all ij}$$

$$\text{where } \sum_{i=1}^{12} s_i = 12$$

The seasonally adjusted index is calculated as

$$y_{ij}^{sc} = y_{ij} - S_i = y_{ij} / s_i$$

and the irregular component is given by

$$I_{ij} = y_{ij}^{sc} - T_{ij} = \left(1 - 1/i_{ij}\right) y_{ij} / s_i$$

$$\text{where } i_{ij} = y_{ij} / \left(T_{ij}.s_i\right)$$

1.2.3 Census Method 1

This method was first developed at the Bureau of Census in 1954 to seasonally adjust economic time series. The seasonal and error variance is removed by calculating moving averages whose number of terms equals the periodicity of the time series under investigation. This procedure removes seasonality and reduces the unsystematic error throughout the series. This moving average is used as an estimate of the trend-cycle component. The ratio of the original series to the trend-cycle component is then calculated so that the seasonal and error components can be isolated by a process of averaging to obtain the pure seasonal component.

1.2.4 Census X 11

The X11 variant of the Census Method II as outlined in Shiskin *et. al.* (1967), was developed at the U.S. Bureau of the Census, and was adopted since 1965 as their standard seasonal adjustment program. Like previous methods, this method is based on the ratio-to-moving average technique. The Census X11 method offers a choice between additive and multiplicative models and can be applied to both monthly and quarterly time series. Moreover, the procedure contains options for adjusting for trading-day variations and provides for the treatment of outliers. Despite the extensive options available, calculations in practice are based on standardised procedures.

The Census X11 method is widely used in practice because it can be easily applied to a variety of economic time series. However, in spite of its ease of maneuverability, some criticisms have been leveled against the method:-

First, the procedure is not based on any statistical model or method. The absence of an underlying model is thought to be a serious deficiency as it prevents clear statistical interpretation of the results. Cleveland and Tiao (1976) have attempted to provide a stronger statistical base for the method.

Second, the Census X11 Method tends systematically to underestimate the changes in the seasonal patterns at the beginning and at the end of the series.

2.1.5 X11-ARIMA

The Statistics Canada X11-ARIMA method of seasonal adjustment was first developed by Dagum in 1975 and updated in 1978 and is an extension of the Census X11 method. This method is thought to have two major advantages over other linear smoothing techniques, namely:-

(a) it offers an ARIMA model for the series;

(b) it minimises the revision of the seasonal in mean square error.

The X11-ARIMA models the original series by fitting an ARIMA (p,d,q)x(P,D,Q) model, and extends the series at both ends by 'forecasting' and 'backcasting'. Two options are available in the software package for model selection. The first utilises an automatic model selection, while in the second, the analyst can determine his own ARIMA model. This paper adopts the first option i.e. automatic model selection. The X11-ARIMA software mechanically tests the following three alternative models:

(0,1,1) x (0,1,1)s
(0,2,2) x (0,1,1)s
(2,1,2) x (0,1,1)s

For each of these models the program checks whether the model yields an adequate description of the series and whether reliable out of sample forecasts were generated for the last three years of the sample period. The ARIMA model is rejected if the mean absolute forecast error is more than 5 per cent for normal series or more than 12 per cent for violently fluctuating series. The usual Box-Pierce test is conducted on the residuals to test for independence of the error terms. The method of automatic model selection has been criticised by Fase and Den Butter [1991], largely because it has been unsuccessful in the majority of cases. Moreover, in many of the time series, examined, the best automatic model differed substantially from the best judgment based selection. However, Fase and Den Butter noted that in these instances the seasonal factors based on automatic selection were always more stable than those obtained by judgment selection. Indeed, where statistical agencies use the X11-ARIMA for adjusting a large number of time series the judgment option is only resorted to if the automatic option fails. These points may be taken as a weak justification for the use of the automatic option in this paper.

Whatever the option chosen, the ARIMA model is simply used for extrapolation and the resulting series is then seasonally adjusted by applying various linear filters of the X11 type. In addition, the software also provides an option for applying a centered 24-term filter instead of a 12-term filter to estimate the preliminary trend-cycle component. This new filter gives better results for series strongly affected by short cycles or sudden changes in trend.

FIGURE 1.1
BROAD MONEY SUPPLY, CEMENT AND RETAIL SALES

The Series Used

Chart 1.1 - Broad Money Supply ($TT Mn)

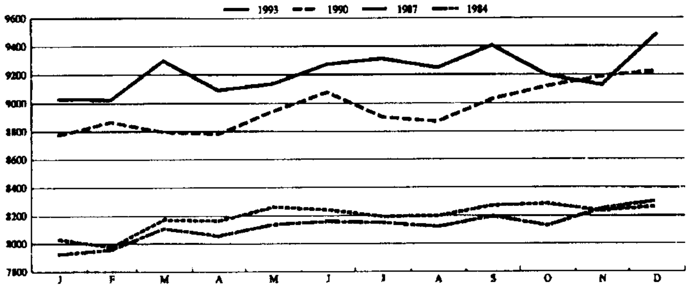


Chart 1.2 - Local Sales of Cement (000's Tonnes)

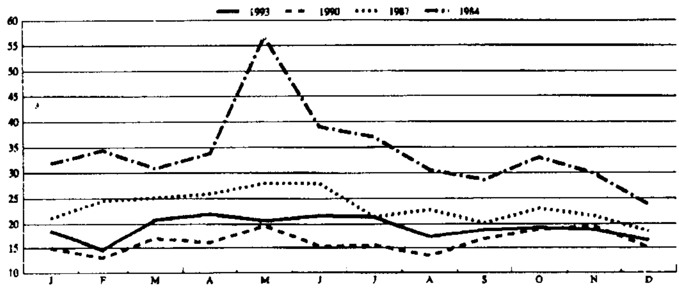
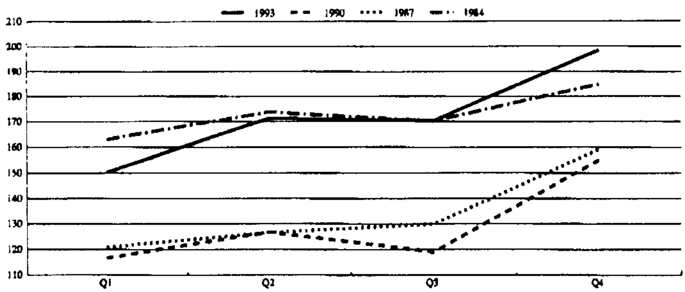


Chart 1.3 - Index of Retail Sales (1979 = 100)



2.1.6 SABL Method

The SABL procedure, like the Census X11 method employs the technique of repeated filtering, to decompose the original series into its usual three components. Unlike the Census X11 method however, its filters are more robust, thereby avoiding over adjustment at the beginning and end of the series. An important difference in the SABL method is that it employs moving medians rather than moving averages. The SABL method incorporates an option to apply the Box-Cox (1964) power transformation which allows for intermediate forms of adjustment (i.e. between an additive and a multiplicative specification). In this paper however, in order to ensure that no method is given undue advantage over the other, the optimal transformation option was not selected. Instead a log transform was applied to all series that were adjusted multiplicatively and no transformation for those series adjusted additively. Another important feature which distinguishes SABL from Census X11 is its extensive use of graphic displays as tools for analysis and diagnosis. This proves particularly useful when analyzing seasonality in a small number of series.(see Butter and Fase (1991), p. 75).

2.2 Description of Time Series

The seasonal adjustment methods described above were applied to three different macro-economic series, one of which was chosen from the monetary sector. The other series were chosen from the real sector. The three series considered for analysis were:-

1. Broad Money Supply M2 (TT$Mn), monthly (1982:1 1993:12)

2. Local Sales of Cement ('000 tonnes) monthly (1982:1 1993:12)

3. All Items Sections of the Index of Retail Sales (Avg. 1979 = 100), quarterly (1982:1 1993:4)

As a first step in assessing the effects of the application of the various seasonal adjustment techniques on the series, the original series were first plotted and an attempt was made to identify any distinct seasonal fluctuations in the data. Chart 1.1 presents the broad money supply (M2) for selected years. During the period 1982:1 to 1993:12, consistent seasonal highs were recorded in September and December and to a lesser extent in June. In addition, between 1984 and 1993, seasonal highs were also observed in March. Seasonal lows occurred in October in the earlier years of the series (1982 - 1989) and thereafter shifted to November. The December high reflects the corresponding high in the currency series. The year 1988 appeared to be an abnormal one; in that year an uncharacteristic seasonal low was recorded in December. This probably reflects the fact that in that year, Trinidad and Tobago was in the midst of a deep recession, which may explain the atypical pattern of low consumption in the holiday season.

The other seasonal variations in the series reflect the movements in the commercial bank deposits series. For instance, the March high possibly reflects the accumulation of demand and savings deposits in the period of low rates of private consumer spending. The June, July high could occur because of increased loan demand to finance holiday travel abroad. The October, November troughs reflect the slower rate of deposit accumulation as private spending begins to accelerate and loan demand begins to rise in anticipation of Christmas.

The real sector series - local sales of cement - is presented in Chart 1.2. Examination of the graph shows the presence of marked seasonal stability. Distinct seasonal peaks normally occur in the dry months of May and October (the *petit careme*) and seasonal troughs usually occur in September and December. This series is highly correlated with construction activity in Trinidad and Tobago. The declining trend in local sales of cement appeared to have varied directly with the decline of the construction industry during the recession. In Trinidad and Tobago construction is highly dependent upon weather conditions. Construction activity usually peaks in the dry months of April, May, June and October.

The All Items Sections of the Index of Retail Sales (Average 1979=100) is a quarterly series. Chart 1.3 shows a characteristic seasonal pattern; there is a seasonal peak in the fourth quarter as anticipatory consumption for the holiday season increases and a seasonal trough usually occurs in the first quarter.

Tables 1 to 3 present the characteristics of the series in tabular form. Table 1 shows the means of the series for the whole period 1982 to 1993, and the means computed for the first and second half of the sample periods respectively i.e. 1982 to 1987 and 1988 to 1993. An examination of Table 1 reveals

TABLE 1
RUNNING MEANS FOR THE SERIES

	Broad Money Supply M2 (TT$ Mn)	Local Sales of Cement (tonnes)	Index of Retail Sales (Avg. 1979 =100)
Means			
1982 to 1993	8377.05	25279.42	152.15
1982 to 1987	7764.89	31657.75	157.91
1988 to 1993	8989.22	18901.08	146.39

that of the three series tested, the mean of the broad money supply series was the only one larger in the second half of the sample period.

The average monthly and quarterly deviations of the series from their trend value is shown in Table 2. This measure provides a first indication of the size of the seasonal component. Table 2 shows that the local sales of cement series has the largest seasonal variations when compared with the other series. In addition, the table corroborates the presence of a definite seasonal high in May and a seasonal trough in December for the local sales of cement series. The broad money supply series, according to this measure, has a seasonal high in June and a trough in October. For the Index of Retail Sales, a seasonal high occurs in the fourth quarter and a trough in the first quarter.

TABLE 2
MEAN MONTHLY AND QUARTERLY DEVIATION FROM THE TREND

Monthly Series	Broad Money Supply M2 (TT$ Mn)	Local Sales of Cement (tonnes)	Quarterly Series	Index of Retail Sales (Avg. 1979=100)
January	-30.91	-3239.57		
February	-45.60	-2516.42		
March	34.95	361.15	Qtr 1	-12.43
April	10.50	2716.93		
May	83.35	6611.65		
June	112.32	1936.12	Qtr 2	-6.59
July	1.33	851.10		
August	-30.52	-1037.68		
September	-13.45	-1709.18	Qtr 3	-3.24
October	-56.40	354.12		
November	-44.32	-647.25		
December	14.82	-3745.96	Qtr 4	18.82

Note: The mean of the actual deviation from the trend is calculated, not the mean of the absolute value from the trend

Finally, to determine whether the series in question were more suited to additive or multiplicative adjustment a trend regression was fitted to the individual series. The choice among the two types of adjustment was made on an ad-hoc basis by using a simple regression between the preliminary trend and the absolute value of the preliminary seasonal component of a series. This regression is of the form:

$$|y - y_T| = \alpha + \beta y_T$$

where y is the value of the original series and y_T the centered moving average of y over the period of one year. If the components are not correlated, i.e., if β does not differ significantly from zero, additive adjustment would probably be appropriate. If β is significant, a multiplicative method may be best. Series with negative values must be adjusted additively since the multiplicative method is based on the log of the series. In practice, this approach was less than satisfactory and tended to be very sensitive to outliers in the series. Alternatively, the power transformation tests can provide similar information. Table 3 presents the least squares estimates of the coefficients α and β, together with their corre-

TABLE 3
IDENTIFICATION OF MULTIPLICATIVE OR ADDITIVE ADJUSTMENT

	Alpha	Beta	Power Transformation	Choice of Adjustment Method
Broad Money Supply M2 (TT$ Mn)	324.90 (4.97)	-0.03 -(3.58)	None	Additive
Local Sales of Cement (tonnes)	-1182.63 -(1.53)	0.16 (5.67)	-0.25	Multiplicative
Index of Retail Sales (Avg. 1979 =100)	5.94 (0.55)	0.04 (0.54)	0.5	Additive

Note: Identification according to | Y - MAVEC(Y) | = Alpha + Beta * Y, t - values in parentheses sponding t-values; the results of the transformation tests, and finally the choice of adjustment method adopted. However, our analysis does not concern itself with intermediate adjustment techniques. Observation of the table suggests that the local sales of cement series should be adjusted multiplicatively while the remaining two series should be adjusted additively.

2.3 Application of Seasonal Adjustment Methods

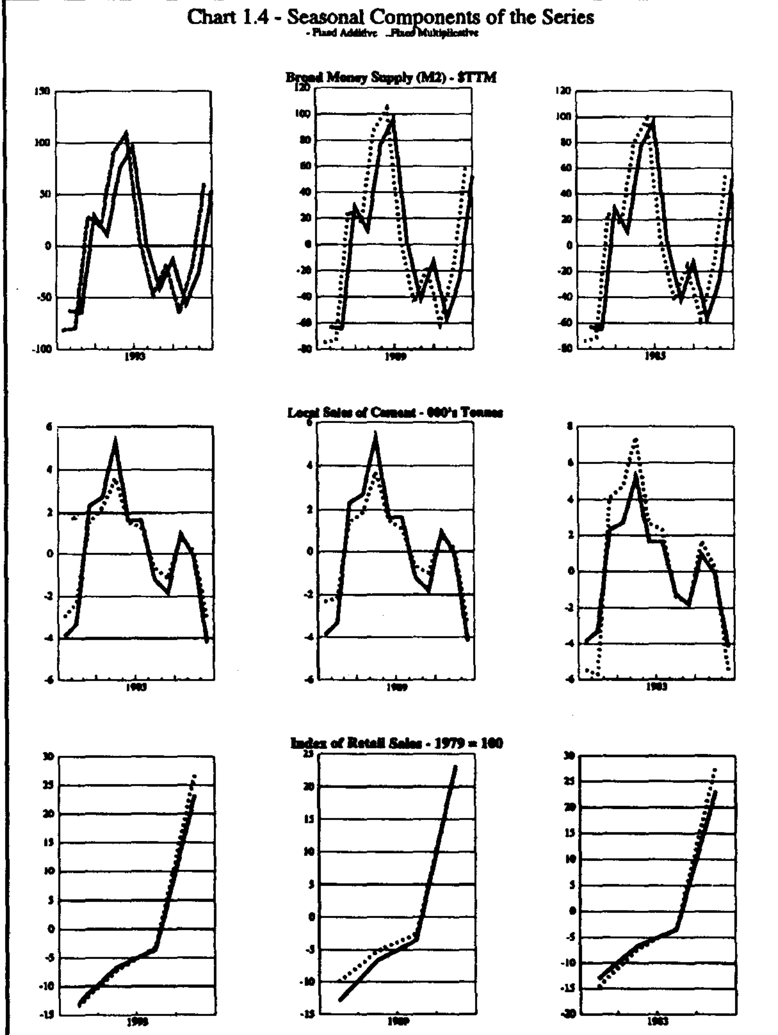
2.3.1 Differences in Seasonal Components

In this section an evaluation of the performance of the six methods is undertaken for each of the three series. In particular, differences in the components produced by each method are analysed and this is followed by an assessment of the comparative performance of each method based on a series of objective criteria outlined by Fase and Den Butter (1991).

(a) Fixed Additive vs. Fixed Multiplicative Methods

For all series concerned, the seasonal component according to the fixed additive and fixed multiplicative method were analysed on a yearly basis (Chart 1.4). The fixed multiplicative method yields seasonal components, which, when compared with the fixed additive method, deviate more widely from each other at the beginning and end of the sample period but otherwise follow each other quite closely. An exception here is the broad money supply series (M2) whose seasonal components according to the additive method appear to lag about a half-period behind the seasonal components of the other series.

CHART 1.4
SEASONAL COMPONENTS OF THE SERIES
-Fixed Additive .. Fixed Multiplicative



(b) Census Method 1 vs. Census X11 Method

Chart 1.5 reveals that for the Census Method 1, shifts in the seasonal pattern are reflected in changes in the size of the seasonal component. The estimated seasonal pattern produced by Census X 11 appears to be stable and changes little over the years. For instance, the application of the Census Method 1 (additive variant) to the broad money supply series, rendered seasonal components which changed very little over the years, even though seasonality in this series was obviously changing. The multiplicative variant of the Census Method 1, appears to be more sensitive to changes in the size of the seasonal component, even though it still fails to reflect changing seasonal patterns.

In contrast, Chart 1.5 seems to suggest that the Census X11 method (whether additive or multiplicative variant) is more sensitive to the changing seasonality of the series than the Census 1 method. Although this method tends systematically to underestimate the changes in the seasonal pattern at the beginning and end of the series, the application of the method to the series renders better seasonal components than the other methods previously considered.

(c) Census X11 vs. X11-ARIMA

Chart 1.6 shows that adjustment of the individual series by these two methods yields very similar seasonal components. For the broad money supply series, the X11-ARIMA method appears to be more sensitive to the changing seasonality in the series than the Census X11 method. The difference between the two methods are larger at the beginning and end of the sample period, but otherwise the differences in the size of the estimated seasonal components are small.

CHART 1.5
SEASONAL COMPONENTS OF THE SERIES
-Census Method 1 - Census X11

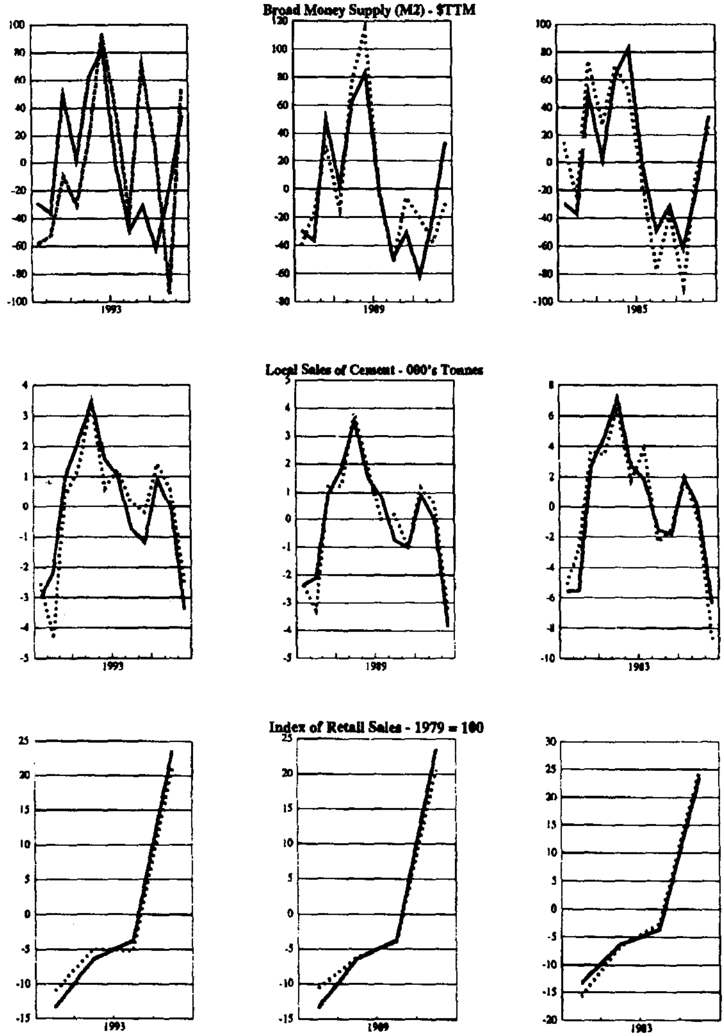
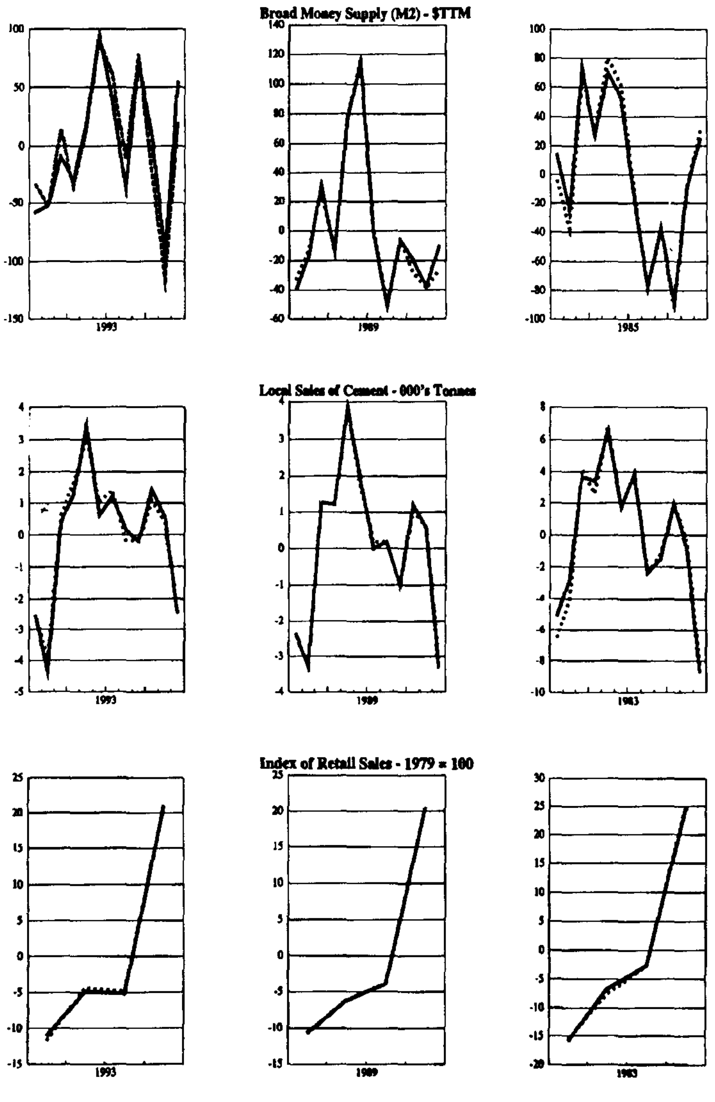


CHART 1.6
SEASONAL COMPONENTS OF THE SERIES
-Census X11 and .. X11-ARIMA



(d) X11-ARIMA vs. SABL Method

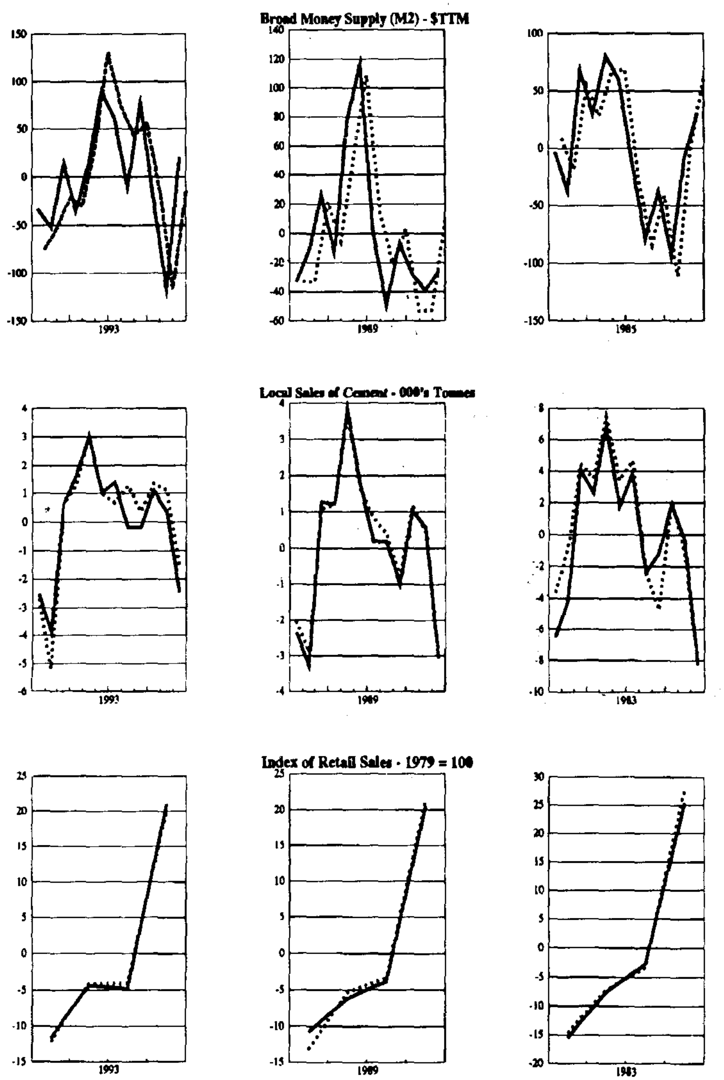
The difference in seasonal components and seasonal patterns produced by the two methods are very apparent (see Chart 1.7). For the broad money supply, the SABL method tended to overestimate the changes in the seasonal components at the beginning and end of the series. For the local sales of cement series, the SABL method was much better than X11-ARIMA in detecting the changing seasonal pattern.

Table 4 summarises the differences obtained from applying the six adjustment methods using the average periodic (monthly or quarterly) absolute percentage change in the original and seasonally adjusted series. This statistic represents a measure of smoothness of the series. Generally, seasonally adjusted data should be smoother than the original series. From an intuitive standpoint therefore, the value of the statistic for the seasonally adjusted data should be smaller than the original data. This proved true in all instances. Additionally, in all instances, except for the All Sections Index of Retail Sales series where the Census X11 method yielded the lowest statistics, the statistics produced by the X11-ARIMA method were always the lowest.

TABLE 4
AVERAGE PERIODIC ABSOLUTE PERCENTAGE CHANGE IN ORIGINAL AND SEASONAL ADJUSTED SERIES

	Broad Money Supply M2 (TT$ Mn)	Local Sales of Cement (tonnes)	Index of Retail Sales (Avg. 1979 =100)
Unadjusted data :	0.98	12.33	12.31
	Seasonally adjusted data		
Fixed Additive	0.85	9.98	4.89
Fixed Multiplicative	0.86	9.53	4.59
Census Method 1	0.83	9.49	4.95
Census X11	0.80	8.41	4.58
X11 ARIMA	0.79	8.33	4.61
SABL	0.81	8.96	4.86

CHART 1.7
SEASONAL COMPONENTS OF THE SERIES
-X11 Arima ..SABL



The Theil's Inequalities Coefficient (IC) was also employed to determine the extent to which the estimated seasonal components differed from each other.

$$IC_{m,n} = \frac{\sqrt{\sum_{t=1}^{N}\left(S_t^{(m)} - S_t^{(n)}\right)^2}}{\sqrt{\sum_{t=1}^{N} S_t^{(m)^2}}\sqrt{\sum_{t=1}^{N} S_t^{(n)^2}}}$$

If $IC_{m,n} = 0$, then the two methods m and n have produced identical seasonals. However, if $IC_{m,n}$ equals one, then the seasonal components according to one method differ on average as much from the other, as they would have if the other series were not seasonally adjusted. Table 5 shows that the values of most of these coefficients were close to zero, indi-

TABLE 5
DIFFERENCES BETWEEN THE SEASONAL COMPONENTS ACCORDING TO THE ADJUSTMENT METHODS CONSIDERED, MEASURED BY THEIL'S INEQULAITY COEFFICIENT

	Fixed Additive	Fixed Multiplicative	Census Method 1	Census X11	X11 ARIMA	SABL
Broad Money Supply M2 (TT$Mn)						
Fixed Additive	0.00	0.07	0.18	0.33	0.32	0.32
Fixed Multiplicative	0.07	0.00	0.22	0.35	0.35	0.35
Census Method 1	0.18	0.22	0.00	0.30	0.30	0.32
Census X11	0.33	0.35	0.30	0.00	0.10	0.19
X11 ARIMA	0.32	0.35	0.30	0.10	0.00	0.16
SABL	0.32	0.35	0.32	0.19	0.16	0.00
Local Sales of Cement (tonnes)						
Fixed Additive	0.00	0.16	0.16	0.20	0.19	0.23
Fixed Multiplicative	0.16	0.00	0.05	0.15	0.13	0.17
Census Method 1	0.16	0.05	0.00	0.15	0.13	0.18
Census X11	0.20	0.15	0.15	0.00	0.04	0.09
X11 ARIMA	0.19	0.13	0.13	0.04	0.00	0.10
SABL	0.23	0.17	0.18	0.09	0.10	0.00
Index of Retail Sales (Avg. 1979 =100)						
Fixed Additive	0.00	0.06	0.01	0.06	0.06	0.05
Fixed Multiplicative	0.06	0.00	0.06	0.06	0.06	0.07
Census Method 1	0.01	0.06	0.00	0.07	0.06	0.04
Census X11	0.06	0.06	0.07	0.00	0.01	0.05
X11 ARIMA	0.06	0.06	0.06	0.01	0.00	0.04
SABL	0.05	0.07	0.04	0.05	0.04	0.00

cating that in most instances the various methods produced similar seasonals.

An examination of the extent to which the various adjustment methods attribute fluctuations in the series to seasonality was also attempted using the average size of the seasonal component (AS) defined as

$$AS = \frac{1}{n}\sum_{t=1}^{N} |S_t|$$

Table 6 suggests that for local sales of cement, the average size of the seasonal component according to the fixed additive method, is larger than those produced by the other methods. For the broad money supply (M2), the fixed multiplicative adjustment method produced the largest AS statistic. This indicates that these methods probably overestimated the average size of the seasonal component and are probably not the most appropriate methods to smooth these series. For the other series, the average size of the seasonal component varied little from one seasonal adjustment method to the next.

TABLE 6
AVERAGE SIZE OF THE SEASONAL COMPONENTS

	Broad Money Supply M2 (TT$ Mn)	Index of Retail Sales (Avg. 1979 =100)	Local Sales of Cement (tonnes)
Fixed Additive	44.22	11.59	2420.75
Fixed Multiplicative	48.62	10.80	2153.60
Census Method 1	38.41	11.76	2105.58
Census X11	40.29	10.77	2140.90
X11 ARIMA	40.62	10.81	2141.89
SABL	41.78	11.22	2128.37

Table 7 utilises the average change in the seasonal component to ascertain the extent to which the adjustment methods correctly identify changes in the seasonal pattern. This statistic is calculated as follows:

$$AC = \frac{1}{n-1}\sum_{j=1}^{n-1} \frac{\sum_{i=1}^{12} \left| S_{j.12+i} - S_{(j-1).12+i} \right|}{\sum_{i=1}^{12} \left| S_{j.12+i} \right|}$$

where AC = Average Change in the Seasonal Component

TABLE 7
AVERAGE ABSOLUTE PERCENTAGE CHANGE IN THE SIZE OF THE SEASONAL COMPONENTS

	Broad Money Supply M2 (TT$ Mn)	Local Sales of Cement (tonnes)	Index of Retail Sales (Avg. 1979 =100)
Fixed Additive	0.00	0.00	0.00
Fixed Multiplicative	0.04	0.16	0.09
Census Method 1	0.00	0.17	0.00
Census X11	0.67	0.32	0.06
X11 ARIMA	1.58	0.34	0.06
SABL	1.29	0.39	0.03

The results from this table show, as expected, that with respect to the more sophisticated seasonal adjustment methods, relatively large changes in the seasonal components were calculated for the broad money supply and local sales of cement; for the fixed additive method, the calculated seasonal components do not change. Of the more sophisticated adjustment methods, Census X11, X11-ARIMA and SABL, the latter, by comparison, computes relatively large changes in the seasonal components, except for the Index of Retail Sales series. On average, the Census Method 1 produced the smallest average absolute percentage changes in its seasonal components. From examination of this table, one can conclude that the SABL method is probably the most sensitive to changes in the seasonal patterns of local sales of cement series. For the broad money supply series, the X11-ARIMA method is the most sensitive to changes in the seasonal pattern, and for the Index of Retail Sales the fixed multiplicative method was best.

2.3.2 *Comparative Analysis*

Fase and Den Butter (1991), outline the ideal properties for seasonal adjustment procedures. They suggest that any seasonally adjusted series should satisfy basic axiomatic properties of orthogonality, idempotency and symmetry. In practice, though, an important criterion for the assessment of any seasonal adjustment technique is the stability of the seasonal estimates when new observations are added. This is very important, as the more stable the seasonal components rendered by any seasonal adjustment technique, the more likely are policy makers to use seasonal figures in their analysis.

(a) Orthogonality

Ideally, in assessing the strength of any particular seasonal adjustment method, orthogonality of the seasonal and trend-cycle components should not exist, i.e. the seasonal components and the seasonally adjusted series should not be correlated. Table 8 shows that the correlation coefficients of the seasonal components and the seasonally adjusted series are relatively small for all series across the various methods under review. As such, this test does not really discriminate between the various methods.

TABLE 8
CORRELATION COEFFICIENT OF SEASONAL COMPONENT AND SEASONALLY ADJUSTED SERIES

	Broad Money Supply M2 (TT$ Mn)	Local Sales of Cement (tonnes)	Index of Retail Sales (Avg. 1979 =100)
Fixed Additive	0.00	0.02	-0.07
Fixed Multiplicative	0.01	0.08	-0.05
Census Method	-0.00	0.08	-0.08
Census X11	0.01	0.10	-0.02
X11 ARIMA	0.01	0.10	-0.03
SABL	-0.00	0.13	-0.06

(b) Idempotency

Idempotency of a time series exists if repeated applications of the method yields exactly the same seasonally adjusted series as the first application. The statistic used to test for idempotency (ID) is calculated as follows:

$$ID = \frac{100}{12n}\sum_{i=1}^{12}\sum_{j=1}^{n}\frac{\left|s_{ij}^{sc} - s_{ij-1}^{sc}\right|}{y_{ij}^{sc}}$$

where y_{ij}^{sc} = seasonally adjusted series

s_{ij}^{sc} = estimated seasonal component

n = number of years in the sample period

Where idempotency exists ID equals zero. Table 9 indicates that the fixed additive method, by definition, is fully idempotent. Application of the Census Method 1 to the index of retail sales and the broad money supply produced ID's of zero.

TABLE 9 IDEMPOTENCY OF METHODS			
	Broad Money Supply M2 (TT$ Mn)	Local Sales of Cement (tonnes)	Index of Retail Sales (Avg. 1979 =100)
Fixed Additive	0.00	0.00	0.00
Fixed Multiplicative	0.02	1.76	0.83
Census Method 1	0.00	1.70	0.00
Census X11	0.13	2.23	0.37
X11 ARIMA	0.13	2.20	0.39
SABL	0.13	2.32	0.26

(c) *Residual Seasonality*

Residual seasonality exists when the irregular component of a particular month still shows a seasonal pattern. This may be revealed by an examination of the autocorrelation function for particular months or quarters over the years of the sample period. As such, the Box-Pierce Q statistic calculated for each period over the years of the sample provides an adequate summary measure. The Q statistic composed of the first K residual autocorrelations is denoted by

$$Q = T \sum_{k=1}^{K} \hat{r}_k^{\,2}$$

and is approximately distributed as Chi-square with k degrees of freedom. Tables 10.1 and 10.2 show the number of significant periods in the test for positive autocorrelation of the irregular components per month and per quarter respectively. Table 10.1 indicates that the SABL method produced the greatest number of significant months (i.e. where residual autocorrelation existed) among all the methods. For the quarterly series, the X11-ARIMA method produced the greatest number of significant periods, indicating the possibility of some over adjustment in the respective series. Generally, for the well-behaved series, the number of periods that tested significant for residual autocorrelation were low.

TABLE 10.1
NUMBER OF SIGNIFICANT MONTHS IN THE TEST ON POSITIVE AUTOCORRELATION OF THE IRREGULAR COMPONENTS PER MONTHS

	Broad Money Supply M2 (TT$Mn)	Local Sales of Cement (tonnes)	Total
Fixed Additive	1	0	1
Fixed Multiplicative	1	0	1
Census Method I	4	1	5
Census X11	5	1	6
X11 ARIMA	5	0	5
SABL	6	1	7

TABLE 10.2
NUMBER OF SIGNIFICANT MONTHS IN THE TEST ON POSITIVE AUTOCORRELATION OF THE IRREGULAR COMPONENTS PER QUARTER

	Index of Retail Sales (Avg. 1979=100)	Total
Fixed Additive	0	0
Fixed Multiplicative	0	0
Census Method I	0	0
Census X11	2	2
X11 ARIMA	3	3
SABL	1	1

(d) Residual Trend Cycle Movements

This occurs when the series has not been effectively decomposed into its constituent trend cycle and other components. This was tested by an examination of autocorrelation of the irregular component for the whole series over all the months and years. Again the Box-Pierce Q statistic served as a summary measure. Table 11.1 shows that, on average, the X11-ARIMA method performed best on this test for the monthly series while Table 11.2 shows that all methods produced similar results.

TABLE 11.1
TEST ON POSITIVE AUTOCORRELATION OF THE IRREGULAR COMPONENT PER WHOLE SERIES

	Broad Money Supply M2 (TT$Mn)	Local Sales of Cement (tonnes)	Total number of series with a significant test value
Fixed Additive	*	*	2
Fixed Multiplicative	*	*	2
Census Method I	*	*	2
Census X11	*	*	2
X11 ARIMA			0
SABL	*	*	2

Note: * Indicates significant positive autocorrelation

TABLE 11.2
TEST ON POSITIVE AUTOCORRELATION OF THE IRREGULAR COMPONENT PER WHOLE SERIES

	Index of Retail Sales (Avg. 1979=100)	Total number of series with a significant test value
Fixed Additive	*	1
Fixed Multiplicative	*	1
Census Method I	*	1
Census X11	*	1
X11 ARIMA	*	1
SABL	*	1

Note: * Indicates significant positive autocorrelation

(f) *Stability*

For official statistical agencies, the stability test is probably the most important criterion for assessing the suitability of a particular seasonal adjustment method. An adjustment procedure is stable if the seasonally adjusted series is not unduly affected when updated with new data. This is an important requirement for decision-making purposes. Fase and Den Butter suggests that the stability of the estimates of the seasonal component can be determined by comparing the seasonals obtained from different, though overlapping, sample periods. The series concerned were adjusted successively from 1982-1990, 1982-1991, 1982-1992, 1982-1993, to obtain the corresponding seasonal components for the above periods. For each pair of successive periods, the inequality between the relevant seasonals were measured. The stability measure is summarized as:

$$ST = \frac{1}{3}\left(CP_{91}^{90} + CP_{92}^{91} + CP_{93}^{92}\right)$$

where *CP* summarizes the inequality between seasonals for the periods concerned. When *ST* equals zero, full stability exists. Table 12 presents the mean of the inequalities between seasonals and concludes that generally all *STs* are close to zero. The worst results were obtained by the application of the SABL method to all series. However, when the results of the Census X11 and the X11-ARIMA are compared, the X11-ARIMA method produced in all instances, the higher statistic. This result is quite surprising since the *raison d'être* for the ARIMA extension of the basic Census X11 is enhanced stability. Low *STs* were produced by all methods for the local sales of cement and the index of retail sales series indicating the relative stability of these series. Examination of

Table 12 shows that, on average, the Census X11 procedure produced the most stable seasonal components. It should be noted that Fase and Den Butter obtained a similar result and for this reason the Census X11 method was chosen by the Netherlands Central Bank for the seasonal adjustment of a large number of macroeconomic and financial data.

TABLE 12
STABILITY OF THE SEASONAL COMPONENTS UPON EXTENSION OF THE ADJUSTMENT PERIOD BY ONE YEAR

	Broad Money Supply M2 (TT$ Mn)	Local Sales of Cement (tonnes)	Index of Retail Sales (Avg. 1979 =100)
Fixed Additive	0.12	0.04	0.01
Fixed Multiplicative	0.13	0.04	0.02
Census Method 1	0.11	0.04	0.02
Census X11	0.11	0.03	0.02
X11 ARIMA	0.12	0.04	0.03
SABL	0.16	0.09	0.05

3. SUMMARY AND CONCLUSION

The paper examined the major issues involved in the establishment of successful seasonal adjustment programs for official statistical agencies. A number of critical success factors were identified including, the processes required, the role of an integrated processing environment and the need for the statistical agency to market the seasonal numbers. The paper also examined in some detail the issues that ought to be considered when choosing among different seasonal adjustment methods. A number of tests were developed to discriminate among seasonal adjustment methods, and the performance of six commonly available seasonal adjustment methods were examined using a small number of actual Trinidad and Tobago time series. The results obtained are not meant to prove conclusively that any one technique is better than the other for recommendation to statistical agencies. The number of series tested was much too small to lead to such a conclusion. However, we believe our findings are interesting because they suggest that more exhaustive testing will not result in a clear winner as some methods are likely to perform well on some tests and to fare badly on others. This is particularly true of the Census X11 and the X11-ARIMA methods which emerged as top contenders in our study. However, if stability was given the highest weight, the performance of the X11-ARIMA was quite disappointing as the Census X11 method outperformed it in this area.

Another major limitation of this study is the omission of the application of spectral methods. Granger and Newbold (1977) demonstrated how the adequacy of seasonal adjustment methods can be diagnosed by using spectral analysis. However, as summary statistics for spectral analysis are not well developed, the inclusion of this type of analysis would have greatly added to the volume of diagrams and charts in this paper. In a forthcoming study, the tests developed, in this paper will be applied to a large number of macroeconomic time series. This will provide more definitive conclusions about the applicability of traditional seasonal adjustment techniques in the Trinidad and Tobago context.

ENDNOTES

1. See Nicholls (1989) for the first attempt at seasonally adjusting the QGDP Index in Trinidad and Tobago

2. The acronym ARIMA stands for Autoregressive Integrated Moving Average.

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MACROFINANCIAL MODELLING: A PARAMETRIC VS NON-PARAMETRIC APPROACH

Surendra Arjoon

ABSTRACT

This paper examines macro-financial data to explain the behaviour of measures of financial deepening in Trinidad and Tobago. A non-parametric approach is used to identify the shortcomings of the classical regression framework. The non-parametric model gives significantly better overall fit than its parametric counterpart. Results show that nominal deposit rates are significant and have a positive influence in explaining overall financial and monetary depth; savings in the form of accumulation of financial wealth is a key determinant of overall financial depth; inflation has a positive, though insignificant, influence on overall financial depth. The pace and diversity of developments in regression and econometric methods have rendered computer software packages inadequate for contemporary research methodologies. This is particularly the case for non-parametric regression techniques. This paper also gives the derivation of simple formulae of some commonly used non-parametric functionals using the normal kernel. Results in this paper are intended to be illustrative and instructive in deriving other non-parametric functionals of interest which may not be commercially available. These results can be easily programmed using computer facilities that are currently available in most institutions. The non-parametric functionals for the macro-financial model were based on programmes written in the C language.

INTRODUCTION

The nature and structure of the economies of most developing countries make economic modelling based on traditional theories and methods a difficult task. Indeed, traditional economic theory has limited applications in economies that are characterised by imperfect competition, over-valued exchange rates, frequent devaluations, inefficient markets and institutional and other non-market factors, including behavioural and cultural factors. Researchers in developing countries often require models that take these factors into account. Quite often, however, investigators spend a significant amout of time refining or adapting models to fit the environment in developing countries; justifying results that are inconsistent with the realities of the economy; or commenting on the inadequacies of the models used and their assumptions. In most instances, there is a high degree of incompatibility between the data and the model.

The financial system is especially important in developing countries since it provides intermediation services to an economy by co-ordinating resource flows between savers and investors. There is much evidence which suggests that formal financial systems with their economies in information processing and risk-pooling, are generally more efficient than informal systems. This paper utilises correlation, parametric and non-parametric analysis to analyse measures of financial deepening in Trinidad and Tobago. Several measures of financial depth are presented. The non-parametric approach is used to identify the shortcomings of the classical regression framework in explaining the behaviour of measures of financial depth.

The paper is divided into four (4) sections. Section 1 presents a brief literature review on the major applications of non-parametric methods. The advantages and limiatations of non-parametric regression methods are also discussed. Section 2 compares the results of applying parametric and non-parametric methods to analyse financial deepening in Trinidad and Tobago. The development of appropriate computer software packages has not kept pace with the recent developments in non-parametric techniques. Researchers need to acquire, or at least to have access to, some programming expertise in order to develop or to modify existing and new computer routines to suit contemporary methodologies. Section 3 gives the derivation of simple formulae of some commonly used non-parametric regression functionals using a normal kernel density estimation technique. In particular, those functionals considered in this paper are the estimators for the regression functional, response coefficients and their associated variance-covariance, and the non-parametric residual vector. In each case, the one regressor model is derived and the corresponding multivariate case is given as an extension to the univariate case. These results are intended to be illustrative and instructive in deriving other non-parametric functionals of interests which may not be commercially available nor easily programmed with existing computer facilities in most institutions.[1] For further details on non-parametric regression methods see Singh *et al* (1987), Devroye and Gyorfi (1984), Eubank (1988), Hardle (1990), and Silverman (1986), Prakasa Rao (1981) and Ullah (1989). The final section concludes with a summary of the results of the investigation.

1. THE NON-PARAMETRIC APPROACH: A BRIEF SURVEY

The advantages of non-parametric (and semi-parametric) models have been well documented in papers by Racine (1988), Rilestone and Ullah (1986), Singh *et. al* (1987), Ullah

(1988a, b), Ullah and Vinod (1988), and Vinod and Ullah (1988). These advantages include robustness with respect to the data and the functional form since the latter need not be specified; improved inference; avoidance of the problems of multicollinearity; and more meaningful interpretations of the response function. Non-parametric estimation essentially employs approximations to an unknown density function and refers to any statistical procedure which does not make any assumptions regarding the underlying data generating process. A non-parametric approach is especially useful in providing the appropriate functional form of a regression model; the distributive form of a disturbance random variable; and to guide in the choice of relevant explanatory variables (see Delgado and Robinson (1992)). Non-parametric regression methods can also be employed to gauge the goodness of particular parametrisations of conditional expectations and the usefulness of candidate explanatory variables without specifying functional forms. Recent work on non-parametric regression analysis has focussed on inference - especially hypothesis testing (see, for example, Rilestone (1991) and Robinson (1991)).

Applications of non-parametric statistical estimation are vast and growing in a number of diversified areas. In the areas of consumer theory, Hausman and Newey (1993) examined an application to gasoline demand in order to look at the shape of the demand curve and the average magnitude of welfare loss from a tax on gasoline. Bierens (1990) demonstrated the usefulness of non-parametric regression analysis for functional specification of household Engel curves. Azzalini *et al* (1988) and Eubank and Spiegelman (1990) investigated the use of the non-parametric methodology to test the adequacy of parametric models.

With regards to policy analysis, Stock (1985) addressed the problem of estimating the benefits of cleaning up unsafe hazardous waste using housing value data. Triest (1987) used non-parametric regression estimators to investigate two issues which arise in estimating labour supply functions in the presence of income taxation, namely, whether there is sufficient information in available data sets to use the complete budget constraint estimation method; and whether the effective marginal tax rate is less than the statutory marginal tax rate. Ahn and Powell (1993) also looked at estimating labour supply in a censored selection model while Pace (1993) applied non-parametric methods to real estate valuation models. McCaffrey (1992) has recently estimated the Lyapunov Exponent of a chaotic system with non-parametric regression.

In the field of resource economics, Berck (1988) tested the hypothesis that the net extraction cost price of a natural resource does not change with volume, which is a consequence of Hotelling's theory. The test rejected the pure form of the Hotelling theory and showed that it was necessary to adjust sales prices for volume sold.

In the field of time series analysis, Hardle and Vieu (1990) have utilised kernel regression methods to smoothen time series data. In their study, a class of non-parametric regression smoothers for time series was defined by the kernel method which allows flexible modelling without reference to a specific parametric class. These authors also demonstrated that the technique is also applicable to detect non-linear dependencies in time series and to predict smooth regression models with serially correlated observations.

One area in which the application of non-parametric regression techniques is growing is that of financial modelling. For example, McCurdy and Stengos (1992) computed parametric estimates of a time-varying risk premium model and compared the one-step-ahead forecasts implied by that model with those given by a non-parametric estimator of the conditional mean function. The kernel estimator was used to assess the adequacy of the parametric model in capturing any structure in the excess returns. Arjoon (1993) has estimated financial models of the demand for money and savings in Trinidad and Tobago, using both parametric and non-parametric regression techniques.

One of the difficulties in the application of non-parametric regression methods is the choice of window widths. The selection of window widths introduces an element of arbitrariness into the estimation process. No consensus on the method of selecting window widths has been reached. Too small a value, may undersmooth and induce bias. In addition, most distributions are characterized by few points in their tails, and consequently a different or variable window width may improve estimation in the tails for the said distribution. Nychka (1991) explores choosing a range for the amount of smoothing in non-parametric regression. One of the ways to ensure bias reduction for particular choices of the window width is to use "higher-order" kernels as proposed by Bartlett (1963). Robinson also (1988) discussed alternative bias reduction methods.

The rate of convergence of the regression coefficients in the classical parametric framework is the square root of n, where n is the sample size. In the non-parametric case, it turns out to be $(nh^{k+2})^{1\backslash 2}$, where h is the window width and k is the number of regressions. This slower rate of convergence implies that the standard errors of non-parametric estimates typically turn out to be larger than their corresponding parametric counterparts and the associated test statistics are less efficient.

This so-called "curse of dimensionality" may be avoided. Andrews and Whang (1980) considered series estimates of Additive Interactive Regression (AIR) models. AIR models are non-parametric regression models that generalize additive regression models by allowing interactions between different regressors. AIR models were found to circumvent the "curse of dimensionality" that afflicts the estimation of fully parametric regression models. The kernel regression estimator is robust to specification error. However, the restriction that the conditional expectation of the residual be zero throughout the entire domain is often violated. Bradley (1992) proposed a correction for this violation through a limited information two stage kernel regression.

The multivariate kernel density estimation technique is used to estimate the conditional mean defined as

$$E(y \mid x) = \int_{-\infty}^{\infty} y\, f(y \mid x) dy$$

The underlying estimated model is assumed to be of the form

$$y = E[y \mid x] + \varepsilon$$

where ε is a white noise error term

The response coefficients and associated standard errors for the k^{th} conditioning variable are evaluated holding the other $(k\text{-}1)$ variables constant at their mean values. The j^{th} response coefficient at observation i, is defined as

$$\hat{\beta}(x_j)_i = \frac{\partial \hat{E}\left[y \mid x_1 = \bar{x}_1, x_2 = \bar{x}_2, \ldots, x_p = \bar{x}_p\right]}{\partial x_j}$$

2. MACROFINANCIAL MODELLING: EMPIRICAL RESULTS

The financial deepening literature and other mainstream monetary theory suggest that overall financial depth is influenced by policy variables, in particular, financial prices, and by institutional factors including a country's overall level of development and wealth. Two policy variables, the nominal weighted average deposit rate (DR) and the inflation rate (INF) are included in the model specifications. Furthermore, real total assets (RTA) are also included in the specifications and can be considered as savings in the form of accumulated financial wealth. This variable may also be utilised as an indicator of development.

Financial deepening should be positively related to overall economic performance and can also be influenced by institutional factors. The mix between monetary and non-monetary financial instruments varies with financial wealth, since relative prices of these alternative instruments influence wealth holders and, consequently, the depth of the financial system. It is assumed that all monetary instruments pay no interest but non-monetary instruments have an interest rate equal to the deposit rate (DR). Correlation and regression analysis (parametric and non-parametric) are employed to develop a model to examine the determinants of the various measures of financial deepening.

The data span the first quarter of 1982 through the second quarter 1992, and were taken from various publications of the Central Bank and Central Statistical Office of Trinidad and Tobago. The data include measures of Monetary Depth (MD), Financial Depth (FD), and Non-Monetary Depth (NMD) defined as the ratio of the stocks of money[2] plus liquid liabilities[3] plus quasi-liquid liabilities[4] to the total assets of the financial system.

2.1 Correlation Analysis

Results of the Pearson correlation coefficients are presented below in Table 1. The significant negative correlation between monetary and non-monetary depth is not surprising since economic agents switch from holding money balances to holding interest-bearing liabilities. Furthermore, the strong positive correlation between financial and monetary depth indicates a preference to hold money balances rather than quasi-liquid financial instruments when there is financial deepening. A counter-intuitive point to note is that the nominal deposit rate is statistically significant, positively correlated with

TABLE 1
PEARSON CORRELATION COEFFICIENTS

	FD	MD	NMD	DR	INF	RTA	RDR
FD							
MD	0.74*						
NMD	0.10	-0.59*					
DR	0.48*	0.47*	-0.11				
INF	0.26**	0.21	-0.01	0.19			
RTA	0.70*	0.70*	-0.20	0.72*	0.22		
RDR	0.13	-0.10	-0.03	0.07	-0.96*	-0.03	

* *Significant at the 5% level*
** *Significant at the 10% level*

monetary balances, and negatively correlated, though insignificant, with non-monetary balances. As expected, overall financial depth and nominal deposit rates are significantly positively correlated. There is evidence, therefore, that increasing the nominal deposit rates results in increased holdings of money balances as agents move away from non-monetary instruments.

The real deposit rates are weakly negatively correlated with all depth measures. Nominal deposit rates and inflation are weakly correlated which suggest that interest rate management by the monetary authorities has been passive. This is reinforced by the fact that financial depth and inflation are positively correlated at the 10% significance level. The low level of inflation experienced in the last decade in Trinidad and Tobago has in fact stimulated growth and development. Financial wealth is positively correlated with financial and monetary depth, and negatively correlated with non-monetary depth. This indicates that augmenting domestic resource mobilization through financial deepening comes largely through the increased holding of money balances.

2.2 Regression Analysis

In the first instance, both parametric and non-parametric regressions are used to explain FD, MD, and NMD with independent variables real deposit rate (RDR) and real total assets (RTA). The results are presented in Table 2 and Table 3.

The parametric specification shows that RTA, INF and DR explain 50% of the variation in both FD and MD, respectively whereas only 1% of the variation in NMD is explained by the regression. The corresponding figures for the non-parametric regression are 65%, 72% and 35%, respectively. These results indicate that the non-parametric model fits much better than their parametric counterparts. Furthermore, both the parametric and non-parametric results show that financial wealth (RTA) is significant in explaining FD and MD.

The second set of specifications separates the real deposit rate (RDR) into an inflation component and the weighted nominal deposit rate. This dissagregation allows the investigation of the separate influences of these two components. As in the previous parametric specification, 50% of the variations in FD and MD are explained by the regressors DR, INF and RTA

TABLE 2
PARAMETRIC REGRESSION RESULTS

	Dependent Variables		
Independent Variables	FD	MD	NMD
RDR	-0.1606	-0.0012	-0.0004
RTA	0.1051*	0.0013*	0.0003
R^2	0.50	0.50	0.01

* *Significant at the 5% level*

TABLE 3
NONPARAMETRIC REGRESSION RESULTS

	Dependent Variables		
Independent Variables	FD	MD	NMD
RDR	0.0008	-0.0035	-0.0027
RTA	0.0010*	0.0020*	-0.0010
R^2	0.65	0.72	0.35

* *Significant at the 5% level*

while only 1% of the variation in NMD is explained by these variables. The non-parametric goodness of fit statistics for FD, MD and NMD are 77%, 80% and 58%, respectively.

The parametric results show that financial prices are not the dominant factor in determining depth measures. This result

TABLE 4
PARAMETRIC REGRESSION RESULTS

	Dependent Variables		
Independent Variables	FD	MD	NMD
DR	-0.0027	-0.0055	0.0028
INF	0.0016	0.0011	0.0005
RTA	0.0011*	0.0014*	-0.0003
R^2	0.50	0.50	0.01

* *Significant at the 5% level*

TABLE 5
NONPARAMETRIC REGRESSION RESULTS

	Dependent Variables		
Independent Variables	FD	MD	NMD
DR	0.0167**	0.0309*	-0.0141
INF	0.0004	-0.0009	0.0013
RTA	0.0003	0.0013*	-0.0010*
R^2	0.77	0.80	0.58

* *Significant at the 5% level*
** *Significant at the 10% level*

is contradicted by the non-parametric results which suggest that the nominal deposit rate is significant in determining financial and monetary depth. In both methods, financial wealth is significant in the MD equation. This indicator of development is also significant in the FD parametric specification and in the NMD non-parametric regression. The non-parametric results show that inflation has a negative, but insignificant, influence on monetary depth. Results of both regression methods show that low inflation has contributed positively to overall financial and monetary depth.

3. THE DERIVATION OF NON-PARAMETRIC FUNCTIONALS

Due to the fact that very little work has been attempted in the Caribbean in the non-parametric vein, it is useful to indicate a few of the main derivations of the functionals (see Ullah 1988a)) to facilitate efficient programming of the methods. Consider a $(k+1)$ vector of random variables $(y_i, x_{1i}, \ldots, x_{ki}) = (y_i, x_i) = (y, x)$ with each element of size $(nx1)$. In order to simplify long and complex mathematical relationships, the following notation will be used throughout this paper:

$$Ew_i = e^{\left(-\frac{1}{2}w_i^2\right)}$$

$$EwJ_i = e^{\left(-\frac{1}{2}\sum_j w_{ji}^2\right)}$$

$$EwJ1_i = e^{\left(-\sum_j w_{ji}^2\right)}$$

$$K_1 = K\left(\frac{y_i - y}{h_i}, \frac{x_i - x}{h_i}\right)$$

$$K = K\left(\frac{x_i - x}{h_i}\right) = k(w_i)$$

$$w_i = \frac{x_i - x}{h_i}$$

h_i *- window width size or band size = h (for the one regressor case)*

Unless specified otherwise, summation notations are indexed by *i*, (*i* = *1, ..., n*) and product notations are indexed by *j*, (*j* = *1, ... k*). The choice of kernel[5] is usually any symmetric probability density. In this case a normal kernel is used, that is,

$$K = \frac{1}{\sqrt{2\pi}} Ew_i \qquad (1)$$

The kernel estimation used is that proposed by Rosenblatt (1956), who estimated the density, *f*, at a point (*y, x*) as

$$\hat{f}(y,x) = \frac{1}{n\prod_{j=1}^{k+1} h_j} \sum K\left(\frac{y_i - y}{h_i}, \frac{x_i - x}{h_i}\right)$$

$$= \frac{1}{n\prod_{j=1}^{k+1} h_j} \sum K_1 \qquad (2)$$

where h_j is the window width size or band size[6].

3.1 Regression Function

The non-parametric regression model can be represented as $y = R(x) + e$ where $R(x)$ is the non-parametric regression function and e is the error vector. The regression function is in fact an unspecified conditional mean, if it exists, defined as

$$R(x) = E(y \mid x)$$

$$= \int y\, f(y \mid x)\, dy$$

$$= \int y \frac{f(y,x)}{g(x)} dy$$

where f and g are the corresponding joint and marginal densities respectively. Using equations (1) and (2) for the one regressor case (k=1), the estimated regression function can be rewritten as:-

$$\hat{R}(x) = \int y \left\{ \frac{1}{nh^2} \Sigma K \Big/ \frac{1}{nh} \Sigma k(w_i) \right\} dy$$

where $w_i = (x_i - x)/h$

$$= \sum y_i k(w_i) \Big/ \sum k(w_i)$$

$$= \sum y_i \left(1/\sqrt{2\pi}\right) E w_i \Big/ \sum \left(1/\sqrt{2\pi}\right) E w_i$$

$$= \sum y_i E w_i \Big/ \sum E w_i \tag{3}$$

The extension to the multivariate case can be easily shown to be

$$\hat{R}(x) = \sum y_i EwJ_i \Big/ \sum Ew\, J_i \tag{4}$$

3.2 Response Function

The response function estimator is simply the partial derivative[7] of the estimated regression function defined as

$$\hat{r}_i(x) = \frac{\partial}{\partial x_i} \hat{R}(x)$$

$$= \sum y_i \left[\frac{k'(w_i)}{\sum k(w_i)} - \frac{k(w_i) \sum k'(w_i)}{\left[\sum k(w_i)\right]^2} \right]$$

$$\text{where } k'(w_i) = \frac{\partial}{\partial x_i} k(w_i) = \frac{\partial}{\partial x_i}\left(1/\sqrt{2\pi}\right)Ew_i = \left(1/h\sqrt{2\pi}\right)w_i Ew_i \quad (6)$$

Using results (5) and (6), the response function estimator can be simplified as

$$\hat{r}(x) = \frac{1}{h\sum Ew_i}\sum y_i Ew_i\left[w_i - \frac{\sum w_i Ew_i}{\sum Ew_i}\right] \quad (7)$$

For the multivariate case, the response function estimate for the s^{th} coefficient turns out to be

$$\hat{r}_s(x) = \frac{1}{h_s\sum EwJ_i}\sum y_i EwJ_i\left[w_{si} - \frac{\sum w_{si} EwJ_i}{\sum EwJ_i}\right]$$

3.3 Variance-Covariance of the Response Coefficient

There are two cases to consider namely, the variance based on the assumption of fixed regressors and the unconditional variance. In the first case, the variance of the response function estimator based on (5) is given by:-

$$VAR\hat{r}(x) = VAR(y/x)\Sigma\left[\frac{k'(w_i)}{\Sigma k(w_i)} \; \frac{k(w_i)\Sigma k'(w_i)}{\left[\Sigma k(w_i)\right]^2}\right]^2 \quad (9)$$

where the estimate of the (heteroscedastic) conditional variance is given by

$$\hat{V}AR(y \mid x) = \frac{\Sigma y_i^2 k(w_i)}{\Sigma k(w_i)} - \hat{R}^2(x)$$

$$= \frac{\Sigma y_i^2 Ew_i}{\Sigma Ew_i} - \hat{R}^2(x)$$

and for the k-regressor case,

$$\hat{V}AR(y \mid x) = \frac{\Sigma y_i^2 EwJ_i}{\Sigma EwJ_i} - \hat{R}^2(x) \tag{10}$$

Using equations (1), (6) and (9), the estimated conditional variance of the response coefficient estimate can be simplified as follows:

$$V\hat{A}R\, \hat{r}(x) = \frac{V\hat{A}R(y \mid x)}{\left[h\sum Ew_i\right]^2} \sum \left[Ew_i \left(w_i - \frac{\sum w_i Ew_i}{\sum Ew_i} \right) \right]^2 \tag{11}$$

For the k-regressor case, both the variance and covariance terms need to be considered. The estimated conditional variance of the s^th^ response coefficient is given by

$$V\hat{A}R\, \hat{r}_s(x) = \frac{V\hat{A}R(y/x)}{\left[h_s \Sigma EwJ_i\right]} \Sigma \left[EwJ_i \left(w_{si} - \frac{\Sigma w_{si} EwJ_i}{\Sigma EwJ_i} \right) \right]^2 \tag{12}$$

and the estimated covariance between the s^{th} and t^{th} terms is

$$C\hat{O}V\left[\hat{r}_s(x), \hat{r}_t(x)\right] = \frac{V\hat{A}R(y \mid x) \sum EwJ1_i}{\left[h_s h_t \sum EwJ_i\right]^2} \left[\left(w_{si} - \frac{\sum w_{si} EwJ_i}{\sum EwJ_i} \right) \right] \left[\left(w_{ti} - \frac{\sum w_{ti} EwJ_i}{\sum EwJ_i} \right) \right] \tag{13}$$

In the second case, the asymptotic unconditional estimate of the variance for k-regressors (See Ullah 1988(a)) is approximated by:-

$$\hat{A}VAR\, \hat{r}(x) \cong \frac{V\hat{A}R(y \mid x)}{\hat{f}(x) n \prod_{j=1}^{k+2} h_j} \int \left[k'(w)\right]^2 dw \tag{14}$$

and yields

$$\hat{A}VAR\, \hat{r}(x) = \frac{\sqrt{2}\, V\hat{A}R(y \mid x)}{4h^4 \sum EwJ_i} \tag{15}$$

The corresponding estimates of the asymptotic unconditional variance for the multivariate case can be written as follows:-

$$\hat{A}VAR\ \hat{r}_s(x) = \frac{VAR(y/x)}{2^{(4-k)/2} h_s^2 \left(\prod_{j=1}^{k} h_j \right)^{2/k} \Sigma EwJ_i} \tag{16}$$

while that for the covariance term is:-

$$AC\hat{O}V[\hat{r}_s(x)\hat{r}_t(x)] = \frac{VAR(y/x)}{2\pi^{(4-k)/2} h_s h_t \left(\prod_{j=1}^{k} h_j \right)^{2/k} \Sigma EwJ_i} \tag{17}$$

3.4 Residuals

Another regression functional of considerable interest is the non-parametric residuals, evaluated as

$$\hat{e}_i = y_i - \hat{R}(x) \tag{18}$$

The computational form of $\hat{e}_i$ is therefore given by

$$\hat{e}_i = y_i \left[1 - \frac{Ew_i}{\sum Ew_i} \right] \text{ for the one regressor case} \tag{19}$$

and

$$\hat{e}_i = y_i \left[1 - \frac{EwJ_i}{\sum EwJ_i} \right] \text{ for the } k \text{ regressor case} \tag{20}$$

The corresponding conditional variance of the non-parametric residuals in the case of the single regressor can be computed using:-

$$VAR(\hat{e}_i \mid x) = \frac{\sum \hat{e}_i^2 Ew_i}{\sum Ew_i} - \left[\frac{\sum \hat{e}_i Ew_i}{\sum Ew_i}\right]^2 \quad (21)$$

and for the k-regressor case with:-

$$VAR(\hat{e}_i \mid x) = \frac{\sum \hat{e}_i^2 EwJ_i}{\sum EwJ_i} - \left[\frac{\sum \hat{e}_i EwJ_i}{\sum EwJ_i}\right]^2 \quad (22)$$

4. CONCLUSION

The non-parametric model gives significantly better overall fit than its parametric counterpart. Since macro financial data are generally quite reliable, the non-parametric approach allows the data to "speak for themselves" and better captures the true underlying data generation process. The evidence shows that the parametric regressions may be mis-specified resulting in inconsistent estimates. The associated test statistics may also be invalid. Results based on mis-specified equations can have serious consequences when used for policy analysis.

Notwithstanding the limitations of the parametric analysis, results of this study show that from a policy perspective, nominal deposit rates are significant and have a positive influence in explaining overall financial and monetary depth; savings in the form of accumulation of financial wealth (real total assets) - an indicator of development - are a key determinant of all depth measures; inflation has a positive, though insignificant, influence on overall financial depth.The last result suggests that a moderate level of inflation as experienced in the Trinidad and Tobago case which averaged 2.4% for the period under study, stimulates growth and development through the process of financial deepening. Bourne(1988) in his study on financial deepening concluded that the inflation response was weak and that the nominal interest rate variable was not statistically significant. This finding contrasts with the result in our paper which found the nominal interest rate to be a signficant factor over the period 1982-1992. The result of this paper also provides a framework to conduct further macro-financial investigation.

ENDNOTES

1. Although there are commercially available computer programmes for Non-Parametric regression analysis, for example, IMSL, CURVDAT, TIMESLAB, XploRE, N-Kernel, and S-Plus (see Delgado and Robinson (1992) for further details on software packages), results in this paper are intended to be illustrative and instructive in deriving other functionals of interest (hazard and entropy functionals for example) which may not be commercially available. Non-Parametric estimates are relatively easy to compute in GAUSS, MATLAB, and MATHEMATICA (see Muller (1988)).

2. Money - the sum of currency (notes and coins in active circulation) plus demand deposits held in commercial banks.

3. Liquid Liabilities - Money, plus interest bearing liabilities of commercial banks, plus demand and interest bearing liabilities of the "non-bank" financial intermediaries (includes Trust and Mortgage companies, Finance Houses and Life Insurance companies).

4. Quasi-Liquid Liabilities - Liquid Liabilities net of Money, i.e. interest bearing liabilities.

5. Other kernels that have higher order differentiability can be used. See Ullah (1988a) for details.

6. The optimal choice of h is based on minimizing the approximate (integrated) mean square error. For details see Ullah (1988a). An intuitive choice of the window width can be taken as

$$h_i = \frac{\hat{\sigma}_i}{n^{1/(k+4)}}$$

where $\hat{\sigma}_i$ *is the sample standard deviation of* x_i

7. One can also use the alternate definition for the partial derivative to evaluate the response function as

$$r(x) = \lim_{h \to o} \frac{R\left[x + \frac{h}{2}\right] - R\left[x - \frac{h}{2}\right]}{h}$$

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