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A MODEL OF INFLATION

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A MODEL OF INFLATION IN BARBADOS

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This study empirically investigates the inflationary process in Barbados over 1961-1993 with a view to identifying a reliable model of inflation for this small open economy (SOE). It draws on the most recent thinking (with respect to inflation and econometric theory) and on insights from previous studies in order to identify a set of key variables which not only explain Barbados' historical inflation experience, but also offer some degree of stability in terms of their predictive capability.

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INTRODUCTION:

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

This study empirically investigates the inflationary process in Barbados over the period 1961-1993 with a view to identifying a reliable model of inflation for this small open economy (SOE). It draws on recent thinking (with respect to inflation and econometric theory) and on insights from previous studies in order to identify variables which not only explain Barbados' historical inflation experience, but also offer some degree of stability in terms of their predictive capability. The results should prove useful in improving forecasts of inflation in Barbados.

The paper comprises five main sections. **Section 1** contains a brief descriptive history of inflation in Barbados, followed by a summary of the methodology and results of previous studies of inflation in Barbados and the Caribbean. The section ends with a look at the state of the art in the theory of inflation in open economies. Based on the insights gleaned from this section, the process of modelling inflation in Barbados is conducted in **Section 2**, with two alternative models being derived. **Section 3** discusses the specification of the econometric test and of the data. **Section 4** discusses the empirical results in light of theoretical expectations as well as the satisfaction of statistical and econometric criteria. **Section 5** gives the conclusion, which specifically addresses the extent to which this study satisfies its main purpose/objective.

1 - HISTORICAL EXPERIENCE AND THEORETICAL BACKGROUND

HISTORICAL BACKGROUND:

Chart 1 (see the appendix) plots the time path of the percentage change in the rpi from year to year (i.e. the annual inflation rate as represented by the variable **infl**) over the period 1960-1994. Inflation was recorded at a relatively steady rate of close to 1% during the early 1960s; from the mid-1960s the rate began to fluctuate; it rose to more than 10% in 1971 and by 1974, the annual inflation rate had reached a record high of almost 40%, shooting up sharply from a rate of less than 10% in 1972. Although this abated rapidly (and at a constant rate over the next two years) to a rate of approximately 5% in 1976, by 1981 the rate had increased again to just under 15%. Following this, the annual inflation rate declined and by 1986, for the first time since 1969, it fell below the 1% level. However, this rate was not maintained: it began to rise again with some fluctuation up until 1991, when the rate was just over 6%. Since then the rate of inflation in Barbados declined and, after only seven years, once again fell below 1% in 1994.

A LOOK AT PREVIOUS STUDIES:

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

The earliest studies for Barbados indicate that the main determinant of inflation is rising import prices, with other factors such as wage rate, interest rate and tax rate increases also contributing to the inflationary process. But it was **Downes (1985)** who conducted the first econometric investigation into the causes of inflation in Barbados, so that for the first time there was quantification of the effects of various factors.

Operating on the premise that in a SOE excess aggregate demand tends to affect the balance of payments (BOP), rather than inflation, Downes (on p. 524) said that Barbados' inflationary process "...is fueled by cost-push and institutional factors more than by demand-pull factors" (such as increases in the money supply or credit expansion). He contended that although demand-pull factors may have some effect on inflation, where the ratio of non-tradables to tradables is high and in the absence of excess capacity, neither of these conditions holds for Barbados.

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

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

where the percentage change of the variables at time t is given as p_t, domestic price level; pm_t, import price index; r_t, cost of credit; T_t, tax rates vector; Q_t, vector of other factors; and finally, w_{t-i}, wage rate (at time t-i, t =0,1...), since he believed that "... if wage

increases have any impact on the inflation rate, this will occur with a lag that varies with the length of the contractual period" (p. 524).

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

The current wage rate proved to be an insignificant variable at the 5% level with the wrong a priori sign. This result was consistent with Downes' belief that changes in the current wage rate do not significantly affect current price changes. He argued that the wage bargaining process is such that workers and/or trade unions seek to catch up with inflation and that "... if wage increases have any impact on the inflation rate, this will occur with a lag that varies with the length of the contractual period" (p. 524). However, introducing a lagged wage rate variable (w_{t-1}) did not change the results significantly, leading him to conclude that wage rate increases were not a critical factor in the inflationary process.

Even after removing the effects of wages there were noticeable divergences between actual and predicted values of inflation for the periods 1965-68 and 1972-73. Therefore, he used dummy variables to capture the events of these two periods - high inflation and devaluation in the first

period, and drastic increases in oil and other commodity prices in the second - and obtained the following:

$$p_t = 1.06 + 0.64pm_t + 0.30r_t + 6.25D_t$$

$$(1.42) \quad (11.12) \quad (5.29) \quad (5.27)$$

$$\bar{R}^2 = 0.96 \quad DW = 1.88 \quad SEE = 2.19 \quad F = 95.14 \quad RMSE = 3.33 \quad U = 0.134$$

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

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

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

simultaneous system and consist of two output equations (for the tradable and non-tradable sectors, respectively) and a price equation for the non-tradable sector. The remaining equations model the wage-determination process as well as the impact of disturbances to the banking system on interest costs (and by extension on prices).

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

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

$$\mathbf{LP_n = -0.72 - 0.6LQ_n + 1.55P_t - 0.03LS + 0.59L_r}$$

$$\mathbf{(-0.98)\ \ (-0.54)\qquad (8.05)\ \ (-0.11)\qquad (3.26)}$$

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

As expected, Holder & Worrell found that "...foreign prices play a large direct role in domestic price formation ... contributing about one-third to domestic price formation in each of the three countries tested" (p. 420). Further, the cost of imported raw materials was found to be very significant in the determination of production costs in Barbados and Trinidad & Tobago. Exchange rate changes, trade protection and other domestic policies which influence the local price of traded goods were found to have a similar influence to that of foreign prices. But wages were found to be important only in Jamaica, whilst it was only

in Barbados that increases in the interest rate were inflationary. Finally, exogenous increases in real income were not inflationary in any of the three countries.

Downes, Holder & Leon (1987b) extended the analysis of Downes (1985). Augmenting the set of explanatory variables considered, they utilized cointegration theory and the Error Correction Mechanism (in the form of Granger's Representation Theorem) to model an inflation relationship for Barbados.

Their proposed 'long-run' theoretical relationship hypothesized that domestic prices, wages, labour productivity, unemployment and external prices define an 'equilibrium' sub-space. This relationship is consistent with previous studies [e.g. Downes (1985), Holder & Worrell (1985)], "*albeit* in a piecemeal context". However, DHL also argued that high levels of unemployment can weaken unions' bargaining power whilst supporting employers' resistance in the wage-determination process, so that the unemployment variable is representative of conditions in the labour market.

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

$$\mathbf{lp = 0.23 + 0.82lw - 0.58lprod + 0.48lpt + 0.006ur}$$

$$\mathbf{(1.66)\ (14.58)\ \ (7.94)\ \ \ (8.12)\ \ \ \ (2.09)}$$

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

$$\mathbf{(ACF)LAG\ 1\text{-}10:\ 0.027,\ -0.25,\ -0.158,\ -0.261,\ 0.062,\ 0.1,\ 0.032,\ -0.022.\ 0.105}$$

$$\mathbf{SE = 0.192}$$

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

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

$$\mathbf{dp = -0.005 + 0.65dw - 0.52dprod + 0.25dpt + 0.21dpm}$$

$$\mathbf{(0.33)\ \ (4.81)\ \ \ (5.35)\ \ \ \ \ \ (4.64)\ \ \ (3.05)}$$

$$\mathbf{+ 0.004dur + 0.19dp(-1) - 0.83ec(-1)}$$

$$\mathbf{(1.74)\ \ \ \ \ (2.51)\ \ \ \ (5.61)}$$

$$\mathbf{\bar{R}^2 = 0.91\ \ SER = 0.22\ \ DW = 2.30\ \ RMSE = 0.018}$$

$$\mathbf{RESET\ [F(3,21)] = 1.01\ \ CHOW\ [F(2,\ 15)] = 0.17}$$

$$\mathbf{INVR\ [X^2(7)] = 7.00\ \ NRM\ [X^2(2)] = 0.23\ \ PC\ [X^2(2)] = 0.33}$$

$$\mathbf{SC\ [X^2(1)] = 2.0\ \ SCNL\ [X^2(1)] = 0.46}$$

where '**d**' represents the first difference of the previously defined variables; **dpm** is the first

difference of the log of import prices; and ec is the residual from the long-run estimated equation.

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

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

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

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

Using the MICROFIT regression package, OLS was used to estimate the static 'long-run' or co-integrating price equations for Barbados, while the 'short-run' dynamic inflation equation was estimated using the generalized instrumental variable estimator (GIVE). The Dickey Fuller (DF) and Augmented Dickey Fuller (ADF) test statistics indicated that narrow money supply (**M1**), the exchange rate (**ER**), the USA price level (**USP**), the nominal wage rate index (**WR**), labour productivity (**PROD**), and the retail price index (**P**), are co-integrated and the error term was stationary at the 5% level of significance. The estimated 'short-run' equation was:

$$\begin{aligned} \mathbf{dlp} = {} & \mathbf{-0.04 + 2.84dlxr + 0.75dlusp + 0.76dlr - 0.50dlprod + 0.23dlp(-1) - 0.84ec(-1)} \\ & \mathbf{(-1.17)\quad (5.73)\quad (1.81)\quad (3.41)\quad (-1.82)\quad (2.02)\quad (-3.40)} \\ & \mathbf{\bar{R}^2 = 0.88\ \ F(6, 13) = 23.81\ \ SER = 0.02\ \ DW = 1.16} \\ & \mathbf{SC(X_1^2) = 1.85\ \ FF(X_1^2) = 0.66\ \ NORM(X_1^2) = 0.91} \\ & \mathbf{HET(X_1^2) = 0.39\ \ SAR(X_1^2) = 3.29\ \ RMSE = 0.02} \end{aligned}$$

This equation was favoured in a model selection exercise over one which included changes in money supply and the lagged error term from a co-integrating equation with **IM1**, **IXR**, **IUSP**, **IWR** and **IPROD**; for Barbados, but not for Jamaica or Trinidad & Tobago, the **M1** variable could be dropped from the equation without the result changing significantly. They concluded that there is a "negligible or non-existent" monetary policy effect in Barbados, consistent with the result of Downes et al (1987). Generally, the results supported those of previous studies, which have indicated that inflation in Barbados is largely a cost-push phenomenon with significant import influences.

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

Coppin argued *inter alia* that demand-side factors, such as the level of real tourism activity, should be included in the inflation determination equation for the Barbados economy. Although real quarterly GDP statistics do not exist, he argued that to the extent that the tourism sector drives the domestic economy, the available quarterly tourism data may serve as a useful proxy for output in a two-sector Scandinavian Model of inflation (see Section 2 for a description of this model). Increased levels of economic activity resulting from increased tourism output exert upward pressure on prices, particularly in the non-traded goods sector. Based on this, he tested several variants of the model due to Downes (1985), augmented by proxied real output as a regressor variable:

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

where **p** is the percentage (quarterly) change in the consumer price index, **y** is the log of output (proxied by the log of real tourism activity), $\mathbf{p^*}$ is the percentage (quarterly) change in the index of import prices, **u** is the rate of unemployment, **r** is the interest rate (proxied by the average lending rate), and **t** is the change in tax rate (proxied by the consumption tax rate). By including **u** in some specifications, he allowed the data to determine the superiority

between output and unemployment (alternative variables in the short-run Phillips Curve model). All models tested included quarterly dummy variables to capture seasonality in the rate of price formation, where Q_i is a 0-1 dummy variable for quarter i.

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

$$\mathbf{-11.69 + 0.04lny + 0.09p^* + 0.24r + 3.6Q_2 + 2.4Q_3 + 1.4Q_4}$$

$$\mathbf{(-4.30)\quad (4.13)\quad (2.33)\quad (2.22)\quad (5.76)\quad (4.87)\quad (2.83)}$$

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

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

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

significance. However, the results with respect to interest rates are varied and tax rates have been ruled out in all the quantitative studies where considered.

THEORETICAL BACKGROUND:

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

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

rising marginal and average labour costs for the production of non-tradables result in more rapidly rising prices for non-tradables.

2 - MODELLING INFLATION IN BARBADOS

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

The Scandinavian Model

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

Output prices of the tradable sector are largely determined on the world market, and this means that the upward adjustment of prices cannot be used to compensate for cost increases -

which must therefore be entirely absorbed through reduced profits and sometimes even reduced production. On the other hand, industries in the non-tradable sector do not face the risk of losing their market share to foreign competitors, and therefore they tend to compensate for increased costs by raising output prices.

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

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

$$\dot{p}_T = \dot{p}_W \qquad \text{identity} \qquad (1)$$

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

$$\dot{w}_T = \dot{p}_T + \dot{\lambda}_T \qquad (2)$$

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

$$\dot{w}_N = \dot{w}_T = \dot{w} \qquad (3)$$

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

$$\dot{\lambda}_T > \dot{\lambda}_N \qquad (4)$$

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

$$\dot{p}_N = \dot{w}_N - \dot{\lambda}_N \qquad (5a)$$

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

$$\dot{p}_N = \dot{p}_W + \dot{\lambda}_T - \dot{\lambda}_N \qquad (5b)$$

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

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

Substituting for $\dot{p}_N$ as in (4) we obtain:

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

and through a series of further substitutions (as detailed in the appendix) we get:

$$\dot{p} = \dot{p}_W + (1 - \alpha)(\dot{\lambda}_T - \dot{\lambda}_N) \qquad (6b)$$

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

$$\dot{p} = f(\dot{p}_W, \dot{\lambda}_T, \dot{\lambda}_N) \qquad (6c)$$
$$\quad + \; + \; -$$

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

The results of previous studies for Barbados are consistent with the Scandinavian Model. However, equation **5a** is an extreme simplification. Prices are not only determined by (unit)

labour cost; other supply conditions along with demand conditions also figure into the determination of prices in the non-tradable sector. Holder & Worrell(1985) argue that most activities in the non-traded sector are dominated by a few large firms exercising market leadership and "...the market may best be seen through the eyes of decision-makers in the dominant firms" (p.415). This contrasts with the Scandinavian Model's assumption of competitive firms in both the tradable and non-tradable sectors. The expected demand for their product (q_N^*) as perceived by non-tradable suppliers, is based on real national income (y), the relative prices of the tradable sector and non-tradable sector goods (p_T / p_N), and the cost of consumer credit (r). From this we may derive the following demand function for our purposes:

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

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

$$\dot{q}_N = \dot{q}_{N-1} + v(\dot{q}_N^* - \dot{q}_{N-1}) \qquad (8)$$

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

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

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

Combining the demand and supply of non-tradables (using **7, 8** and **9**, as detailed in the appendix - p.31) gives:

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

where $a_0 = (\beta_0 + \alpha_0 \beta_1 v) / (1 + \alpha_2 \beta_1 v)$; $a_1 = \beta_1 (1 - v) / (1 + \alpha_2 \beta_1 v)$; $a_2 = \alpha_1 \beta_1 v / (1 + \alpha_2 \beta_1 v)$;

$a_3 = (\alpha_2 \beta_1 v + \beta_3) / (1 + \alpha_2 \beta_1 v)$; $a_4 = (\alpha_3 \beta_1 v + \beta_4) / (1 + \alpha_2 \beta_1 v)$; $a_5 = \beta_2 \mu / (1 + \alpha_2 \beta_1 v)$.

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

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

This gives us our preferred test equation and/or **Model 1**:

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

The model may be carried one step further to incorporate import duties and other indirect taxes into equation **1** such that:

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

and this will give us an extended test equation and/or **Model 2**:

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

3 - ECONOMETRIC & DATA SPECIFICATION:

This study uses annual figures for the period 1961-1993 obtained from the Central Bank's data base, most of which appears in the Bank's Annual Statistical Digest. The change in (first difference of) the log (as denoted by **CL**) was used as representative of the rate of change for each variable in the two equations, except the cost of consumer credit variable, which enters both equations at its level. The following data specifications have been used.

The general level of prices (p) is proxied by the annually averaged retail price index (**RPI**) based on 1980 prices. The series used was a product of splicing since in October 1979 the Central Bank replaced its old index with a base of October 1965 by a new index with a base of March 1980. Data prior to the time of change were obtained by multiplying all items of old index by the ratio:

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

The world price level (p_W) is proxied by the CIF import price index for Barbados (**BPM**).

Output in the non-tradable sector in the previous time period (q_{N-1}) is the value of the non-tradables proportion of real gross domestic product (GDP) at factor cost and 1974 prices at that time (denoted by **QN1**).

Real national income (y) is proxied by the annual estimates of real GDP at factor cost and 1974 prices (and is denoted by **RY**). This is consistent with convention and, though limited, is the best measure available, since data are not collected on income for Barbados.

The annual average of quarterly data regarding the commercial bank prime rate on loans (denoted by **R**) is used to represent the cost of consumer credit (r).

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

4 - EMPIRICAL RESULTS:

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

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

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

Finally, an unrestricted ECM (consistent with the general model proposed by Engle & Granger, 1987) was derived from Model 1 and estimated. The model was then re-parameterized by dropping insignificant variables and, in addition to the standard diagnostic tests, its within-sample forecasting performance was tested by ignoring the last two observation years (see **Table 3** for the results, **Chart 2** for the fit of the model, and **Chart 3** for the forecast fit, in the appendix).

In terms of the a priori economic expectations the only discrepancy is the fact that the coefficient on **CLQN1** appears to be zero. This may be a result of the high collinearity between that variable and **CLRY**. All other variables are significant and the signs are as expected. The adjusted goodness of fit measure (see **Table 3**) is quite good considering that the model is in difference from. The various diagnostic tests indicate no significant serial correlation, non-normality, heteroscedasticity, or non-linearity. In terms of the within-sample analysis of the model, constancy of parameters is indicated and the forecast fit for the model is picking up the movements of the actual data fairly well.

The restricted ECM (derived from Model 1) has succeeded in explaining about 76% of the variance in inflation, with import prices having the greatest impact; a 5% change in the rate of domestic inflation for every 10% increase in the rate of import price inflation. There are also strong influences from one year to the next, consistent with the results of Downes, Scantlebury-Maynard & Worrell (1992), which showed previous inflation rates to be significant (p. 9). Unit

labour costs, the consumer credit rate and real national income would prove useful in explaining inflation in Barbados.

5 - CONCLUSION:

This study has utilized recently developed econometric methodologies (co-integration and ECM) to investigate the process of inflation in Barbados. The main objective was to identify a reliable model of this phenomenon as measured by goodness of fit, predictive stability etc. The model was also required to satisfy the basic diagnostic requirements (i.e. no serial correlation, linearity, normality and no heteroscedaticity).

The results suggest that such a model has been identified in Model 1. As expected, import prices have the greatest impact. There are also strong influences from one year to the next. Further, there is some indication that movements in unit labour costs, the consumer credit rate and real national income play a significant role in the determination of inflation.

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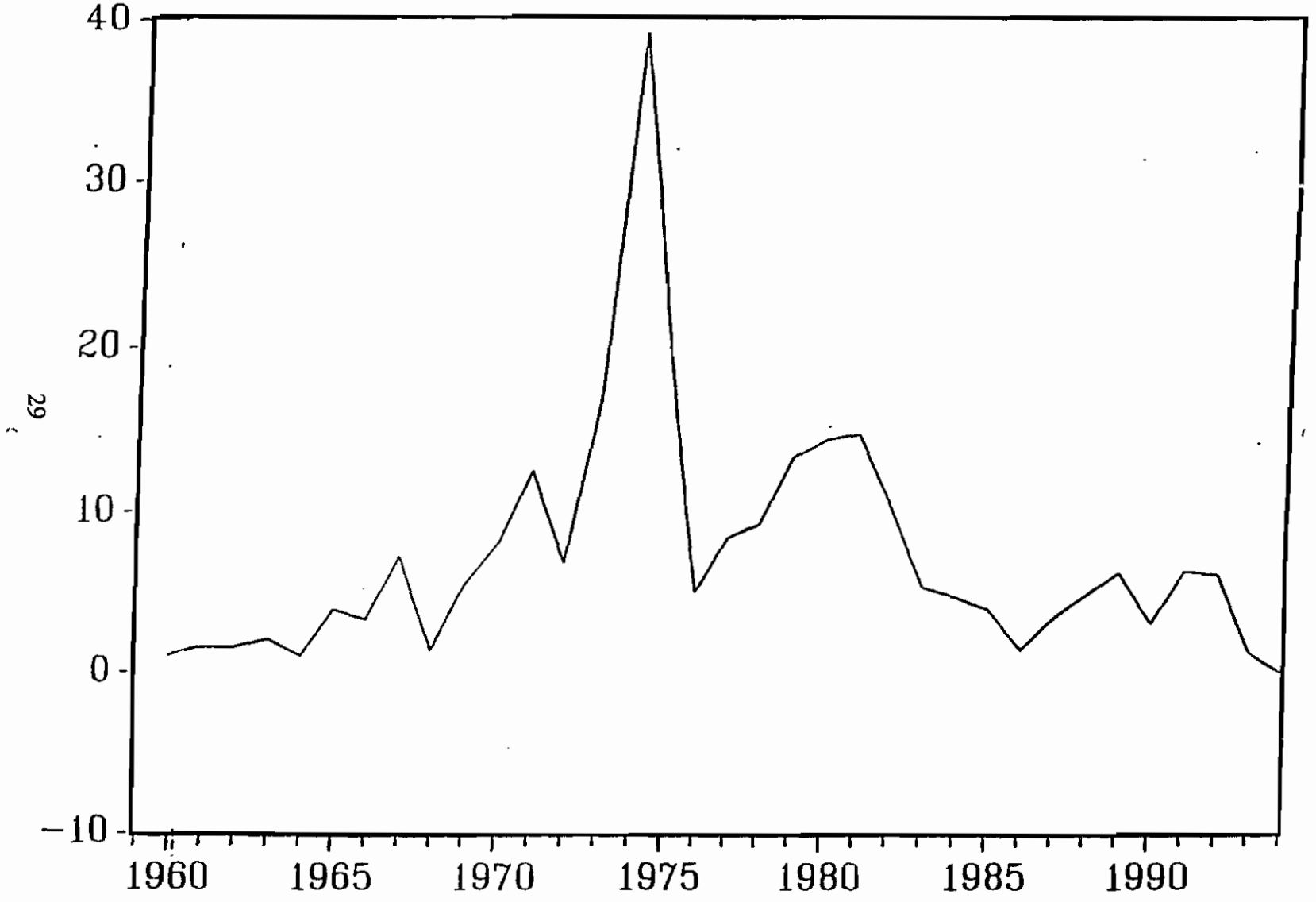
APPENDIX

Chart 1



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

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

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

$$\dot{q}_N = \dot{q}_{N-1} + v [\alpha_0 + \alpha_1\dot{y} + \alpha_2(\dot{p}_T - \dot{p}_N) + \alpha_3 r - \dot{q}_{N-1}]$$

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

Substituting for q_N as in (8b) into (9a) we get:

$$\dot{p}_N = \beta_0 + \beta_1\{(1 - v)\dot{q}_{N-1} + v[\alpha_0 + \alpha_1\dot{y} + \alpha_2(\dot{p}_T - \dot{p}_N) + \alpha_3 r]\} + \beta_2(\dot{w} - \dot{\lambda}_N) + \beta_3 r + \beta_4\dot{p}_T \qquad (9b)$$

Grouping like terms we get:

$$(1 + \alpha_2\beta_1 v)\dot{p}_N = (\beta_0 + \alpha_0\beta_1 v) + \beta_1(1 - v)\dot{q}_{N-1} + \alpha_1\beta_1 v\dot{y} + (\alpha_2\beta_1 v + \beta_4)\dot{p}_T$$

$$+ (\alpha_3\beta_1 v + \beta_3) r + \beta_2(\dot{w} - \dot{\lambda}_N)$$

and assuming that:

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

then

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

where $a_0 = (\beta_0 + \alpha_0\beta_1 v) / (1 + \alpha_2\beta_1 v)$; $a_1 = \beta_1 (1 - v) / (1 + \alpha_2\beta_1 v)$; $a_2 = \alpha_1\beta_1 v / (1 + \alpha_2\beta_1 v)$;

$a_3 = (\alpha_2\beta_1 v + \beta_3) / (1 + \alpha_2\beta_1 v)$; $a_4 = (\alpha_3\beta_1 v + \beta_4) / (1 + \alpha_2\beta_1 v)$; $a_5 = \beta_2\mu / (1 + \alpha_2\beta_1 v)$.

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

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

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

$$\dot{q}_N = \dot{q}_{N-1} + v [\alpha_0 + \alpha_1\dot{y} + \alpha_2(\dot{p}_T - \dot{p}_N) + \alpha_3 r - \dot{q}_{N-1}]$$

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

Substituting for q_N as in (8b) into (9a) we get:

$$\dot{p}_N = \beta_0 + \beta_1\{(1 - v)\dot{q}_{N-1} + v[\alpha_0 + \alpha_1\dot{y} + \alpha_2(\dot{p}_T - \dot{p}_N) + \alpha_3 r]\} + \beta_2(\dot{w} - \dot{\lambda}_N) + \beta_3 r + \beta_4\dot{p}_T \qquad (9b)$$

Grouping like terms we get:

$$(1 + \alpha_2\beta_1 v)\dot{p}_N = (\beta_0 + \alpha_0\beta_1 v) + \beta_1(1 - v)\dot{q}_{N-1} + \alpha_1\beta_1 v\dot{y} + (\alpha_2\beta_1 v + \beta_4)\dot{p}_T$$

$$+ (\alpha_3\beta_1 v + \beta_3) r + \beta_2(\dot{w} - \dot{\lambda}_N)$$

and assuming that:

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

then

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

where $a_0 = (\beta_0 + \alpha_0 \beta_1 v) / (1 + \alpha_2 \beta_1 v)$; $a_1 = \beta_1 (1 - v) / (1 + \alpha_2 \beta_1 v)$; $a_2 = \alpha_1 \beta_1 v / (1 + \alpha_2 \beta_1 v)$;

$a_3 = (\alpha_2 \beta_1 v + \beta_3) / (1 + \alpha_2 \beta_1 v)$; $a_4 = (\alpha_3 \beta_1 v + \beta_4) / (1 + \alpha_2 \beta_1 v)$; $a_5 = \beta_2 \mu / (1 + \alpha_2 \beta_1 v)$.

Table 1: Testing for Unit Roots

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

95% critical values in brackets

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

C2 ... The respective variable has been differenced twice

Table 3: ECM Results

Unrestricted ECM - 1964-1993

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

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

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

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

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

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

Restricted ECM - 1964-1993

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

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

$\bar{R}^2 = 0.761$ DW = 1.733 LMSC[$\chi^2(1)$] = 1.139

RESET[$\chi^2(1)$] = 0.507 NORM[$\chi^2(2)$] = 2.189 ARCH[$\chi^2(1)$] = 1.062

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

Restricted ECM - 1964-1991

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

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

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

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

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

CHART 2

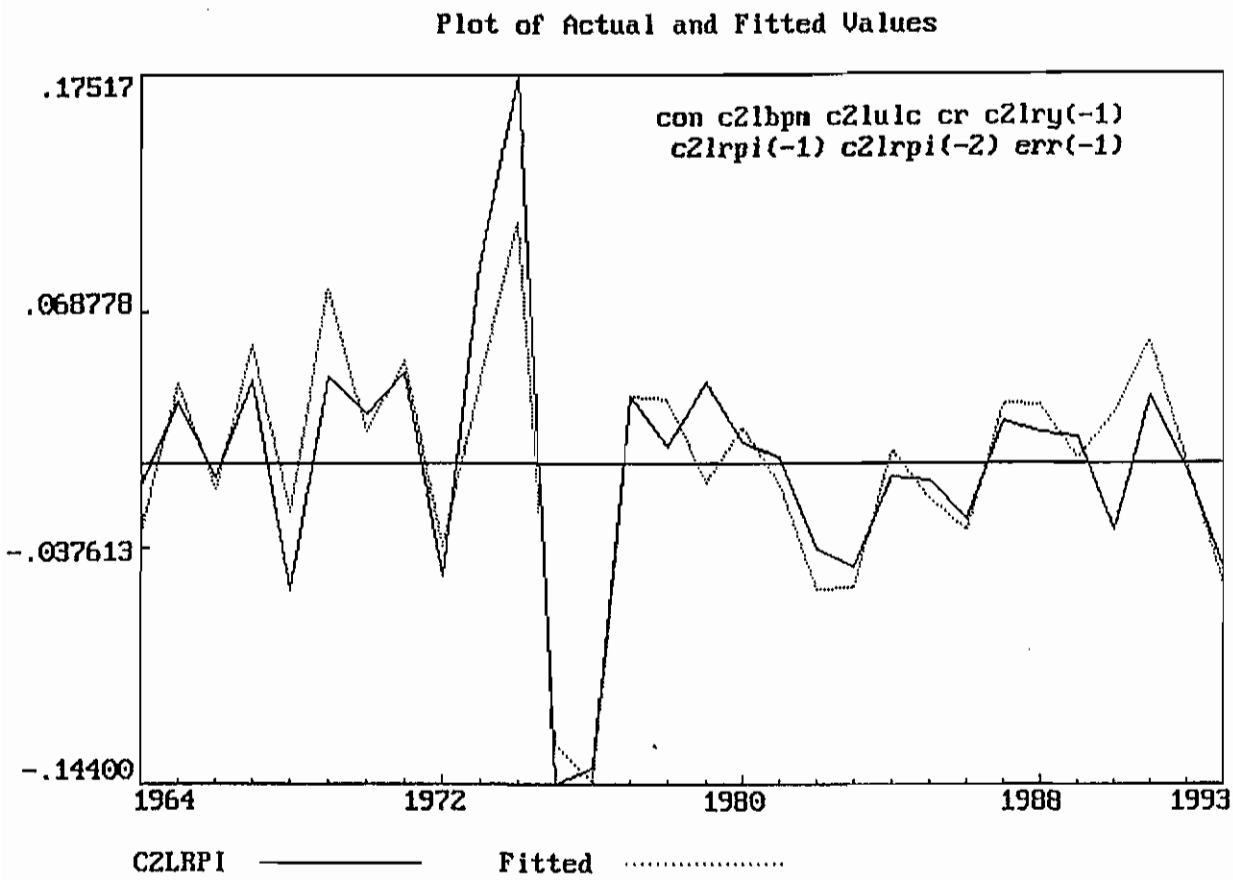
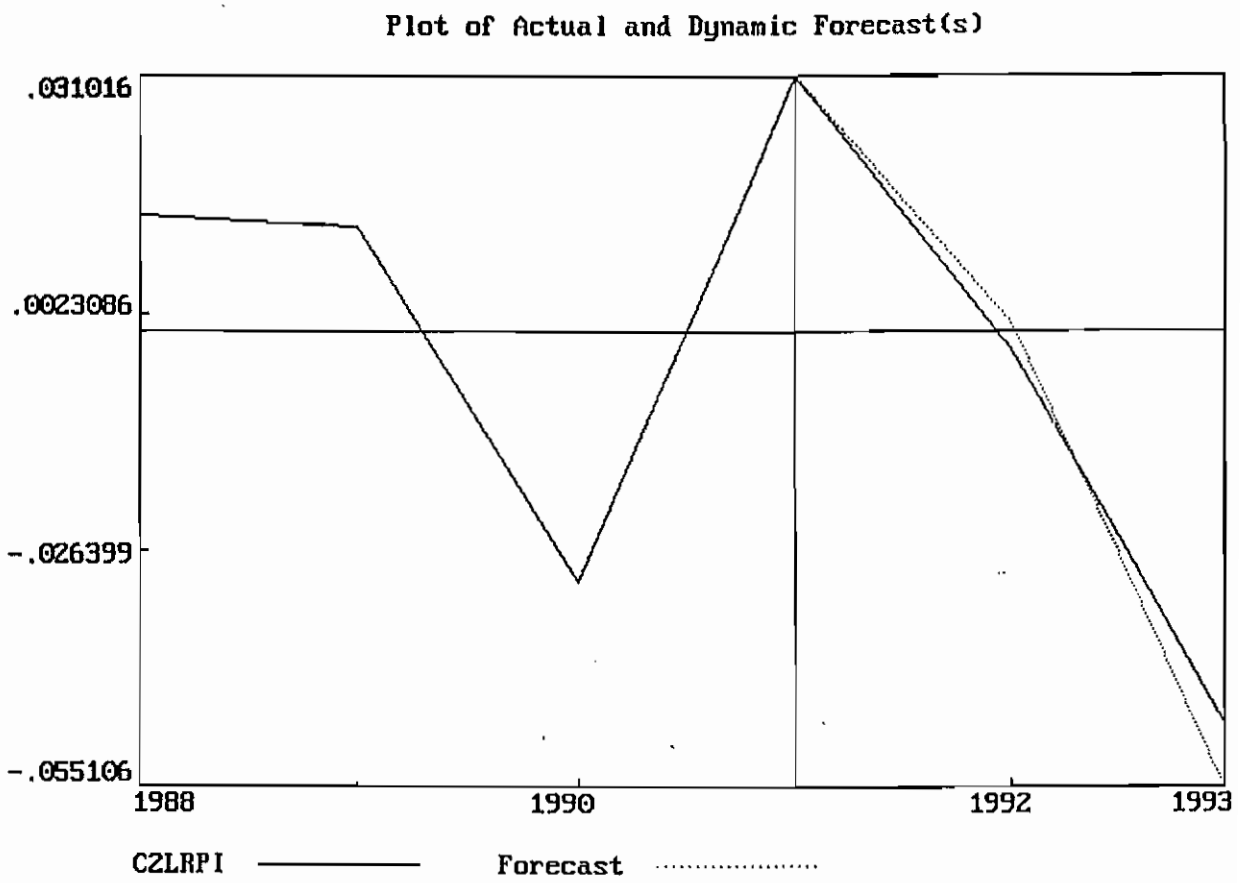

Plot of Actual and Fitted Values
.17517
.068778
-.037613
-.14400
1964
1972
1980
1988
1993
con c2lbpm c2lulc cr c2lry(-1)
c2lrpi(-1) c2lrpi(-2) err(-1)
C2LRPI
Fitted

CHART 3


Plot of Actual and Dynamic Forecast(s)
.031016
.0023086
-.026399
-.055106
1988
1990
1992
1993
C2LRPI
Forecast