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

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(WITH AN APPLICATION TO TRINIDAD & TOBAGO)

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Pre-Cointegration Macroeconometric Modelling

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

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

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

Steps in Macroeconometric Modelling with Cointegration

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

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

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

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

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

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

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

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

How do we get out of this dilemma? For a small system, Bagliano *et al.* (1991) propose the following four (4) steps:

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

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

3. The (lagged) ECM terms constructed as residuals from the estimation of the equilibrium relations are then included in the reduced form of the system; such reduced form is then estimated and its congruency with the data evaluated

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

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

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

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

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

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

The third and final step in the procedure now follows:

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

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

A Prototype Macroeconometric Model of The Trinidad & Tobago Economy

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

Table 1
Prototype Model of The Trinidad & Tobago Economy

BLOC 1	$Y = C + I + X - M$	(1.1)
	$C = C_p + C_g$	(1.2)
Aggregate Expenditure Bloc	$I = I_p + I_g + I_s$	(1.3)
	$C_p = f_1(Y, \frac{L_1}{P_c}, \ldots)$	(1.4)
	$I_p = f_2(Y, I_g, r, \ldots)$	(1.5)
BLOC 2	$GDEF = C_g{*}P_g + O_g - T$	(2.1)
Public Sector Bloc	$T = t{*}Y{*}P_y$	(2.2)
BLOC 3	$\frac{L_1}{P_c} = h_1(Y, r, \ldots)$	(3.1)
Financial Sector Bloc	$\Delta XD_g = GDEF - \Delta ID_g$	(3.2)
	$\Delta XD = \Delta XD_g + \Delta XD_o$	(3.3)
	$\Delta L = \Delta R + (\Delta ID_g - \Delta NBCR_g) + \Delta CR_p + \Delta L_o$	(3.4)
	$L_2 = L - L_1$	(3.5)
	$r = \frac{(1 + r^n)}{(P_r / P_{r-1})} - 1$	(3.6)
	$\Delta R = X{*}P_x - M{*}P_m + \Delta XD + \Delta DFI + \Delta R_o$	(4.1)
BLOC 4	$X = X_1 + X_2 + X_o$	(4.2)
	$M = M_g + M_o$	(4.3)
Balance of Payments Bloc	$X_2 = k_1(Y_w, \frac{P_e}{P_w}, \ldots)$	(4.4)
	$M_g = k_2(Y, \frac{P_m}{P_r}, \ldots)$	(4.5)
BLOC 5	$P_y = l_1(w, P_r, P_x \ldots)$	(5.1)
	$P_m = l_2(P_w, \ldots)$	(5.2)
Wages and Prices Bloc	$P_g = l_3(w, P_x, \ldots)$	(5.3)
	$P_r = l_5(w, P_m, \ldots)$	(5.4)
	$w = l_6(P_r, U_R, C_g, \ldots)$	(5.5)
BLOC 6	$K = I_p + I_g + (1-\gamma) K_{-1}$	(6.1)
	$UNEMP = N - EMP$	(6.2)
Output and Employment Bloc	$N = m_2(w, POP, Y, \ldots)$	(6.3)
	$U_R = UNEMP / N$	(6.4)
	$EMP = m_3(w, Y, \ldots)$	(6.5)

"Endogenous" Variables

C = Total Consumption Expenditure (constant prices)

C_p = Private Consumption Expenditure (constant prices)

EMP = Level of Employment

GDEF = Govenment Overall Budget Deficit (Central Government Borrowing Requirement)

I = Gross Capital Formation (constant prices)

I_p = Private Sector Fixed Capital Investment (constant prices)

K = Gross Capital Stock (constant prices)

L = Money Supply, M_2 (assumed equal to demand)

L_1 = Money Supply, M_1 (assumed equal to demand)

L_2 = Stock of Quasi Money

M = Imports of Goods and Services (constant prices)

M_g = Imports of Goods (constant prices)

N = Total Labour Force

P_c = Private Consumption Expenditure Deflator

P_g = Government Consumption Expenditure Deflator

P_m = Imports Deflator

P_r = Index of Domestic (Retail) Prices

P_y = National Output Deflator

r = Real rate of Interest

R = Stock of Foreign Assets

T = Government Tax Receipts

UNEMP = Level of Unemployment

U_R = Unemployment Rate

w = Wage Rate

X = Exports of Goods and Services (constant prices)

X_2 = Non Petroleum Exports (constant prices)

Y = National Output (constant prices)

XD = Total External Indebtedness

XD_g = External Indebtedness of Central Government

"Exogenous" Variables

C_g= Government Consumption Expenditure (constant prices)

CR_p = Bank Credit to the Private Sector

DFI = Direct Foreign Investment Stock

I_g = Public Sector Fixed Capital Investment (constant prices)

I_s = Investment in Stock (constant prices)

ID_g = Internal Indebtedness of Central Government

L_0 = Residual Factors Affecting Money Supply

M_s = Imports of Services

$NBCR_g$ = Non Bank Credit to Central Government

O_g = Other Government Expenditure (Net)

POP = Size of Population

P_w = Index of World Prices

P_x = Exports Deflator

r^n = Nominal Rate of Interest

R_0 = Residual Factors Affecting Stock of Foreign Assets

t = Tax rate

X_1 = Petroleum Exports

X_0 = Exports of Services

XD_0 = External Indebtedness of Non Central Government Sector (including State Enterprises and Central Bank)

Y_w = World GDP

γ = Rate of Asset depletion

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

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

Determination of the Order of Integration

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

As anticipated, most of the variables are I(1). In Table 2 below, only those appearing in behavioural equations and which were found not to be I(1), or not clearly so, are reported together with their ADF test statistics (the statistic in parentheses was calculated on the assumption of the presence of a deterministic trend):

Table 2

<u>Determination of Order of Integration (d) of Selected Series</u>

Variable	ADF test statistic H_0: d=1 H_1: d=0	ADF test statistic H_0: d=2 H_1: d=1	ADF test statistic H_0: d=3 H_1: d=2	Decision
P_m	4.100 (0.3824)	-1.821 * * * (-3.029)	-6.09 * (-5.993*)	d = 2
P_r	14.64 (-0.2519)	0.0073 (-4.291**)	-5.38* (-5.391*)	d = 2
P_m/P_r	-1.993* * (-1.114)	(-4.826 *)		d = 0
Y_w	6.173 (-0.6043)	-1.294 (-3.964 **)	-5.025 *	d = 1
P_w	4.187 (-0.5013)	-1.319 (-2.374)	-3.72* (-3.639 **)	d = 2
P_y	5.973 (-1.794)	-1.546 (-3.835 **)	-6.48*	d = 2

* rejection of H_0 at the 1% significance level
** rejection of H_0 at the 5% significance level
*** rejection of H_0 at the 10% significance level

The correlogram of each series was inspected and used in the determination of the order of integration. Of particular interest is Y_w (which in the study is US GDP): an investigator may be tempted to classify it as an I(2) using the ADF test statistic but examination of the correlogram suggested strongly that it was a random walk (with drift) and was therefore retained as I(1). This is supported by the ADF test statistic (with trend) which is significant at the 5% level.

Estimation of the Prototype Model

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

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

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

The results obtained are shown below and some justification is given for the long run equation retained.

Private Consumption Expenditure

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

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

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

CRDW = 1.67 ADF = -3.75

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

Private Investment Expenditure

$$\Delta I_p = \underset{(3.81822)}{0.65999\,\Delta I_{p-1}} - \underset{(2.26727)}{0.18115\,\Delta Y_{-1}} + \underset{(2.63458)}{0.36015\,\Delta I_g} - \underset{(3.55875)}{0.7266\,IPECM_{-1}}$$

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

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

CRDW = 1.12 ADF = -4.856 ***

In this case, the long-run equation could be retained on the basis of the ADF test since the test statistic is significant at the 10% level (indicated by ***), but it also "passes" on the basis of the CRDW test and inspection of the correlogram which shows that the residuals are stationary.

Import Demand Equation

$$\Delta M_g = \underset{(2.76685)}{0.28284\,\Delta Y} - \underset{(2.13164)}{1331.73\,(P_m/P_r)} - \underset{(3.98297)}{0.86984\,MGECM_{-1}}$$

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

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

CRDW = 1.49 ADF = -4.05

Once again, both test statistics are significant (at least at the 10% level) and inspection of the correlogram indicated that the residuals were white noise.

Money Demand Equation

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

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

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

CRDW = 1.35 ADF = -3.44

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

Export Demand Equation

$$\Delta X_2 = \underset{(1.57915)}{-0.30585\,\Delta X_{2\,-1}} + \underset{(2.38615)}{0.76436\,\Delta Y_w} \underset{(1.62956)}{-43933.6\,\Delta(P_x/P_w)} \underset{(3.52691)}{-0.65651\,X2ECM_{-1}}$$

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

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

CRDW = 1.44 ADF = -3.84 ***

This is a clear case and, to boot, inspection of the correlogram revealed that it was white noise.

Government Consumption Expenditure Deflator

$$\Delta P_g = \underset{(2.21352)}{0.23993\,\Delta P_{g-1}} + \underset{(5.28358)}{0.03179\,\Delta(W\$/N)_{-1}} - \underset{(3.67470)}{0.64715\,PGECM_{-1}}$$

$\bar{R}^2 = 0..686$ DW = 1.89

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

CRDW = 0.898 ADF = -2.48

In this case, it was the "rate of change" that was explained by the long run equation. Almost complete reliance was put on examination of the correlogram which revealed that the residuals formed a stationary process.

Index of Retail Prices Equation

$$\Delta^2 \log P_r = \underset{(4.480)}{0.652\,\Delta^2 \log P_w} - \underset{(3.63)}{0.673\,PRECM_{-1}}$$

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

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

CRDW = 1.14 ADF = -3.82 **

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

Wages Equation[1]

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

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

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

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

$CRDW = 1.40$ $\qquad$ $ADF = -3.84$ ***

Both the CRDW and the ADF are significant and the correlogram shows that the series tested is white noise.

Employment Equation

$$\Delta EMP = 0.4245\,\Delta EMP_{-1} - 1.482\,\Delta w + 0.00678\,\Delta Y - 0.5668\,EMPECM_{-1}$$
$$(2.593)\quad (1.537)\quad (2.261)\quad (3.45805)$$

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

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

$CRDW = 1.01$ $\qquad$ $ADF = -2.89$

Inspection of the correlogram revealed that the process was stationary.

Labour Force Equation

$$\Delta N = 1.27532 + 0.16313\,\Delta POP + 0.00878\,\Delta X_1 - 0.63127\,NECM_{-1}$$
$$(0.56744)\quad (1.76909)\quad (2.26911)\quad (3.02515)$$

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

$$NECM = N - (243.03 + 0.147\,POP + 0.0106\,X_1 + 3.37\,TIME)$$

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

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[1] w is the real average wage rate measured here as $\frac{W\$}{(EMP * P_r)}$. It is I(1).

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

National Output Deflator Equation[2]

$\Delta^2 \log P_y$	$= 0.280\ \Delta \log P_x$	$- 0.262\ \Delta \log P_{x-1}$	$+ 1.24\ \Delta^2 \log P_r$	$- 1.00$ PY
	(5.751)	(5.714)	(4.741)	(4.165)

$R^2 = 0.864$ DW = 1.96

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

CRDW = 1.89 ADF = -4.24 **

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

[2] $\Delta \log P_x$ is I(0)

Solution of the Model

The model contains the estimated equations and the identities was solved using a Gauss-Seidel algorithm. The actual and simulated values are compared in Table 3 below:

Table 3

Comparison of Actual and Simulated Values of "Endogenous" Variables Using The Theil Inequality Coefficient and its Decomposition[3]

Variable	Theil's U	U_m	U_r	U_d
C	0.0741	0.0000	0.0054	0.9946
C_p	0.0972	0.0000	0.0012	0.9988
EMP	0.0294	0.0593	0.0244	0.9164
GDEF	0.5011	0.1922	0.1091	0.6987
I	0.0939	0.0347	0.0369	0.9284
I_p	0.1924	0.0347	0.0537	0.9116
K	0.0255	0.7526	0.0536	0.1938
L	0.3025	0.0342	0.1382	0.8277
L_1	0.1804	0.0322	0.2971	0.6706
L_2	0.4497	0.0200	0.2920	0.6880
M	0.0953	0.0007	0.0024	0.9970
M_g	0.1200	0.0007	0.0002	0.9992
N	0.0179	0.0020	0.0033	0.9947
P_g	0.1352	0.3158	0.0994	0.5848
P_r	0.0686	0.5247	0.3256	0.1497
P_v	0.0507	0.2317	0.0691	0.6991
R	0.6269	0.0342	0.4902	0.4757
r	0.4340	0.0108	0.0000	0.9892
T	0.0472	0.0014	0.0161	0.9825
UNEMP	0.1340	0.0969	0.3995	0.5036
U_R	0.1300	0.0773	0.4021	0.5205
w	0.1919	0.1104	0.4586	0.4310
W$	0.1208	0.4098	0.1588	0.4314
X	0.0333	0.0200	0.0560	0.9240
X_2	0.1277	0.0200	0.2297	0.7503
ΔXD	0.8547	0.1922	0.6006	0.2072
ΔXD_g	1.9980	0.1922	0.6284	0.1794
Y	0.0444	0.0027	0.0201	0.9772

Theil's U = Theil's Inequality Coefficient
U_m = Proportion of Error due to Bias
U_r = Proportion of Error due to Variance
U_d = Proportion of Error due to Covariance

Many of the variables perform very well on the basis of Theil's U and its decomposition but some do not do so well. The model may require some fine tuning to perform better on the basis of these criteria.

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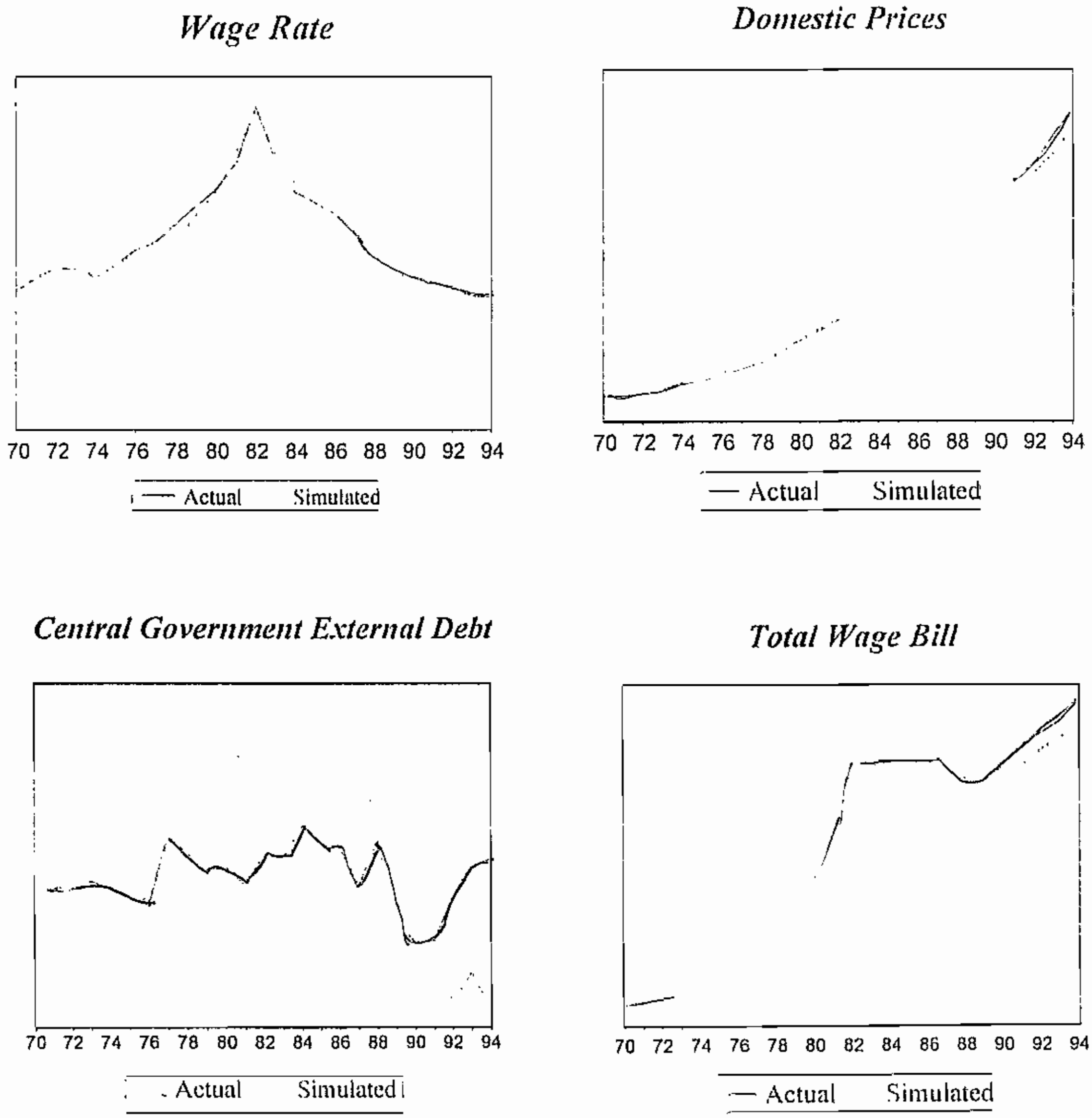
[3] The meaning and usefulness of these measures are explained in Maddala (1977)

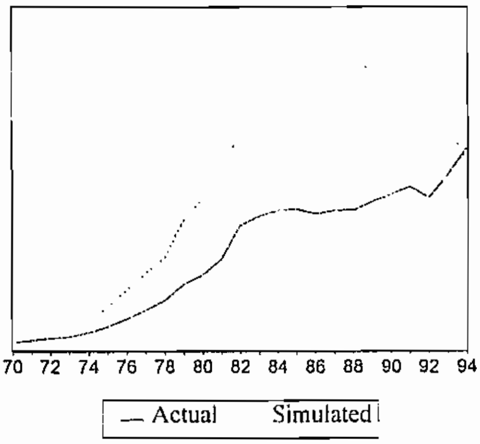
Exhibit 1 below shows the time plots of the actual and simulated values and complements the summary measures shown in Table 3.

Exhibit 1

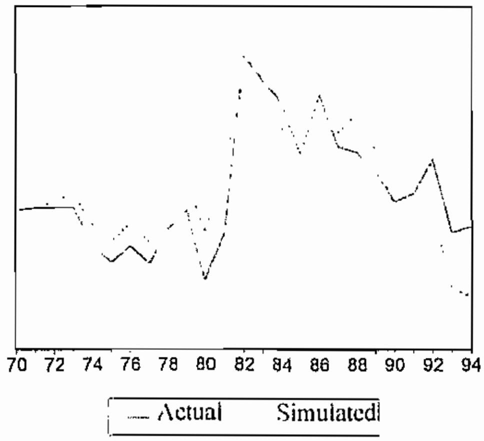
Time Plots of Actual and Simulated Values



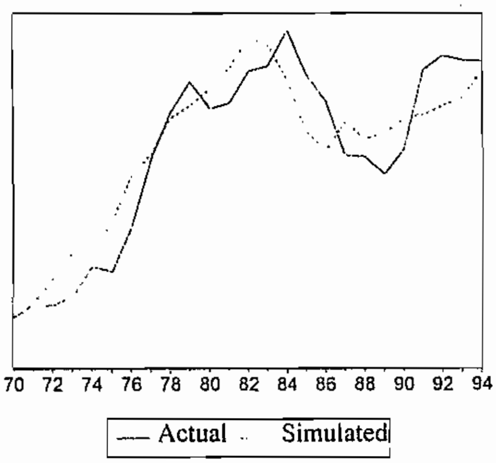
Broad Money Supply



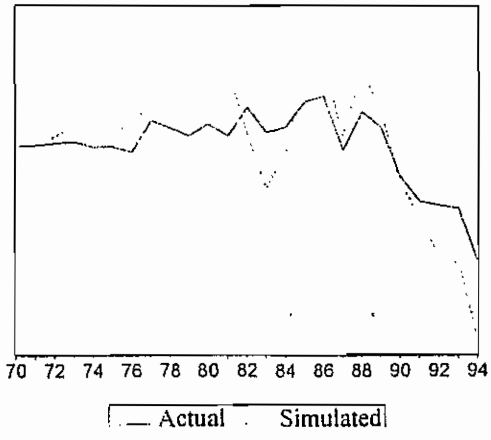
Overall Government Budget Deficit



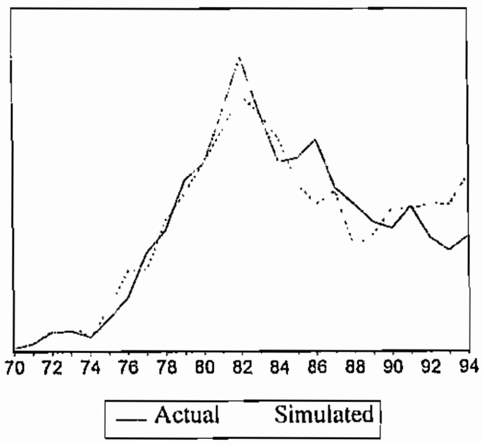
Employment



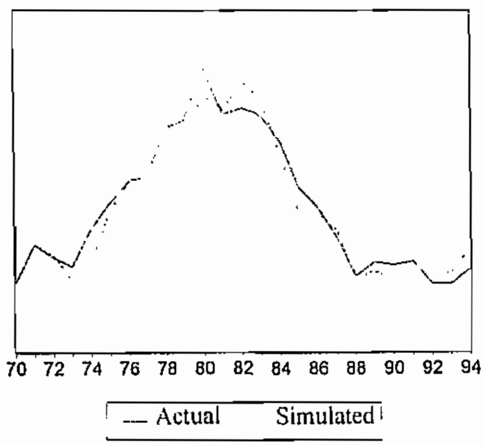
External Debt



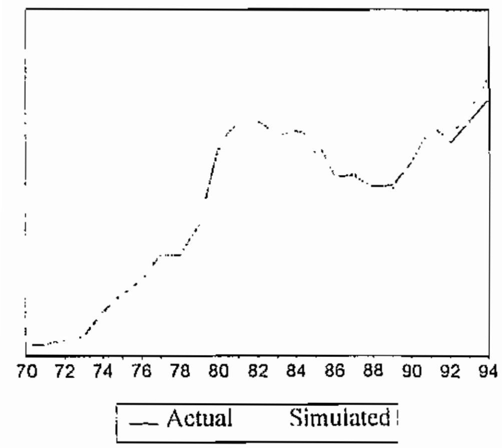
Total Consumption Expenditure



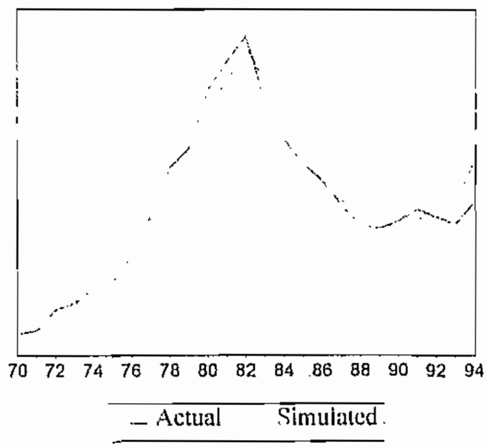
Gross Capital Formation



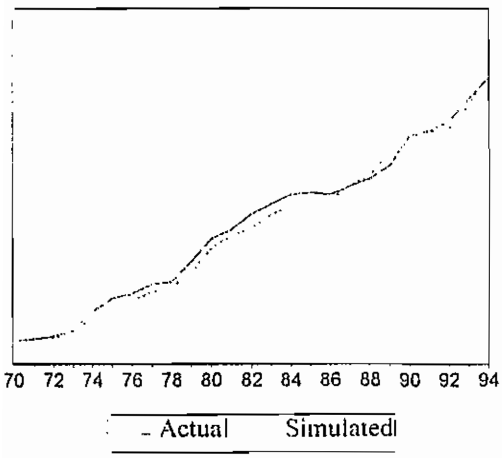
Government Revenue



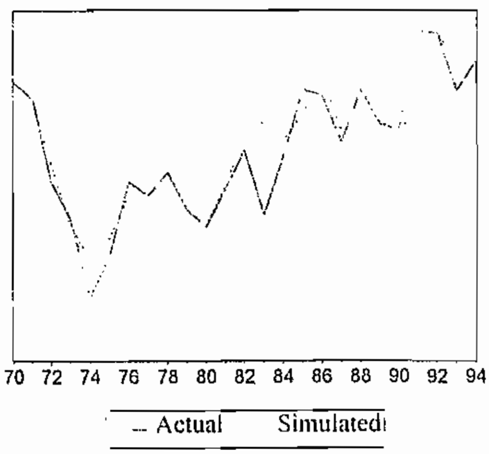
Gross Domestic Product



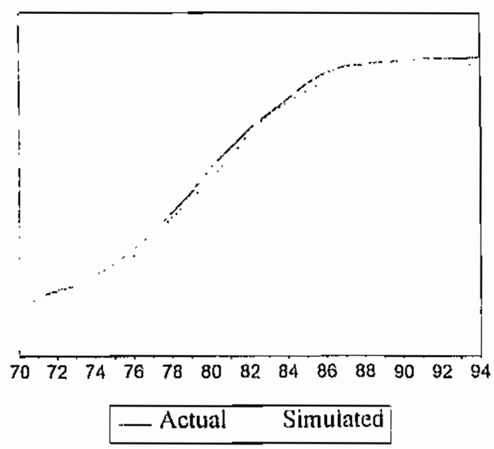
Implicit GDP Deflator



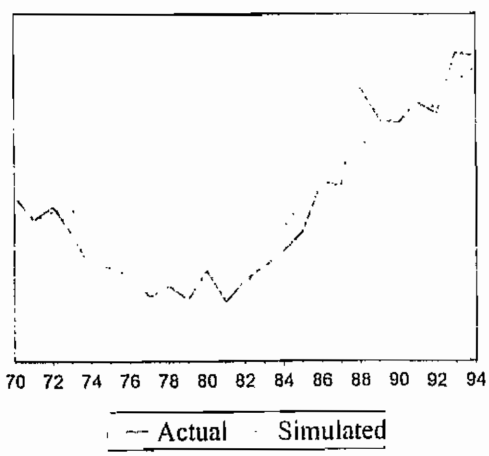
Loan Rate



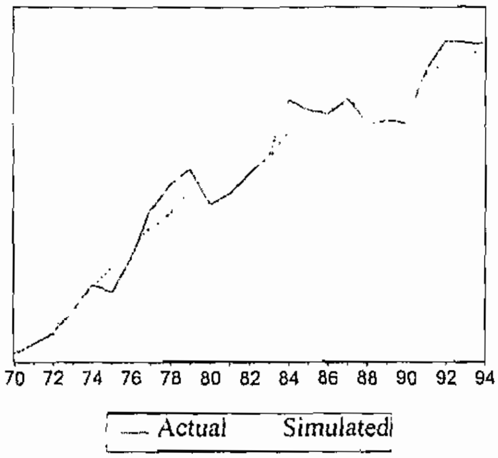
Capital Stock



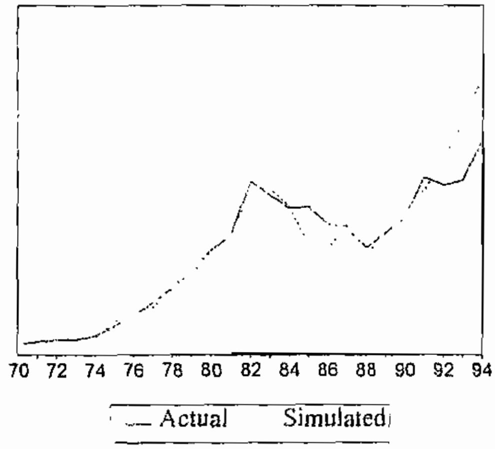
Non Petroleum Exports



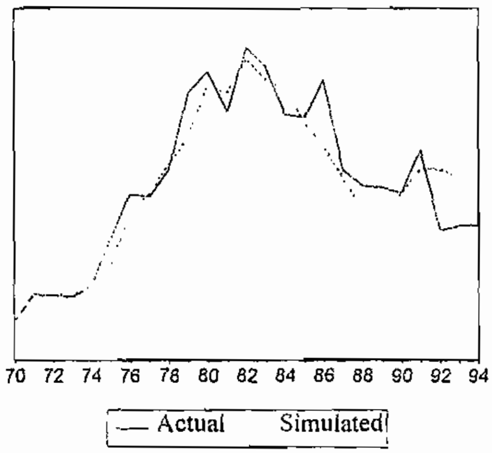
Labour Force



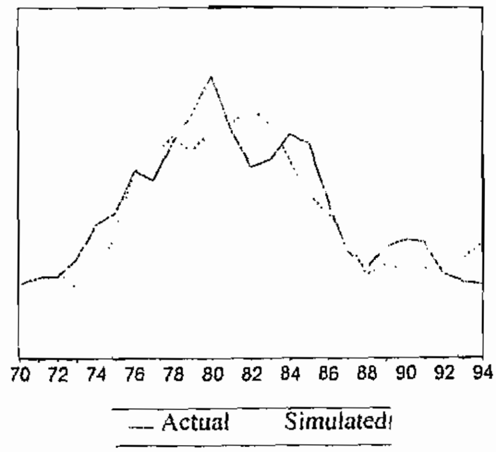
Narrow Money



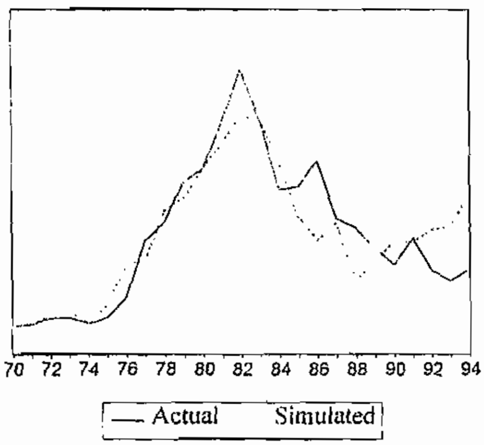
Imports of Goods



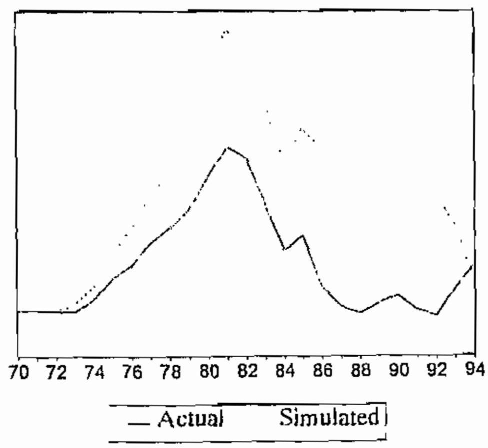
Private Investment



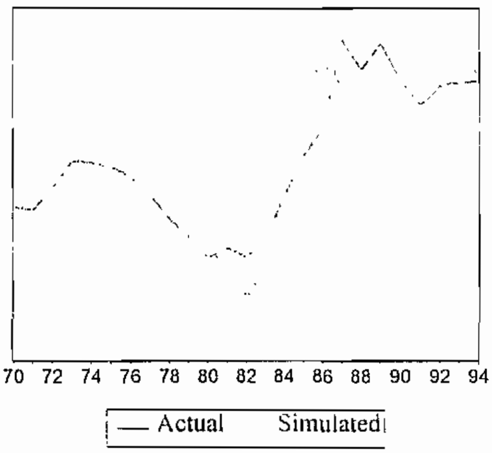
Private Consumption Expenditure



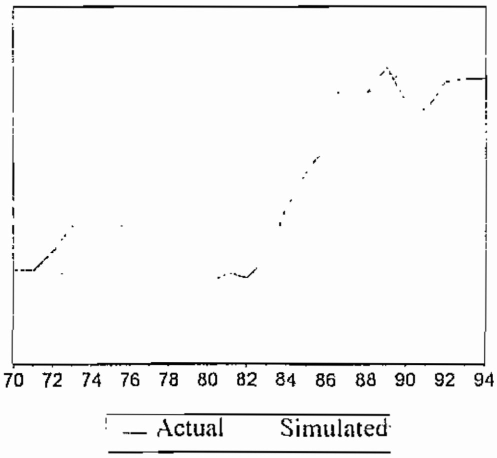
Foreign Exchange Reserves



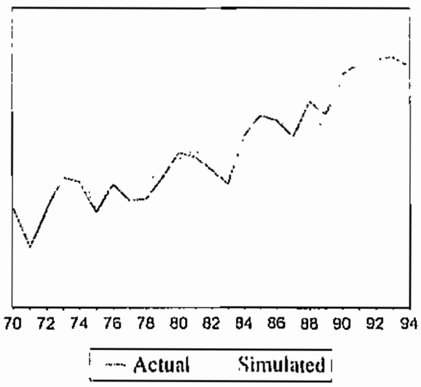
Unemployment Rate



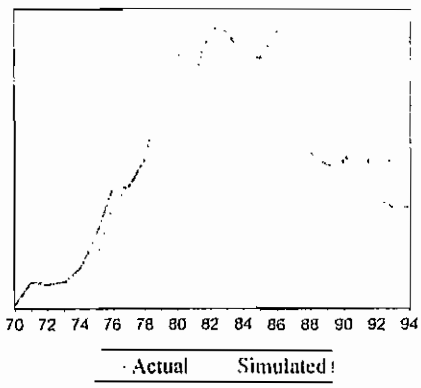
Unemployment



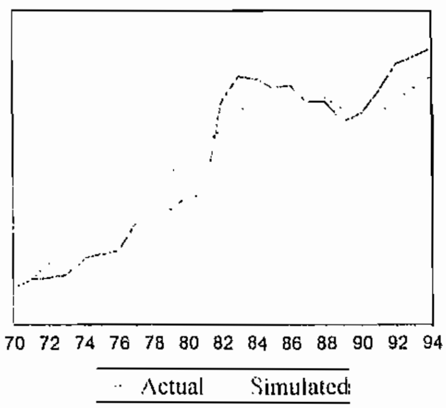
Exports of Goods and Services



Imports of Goods and Services



Government Consumption Expenditure Deflator



In many cases the plots shown strengthen what appears to be weak cases based on the results shown in Table 3. Take for instance P_r for which $U_d = 0.1497$ (the ideal value is one) where the time paths shown are extremely close to each other and follow more or less the same pattern. The same can be said for Capital Stock (K).

The model was also subjected to exogenous shocks in order to establish its stability and the nature of its dynamic reponse to stimuli. In no situation studied did the model not converge or behave in a manner for which no plausible theoretical explanation could be given.

Conclusion

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

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

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