POLICY-MAKING AND FORECASTING WITH A PESARAN-TYPE CORE MODEL OF THE TRINIDAD & TOBAGO ECONOMY

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ABSTRACT

This principal objective of this paper is the construction and evaluation of a Pesaran-type core quarterly econometric model of the Trinidad and Tobago economy using data covering the period 1970-1998. It represents the first step in the construction of a more comprehensive model of the Trinidad & Tobago economy with this core at the centre. Such a model will be used for forecasting and for policy evaluation.

In the paper, the econometric methodology to be employed is presented and discussed. This is followed by a description of the hypothesized long run relations in the core model which are derived from economic theory as well a discussion about the associated problems relating to the corresponding data to be used. The core model is estimated after testing for unit roots and cointegration vectors. The Error Correction form of the model is then derived and evaluated. Persistence profiles based on system wide shocks are derived and discussed. Forecasts derived from the model are compared to those obtained from benchmark ARIMA models.

Keywords: Core model, long-run relations, cointegration, persistence profiles, short-term forecasts.

1. Introduction

This principal objective of this paper is the construction and evaluation of a Pesaran-type core quarterly econometric model of the Trinidad and Tobago economy using data covering the period 1970-1998. Useful methodological references are Pesaran (1997), Pesaran and Smith (1998), Garratt et al. (1998, 1999), Pesaran et al. (1999) and Pesaran and Shin (1999). It represents the first step in the construction of a more comprehensive model of the Trinidad & Tobago economy with this core at the centre. Such a model will be used for forecasting and for policy evaluation.

Economy-wide models of the Trinidad & Tobago have, to date, been constructed using structural econometric models (SEMs). Examples are Hilaire et al. (1990), Watson and Clarke (1997) and Watson and Teelucksingh (2001). All three models use annual data and are estimated using classic least squares procedures[1]. In addition, they are evaluated using standard simulation techniques.

SEMs have been severely criticised – see, for instance, Sims (1980) – and alternative approaches, including variants of the VAR approach introduced by Sims, have been sought to respond to the criticism. The Pesaran approach, or the Structural Cointegrating VAR (SCVAR) approach, is one such proposed alternative.

In the following section, the econometric methodology to be employed is presented and discussed. This is followed in section 3 by a description of the hypothesized long run relations in the core model which are derived from economic theory. In this section there is as well a discussion about the associated problems relating to the corresponding data to be used. In section 4, the core model is estimated. This involves pre-tests for unit roots as well as tests for cointegration vectors. The Error Correction form of the model is then derived and evaluated. In section 5, persistence profiles based on system wide shocks are derived and discussed and, in section 6, the short-term forecasting performance of the core model is considered. We conclude the paper in section 6.

2. Econometric methodology

A modern VAR analysis may very well begin with a structural VAR of the form:

$$\sum_{j=0}^{p}\Phi_j \mathbf{y}_{t-j} = \mu_0 + \mu_1 t + \Psi \mathbf{d}_t + \Theta \mathbf{f}_t + \sum_{j=0}^{p}\Gamma_j \mathbf{x}_{t-j} + \mathbf{u}_t,\ t = 1,2, .., T \qquad (1)$$

where

- Φ_j, j = 0, 2, ..,p are G×G matrices and Γ_j, j = 0, 2, .., p are G×K matrices of fixed coefficients.

[1] In Watson and Teelucksingh, some attempt is made to use the Engle-Granger 2-step procedure.

- y_t is a (G×1) vector of endogenous variables
- x_t is a (K×1) vector of (weakly) exogenous variables
- μ_0 is the (G×1) constant term vector
- μ_1 is a (G×1)vector of fixed coefficients
- t is the trend variable (used also as the time subscript)
- d_t is a (k×1) vector of "intervention" dummies
- f_t is a (s×1) vector of seasonal dummies (s+1 is the number of "seasons")
- Ψ is a (G×k) matrix of fixed coefficients
- Θ is a (G×s) matrix of fixed coefficients
- u_t is the (G×1) error vector of independently, identically distributed random variables with mean zero and covariance matrix Ω.

See Giannini (1992) and Mosconi (1998).

When the y and x vectors are I(1) and cointegrated, equation (1) may be re-written as:

$$\Phi_0\Delta y_t = \mu_0 + \mu_1 t + \Psi d_t + \Theta f_t + \alpha\beta' z_{t-1} + \Pi_0 \Delta x_t + \sum_{j=1}^{p-1} \Pi_j \Delta z_{t-j} + u_t \qquad (2)$$

where $z'_t = (y'_t, x'_t)$ and α and β are (Gxr) matrices of full column rank and $\beta' z_{t-1}$ gives the r linear combinations of z that are cointegrated. Johansen (1992), (1994) shows that the dynamics of y_t as well as the asymptotics of the system are affected by the way the constant term and the trend enter into the model. Consider the following decompositions:

$$\mu_0 = \alpha\mu_{01} + \alpha_\perp \mu_{02}$$

$$\mu_1 = \alpha\mu_{11} + \alpha_\perp \mu_{12}$$

where $\alpha_\perp$ is a Gx(G-r) matrix of full rank, orthogonal to α. It can be shown that (2) may be re-written as:

$$\Phi_0\Delta y_t = \alpha_\perp \mu_{02} + \alpha_\perp \mu_{12} t + \Psi d_t + \Theta f_t + \alpha \begin{pmatrix} \beta \\ \mu_{01} \\ \mu_{11} \end{pmatrix} \tilde{z}_{t-1} + \Pi_0 \Delta x_t + \sum_{j=1}^{p-1} \Pi_j \Delta z_{t-j} + u_t \qquad (3)$$

where $\tilde{z}'_t = (z'_t, 1, t)$. In this paper, we will use this form of the model with the restriction that $\mu_{12} = 0$. μ_{01}, μ_{02}, and μ_{11} are unrestricted.

There are two "identification" problems associated with the model as shown in (1) and (2). The first concerns the identification of the short-run coefficients Φ_0, Γ_0, Φ_j and Γ_j, j = 0, 1, 2, .., p. Secondly, there is the identification of the β matrix. Furthermore, solving one of the identification problems does not help us to resolve the other. See Pesaran and Shin (1999).

In this paper, we will assume that the short-run coefficients are unrestricted. In such a case, we may work with the reduced form of the Model:

$$\Delta y_t = \Phi_0^{-1}(\mu_0 + \mu_1 t + \Psi d_t + \Theta f_t + \alpha\beta' z_{t-1} + \Pi_0 \Delta x_t + \sum_{j=1}^{p-1} \Pi_j \Delta z_{t-j} + u_t)$$

which may also be re-written as:

$$\Delta y_t = \mu_0^* + \mu_1^* t + \Psi^* d_t + \Theta^* f_t + \alpha^* \beta' z_{t-1} + \Pi_0^* \Delta x_t + \sum_{j=1}^{p-1} \Pi_j^* \Delta z_{t-j} + u_t^* \qquad (4)$$

where $x^* = \Phi_0^{-1} x$. This is the form of the core model that we are going to estimate in this paper and the SCVAR approach will be used to do it.

The strategy of the SCVAR approach is as follows. It requires, in the first instance, a rigorous theoretical derivation of key long run (equilibrium) relationships within the economy, $\beta' z_{t-1}$. These are then imbedded in an otherwise unrestricted VAR like (4). The x variables in this context may be interpreted as forcing variables and may eventually be assumed to follow the VAR(s) process:

$$\Delta x_t = b_0 + (Db_1)t + Dx_{t-1} + \sum_{j=1}^{s-1} R_j \Delta x_{t-j} + \varepsilon_t \qquad (5)$$

There is a limit to the amount of variables that may be included in the core model defined by (4) and (5). Firstly, the z-variables must all be I(1) and to establish this may require a considerable pre-testing effort. Secondly, the inclusion of too many variables weakens the power of the cointegration tests. This clearly has implications for the issues that may be addressed by the core model which may be of direct interest to the policy maker. The large SEMs incorporated a host of variables and consequently allowed for the analysis of a host of issues. The track record of these models, however, leaves a lot to be desired and leads one to question the utility of employing these large, multipurpose models which distinguish themselves by being unwieldy and error prone. The SCVAR approach to dealing with meeting the demands of the various users is the development of satellite models which can be attached to the core and used for purposes similar to those of the SEMs. The construction of such satellites is left for a later date.

3. Model and data

Trinidad & Tobago is a twin island independent republic with a population of about 1.25 million. Its main resource is petroleum (this is likely to remain the case for some time to come) and as a consequence, the price of oil, which is determined independently of Trinidad & Tobago production, is an extremely important (exogenous) variable. In fact, a particular feature of economies like that of Trinidad & Tobago, not unrelated to its small size, is its heavy dependence on the outside world and in particular the absolute necessity to earn foreign exchange as a prerequisite to survival. The government of Trinidad & Tobago is an active economic agent, intervening through fiscal and monetary measures to attain goals consistent with high incomes to or close to a level that is compatible with full employment in an environment of a stable exchange rate and moderate price levels.

For these and other reasons, Trinidad & Tobago has been described as a small open petroleum economy in the spirit of Seers (1964). The term "small" may be misleading as a description of such economies and perhaps the term "micro" may be more appropriate. The economy of Trinidad & Tobago is certainly much smaller than that of the United Kingdom which Garratt et al (1998) describe as a small open economy.

There are (at least) two fundamental challenges to applying the SCVAR approach to model the Trinidad & Tobago economy. In the first place, there is a serious body of economists which challenges the applicability of standard economic theory to such an economy. To make matters worse, there is no general agreement about what constitutes an acceptable economic theory which could be applied. See Célimène and Watson (1991). The second problem is one of data, or rather the general absence of it. And data deficiency is not limited only to questions of data quality. Data might be, above all, deficient in quantity and it is this aspect of data deficiency - the quantity aspect - that is the principal preoccupation here. Data series required for a macroeconometric model of even the most modest size might be either non existent, or plagued by missing values, or too short, or, finally, of inappropriate frequency even when the requirements are as modest as those of a Pesaran-type core model.

3.1 Theoretical issues

In the absence of a well defined theoretical framework for the Trinidad & Tobago economy, we propose to examine the model of the UK economy rigourously derived by Garratt et al. (1998) and to see how, *mutatis mutandis*, that model may be adapted to the Trinidad & Tobago case. They establish a system of 6 long run relations (one of which is eventually eliminated) from the system derived from production, trade, arbitrage, solvency and portfolio balance conditions. Many of the underlying assumptions used in their arguments do not appear to hold up in the Trinidad & Tobago case.

We arrive at the following 3 long run relations:

$$p_t = a_{10} + a_{11}t + \beta_{15}(er_t + p_t^* - p_t) + \beta_{16}(p_t^0 - p_t^*) + \varepsilon_{1t} \qquad (6)$$

$$(er_t + p_t^* - p_t) = a_{20} + a_{21}t + \beta_{23}r_t + \beta_{26}(p_t^0 - p_t^*) + \varepsilon_{2t} \qquad (7)$$

$$h_t = a_{30} + a_{31}t + \beta_{32}y_t + \beta_{33}r_t + \varepsilon_{3t} \qquad (8)$$

All variables are expressed in logarithmic form and:

p_t = Domestic price level

er_t = Nominal exchange rate (cost in TT dollars of one unit of foreign currency)

p_t^* = Foreign price level

p_t^0 = Oil price

r_t = Interest rate

h_t = Stock (real) of high powered money

y_t = National income

The entities $(er_t + p_t^* - p_t)$ and $(p_t^0 - p_t^*)$ may be interpreted as, respectively, the real effective exchange rate and the real price of oil. The latter is taken as a long run forcing variable.

Equation (6), which we term the price relation, is derived from the arbitrage conditions. It explains the national price level as a function of the effective exchange rate and the real oil price. As the national currency becomes weaker (er increases) or as US prices rise (or both), local prices should rise. This is simply because local prices will reflect the heavy dependence on imported goods (consumer and capital) which will have become more expensive. The value $\frac{\beta_{15}}{1+\beta_{15}}$ measures the (logarithmic) rate of change in the price level relative to the nominal exchange rate and the US price level. It is therefore expected to be positive. This implies in turn that either $\beta_{15} > 0$ or $\beta_{15} < -1$. As the oil price increases, there are massive inflows of (windfall) funds into the national economy leading to increased demand, bottlenecks in production and distribution and rising prices. So we expect β_{16} to be positive.

Equation (7), which we term the exchange rate relation, derives from the trade relations. The role of the interest rate in the determining the strength of the national currency in the context of a country like Trinidad & Tobago is somewhat ambiguous. It may be argued, on the one hand, that the exchange rate will be stronger in the presence of rising interest rates (in which case β_{23} is expected to be negative). Indeed, it is theoretically feasible that the monetary authority may act to bring about a rise in interest rates to encourage holders of foreign currency to deposit their funds in local banks and in local currency, so defending the strength of the currency. A high interest rate compensates against the fear of a declining exchange rate following, for instance, a deterioration of the oil price. The fundamental assumption here is that holders of foreign currency are attracted away from the local market more by this fear than higher interest rates elsewhere. Prior to the introduction of a floating exchange regime in April 1993, it was in fact illegal to hold foreign accounts although, of course, this did little to prevent the existence of such accounts. Since liberalisation, the local interest rates are generally much higher than corresponding rates in the US.

On the other hand, it is not certain that holders of foreign currency will find holding balances in TT dollars more attractive simply because of a higher interest rate. The TT dollar can hardly be described as hard currency and there is always the potential risk that such balances may not easily be reconvertible into a hard currency. Rising interest rates, following a decline in oil prices, may come as too little too late. There is also the possibility that rising rates are a signal to holders of foreign balances that the monetary authority is aware of some downward pressure on the value of the currency of which they (the holders of such currency) may be unaware. In this case, such holders may take action that may have precisely the effect of lowering the value of the national currency (in which case β_{23} is expected to be negative).

The final variable in this relation is the oil price. There is no ambiguity here: the national currency is expected to get stronger as the price of oil increases. We therefore expect β_{26} to be negative.

Equation (8), which we term the money relation, derives from the solvency relations. It is in many respects a "liquidity preference" function showing money demand as a function of income and the interest rates. β_{32} is expected to be positive and β_{33} negative. There is, however, a possible reasonable theoretical justification for a positive relationship between the interest rate and money demand. The securities and bonds market is in embryonic stage in Trinidad & Tobago so that alternatives to holding money for speculative purposes are quite limited. It is possible that savers are *target* savers in the sense that the interest so gained is seen as a source of future income determined in advance. Higher interest rates mean that the same income may be obtained by smaller savings balances, releasing funds for transactions purposes. The result is, as interest rates rise, more cash balances are held.

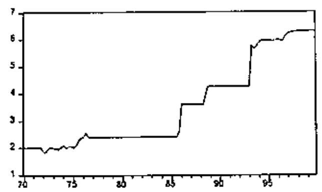
3.2 Data issues

The model outlined above contains 7 distinct variables for which data must be collected. Each one presents its own distinct problems which must be resolved before we can proceed. The data for the national price level almost selects itself: the retail price index, published monthly and in timely fashion by the Central Statistical Office, is the only price index available on a quarterly basis. It is well known that this and similar indices world-wide measure the movement in a fairly rudimentary basket of goods and services and so may be quite inappropriate for representing general price movements.

The exchange rate is measured as the rate of the TT dollar against the US dollar and the level of foreign prices is taken to be prices prevailing in the US as measured by the US consumer price index. This is because of the pre-eminence of the US in the trading relations of Trinidad & Tobago. Even before the attainment of independence from Britain in 1962, the USA was by far Trinidad & Tobago's major trading partner. The TT dollar was pegged to the £ sterling until 1976 when it was pegged to the US dollar. It remained attached at a fixed rate to the US dollars (with intervening devaluations) until 1993 when a floating rate regime was introduced. Since then, the Central Bank has played a major role in stabilising the value of the TT dollar against the US dollar by making appropriate interventions. The TT dollar keeps a fairly steady rate against the US dollar over relatively prolonged periods of time, even in the period of so-called liberalisation, largely because of this intervention. Figure 1 below shows the deterioration of the TT dollar against the US dollar over time through what appears to be a series of discrete jumps:

Figure 1

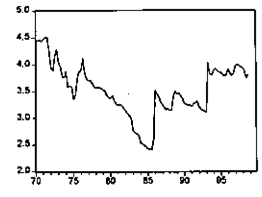
TT dollar per US dollar



The corresponding graph of the real effective rate of exchange, which is the variable entering into the model, is shown below:

Figure 2

Real effective exchange rate of TT dollar against US dollar



The advantage of using this measure rather than the nominal rate is that it reflects the real buying power of the TT dollar in the US market and is thus a better representation of a "true" rate of exchange.

There is no existing quarterly series for GDP in Trinidad & Tobago. However, since 1982, the Central Bank has been publishing a quarterly real GDP index. A quarterly series for real GDP is computed in two steps. In a first step, annual constant price data for the period 1971 to 1981 are converted to quarterly data using the well-known Lisman-Sandee procedure. Secondly, GDP growth rates derived from the Central Bank Quarterly (real) GDP index were applied from 1982, first quarter, to 1998, fourth quarter (using the value for 1981, fourth quarter, as an initial value) to generate quarterly GDP series from 1982 to 1998.

The remaining variables present less difficulties. The real stock of high powered money is obtained as the nominal stock deflated by the retail price index. The interest rate used is based on the weighted average loan rate R_t, published monthly by the Central Bank of Trinidad & Tobago, and calculated as follows:

$$0.25 \log (1 + R_t/100)$$

Finally, the oil price is the US price per barrel of a combination of the spot price of Arabian Light Crude and the West Texan Intermediate.

4. Estimation of the Core Model

The estimation method to be employed requires that each of the variables in the theoretical model derived in the previous section be I(1). The summary results displayed in Table 1 below show that this is indeed the case for the variables p_t, $(er_t + p_t^* - p_t)$, $(p_t^0 - p_t^*)$, h_t, y_t, and r_t.

Table 1
Dickey-Fuller Tests

Variable	p_t	y_t	r_t	h_t	$(er_t + p_t^* - p_t)$	$(p_t^0 - p_t^*)$
ADF level	-0.0228	-1.9427	-2.0242	-1.8362	-2.1445	-2.4368
ADF 1st diff	-3.3297	-2.8382	-7.1246	-11.6395	-9.7524	-6.8649

95% critical value for the Dickey-Fuller statistic (level) = -3.45
95% critical value for the Dickey-Fuller statistic (1st diff) = -2.89
90% critical value for the Dickey-Fuller statistic (level) = -3.15
90% critical value for the augmented Dickey-Fuller statistic (1st diff) = -2.58

The test for variables in levels includes a constant and a trend term while the test in first differences includes only a constant term. The order of the ADF is chosen on the basis of the AIC criterion and only the statistic satisfying that criterion is shown here. All variables in first differences are significant at the 5% level except for GDP which is only just not significant at this level but significant at the 10% level.

The AIC criterion is used to select the underlying VAR for cointegraion analysis and we decide on a VAR(4) model. Using this model with unrestricted intercepts and restricted trends, and using the real oil price as a forcing variable, we proceed with the cointegration analysis. The summary results of this analysis appear in Table 2 below:

Table 2
Tests for Cointegration Rank

(a) Maximum Eigenvalue Statistic

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	79.1421	40.8900	37.9200
r<= 1	r = 2	36.4455	34.7000	32.1200
r<= 2	r = 3	27.2942	28.7200	26.1000
r<= 3	r = 4	13.9009	22.1600	19.7900
r<= 4	r = 5	8.2376	15.4400	13.3100

(b) Trace Statistic

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	165.0203	97.8300	93.1300
r<= 1	r>= 2	85.8782	72.1000	68.0400
r<= 2	r>= 3	49.4327	49.3600	46.0000
r<= 3	r>= 4	22.1385	30.7700	27.9600
r<= 4	r = 5	8.2376	15.4400	13.3100

The Trace Statistic leads clearly to the conclusion that there are exactly 3 cointegrating vectors. The Maximal Eigenvalue Statistic is a bit ambiguous. If we set the level of significance at 5%, we will conclude that there are only two cointegrating vectors. However, at the 10% level of significance we will conclude that there are three cointegrating vectors. There seems, therefore, to be sufficient evidence to support the conclusion that there are exactly three cointegrating vectors which accords with the underlying theory.

The next step is to estimate a model subject to exactly identifying restrictions, in this case 9 (3 per cointegrating vector identified). The equations corresponding to the exactly identified system which was successfully estimated are:

$$p_t = a_{10} + a_{11} t + \beta_{14} h_t + \beta_{15}(er_t + p_t^* - p_t) + \beta_{16}(p_t^0 - p_t^*) + \varepsilon_{1t} \qquad (6')$$

$$(er_t + p_t^* - p_t) = a_{20} + a_{21} t + \beta_{23} r_t + \beta_{24} h_t + \beta_{26}(p_t^0 - p_t^*) + \varepsilon_{2t} \qquad (7')$$

$$h_t = a_{30} + a_{31} t + \beta_{32} y_t + \beta_{33} r_t + \beta_{36}(p_t^0 - p_t^*) + \varepsilon_{3t} \qquad (8')$$

The next step is to test the overidentifying restrictions implied by the system (6), (7) and (8). We impose, in the first instance, 3 overidentifying restrictions (one in each equation). The log-likelihood ratio (LR) statistic for the joint test of the overidentifying restrictions is 12.23 with a p-value of 0.007. We then added a further restriction on the exchange rate relation: the nullity of coefficient of the trend variable. The LR statistic in this case was 12.93 and the corresponding p-value was 0.012. The data seem therefore to reject the theory underlying the restrictions implicit in the model (6)-(8) unless we are prepared to use a significance level as low as 1%.

Garratt et al. (1998), who themselves obtain a p-value of 0.0001, argue cogently that the null need not be rejected. They claim that "in view of the relatively large dimension of the underlying VAR model, the number of restrictions considered and the available sample size, it is important that the validity of the asymptotic critical values are (sic) evaluated by means of bootstrap techniques". We applied such techniques (10,000 re-samples were used) and obtained the following quantiles for the LR statistic:

Table 3

Quantiles of the LR Statistic

90%	95%	97.5%	99%
62.19	75.78	88.60	104.30

The null hypothesis cannot be rejected on the basis of the calculated LR-value of 12.93. The long run relationships of the core model, defined by equations (6)-(8), but excluding the trend coeffcient in equation (7), are therefore properly estimated as:

$$p_t = 2.75 + \underset{(0.002)}{0.0292}\, t - \underset{(1.26)}{3.125}\,(er_t + p_t^* - p_t) - \underset{(0.194)}{0.306}\,(p_t^0 - p_t^*) + \hat{\varepsilon}_{1t} \quad (6")$$

$$(er_t + p_t^* - p_t) = 1.288 + \underset{(5.66)}{16.5}\, r_t - \underset{(0.027)}{0.181}\,(p_t^0 - p_t^*) + \hat{\varepsilon}_{2t} \quad (7")$$

$$h_t = -12.95 - \underset{(0.002)}{0.010}\, t + \underset{(0.199)}{2.26}\, y_t + \underset{(15.19)}{61.26}\, r_t + \hat{\varepsilon}_{3t} \quad (8")$$

Standard errors (asymptotic) are shown in parentheses. The first equation (the price relation) explains the price level as a linear combination of the real effective exchange rate and the real price of oil. The exchange rate coefficient carries the correct sign and size and is significant. The oil price variable is incorrectly signed but not significant.

The second equation (the exchange rate relation) explains the effective exchange rate as a linear combination of the interest rate and the oil price. The oil price carries the correct sign and is very significant. The interest rate variable is positive and significant, indicating that holders of foreign currency view rising interest rates as a signal of "trouble ahead" whereupon they take action resulting in the decline in the value of the national currency. Finally, in the case of the third cointegrating equation (the money relation), the stock of money is explained as a linear combination of GDP and the interest rate. The GDP coefficient is significant and correctly signed. The interest rate variable is significant but appears to be incorrectly signed. However, as we discussed in the previous section, a positive relationship between money and interest rates is not implausible in the Trinidad & Tobago context.

The Error Correction form of the core model was then estimated. Selected results of this exercise are shown in Table 4 below. These include the coefficient values associated with the error correction terms and the forcing variable, together with the corresponding p-values, as well as some measures of goodness of fit of the individual equations.

Table 4

Error Correction Form of Core Model (Extracts)

Equation	Δp_t	Δy_t	Δr_t	Δh_t	$\Delta(er_t + p_t^* - p_t)$
$\hat{\varepsilon}_{1,t-1}$	-0.0245 [0.267]	-0.0597 [0.0800]	-0.0035 [0.006]	-0.2112 [0.096]	-0.1365 [0.050]
$\hat{\varepsilon}_{2,t-1}$	0.0474 [0.346]	0.3114 [0.000]	0.0072 [0.014]	0.6478 [0.025]	0.1915 [0.223]
$\hat{\varepsilon}_{3,t-1}$	-0.0320 [0.073]	-0.0329 [0.227]	0.0011 [0.276]	-0.4989 [0.000]	-0.0341 [0.538]
$\Delta(p_t^0 - p_t^*)$	0.0236 [0.103]	0.0049 [0.824]	0.0013 [0.1255]	-0.0268 [0.744]	-0.1126 [0.014]
$\Delta(p_{t-1}^0 - p_{t-1}^*)$	0.0134 [0.400]	-0.0216 [0.375]	0.0011 [0.206]	-0.0707 [0.435]	0.0806 [0.107]
$\Delta(p_{t-2}^0 - p_{t-2}^*)$	0.0153 [0.335]	-0.0148 [0.543]	0.0004 [0.624]	-0.0641 [0.477]	-0.0355 [0.473]
$\Delta(p_{t-3}^0 - p_{t-3}^*)$	-0.011 [0.447]	0.0045 [0.842]	-0.0005 [0.494]	-0.0452 [0.595]	0.0521 [0.264]
$\overline{R}^2$	0.183	0.468	0.114	0.252	0.084
Benchmark $\overline{R}^2$	0.145	0.568	-	0.065	-
p- value for $\chi^2_{SC}(4)$	0.696	0.001	0.213	0.832	0.456
p- value for $\chi^2_{FF}(1)$	0.655	0.217	0.600	0.141	0.000
p- value for $\chi^2_{N}(2)$	0.00	0.218	0.000	0.001	0.000
p- value for $\chi^2_{H}(1)$	0.796	0.139	0.842	0.000	0.206

The error correction terms $\hat{\varepsilon}_{1,t-1}$, $\hat{\varepsilon}_{2,t-1}$ and $\hat{\varepsilon}_{3,t-1}$ are derived from equations (6"), (7") and (8").

The diagnostics are χ^2 statistics for serial correlation (SC), functional form (FF), normality (N) and heteroscedasticity (H).
The figures shown in squared parentheses are the p-values associated with the corresponding coefficient estimates.

The overall results appear to be acceptable. The $\bar{R}^2$ values are reasonable given the fact that the regressions explain variations in the changes of the endogenous variables in the model. For puposes of comparison, we obtained what we considered best fit ARIMA type models for Δp_t, Δy_t, Δr_t, Δh_t and $\Delta(er_t + p^*_t - p_t)$. We used a procedure outlined by Koreisha and Pukkila (1998) to do this. Two of the variables (Δr_t and $\Delta(er_t + p^*_t - p_t)$) were identified as white noise. The others were fitted to standard ARIMA type models and their $\bar{R}^2$ values are used as benchmarks to compare with those obtained from the core model. These benchmarks are recorded in Table 4 above. As can be seen, these simpler univariate models result in $\bar{R}^2$ values that are comparable to those obtained from the core model and in two out of three cases the values are smaller in the univariate case.

The long run relations make an important contribution in each of the equations and are significant at the 5% level in at least one instance in each equation. The oil price variable (which is the long run forcing variable) intervenes significantly (at least at the 10% level) in two of the 5 equations.

The diagnostic statistics show that serial correlation is rejected in all but the GDP equation. Four of the five equations show that the functional form is properly specified and only one of the five shows some evidence of heteroscedasticity. Normality, however, is rejected in all but one case.

5. Persistence Profiles

For determination of the persistence profiles it is assumed that the oil price variable is strictly exogenous. Using the procedure developed by Koreisha and Pukkila (1998), we arrived at the following additive ARIMA model (standard errors shown in parentheses):

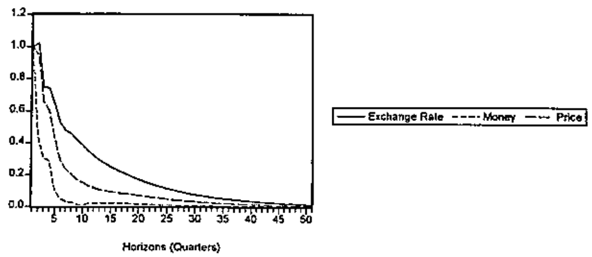
$$\Delta(p^o_t - p^*_t) = \underset{(0.087)}{0.384}\,\Delta(p^o_{t-1} - p^*_{t-1}) - \underset{(0.088)}{0.167}\,\Delta(p^o_{t-5} - p^*_{t-5}) + u_t \qquad (9)$$

$\bar{R}^2 = 0.170$, p-values: $\chi^2SC = 0.235$, $\chi^2FF = 0.31$, $\chi^2N = 0.000$, $\chi^2H = 0.342$

Figure 3 below shows the persistence profiles of the 3 long run relations in the model. They show the speed at which the different relations will return to long-run equilibrium following a system wide shock.

Figure 3

Persistence Profiles of the effect of a system-wide shock



Garrat et al. (1998) define a half-life measure which describes the horizon over which the profile falls to 0.5. Given that the profile starts at 1 and falls to zero, this gives a simple indication of the speed of adjustment of a profile and makes it easy to compare the response rate of the different profiles. All the relations tend rather rapidly to their equilibria following a shock. The fastest response comes from the money relation whose half-life is less than one quarter. It is followed by the price relation whose half-life is a little more than 3 quarters and the exchange relation with a half-life of just over 5 quarters. These seem to be compatible with received economic theory and other empirical results.

6. Short-term forecasting performance of the Core Model

The Core Model was used to obtain *ex ante* forecasts for the four quarters of 1999 for the variables p_t, y_t, r_t, h_t and $(er_t + p^*_t - p_t)$. Using the Root Mean Square Error (percentage) criterion, we also compared these forecasts with those obtained from the benchmark univariate ARIMA models. The results of the exercise are summarized in Table 5 below:

Table 5

Comparison *ex ante* forecasts from Core and ARIMA models

(Root Mean Square Percentage Errors)

Horizon	p_t		y_t		r_t		h_t		$(er_t + p_t^* - p_t)$	
	ARIMA Model	Core Model	ARIMA Model	Core Model	ARIMA Model	Core Model	ARIMA Model	Core Model	ARIMA Model	Core Model
1	0.163	4.091	0.546	0.262	1.589	4.373	0.764	0.049	0.044	4.575
2	1.054	5.472	0.546	0.403	1.997	3.989	0.540	0.341	0.466	3.558
3	1.388	6.831	0.579	0.532	2.704	3.546	0.503	0.369	0.475	3.222
4	1.328	7.872	0.546	0.647	2.389	3.264	0.535	0.329	0.445	3.180

The forecasts based on the univariate models are, perhaps not surprisingly, unambiguously better that those obtained for the core model except in the case of GDP. But the forecasts from the Core Model can in no way be considered as poor. Of course, the Core Model may be used for much more than the mechanical generation of forecasts. In particular, it may be used to study the nature and extent of responses to policy initiatives, both in the short and the long run, which cannot bee achieved through the use of the univariate ARIMA models. This more than compensates for its marginally inferior forecasting performance.

6. Conclusion

The results obtained up to now are encouraging. The three long-run relations hypothesised by economic theory were empirically verified and the corresponding Error Correction form had satisfactory diagnostics. The Persistence Profiles, a useful tool for policy analysis purposes, are not at odds with the predictions of economic theory. The forecasting performance is good although Univariate ARIMA models perform better. At a later date, satellite models of other aspects of the Trinidad & Tobago economy will be constructed and used alongside the core for policy making and forecasting purposes.

References

Célimène, F. and P. Watson (1991) Economie Politique Caribéenne Economica

Garratt, A., K. Lee, M.H. Pesaran and Y. Shin (1998), "A long run structural macroeconometric model of the UK", Department of Applied Economics Working Paper, University of Cambridge.

Garratt, A., K. Lee, M.H. Pesaran and Y. Shin (1999), "A structural cointegrating VAR approach to macroeconometric modelling", S. Holly and M. Weale (eds.) Econometric modelling: techniques and applications, Cambridge University Press.

Giannini, C. (1992), Topics in structural VAR econometrics, Springer Verlag.

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

Johansen, S. (1992) "Determination of the cointegration rank in the presence of a linear trend", Oxford Bulletin of Economics and Statistics, 54, 383-397.

Johansen, S. (1994) "The role of the constant and linear terms in cointegration analysis of nonstationary variables", Econometric Reviews, 13, 205-229.

Koreisha, S.G. and Pukkila, T. (1998) "A two-step approach to identifying seasonal autoregressive time series forecasting models", International Journal of Forecasting, 14, 483-496.

Mosconi, R. (1998), MALCOLM: the theory and practice of cointegration analysis in RATS, Libreia Editrice Cafoscarina.

Pesaran, M.H. (1997), "The role of economic theory in modelling the long run", The Economic Journal, 107, 178-191.

Pesaran, M.H. and R. Smith (1998), "Structural analysis of cointegrating VARs", Journal of Economic Surveys, 12, 471-505.

Pesaran, M.H. and Y. Shin (1999), "Long run structural modelling", Department of Applied Economics Working Paper, University of Cambridge.

Pesaran, M.H., Y. Shin and R.J. Smith (1999), "Structural analysis of vector error correction models with I(1) exogenous variables", Department of Applied Economics Working Paper, University of Cambridge.

Seers, D. (1964), "The Mechanism of an Open Petroleum Economy", Social and Economic Studies, 13, 233-242.

Sims, C.A. (1980), "Macroeconomics and reality", Econometrica, 48, 1-49.

Watson, P.K and S.S. Teelucksingh (2001), "Policy making and forecasting in Trinidad & Tobago using a medium-size structural econometric model" in A. Maurin and P.K. Watson (eds.) Empirical studies in Caribbean Economy, Caribbean Centre for Monetary Studies.

Watson, P.K. and R. Clake (1997), "A Policy Oriented Macroeconometric Model of Trinidad & Tobago" in E. Edinval, A. Maurin and J G. Montauban (eds.) Stratégies de développement comparées dans la Caraïbe , L'Hermès 265-337