A MODEL OF OUTPUT, WAGES, PRICES AND PRODUCTIVITY IN BARBADOS

by

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Paper Prepared For Presentation At CEMLA In Brasil 1987

Introduction

Macroeconomic models for policy use or policy evaluation are scarce in the Caribbean. Attempts at modelling in the Caribbean have followed the conventional model types developed in the industrialised countries.(See Manhertz (1971) for example). Lloyd Best and K. Levitt (1969) attempted to utilise an input-output model for planning purposes but its data requirements proved demanding and it was never used.[1]

Holder-Worrell (1984), Boamah et al (1984) and McClean (1983) have all argued that the peculiar macroeconomic characteristics of small open economies, such as Barbados, result in economic processes differing generically from those in the developed nations. Specifically, McClean (1983) identifies as other distinguishing characteristics (a) the preponderance of imported goods in the economy's absorption mix and strong export bias in its export mix, (b) endogeneity of the stock of money as well as the monetary base and the tradeable non-tradeable dichotomy. He concludes that the foregoing implies that economic processes in a small open economy are determined differently from those represented by conventional macroeconomic models.

This paper utilises recent developments in cointegration theory to incorporate dynamic modelling in the static model of the Barbadian economy developed by Holder-Worrell (1984) and Boamah et al (1984). Certain extensions and alterations are effected in the processes but the underlying theory is unchanged.

The rest of the paper is organised in four sections. A summary of the model is presented in section 2, and the modelling methodology in section 3. The empirical results are discussed in section 4, and conclusions and directions of future research are stated in the final section.

Model

As earlier mentioned, the genesis of the present model lies in the earlier work of Holder and Worrell (1984)(HW) which was subsequently revised by Boamah et al (1984).

We utilise the familiar tradeable - non-tradeable dichotomy which is extremely important to the small open economy. McClean (1983) notes that firms producing for export are typically supply-side constrained, whilst the output of firms producing goods and services for sale within the geographical confines of Barbados is typically demand side determined. (See also Holder and Worrell [1984]).

Typically, small open economies are characterised as having price elasticities of demand which are infinitely large, and a neglible domestic production in relation to world production. Due to the composition of tradeables (agriculture, tourism and manufacturing) the equation representing tradeable output (qt) will be a demand-supply hybrid. Agriculture and manufacturing are supply side determined whereas tourism is

1. For a brief of analysis of other modelling efforts in the Caribbean see Holder-Worrell (1984).

demand side determined. The tradeables relationship is posited to be positively related to the product price (px) and negatively related to costs of production (labour and capital) as well as increases in taxes on goods and services (itx). Ideally, wages (tw) need to be adjusted to take account of changes in labour quality and production technologies. However, the unavailability of an adequate measure of productivity for the tradeable sector makes the refinement untenable.[2] The cost of financing inventory and customer credit, measured by the loan rate (rl), is another constraint on the firm's level of operations in the short-run. Further, output is expected to increase with growth in our tourism markets (represented by U.S. GNP). Thus

$$Q_t = f_1(\overset{+}{px}, \overset{-}{rl}, \overset{-}{tw}, \overset{+}{USGNP}, \overset{-}{itx}) \tag{1}$$

where the signs above the variables indicate our a priori expectations.

The demand for non-tradeable goods is specified as depending on the level of real government expenditure (rgx), the amount of liquidity in the economy (rhm) and the level of taxes imposed (tau). The level of credit and government activity is expected to impact positively on demand for non-tradeables whilst any increases in taxes, direct or indirect, should lead to a reduction in demand.

2. Brewster (1968,1969) has argued against the convenient assumption of unified wages and productivity.

Therefore,

$$Q_n = f_2(\overset{+}{rgx}, \overset{+}{rhm}, \overset{-}{tau}) \tag{2}$$

The price (pn) at which the output of non-tradeables becomes available will depend on the general level of activity in the sector, and the variables which determine the firms costs: wages, interest rates and price of imported inputs. Thus

$$P_n = f_3(\overset{+}{rgc}, \overset{+}{ntw}, \overset{+}{pt}, \overset{+}{rl}) \tag{3}$$

where the price of tradeables (pt) is used to reflect the cost of imported intermediate and capital inputs. Since the price of tradeables is fixed exogenously on the world market the three behavioural relationships above combine to give the output determination sector. We close the sector with three identities. Total output is the sum of traded and non-traded output, whilst nominal income is the product of output and the GDP deflator (P), the latter of which is a weighted average of the prices in the two sectors. Thus

$$Y_r = Q_t + Q_n \tag{4}$$

$$Y = P(Y_r) \tag{5}$$

$$P = \alpha p_t + (1-\alpha)P_n \tag{6}$$

where α is the share of tradeables in total output (Y_r).

The level of wages is modelled as the result of the bargaining process between employers and unions. Downes-McClean (1982) (DM) utilise the bargaining theory approach to show that wages are a function of prices, productivity, taxes and credit conditions. They conclude that the main features which condition wage agreements in small open economies are the exogeneity of export and import prices and the degree of unionisation. Export prices set an upper limit on feasible wages, and owing to the preponderance of imports in consumption and investment, import prices rather than wages would be the single most important determinant of the aggregate price level.

Our analysis includes unemployment (ur) as an explanatory variable in the wages equation in an effort to capture excess supply/demand conditions in the labour market. It is argued that high levels of unemployment weakens the unions 'pushfulness' and strengthens the employers resistance to high wage demands. In addition, we maintain the productivity variable in the equation despite the assumption of DM (1982) that the inclusion of the productivity variable would have a negligible effect since the level of employment had been relatively stable. That is, wages can be higher if output per head increases and can be bid up (down) if there is pressure from demand (supply).

In our specification we model real rather than nominal wages on the basis of the observation that unions try to maintain real wages in the bargaining process. Specifically

$$R_W = f_4(\overset{-}{ur}, \overset{+}{prod}, \overset{-}{pt}) \qquad (7)$$

Prices are specified as a function of wages, productivity, external prices and the level of unemployment. Wages and productivity are included as separate arguments in contrast to the "corrected-wages" variant used in HW(1984).

$$RPI = f_5\ (\overset{+}{w}, \overset{-}{prod}, \overset{+}{pt}, \overset{+}{ur}) \qquad (8)$$

Productivity is posited to depend on the level of unemployment, real wages, prices and level of activity. The relationship is expected to be positive between productivity and unemployment, real wages and prices, and negative with respect to real government expenditure. Thus,

$$prod = f_6\ (\overset{+}{ur}, \overset{+}{rw}, \overset{+}{pt}, \overset{-}{rgx}) \qquad (9)$$

<u>Table 1</u>

The compiled model is:

<u>Output Determination</u>

1. Tradeable Output

   $qt = f_1(us, px, tw, rl, itx)$

2. Non-tradeable Demand

   $qn = f_2(rgx, rhm, tau)$

3. Price of non-tradeables

   $pn = f_3(rgc, ntw, rl, pt)$

4. $Yr = qt + qn$

5. $Y = P*Yr$

6. $P = \alpha Pt + (1 - \alpha)\ Pn$

Wages, Prices, Productivity

7. Retail Prices

   $rpi = f_4(w, prod, pt, ur)$

8. Real Wages

$rw = f_5(ur, prod, pt)$

9. Productivity

$prod = f_6(ur, rw, pt, rgx)$

Endogeneous Variables: qt, qn, pn, Yr, Y, P, rpi, rw, prod.

Exogeneous Variables: us, px, tw, rl, itx, rgx, rhm, tau, rgc, ntw, pt, ur

Methodology

Conventional econometric theory has been developed on the assumption that the underlying data processes are stationary. Most economic variables that are used in econometric modelling do not exhibit constancy in mean and variance, and therefore classical inference is not valid under these conditions. However, recent developments in econometric theory have shown that valid estimation and inference is possible when a set of non-stationary variables is cointegrated. Broadly speaking, a set of non-stationarity variables is cointegrated if there exists a linear combination of these variables that is stationary. This stationary linear combination can be interpreted as a long-run equilibrium relationship. The series are thus expected to move so that over time they do not drift too far apart. Cointegration theory therefore permits the separation of the long-run information contained in the data from the complex dynamics, about which economic theory is generally silent.

The modelling approach used in this paper follows the above theoretical developments and emphasise the desirability of formulating models that are theoretically consistent and capable of adequately explaining the data generation process. Standard econometric theory indicates that the error-term is a 'catch-all' variable that includes all influences not directly used in the modelling process. In this regard, the error-term will exhibit classical properties only if the classical regression assumptions are upheld. As a corollary, the assumption of classical properties in the error-term implicitly accepts the axiom of correct specification. Thus the modelling process can be viewed as a design problem, the criteria for which, if satisfied, will prove necessary but not sufficient for generating an adequate model. Consequently, we use design criteria as evaluative tools to obtain a tentatively adequate model. Thus diagnostic tests feature strongly in our approach.

The methodology employed is based on the Granger Representation Theorem (See Granger [1981], Granger and Weiss [1983] and Granger [1987] which states that, if a set of variables are cointegrated, then there exists a corresponding error correction representation of those variables which is capable of estimating the short-run dynamics inherent in the data. Further, the long-run static solution is recoverable. Formally,the components of a vector Z_t are cointegrated of order d, b, i.e. $Z_t \sim CI(d,b)$, if each of the components are I(d), and there exists a cointegrating vector $\alpha \neq 0$ such that

$$\varepsilon_t = \alpha^T Z_t \sim I(d-b),\ b>0 \qquad (10)$$

where I(d) implies that the series needs to be differenced d times to achieve stationarity. When the dimension of Z_t is greater than two, α may not be unique as there may be more than one cointegrating vector, some of which may be linearly dependent. For r linearly independent cointegrating vectors and and d=b=1, an error correction represention of r stationary random variables exists, such that

$$A^* (B) (1-B)Z_t = \beta\varepsilon_{t-1} + \delta(B) \mu_t$$

with $A^* (0) = I_N$, N being the dimensionality of Z_t and $\delta(B)$ a finite scalar polynomial in the log operator B. Since the test for cointegration requires the series to be integrated of order d O we proceed in the following manner:

(a) formulate the static 'long-run' theoretical relationship of interest;

(b) investigate the temporal properties of the identified variables;

(c) test for vector of cointegrates variables'

(d) estimate the Error-Correction-Representation; and

(e) test the adequacy of the resulting equation.

To the extent that a significant error-correction term in (d) implies that the set of variables are cointegrated, both (c) and (d) may not be required. However, Z_t in (2) can be tested for stationarity independently of the Error-Correction-Representation (see Dickey and Fuller 1979, 1981). With regard to (b) the order of integration of the series used follows previous work by Downes-Leon (1986) and Holder-Leon-Wood (1987).

Empirical Results

The results of the estimated model are presented below: With the long-run 'static' results in Table 2. The Error-Correction model and the diagnostics tests are reported in Table 3.

Table 2: Long-run 'Static' Estimates

Output Determination

1. lqt = −3.31 + 1.07 lus + 0.64 lpx − 0.46 ltw − 0.30 lrl − 0.003 litx
   (−1.57) (3.65) (4.37) (−2.64) (−2.25) (−2.35)

   $\bar{R}^2$ = 0.919   SE = 0.076   DW = 1.61   DF(t) = −4.22

2. lqn = 3.52 + 0.36 lrgx + 0.52 lrhm − 0.37 ltau
   (9.33) (4.19) (8.67) (−3.66)

   $\bar{R}^2$ = 0.987   SE = 0.051   DW = 2.04   DF(t) = −6.01

3. lpn = −2.13 + 0.18 lgc + 0.55 lntw + 0.17 lrl + 0.77 lpt
   (−5.47) (2.96) (5.87) (1.76) (7.48)

   $\bar{R}^2$ = 0.995   SE = 0.062   DW = 1.68   DF(t) = −4.25

4. lrpi = 0.23 + 0.82 lw − 0.58 lprod + 0.48 lpt + 0.006 ur
   (1.66)(14.58) (7.94) (8.12) (2.09)

   $\bar{R}^2$ = 0.998   SE = 0.034   DW = 1.94   DF(t) = −4.85

5. lrw = −0.63 − 0.009 ur + 0.78 lprod − 0.30 lpt
   (9.79) (3.23) (18.67) (−12.45)

   $\bar{R}^2$ = 0.936   SE = 0.040   DW = 1.53   DF(t) = −3.89

6. lprod = 1.06 + 0.01 ur + 0.83 lrw + 0.22 lpt + 0.29 lrgx
   (7.37) (4.52) (5.33) (3.19) (2.57)

   $\bar{R}^2$ = 0.982   SE = 0.045   DW = 1.65   DF(t) = −4.37

Table 3: ECM Results and Diagnostics+

	DQT	DQN	DPN	DRPI	DRW	DPROD
dus	1.89 (3.28)	-	-	-	-	-
dpx	0.92 (5.07)	-	-	-	-	-
dtw	-0.77 (2.87)	-	-	-	-	-
ditx	-0.003 (3.25)	-	-	-	-	-
dpnt	0.38 (2.29)	-	-	-	-	-
drgx	-	0.23 (2.44)	-	-	-	0.33 (4.04)
drhm	-	0.21 (2.30)	-	-	-	-
dta	-	-0.29 (2.65)	-	-	-	-
dpt	-	-	0.63 (7.41)	0.23 (4.64)	-0.28 (5.91)	0.20 (2.59)
dpm	-	-	-	0.21 (3.05)	-	-
dntw	-	-	0.24 (1.85)	-	-	-
dgc	-	-	0.31 (3.55)	-	-	-
drl*	-	-	0.13 (2.07)	-	-	-0.14 (2.60)
dcr	-	-	-	-	-0.16 (2.64)	0.20 (2.11)
dur	-	-	-	0.004 (1.74)	-	0.01 (2.15)
ec(z)	-0.99 (5.09)	-0.82 (4.62)	-0.66 (4.32)	-0.83 (5.01)	-0.98 (7.24)	-0.94 (4.43)
dprod	-	0.47 (2.82)	-0.49 (2.53)	-0.52 (5.35)	0.69 (6.23)	-

Table 3: ECM Results and Diagnostics+ Cont'd

	DQT	DQN	DPN	DRPI	DRW	DPROD
drpi(-1)	-	-	-	0.019 (2.51)	-0.23 (2.81)	-
drw**	-	-	-	0.65 (4.81)	-	0.67 (3.13)
Constant	-0.04 (1.21)	0.006 (0.60)	0.05 (2.95)	-0.003 (0.33)	0.04 (3.47)	-0.02 (1.21)
R^2	0.60	0.74	0.75	0.91	0.88	0.77
SE	0.06	0.036	0.039	0.022	0.024	0.028
DW	2.17	1.76	1.94	2.30	2.07	2.08
rmse	0.05	0.031	0.033	0.018	0.021	0.023
SC1	1.85	0.57	-0.58	2.00	0.21	-0.33
SCNL	4.79	0.20	0.14	0.46	-0.89	0.55
ARCH	0.62					
NORM	3.26	0.58	0.68	0.23	0.28	2.90
PC1	2.90	2.32	0.70	0.33	0.21	0.80
CHOW	1.18	1.06	0.32	0.17	0.13	0.30
INVR	-	9.14	7.85	7.00	4.37	5.15
RESET	0.02	1.35	1.34	1.01	2.27	1.10

* drl is lagged in the dpn equation.
** dw is used in the drpi equation - not drw.

+ SC1 and SCNL are tests for first order linear and non-linear serial corelation;

ARCH is Engle's autogressive conditional heteroskedastivity test [see Harvey (1981), Sargan (1976) and Pagan and Hall (1983)];

NORM is the Jarque-Bera (1980) normality test;

PC1 is the chi-square test for predictive accuracy;

CHOW is Chow's test for structural change (stability);

INVR is Sargan's test of the validity of the instrument set; and

RESET is Ramsey's specification error test.

The SC1 and SCNL are chi-square for the OLS equation (dqt) but in the case of the TSLS equations it is equal to the t-statistic on the lagged variable.

where

CR	=	Domestic credit (total)
EC(Z)	=	Error correction term for variable (Z)
RGC	=	Real government consumption expenditure
PM	=	Price of imports
Pn	=	Price of non-tradeables
PROD	=	Productivity, defined as output per person employed
Px	=	Price of exports
Pt	=	Price of tradeables
Qn	=	Quantity of non-tradeables
Qt	=	Quantity of tradeables
RL	=	Loan rate of interest
RGX	=	Real Government Expenditure
RHM	=	Total liquidity i.e. NFA + CR
RPI	=	Retail price index
RY	=	Real income
TAU	=	Average tax rate
UR	=	Unemployment rate
US	=	Real US GNP
W	=	Wages
TW	=	Wages in the tradeable sector
NTW	=	___________ non-tradeable sector

and

(i) d denotes first difference;

(ii) l denotes the log of the variable;

(iii) D-W = Durbin Watson Statistic.

(iv) SE = Standard Error of Regression.

(v) $\bar{R}^2$ = Adjusted R^2.

(vi) RMSE = Root mean square error.

The model's long-run 'static' equations were estimated over the period 1958-84. The Dickey-Fuller test DF(t) on the residuals suggests stationarity thus indicating that the variables in each equation are cointegrated. This implies that an error correction representation exists for each of the relationships. We therefore proceeded to estimate the error correction models using the Granger-Engle (1987) two step method over the period 1960-84. The method of estimation used is instrumental variables for the wage-price productivity sector as well as the demand for non-tradeables and OLS for the remainder of output determination sector. The instrument list include current and lagged growth rates of the exogeneous variables, lagged endogeneous variables as well as growth rate of domestic credit. The thorny question of identifiability is addressed here using exclusion restrictions.

The resulting equations seem to provide us with a reasonable description of the two sectors of the economy with only one equation failing to explain over 70% of the variance of its dependent variable. No equation had coefficients which we deemed unacceptable a priori - either in sign or magnitude - and most coefficients were significant at the 5% level. The error-correction term in the dynamic models are all significant supporting the hypothesis that the variables are cointegrated.

The growth in output of tradeable goods responds positively to the growth of exports prices, income growth in our major trading partner, and increases in the price of non-tradeable goods. The coefficients for the first two are extremely strong, possibly indicating that an increase in commodity prices will lead to significant increases in production and that growth in the US market would lead to increase tourist receipts as well as other goods. Any increases in the cost of production, wages or indirect taxes, cause a cutback in production as evidenced by the negative coefficients. Variations in the cost of finance (lrl) impact on the long-run equilibrium solution but have no significant effect in the short-run dynamic model. This may be attributed to the small and irregular increases in the banks' lending rates.

Output of non-tradeable goods increases with growth in government expenditure, total liquidity and higher productivity but falls as taxes increase. Monetary policies to restrain spending can therefore be of use since change in total liquidity (net foreign assets plus domestic credit) have a significant impact on movements in demand. The results would also suggest that cuts in taxes will lead to increases in aggregate demand which in turn will lead to growth in income.

The price at which non-tradeables are sold will rise with increases in the costs of production, whether it be finance costs, labour costs or cost of imported inputs. It will also grow as government consumes more goods and services from this sector. The rate of inflation will increase as wages, external prices and unemployment rises but will fall as output per man grows.

The results of the determination of real wages indicate that real wages will increase as productivity grows but will fall as the cost of imported inputs rise and as credit is increased. These results follow the pattern suggested by DM, who argue that any factor which impinges on the profitability of the firm will have a negative impact on wage increases.

Growth in productivity can be attributed to changes in the level of real wages, changes in output prices and real government expenditure as well as to increases in credit and unemployment; the cost of finance impacts negatively on productivity.

The estimated equations were checked against a series of diagnostic tests to ensure that the classical assumptions were not violated. The tests[3] suggest that the equations are adequate representations of the underlying processes.

3. See Table 3.

Conclusion

This paper utilised cointegration theory and the Error-Correction Mechanism to model output, wages, prices and productivity in Barbados. The resulting equations present the familiar picture of a small open economy exposed to the impact of international influences; the price of tradeable goods influences productivity, wages, prices and output. It also shows that both monetary and fiscal policies can play a crucial role in economic management. Fiscal policy through tax or expenditure policies affect output and prices while monetary policy becomes relevant in maintaining equilibrium in the non-tradeable sector through the level of credit and interest rates.

The current version of the model is incomplete, and we intend to extend the analysis to include the government, monetary and balance of payments sectors. Preliminary work has already been carried out but the results have not been reported. A subsequent possibility is to further disaggregate output; in particular, the tradeable sector can be split into agriculture, tourism and manufacturing in order to separate out the demand component (tourism) from the supply components. We are also considering the idea of modelling employment or unemployment in place of productivity. Finally, we hope to perform policy simulations on the complete model, and to use it for forecasting purposes. We do not foresee any problems with the simulations as most of the rmse's are within an acceptable range.

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