E C O N O M I C S   B U L L E T I N

Money and output interaction in Nigeria: an econometric investigation using multivariate cointegration technique

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Abstract

This paper derives and estimates a barro−type reduced form equation for domestic real output from a simple structural model of an open developing economy in which markets clear continuously and expectations are rational. The form in which open economy variables appeared was explicitly derived from an underlying structural model. The model was adapted to Nigerian Economy by according an important role to imported intermediate goods. The empirical result provided support for the open economy model of output determination in Nigeria.

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I INTRODUCTION

Over the past two decades, macro-economists have debated whether policy makers can systematically use aggregate demand policies to stabilize output around its full employment or “natural” level (Montiel, 1987). Specifically, proponents of “new classical” macroeconomics argued that since only unanticipated aggregate demand shocks can affect the distribution of output about its natural level; aggregate demand policy cannot be systematically used to stabilize output, and may only succeed in destabilizing the price level. The theoretical arguments for these propositions were buttressed with empirical evidence in the form of reduced form output equation developed by Barro (1972 1978, 1979 and 1981), which demonstrated that only the unanticipated component of monetary policy contributed to explaining deviations of output from its natural level in the United States. Barro’s tests have also been applied to small open economies but these applications have either used the original reduced-form output equation or have added ad-hoc variables to take account of the openness of the economies under study. In other words, the estimated reduced form output equation has typically not been derived from an underlying structural model suitable for a small open economy.

The neglect of this issue is particularly surprising for developing countries, where the short-run effects on the level of economic activity of restrictive monetary and fiscal policies associated with adjustment programmes have long been controversial, and where the adoption of such measures has often been postponed for fear of recessionary consequences.

Indeed, ascertaining the empirical relevance of new classical analysis for developing countries is an important step in assessing the short-run costs of adjustment in these economies. Estimating Barro-type reduced form output equations derived from dependent economy structural models for developing countries and testing for systematic effects of anticipated policy changes would appear to be a logical place to start. There have been several attempts at these estimations but more commonly, variables thought to be relevant to open economies or to developing countries have been added to the reduced-form output regression in ad-hoc fashion (see Attfield and Duck, 1983; Edwards, 1983; and Sheehey, 1984). The exclusion of relevant open-economy variables from the regression is likely to result in omitted-variable problems and unless the reduced-form output equation is derived from the underlying structural model, it is difficult to ascertain the form in which the open economy variables should appear.

This paper therefore derives and estimates a Barro-type reduced form equation for domestic real output from a simple structural model of open developing economy in which markets clear continuously and expectations are rational. Unlike the existing literature, the form in which these variables appear is explicitly derived from an underlying structural model. The model is adapted to a dependent developing country setting by according an important role to imported intermediate goods. The resulting equation was estimated for Nigeria using the observed data (1960-1995). Section II presents the econometric methodology and analyses the empirical results. And section III concludes the paper.

II. METHODOLOGICAL AND EMPIRICAL ANALYSIS

It would be useful and interesting to evaluate the empirical success of the open economy version of the Barro-type reduced form model, allowing for the special characteristics of economies such as Nigeria. The empirical application of the reduced- forms output equation necessitates the choice of the data counterparts for variables such as $y_f, p_f, m,$

and *z*. For modeling purposes, these variables (in logarithms) are labeled as y_f=LFRII; p_f=LIPII; m=LMS2 and z=LIMZ. The foreign real income variable used for LFRII is industrial country real GDP. The foreign price variable LIPII needs to be expressed in domestic currency units, and therefore its choice is limited by the exchange rate series that are available for Nigeria. Since an exchange rate for the Nigeria Naira against the aggregate of industrial countries or the world is not available, the United States wholesale price index and the naira/US dollar exchange rate are supposed to be used to construct the series. The wholesale price index is therefore chosen over the other indexes since it contains the highest proportion of traded goods. The choice for the monetary variable is rather more complex. As it is well known, there is a scan theoretical guidance for the selection of a monetary variable between narrow money (LMS1) and broad money (LMS2). Broad money (LMS2) was chosen, since it has been used in most similar studies. For the import variable, LIMZ, it would be ideal to use only imports of intermediate goods rather than total imports. However, a time series of imports of intermediate goods in Nigeria is not readily available, and hence a series for total import volume is used.

Next, we investigate the time series characteristics of our data so as to ensure consistency in subsequent econometric modeling. In Table (2.1), we present evidence on the presence of unit roots in our variables, using two commonly applied tests: Dickey-fuller tests and Augmented Dickey-Fuller tests which uses the regression:

$$\Delta X_t = bX_{t-1} + U_t \qquad U_t \sim IN(0, s^2) \qquad (2.1)$$

to test the null hypothesis of non-stationarity for the series X_t by using the t-statistic on the b parameter. The t-statistic is compared with special critical values constructed by Dickey-Fuller (1979, 1981) and Engle and Granger (1987) using a numerical simulation method. However, the problem is that the residuals from equation (2.1) should be found to be white noise. Otherwise, the equation (2.1) has to be modified to take into account higher order autoregressive process namely:

$$\Delta X_t = bX_{t-1} \sum_{i-j}^{n} \Delta X_{t-1} + U_t \qquad (2.2)$$

where the n is chosen large enough so as to ensure that the residuals are white noise. The t-statistic from equation (2.2) is used to implement an Augmented Dickey-Fuller Test (ADF), which is also reported in Table (2.1) for the variables under consideration.

TABLE 2.1: UNIT ROOT TESTS

VARIABLE X	**UNIT ROOT IN X**		**VARIABLE Δ X**	**UNIT ROOT IN Δ X**	
	DF	**LAG LENGTH**		**DF**	**LAG LENGTH**
LIMZ	-0.0118	0	Δ LIMZ	-3.8697*	0
LINR	-2.2038	0	Δ LINP	-6.8969*	0
LIPII	-3.2718**	0	Δ LIPII	-2.7249	0
LIM2	1.0683	0	Δ LIM2	-2.1489	0
LWM2	-1.4130	0	Δ LWM2	-2.5822	0
LFRII	-1.9180	0	Δ LFRII	-4.5980*	0
LMS2	-1.6487	0	Δ LMS2	-3.8550*	0
RLGDP	-1.3572	0	Δ RLGDP	-3.8046*	0

	ADF	LAG LENGTH		ADF	LAG LENGTH
LIMZ	-1.8502	4	Δ LIMZ	-3.2888**	1
LINR	-1.8290	4	Δ LINP	-4.4521*	1
LIPII	-2.9028	4	Δ LIPII	-3.4108**	1
LIM2	-0.39964	4	Δ LIM2	-2.3446	1
LWM2	-2.000	4	Δ LWM2	-2.8706	1
LFRII	-1.7851	4	Δ LFRII	-4.0725*	1
LMS2	-2.9519	4	Δ LMS2	-3.3329**	1
RLGDP	-1.3579	4	Δ RLGDP	-3.4634**	1

** Indicates statistical significance at 5% level*
*** Indicates statistical significance at 10% level*
95% critical value for the Augmented Dickey-Fuller Statistics = -3.55
90% critical value for the Augmented Dickey-Fuller Statistics = -3.18

Looking at the levels of the variables, there is (not surprising) strong evidence in favour of null hypothesis of non-stationarity. All the test statistics (absolute values) are lesser than the critical values at 5% and 10% significant levels; except for the variable LIPII (which is significant at 10% level). But turning to the first differences of the variables, the tests overall provide support to reject the null hypothesis of non-stationarity of the series, leading us to conclude that all the original series seem to be I (I). The only exceptions were the variables LIM2 and LWM2 (which indeed are not significant) as shown by their test statistics. Having examined the series, the next practical estimation problem however, is the estimation of anticipated components of Δ LFRII, ΔLIPII, ΔLMS2, ΔLIMV. However, table 2.2 reports the cointegration test results of this paper.

TABLE 2.2

TESTING FOR THE NUMBER OF COINTEGRATING VECTORS (r) ASSUMING UNRESTRICTED INTERCEPTS AND NO TRENDS

(A) TEST BASED ON MAXIMAL EIGEN VALUE AND TRACE OF THE STOCHASTIC MATRIX

HO: Null Hypothesis	HO: Alternative hypothesis	Maximal Eigen Values	95% Critical Values	90% Critical Values	Trace Statistics	95% Critical Values	90% Critical Values
R=0	R=1	49.0839	39.8300	36.8400	133.7846	95.8700	91.4000
R=1	R=2	32.4875	33.6400	31.0200	84.7007	70.4900	66.2300
R=2	R=3	27.4466	27.4200	24.9900	52.2132	48.8800	45.7000
R=3	R=4	12.8797	21.1200	19.0200	24.7672	31.5400	28.7800
R=4	R=5	7.3412	14.8800	12.9800	11.8875	17.8600	15.7500
R=5	R=6	4.5463	8.0700	6.5000	4.5464	8.0700	6.5000

(B) TEST USING MODEL SELECTION CRITERIA

RANK	LL	AIC	SIB	HQC
r=0	253.9269	211.9269	179.8733	200.9957
r=1	278.4688	225.4688	185.0203	211.6747
r=2	294.7126	232.7126	185.3954	216.5761
r=3	308.4356	239.4356	186.7761	221.4772
r=4	314.8754	240.8754	184.4001	211.6157
r=5	318.5460	241.5460	182.7811	211.5055
r=6	320.8192	242.8192	183.2911	222.5184

LL Þ MAXIMIZED LOG-LIKELIHOOD
AIC Þ AKAIKE INFORMATION CRITERION
SBC ÞSCHWARZ BAYESIAN CRITERION
HQC Þ HANNAN-QUINN CRITERION

Irrespective of which set of critical values one uses, there is a clear agreement between test results based on the maximum eigen value statistic and the trace statistic. Assuming unrestricted intercepts and no trends in the model, the maximum eigen value statistic does not reject r=3, while the trace statistic does not equally reject r=3. Turning to the model selection criteria, we find that the AIC, SBC, and HQC chooses r=6. Our data therefore seems inconclusive on the appropriate choice of r. But for the purpose of this paper, we choose r=2 and proceed to estimate the error correction model for the prediction variables, as shown in Table 2.3.

TABLE 2.3 ERROR CORRECTION MODEL FOR THE PREDICTION VARIABLES

(A) FOREIGN PRICE PREDICTION EQUATION

$$\Delta LIPH = 0.49982 - 0.084456\Delta RLGDP_{t-1} - 0.025535\Delta LIMZ_{t-1} + 0.030609\Delta LMS2_{t-1} +$$

(0.58611)(=0.72251) (-0.75780) (0.37516)

$$0.48156\Delta LFRII_{t-1} + 0.73131\Delta LIPH_{t-1} + 0.10906\Delta LINR_{t-1} + 0.033506ecm1_{t-1} + 0.0042731\ ecm2_{t-1}$$

(0.76483) (3.7364) (1.7187) (0.75729) (0.096579)

$$[R^2 = 0.68456, s = 0.044245, F(8,25) = 6.7818, DW = 1.7481, x_1(1,24) = 1.5626$$
$$x_2(1) = 2.2205, x_2(1,24), x_3(2) = 0.36578, x_3(2) = 0.36578, x_4(1) 3.5503, x_4(1,32) = 3.7310]$$

(B) FOREIGN INCOME PREDICTION EQUATION

$$\Delta LFRII = 0.028923 + 0.039356\Delta RLGDP_{t-1} + 0.004864\Delta LIMZ_{t-1} - 0.032884\Delta LMS2_{t-1}$$

(1.0286) (1.0211) (0.43789) (-1.2223)

$$0.082790\Delta LFRII_{t-1} + 0.1226\Delta LIPII_{t-1} - 0.00372\Delta LINR_{t-1} - 0.013365ecml_{t-1} + 0.004631ecm^2{}_{t-1}$$

(0.39877) (-1.8990) (-0.17810) (-0.91612) (0.31748)

$$[R^2 = 0.50663, \sigma = 0.14589, F(8,25) = 3.2089, DW = 1.8627, \xi_1(1) = 1.0554, (1,24) = 0.76882\ \xi_2(1)\ 0.46654,$$
$$\xi_2(1,24) = 0.032977, \xi_3(2) = 7.451, \xi_4(1) = 0.0047197, \xi_4(1,32) = 0.004427]$$

(C) MONEY PREDICTION EQUATION

ΔLMS2 = 0.30466 - 0.10276ΔRLGDP$_{t-1}$ - 0.13012ΔLIMZ$_{t-1}$ – 0.40167ΔLMS2$_{t-1}$ - 1.4077ΔLFII$_{t-1}$
(1.1171) (-0.27488) (-0.27488) (-1.2074) (-0.69909)

+0.55759ΔLIPII$_{t-1}$ - 0.43017ΔLINR$_{t-1}$ + 0.37215ecml$_{t-1}$ + 0.23891ecm2$_{t-1}$
(0.89075) (2.1197) (2.6299) (1.6883)

[R^2= 0.41597, s= 0.14151, F(8,25) = 2.2257, DW=2.1530, x_1(1) =1.3236, x_1(1,24) = 0.97216, x_2(1) 0.006901, x_2(1,24) = 0.004871, x_2(2) = 2.2887, x_3(1) = 0.51700, x_4(1,32) = 0.048733]

(D) IMPORT PREDICTION EQUATION

ΔLMS2 = 1.4955 - 0.92466ΔRLGDP$_{t-1}$ - 0.18947ΔLIMZ$_{t-1}$ – 0.45654ΔLMS2$_{t-1}$ - 1.1634ΔLFII$_{t-1}$
(-4.2836) (-0.19322) (-1.3734) (1.3668) (-0.45134)

+3.1981ΔLIPII$_{t-1}$ - 0.37978ΔLINR$_{t-1}$ + 0.060917ecml$_{t-1}$ + 1.0226ecm2$_{t-1}$
(3.9911) (1.4619) (0.33630) (5.6456)

[R^2= 0.72705, s= 0.18114, F(8,25) = 8.3242, DW=1.9405, x_1(1) =0.067942, x_1(1,24) = 0.048055, x_2(1) 3.1055, x_2(1,24) = 2.4124, x_3(2) = 3.6456, x_4(1) = 0.0068908, x_4(1,32) = 0.0064868]

NOTES: *Values in parenthesis are estimated t-ratios; T=1960-1995; x_1 Þlagrange multiplier test of residual serial correlation ($c^2$and F versions); x_2 Þ Ramsey's reset test using the square of the fitted values; x_3 Þ Normality test based on a test of skewness and kurtosis of residuals: x_4 ÞHeteroscedasticity test based on the regression.*

From the above prediction equations the saved fitted values and saved residuals are respectively the anticipated and unanticipated components. The anticipated components are labeled as YDLIMZ, YLMS2, YDLFRII, and YDLIPII; while the unanticipated components are labeled as RDLIMZ, RLMS2, RDLFRII, and RDLIPII. Concerning the statistical attributes of the estimated equations, the various diagnostic checks are insignificant (if regarded as test statistics) and indicate design of a model congruent with the information available. From the reported diagnostic tests, the residuals are white noise, there is no ARCH, RESET, or heteroscedastic evidences of mis-specification; the residuals are approximately normally distributed. In the second stage of the estimation process, the derived equation components are used in the reduced form output equation. The estimation method employs the Cochrane-Orcutt (1949) iterative procedure to compute the maximum likelihood estimators or the regression model and this method therefore were applied in estimating the required domestic output equations as presented in Table 2.4.

TABLE 2.4 ESTIMATED DOMESTIC OUTPUT EQUATIONS USING COCHRANE-ORCUT ITERATIVE TECHNIQUES

VERSION A: CONVERGENCE AFTER EIGHT ITERATIONS

ΔRLGDP= -0.093982 + 0.60538ΔRLGDPt-1 + 0.017448RDLIPII + 0.34762YDLIPII +
(-0.35690) (3.8759) (0.047053) (0.64691)

0.4250RLMS2 + 0.02766YLMS2 + 3.6929RDLFRII + 0.0011902TTR – 0.0444268SAD +
(3.4002) (0.11653) (3.7280) (0.35248) - (1-2767)

0.13292WAD + 1.3047YDLFRII
(3.794) (0.31536)

[R2=0.67III, σ=0.068863, F(12,19) = 3.2309, DW= 1.9923]

VERSION B: CONVERGENCE AFTER SEVEN ITERATIONS

ΔRLGDP= 0.096319 + 0.67105ΔRLGDPt-1 + 0.2620ΔRLDIPII – 0.024285ΔYDLPII+ 0.3930RLMS2
(0.36892) (3.4409) (0.73790) (-0.048499) (3.6196)
+0.052040YLMS2 + 4.3786RDLFRII – 1.6785YDLFRII – 0.078763YDLIMZ + 0.15548RDLIMZ –
(0.22111) (4.8415) (-0.39554) (-0.88780) (1.7646)

0.0018969TTR – 0.018744SAD + 0.11163WAD
(-048433) (-0.62450) (3.09885)

[R2 = 0.75657, σ = 0.062632, F(14,17) = 3.7740, DW = 2.1063]

VERSION C: CONVERGENCE AFTER NINE ITERATIONS

ΔRLGDP = 0.12212 + 0.68476ΔRLGDPt –1 + 0.47129RLMS2 + 0.3528YLMS2 + 4.4372RDLFRII-
(0.71783) (3.9467) (5.0485) (0.16406) (5.3791)

-2.08YDLFRII + 0.023102RDLIMZ – 0.033429DLIMZ – 0.065328DLIMZt-1 – 0.0022670TTR
(0.74942) (2.9665) (-0.46927) (-1.6123) (-0.67992)

-0.026661SAD + 0.095669WAD
(-1.0540) (3.1885)

[R2 = 0.77741, σ = 0.058204, F(13, 18) = 4.8358, DW= 2.1820]

Looking at Table 3.4, version A is an open economy version that includes unanticipated foreign income (RDLFRII) and unanticipated foreign prices (RDLIPII). The versions B and C are complete versions, which include the import variables besides the other closed and open economy variables. In version A, the estimated coefficient on anticipated foreign income (RDLFRII) has the correct sign and very significant at 5 and 10 percent levels. On the other hand, the coefficient on unanticipated foreign prices has the correct sign but not significant. However, the complete models, versions B and performs exceptionally well. Most coefficients have the signs predicted by theory. In particular, the coefficients on lagged imports have the correct sign while the coefficient on unanticipated imports is significant at 10 per cent, 5 per, cent and 1 per cent levels. Also, the restriction on the magnitudes of the coefficient on lagged output (DRLGDPt-1) is positive and less than unity. Our regression results (using Nigerian data) therefore provide support for the open-economy model of output determination. However, on the basis of the three regressions, two tests of exclusion of three import variables were performed. Firstly, we tested for the exclusion of three import variables (RDLIMZ, DLIMZ, and DLIMZ_{t-1}) as well as anticipated components; and obtained the following test statistic: F (9,22) = 4.8010 (significant at 5% level). We can thus reject null hypothesis that these variables should be excluded form the repression. And secondly, we tested for the exclusion of all the open economy variables (RDLIMZ, DLIMZ, DLIMZ (-1) RDLFRII, and RDLIPII) as well as anticipated components; and obtained the following test statistic: F (7,24)= 3.3159 (significant at 5 per cent level). Hence, the null hypothesis that all the open economy variables should be excluded form the regression can also be rejected.

III SUMMARY AND CONCLUSION

This paper has presented a simple "new classical" structural model to take account of features that are likely to be important in a small open dependent developing economy. Previous attempts to estimate Barro-type reduced-form equations for developing countries have either estimated regressions appropriate to closed-economy models or added open economy variables in an arbitrary fashion. There are many ways to 'open-up' closed economy new classical models and what we have presented is a simple example consisting irrelevance of anticipated monetary policy for short-run deviations of domestic output from its "natural level". Thus, only the unanticipated components of external price changes and of changes in the level of external economic activity cause domestic output to deviate from natural level.

In contrast, both anticipated and unanticipated changes in the availability of imported intermediate goods affected output, since these variables operate through the supply side of the economy. Though the model is rather specialized and therefore unlikely to be applicable to a majority of developing countries, it produced good empirical results for the Nigerian economy. From the theoretical analysis, the monetary tightening since it is anticipated, would have no effect on real domestic output in the short run, this result was indeed seen form the insignificant nature of the anticipated components variables on our regression model. Thus, the effect of any stabilization programme is an increase in domestic output and an improvement in the economy's competitiveness. Whether the domestic price level, the real money supply, and real domestic absorption will increase or decrease depends on the magnitudes of various measures adopted and the parameters that characterized a specific economy. It is certainly possible that these measures could simultaneously increase domestic output, reduce the rate of inflation, and improve the balance of trade. In these directions therefore, it is hoped that our findings will quantitatively assist the Nigerian government in their economic reform programmes. Finally, the open dependent economy version of the simplest new classical macroeconomic model generated reduced-form output equations that are quite different from its closed-economy counterpart; so a reformulation of the theoretical model is essential before empirical testing can proceed. However, the simple version of an open dependent economy (new classical) model has proved to be empirically possible. In view of its important policy implications, it merits further development and empirical testing against a well formulated realistic alternative in a developing country setting.

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