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TESTING FOR STRUCTURAL CHANGE: A COINTEGRATION APPROACH

By Maria Socorro Gochoco*

This study investigates whether exogenous shocks and/or economic reform programs such as the financial liberalization program of the early '80s resulted in changes in the dynamic equilibrium relationships among money, output, prices, and in some cases, interest rates. Cointegrating vectors for these variables were estimated over a full-sample period using quarterly data from 1981.1 to 1992.4 as well as a sub-sample period from 1986.1-1992.4. Various hypotheses regarding the neutrality of money on prices or output, the proportionality of the effect of money on prices or output, and the stationarity of velocity were tested using restrictions on the cointegrating vectors. If a regime change did occur after the exogenous shocks and/or the implementation of the financial liberalization program, the sub-period results would differ from the full-sample results.

The results obtained show that when *M*1 is issued, the results obtained for the post-shocks period are quite different from those for the entire sample period. Only the hypothesis regarding the absence of any effect from money to prices is rejected using a sub-period sample, whereas all the different hypotheses are rejected for the full-sample period regardless of the type of monetary aggregate used or whether the interest rate is included or not.

Introduction

In the early 1980s, various exogenous shocks exerted dramatic effects on the Philippine economy. The second oil embargo and the general worldwide recession led monetary and fiscal authorities to adopt economic stabilization measures which were highly contractionary. These, and the lack of internal economic reforms in the earlier period, made the Philippines more vulnerable to these external shocks than was perhaps necessary. By 1983 and two years thereafter, the economy registered negative rates of GNP growth for the first time in its postwar history.

Apart from stabilization measures, the Philippines also embarked on a program of financial liberalization. Beginning in 1981, ceilings on long-term interest rates were lifted. By 1982, those on short-

*Associate Professor, U.P. School of Economics. I thank PCED for the financial support.

term interest rates were lifted as well. The wisdom of undertaking such a program of financial liberalization almost simultaneously with stabilization measures is the subject of much debate. Some argue that the liberalization program had no chance of succeeding under such circumstances, while others counter that a desperate situation needed to be addressed with bold reforms.

The effects of exogenous shocks and economic reform programs, such as the financial liberalization program of the 1980s, have not usually been examined in terms of the ability of these to engineer regime changes. Few studies attempt to characterize changes in the nature of economic interactions both before and after the shocks or the institution of reform programs.

This study attempts to address this shortcoming by investigating the interactions among money, prices, and output in the Philippines using cointegration analysis and quarterly data for the years 1981-1992. Multivariate autoregressive models will be used to evaluate the dynamic long-term equilibrium relationships among money, prices, and output for the entire sample period and for the post-shock period. If exogenous shocks and/or financial liberalization have resulted in structural changes in credit creation and money demand behavior, then we would expect that the long-term relationship of money to prices and output would be altered as well. This means that the results obtaining for the full sample period would be different from the sub-period results. Note that in doing so, the study does not distinguish between exogenous shocks and financial liberalization individually or in combination as the reason for structural change. Part of the reason for the inability to do so is due to data limitations.[1] Ideally, one would wish to examine pre- and post-liberalization effects or pre- and post-shock effects using a longer time series in which it is possible to identify these periods clearly and in which shocks and reform programs do not occur almost simultaneously as is the case here.

[1] In particular, reliable quarterly GNP data prior to 1981 are unavailable. Similarly, longer time series data for different monetary aggregates are still being compiled as of this writing.

Econometric Procedure

This choice among possible specifications regarding the dynamic relationships among money, prices, and output will be made on the basis of the maximum likelihood procedure developed by Johansen (1988). This allows tests of both non-stationarity and cointegration without *a priori* restrictions on the coefficients of possible long-term relationships. It also provides tests of restrictions on the coefficients of any cointegrating vectors. Hence, for example, it is possible to test the hypothesis that money and prices are proportional, and whether the effect of money on output, if existent, is based on money neutrality or not. The results are intended to provide evidence on the magnitude of the linkages between the nominal and real sectors and on whether exogenous shocks and/or financial liberalization have altered these.

Johansen's Procedure[2]

Let a vector autoregressive model in levels be:

$$(1) \qquad X_t = \Pi_1 X_{t-1} + \ldots + \Pi_k X_{t-k} + \mu D_t + \varepsilon_t$$

where X_t and ε_t are of dimension (p x 1), $\varepsilon_t \sim N(0, \Omega)$, D_t is a vector of deterministic variables and the Πs and μs are unknown coefficients.

In difference form, (1) can be written as

$$(2) \qquad \Delta X_t = \Pi X_{t-1} + \Gamma Z_{lt} + \varepsilon_t$$

where Δ is the difference operator, $\Pi = (\Pi_1 + \ldots + \Pi_k - 1)$, Z_{lt} is the stacked vector $\Delta X_{t-1}, \ldots, \Delta X_{t-k+1}, D_t$, and Π and Γ are the corresponding coefficients. The matrix Π provides information regarding long-term relationships among the series. If the matrix Π is of full rank, then X_t is stationary. If Π is the null matrix, then X_t is the usual ARIMA (k, l, 0) process. If the series are non-stationary and cointegrated, then $0 < r = \text{rank } \Pi < p$ and (2) is an error-correction model. r is the number of cointegrating relationships among the series, β are the

[2] See Johansen (1988) and Orden and Fisher (1993) for details.

cointegrating vectors. This means that there are $p \times r$ matrices α and β such that $\Pi = \alpha\beta'$ and $\beta' X_t$ is stationary. The issue of testing a cointegration system is equivalent to testing the rank of Π. Specifically, H_0: $\Pi = \alpha\beta'$ where α and β are $p \times r$ matrices with full column rank and $r \leq p$.

The concentrated likelihood function for (1) or (2) is

$$L = |S_{00} - S_{01}\beta (\beta' S_{11}\beta)^{-1} \beta' S_{10}|^{-T/2}$$

The maximum likelihood solution for β solves:

$$\left|\phi S_{11} - S_{10} S_{00}^{-1} S_{01}\right| = 0$$

for eigenvalues $\hat{\phi}_1, \ldots \hat{\phi}_p$ and eigenvectors $\hat{v} = (\hat{v}_1, \ldots, \hat{v}_p)$ normalized such that $\hat{v}' S_{11} \hat{v} = I$.

To test the null hypothesis of no more than r stationary linear combinations of the series versus, respectively, the alternative of possible stationarity of all series (i.e., $r \leq p$) and the alternative of at most $r + 1$ stationary combinations of the series, the following likelihood ratio statistics are constructed:

$$-T \sum_{i=r+1}^{p} \ln (1 - \hat{\phi}_i) \quad \text{and} \quad -T \ln(1 - \hat{\phi}_{r+1})$$

Distributions of these statistics are tabulated in Johansen and Juselius (1990) and in Banerjee *et al.* (1993).

Tests of linear restrictions on the coefficients of the r cointegrating vectors are of the form $\beta = H\varphi$, where H is a $(p \times s)$ matrix

of known constants ($r \leq s \leq p$) and φ is an (s x r) matrix of free parameters. A likelihood ratio test of the restrictions is

$$T \sum_{i=1}^{r} \left[\ln\left(1-\hat{\phi}_i^*\right) - \ln\left(\hat{\phi}_i\right) \right]$$

which is distributed as $a\ \chi(r(p - s))$.

Tests for Cointegration

The Johansen estimation procedure was initially carried out over the full sample period 81.1 - 92.4 using quarterly data. Two alternative monetary aggregates, namely, *M*1 and total liquidity or *TL*, were employed.[3]

Fourth-order models of money, output, and prices, with and without the 91-day Treasury bill rate were estimated. All of the series except the interest rate are expressed in logs and are end-of-period data. All of the models estimated include a constant and a deterministic time trend.

Results of the stationarity and cointegration tests are shown in Table 1. H_1, Johansen's trace statistic, tests the restriction of no more than r stationary linear combinations of the series versus the alternative of stationarity of all series. H_2, Johansen's maximum eigenvalue statistic, tests the restriction of at most r stationary linear combinations of the series against the alternative of at most $r + 1$ such combinations.

[3] A previous study by Gochoco (1993) finds some support for the use of *M1* as the monetary target using the Engle and Granger cointegration method. On the other hand, some studies for other countries report that the use of a broader monetary aggregate is appropriate e.g., Trehan (1988).

Table 1 - Cointegration Tests: 1981.1 - 1992.4

Money, Prices and Output using *M1*

Test of:	Asymptotic Likelihood Ratio Test		Small Smpl Likelihood Ratio Test		Critical Value	
	H_1	H_2	H_1	H_2	H_1	H_2
$r \leq 2$	13.69	13.69	9.95	9.95	3.76	3.76
$r \leq 1$	30.42	16.53	22.13	12.18	15.41	14.07
$r = 0$	62.42	34.99	47.58	25.67	29.68	20.97

Money, Prices and Output using *TL*

Test of:	Asymptotic Likelihood Ratio Test		Small Smpl Likelihood Ratio Test		Critical Value	
	H_1	H_2	H_1	H_2	H_1	H_2
$r \leq 2$	3.36	3.36	2.42	2.42	3.76	3.76
$r \leq 1$	37.65	34.29	27.38	24.96	15.41	14.07
$r = 0$	85.69	48.04	62.32	34.94	29.68	20.97

Money, Prices, Output, and Interest Rate using *M1*

Test of:	Asymptotic Likelihood Ratio Test		Small Smpl Likelihood Ratio Test		Critical Value	
	H_1	H_2	H_1	H_2	H_1	H_2
$r \leq 3$	14.65	14.65	9.32	9.32	3.76	3.76
$r \leq 2$	35.29	20.64	22.46	13.14	15.41	14.07
$r \leq 1$	59.83	24.54	38.07	15.61	29.68	20.97
$r = 0$	96.56	36.73	61.44	23.37	47.21	27.07

Table 1 (continued)

Money, Prices, Output, and Interest Rate using *TL*

Test of:	Asymptotic Likelihood Ratio Test		Small Smpl Likelihood Ratio Test		Critical Value	
	H_1	H_2	H_1	H_2	H_1	H_2
$r \leq 3$	3.58	3.58	2.28	2.28	3.76	3.76
$r \leq 2$	26.75	23.17	17.02	14.74	15.41	14.07
$r \leq 1$	65.84	39.09	41.90	24.88	29.68	20.97
$r = 0$	108.80	42.96	69.21	27.31	47.21	27.07

Notes: The Johansen trace statistic employed, H_1, tests the restriction of at most r stationary linear combinations of the series against the alternative of possible stationarity of all series. The critical values are given for the 5 percent significance level. H_2 is Johansen's maximum eigenvalue statistic. It tests the restriction of at most r stationary linear combinations of the series against the alternative of at most $r + 1$ such combinations.

The hypothesis of nonstationarity with no cointegration, ($r = 0$), against the alternative of possible stationarity of all series is rejected at the 5 and 10 percent levels of significance. In the system with money, prices, and output, the results suggest nonstationarity with at most three cointegrating vectors as the result for $r \leq 12$ is rejected in the case of $M1$. When TL is used, the results suggest at most two cointegrating vectors.

When the interest rate is included, the results are different. When $M1$ is used, $r \leq 1$, $r \leq 2$, and $r \leq 3$ cannot be rejected at the 10 percent level of significance, leading to the conclusion that the series are stationary with at most one cointegrating vector. When TL is used, $r \leq 3$ is rejected. This suggests that the maximum number of cointegrating vectors is four.

It may be concluded from the above that the maximum number of cointegrating vectors varies with the type of monetary aggregate used as well as whether the interest rate is included or not.

The Cointegrating Vectors

Estimated coefficients of the cointegrating vectors for the period 81.1-92.4 are shown in Table 2. The cointegrating vectors are normalized by the coefficient on money and are expressed with money as a function of the other variables. Tests of several restrictions on the normalized coefficients are also reported. These restrictions embody each of the following hypothesis:

(i) If money and prices are proportional, the coefficient of prices should be equal to unity;

(ii) If money has no effect on prices, the coefficient of prices should be zero;

(iii) If money and output are proportional, the coefficient of output should be equal to unity;

(iv) If money has no effect on output, the coefficient of output should be equal to zero;

(v) The hypothesis of stationary velocity requires that the coefficients of output and prices both be equal to unity.

The full-sample period results shown in Table 2 indicate that all of these hypothesis are rejected, in most cases at the one percent level of significance, regardless of whether $M1$ or TL is used, and whether the interest rate is included or not.

Table 2 - Cointegrating Vectors, 1981.1 - 1992.4

Vector	*M*1	*P*	*Q*	
Normalized Coefficients	1.0	-4.76	-5.66	
Hypothesis				
P = 1		19.98[3]		
P = 0		17.73[3]		
Q = 1			14.04[3]	
Q = 0			11.29[3]	
P = Q = 1			19.15[3]	
Vector	*TL*	*P*	*Q*	
Normalized Coefficients	1.0	0.66	1.96	
Hypothesis				
P = 1		32.13[3]		
P = 0		36.35[3]		
Q = 1			34.13[3]	
Q = 0			36.87[3]	
P = Q = 1			44.09[3]	
Vector	*M*1	*P*	*Q*	*R*
Normalized Coefficients	1.0	-2.79	-2.44	-0.007
P = 1		8.46[2]		
P = 0		8.89[2]		
Q = 1			8.47[3]	
Q = 0			8.79[3]	
P = Q = 1			10.12[3]	
Vector	*TL*	*P*	*Q*	*R*
Normalized Coefficients	1.0	0.41	1.66	0.001
P = 1		22.24[3]		
P = 0		24.05[3]		
Q = 1			24.79[3]	
Q = 0			28.85[3]	
P = Q = 1			40.48[3]	

Note: Chi-square statistics are reported for each hypothesis. These statistics have degrees of freedom equal to the number of restrictions being tested multiplied by the number of cointegrating vectors. Critical values at the 0.10, 0.05 and 0.01 significance levels are $\chi^2(2)$: 4.61, 5.99, 9.21; $\chi^2(3)$: 6.25, 7.81, 11.34, $\chi^2(4)$: 7.78, 9.49, 13.28.

[1] significant at the 0.10 level
[2] significant at the 0.05 level
[3] significant at the 0.01 level

It may be argued that the 1983-1985 period was unique as it was the first time in the country's postwar history in which GNP growth was negative.[4] 1986, on the other hand, saw the end of the Marcos regime and the beginning of the post-EDSA Revolution years. For these reasons and in light of the data limitations, cointegrating vectors were estimated over the sub-period 86.1-92.4. The results are shown in Tables 3 and 4.

Table 3 - Cointegration Tests: 1986.1 - 1992. 4

Money, Prices and Output using *M*1

Test of:	Asymptotic Likelihood Ratio Test		Small Smpl Likelihood Ratio Test		Critical Value	
	H_1	H_2	H_1	H_2	H_1	H_2
$r \leq 2$	5.25	5.25	2.62	2.62	3.76	3.76
$r \leq 1$	14.76	9.51	7.38	4.76	15.41	14.07
$r = 0$	34.31	19.55	17.15	9.77	29.68	20.97

Money, Prices and Output using *TL*

Test of:	Asymptotic Likelihood Ratio Test		Small Smpl Likelihood Ratio Test		Critical Value	
	H_1	H_2	H_1	H_2	H_1	H_2
$r \leq 2$	3.02	3.02	1.51	1.51	3.76	3.76
$r \leq 1$	14.94	11.92	7.47	5.96	15.41	14.07
$r = 0$	50.50	35.56	25.25	17.78	29.68	20.97

Note: See note in Table 1.

[4] The use of dummies for the 1983-1985 period does not substantially alter the results obtained here.

Table 4 - Cointegrating Vectors, 1986.1 - 1992.4

Vector	*M*1	*P*	*Q*
Normalized Coefficients	1.0	1.59	0.85
Hypothesis			
P = 1		2.52	
P = 0		5.84[1]	
Q = 1			0.89
Q = 0			1.78
P = Q = 1			2.97
Vector	*TL*	*P*	*Q*
Normalized Coefficients	1.0	0.17	2.67
Hypothesis			
P = 1		6.49[2]	
P = 0		6.59[2]	
Q = 1			9.15[2]
Q = 0			13.08[3]
P = Q = 1			25.18[3]

Note: See note in Table 2.

The results in Table 3 indicate once again that the hypothesis of nonstationarity with no cointegration ($r = 0$) against the alternative of possible stationarity of all series is rejected at the 5 and 10 percent levels of significance.

The results in Table 4 indicate that whether the monetary aggregate used is *M*1 or *TL*, $r \leq 1$ and $r \leq 2$ cannot be rejected. This suggests nonstationarity of the series with at most one cointegrating vector.

Compared with Table 2, Table 4 shows some notable differences. For example, when *M*1 is used, only the hypothesis of no effect of *M* on *P* ($P = 0$) is rejected at the 10 percent level, whereas in Table 2, all of these hypotheses were rejected at the one percent level of significance regardless of whether *M*1 or *TL* is used.[5] When *TL* is

[5] The effect of *M* on *Q* is less clear, as the hypotheses regarding the proportionality of *M* and *Q*, and the absence of an effect from *M* on *Q* both cannot be rejected.

used, the results are similar to those obtained for the full-sample period in that all the hypotheses are rejected, although the rejections are not as strong as those for the full-sample results in most cases.

Table 5 - Diagnostic Tests for the Estimated Models

Variable	ARCH	DF	ADF	Skewness	Kurtosis	Bera-Jarque
	Model without interest rate (1981.1 - 1992.4)					
*M*1	0.03	-7.76	-4.95	0.59	3.60	3.61
TL	0.35	-5.13	-2.49	0.06	2.98	0.03
	Model with interest rate (1981.1 - 1992.4)					
*M*1	0.28	-7.75	-4.82	0.51	3.60	2.89
TL	0.38	-6.69	-3.44	0.02	2.52	0.45
	Model without interest rate (1986.1-1992.4)					
*M*1	0.39	-4.75	-5.49	0.57	2.48	1.8
TL	0.52	-5.61	-4.18	-0.03	3.32	0.12

Note: The ARCH test has one degree of freedom and is used to test for heteroskedasticity. The results indicate the absence of significant heteroskedasticity. DF and ADF are the Dickey-Fuller and augmented Dickey-Fuller test statistics, respectively, and are used to test for stationarity. The results suggest that the variables are cointegrated. To test for normality, the diagnostic statistics used are skewness centered on zero, kurtosis centered on 3 and the Bera-Jarque statistic distributed as a $\chi^2(2)$. The results suggest that the normality assumption is not violated.

Summary and Conclusions

This study investigated whether exogenous shocks and/or economic reform programs such as the financial liberalization program of the early '80s resulted in changes in the dynamic equilibrium relationships among money, output, prices, and in some cases, interest rates. Cointegrating vectors for these variables were estimated over a full-sample period using quarterly data from 1981.1 to 1992-4 as well as a sub-sample period from 1986.1-1992.4. Various hypotheses regarding the neutrality of money on prices or output, the proportionality of the effect of money on prices or output, and the stationarity of velocity were tested using restrictions on the cointegrating vectors. If a regime change did occur after the exogenous shocks and/or the implementation of the financial liberalization program, the sub-period results would differ from the full sample results.

The results obtained show that when $M1$ is used, the results obtained for the post-shocks period are quite different from those for the entire sample period. Only the hypothesis regarding the absence of any effect from money to prices is rejected using the sub-period sample, whereas all the different hypotheses rejected for the full-sample period are rejected regardless of the type of monetary aggregate used or whether the interest rate was included or not. One might also add that if one's priors are that the exogenous shocks and/or financial liberalization program led to a regime change, then the results using $M1$ seem more reasonable than those obtained when TL is used as the latter was unable to distinguish between the full-sample and post-shocks period. Given the earlier results in Gochoco (1993), there would seem to be reason to give more weight to the results obtained using $M1$.

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