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Cointegrated money in production function: evidence from a developing country

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Abstract

The notion that real money balances is a factor input has attracted considerable amount of attention from researchers and academicians. However, the debate is controversial and the consensus has yet to be developed. This issue becomes more important when a country follows contractionary monetary policy to curb inflation. The limited research for developing countries with sophisticated econometric techniques powered us to conduct this study. The underlying study employs cointegration approach to investigate the validity of money in production function of a developing country for the period 1964-2008. The cointegration results confirm money as an important factor input in the production function in the long run. The variance decomposition results surface money as greater contributor than labor and capital to output variability.

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1. Introduction

The problematic "double coincidence of wants" characteristic of barter system necessitated the invention of money to facilitate transactions. In particular, money is helpful in transactions that are made for production activity. The standard neoclassical production function is primarily concerned with the structural relationship between real output and inputs. Nonetheless, by releasing capital and labor from the process of distribution to that of production, money holdings make it possible for the production sector to save labor and capital which should otherwise be used in exchange. Similarly, money contributes to the expansion and more efficient operation of the market exchange system. These attributes of money make it a resource-saving device and a source of stimulation for market activity. Consequently, money balances make a strong case to be included as an explicit factor input in the production function.

Specifically, Friedman (1959), Levhari and Patinkin (1968), Bailey (1971), and Moroney (1972) were the first to suggest the theoretical framework for role of money in production function. The pioneer empirical work of Sinai and Stokes (1972) on this issue indicates that real money balance has significant positive impact on output. This result is also supported by some other empirical studies such as Apostolakis (1983), You (1981), Short (1979), and Khan and Ahmad (1985). The evidences from these studies suggest that real money variable should be included as a factor input in the aggregate production function. Conversely, a brand of studies also denies the money balances as a conventional factor input [see, for example, Ben-Zion and Ruttan (1975), Fischer (1974), Nicolli (1975), Prais (1975a, 1975b), and Khan and Kouri (1975), Davidson (1979), Nguyen (1986)]. However, in recent years a consensus is developing on the importance of money in output. For example, the New Keynesian economists argued that monetary shocks need not be neutral (Mankiw and Romer, 1991) and the New Classical models may not necessarily allow for the super neutrality of money. Moreover, the New Classical models accept the impact of unanticipated monetary shocks on output.

Most of the empirical studies mentioned above used traditional econometric techniques such as Ordinary Least Square (OLS) for estimations. Recent developments in the subject of econometrics show that in case of non-stationary data, the OLS will give spurious results. Cointegration is the alternative method of estimation in case the variables are non-stationary at levels. In a recent study, Moghaddam (2010) uses cointegration analysis for investigating the role of money in production function. However, that study is conducted for a developed country. The literature lacks a separate study using the same method for a developing country as the results may contradict [Nourzad, 2002]. The study at hands serves to fill this gap. The objective of this work is, therefore, to investigate whether or not money is an omitted variable from the production function of Pakistan. The recent tight monetary policy stance of the State Bank of Pakistan further necessitates the need of this study.

Rest of the study is organized as follows: section 2 describes the methodology and data in detail. Empirical analysis is given in section 3. Section 4 concludes the study.

2. Methodology and Data

Consider the following widely used Cobb-Douglas production function:

$$Y = AL^{\alpha_1} K^{\alpha_2} M^{\alpha_3} e^{u} \qquad (1)$$

where Y is the aggregate output, L, K and M denote labor, capital and real money balances respectively, A is the technological parameter, and e is error term. α_1, α_2 and α_3 are returns to scale associated with labor, capital and real money balances respectively. After taking logs, the model assumes the following form:

$$\log Y_t = \log A + \alpha_1 \log L_t + \alpha_2 \log K_t + \alpha_3 \log M_t + u_t \qquad (2)$$

$$y_t = a + \alpha_1 l_t + \alpha_2 k_t + \alpha_3 m_t + u_t \qquad (3)$$

where small letter notation of a variable represents the log of that variable. The resulting coefficients in equation (3) are the respective elasticities of output with respect to the corresponding variables.

As was discussed earlier, the application of econometric technique depends on the order of integration of the variables. If the variables are non-stationary and are still used in the level form, then the coefficients obtained through Ordinary Least Square (OLS) regression will be meaningless. On the other hand, differencing will result in the loss of long-run relationship among the variables. Cointegration approach provides solution to these problems. The Johansen method of cointegration is employed to the series of same order of integration. This method is useful in two manners: first it tests for the existence of long-run relationship among the variables that are to be used in the analysis, and second it provides us the long-run coefficient estimates of the variables. Furthermore, Vector Error Correction Model (VECM) is used to observe the short-run dynamics. The VECM not only provides the short-run estimates of the explanatory variables but also exhibits the dynamics of conversion to the long-run equilibrium. The ECM for equation (3) can be written is follow:

$$\Delta y_t = a + \sum_{i=1}^{p} \beta_1 \Delta y_{t-i} + \sum_{i=1}^{q} \beta_2 \Delta l_{t-i} + \sum_{i=1}^{r} \beta_3 \Delta k_{t-i} + \sum_{i=1}^{s} \beta_4 \Delta m_{t-i} + \lambda\ EC_{t-1} + u_t \qquad (4)$$

where u_t is the serially uncorrelated random error terms. The EC_{t-1} represents the cointegrating vector and λ is the adjustment coefficient. The size and statistical significance of the EC_{t-1} term is important in the sense that it measures the extent to which error is corrected in each short-run period to the long-run equilibrium in response to random shocks. Since, in ECM the variables on both sides of equation (4) are stationary; the Least Square (LS) method is applicable along with all diagnostic tests.

Time series data for the period 1964-2008 has been obtained from various sources. The data for real Gross Domestic Product (GDP) have been obtained from World Development Indicators (WDI). The year 2000 has been used as the base year. Data for labor is obtained from various issues of Labor Force Survey. Data for capital stock is constructed using past stream of investments, depreciation rate, and growth rate of output (Nehru and Dhareshwar, 1993). Data on variables used in the construction of capital have been obtained from various issues of Pakistan Economic Survey. Lastly, M2 definition of money has been used in this study and the data for M2 was gathered from various issues of Pakistan Economic Survey. The data on M2 is divided by CPI to make it real.

3. Results and Discussion

The standard practice in time series econometrics calls for testing the time series properties of data before further empirical analysis. Following this conventional practice the augmented Dickey-Fuller (ADF) test is used to test for unit root and results are reported in Table 1. The test statistics indicate that all the variables are non stationary at levels but become stationary at the first difference. This implies that these series are integrated of order one.

Table 1: Unit Root Tests

Variable	ADF		Order of Integration
	Level	**First difference**	
y	-3.37	-5.63***	(1)
l	-2.25	-6.72***	(1)
k	-1.98	-5.57***	(1)
m	-3.21	-5.48***	(1)

Note: The regressions in level include both intercept and trend whereas in first difference include intercept only. *** indicates rejection of null hypothesis of non-stationarity of the variable at 1%level of significance

Table 2: Results of Johansen Test for Cointegration

Rank r	Trace Statistics	5% Critical Value	Maximum Eigenvalue	5% Critical Value
$r_0 = 0$	63.51892*	63.87610	36.67420**	32.11832
$r_0 \leq 1$	26.84472	42.91525	12.68102	25.82321
$r_0 \leq 2$	14.16369	25.87211	10.45188	19.38704
$r_0 \leq 3$	3.711809	12.51798	3.711809	12.51798

Note: * and ** indicate the rejection of null-hypothesis at 10% and 5% significance levels respectively.

Next we investigate the existences of a long-run relationship among these variables. For this purpose, the cointegration rank, r, of the time series has been tested by making use of both maximum eigenvalue test and trace test of the Johansen (1988) and Johansen and Juselius (1990) maximum likelihood method. The maximum eigenvalue test is conducted under the null-hypothesis of $r_0 = r$ against the alternative of $r_0 > r$, whereas the trace test is conducted under the null hypothesis of $r_0 \leq r$ against the alternative of $r_0 > r$. The conventional lag selection criteria such as AIC and SBC established that the optimal lag length is one. After the lag length is selected, Johansen test is applied to investigate the long-run relationship among the variables. The results of this test are illustrated in Table 2. The cointegration rank tests based on the maximum eigenvalue statistics and trace test statistics confirmed that there is a unique long-run relationship among these series.

After the long-run relationship is established, we now turn to the long-run results of the model which are presented in Table 3. Since the model is in log-linear form, the coefficients can also be interpreted as elasticities. As is evident from the table, all the three variables are significant at the conventional levels of significances. Importantly, the significance of real money balances confirms that money can enter in the production function as an explicit factor input. This substantiates the notion that money contributes to the expansion and more efficient operation of the market exchange system by shifting the labor and capital from distribution to production process in the long-run.

Table 3: Long-Run Estimates Based on Johansen Cointegration

Dependant variable: **y**

Regressors	**Coefficients**	***t*-Values**
l	0.53	2.82**
k	0.79	10.376***
m	0.27	5.389***

Note: ** and *** show significance at 5% and 1% levels of significance respectively.

Table 4: ECM Results Based on Johansen Cointegration

Dependant variable: Δ***y***

Regressors	**Coefficients**	***t*-Values**
Δ***y(-1)***	0.24	1.48
Δ***l(-1)***	-0.13	-0.73
Δ***k(-1)***	0.14	0.77
Δ***m(-1)***	0.02	0.44
Δ***Ect(-1)***	-0.19	-1.77*
C	0.03	2.05**

Diagnostic test statistics

	Tests-stats	***p*-Value**
Serial correlation	0.23	0.63
Normality	1.58	0.45
ARCH test	0.20	0.65
Ramsey RESET	0.36	0.55

Note: * and ** indicate significance of coefficients at 10% and 5% levels of significance respectively.

We now turn to short-run results which are presented in Table 4. Since the optimal lag length is one, the short-run results are also presented for one lag of each variable. These results seem interesting in the sense that none of the coefficients of explanatory variables is statistically significant at conventional levels of significance. These results are consistent with Moghaddam (2010) who finds that the first lags of all explanatory variables in short-run are insignificant when M2 definition of money is used. It is also evident from Table 4 that the error correction term is statistically significant and has expected sign. The coefficient of error-correction term is –0.19, suggesting that when real output is above or below its equilibrium level, it adjusts by almost 19% within the first year. Thus, the speed of adjustment towards equilibrium is significantly faster for a developing country as compared to a developed one [see Moghaddam, 2010]. The ECM model passes the stability and diagnostic tests. These include the Jarque-Bera statistic for normality of the residuals, the Breusch-Godfrey test for serial correlation, ARCH residual test for homosedasticity and Ramsey RESET test for specification error. The cumulative sum of recursive residual (CUSUM) and cumulative sum of squares of recursive residual (CUSUMQ) statistics in Figures 1 and 2 indicate no evidence of mis-specification and structural instability for the period estimated.

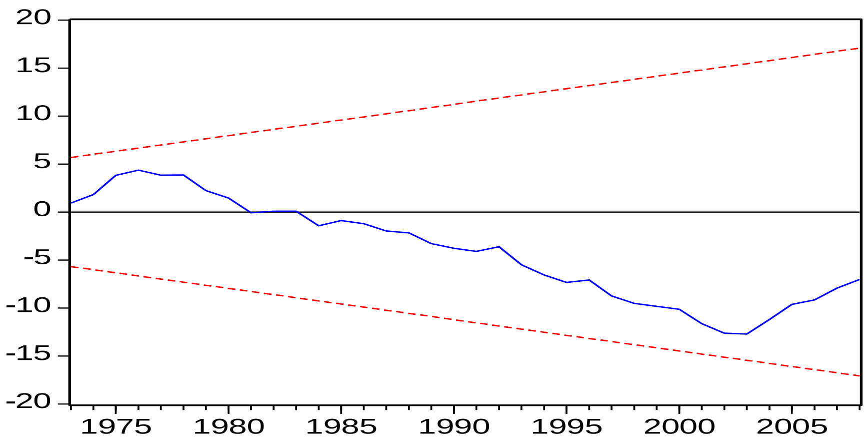

Figure 1: Plot of cumulative sum of recursive residual

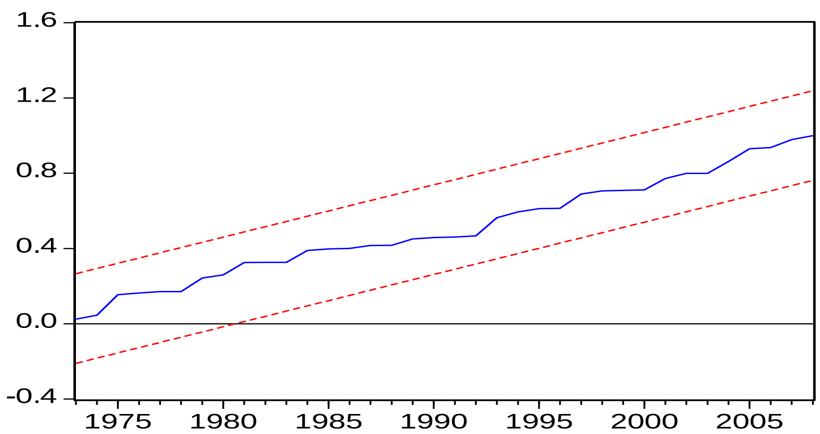

Figure 2: Plot of Cumulative sum of squares of recursive residual

Table 5: Variance Decomposition of Output

Period	S.E.	y	l	k	m
1	0.018	100	0	0	0
2	0.028	96.89	0.012	0.358	2.737
3	0.035	90.59	0.043	1.014	8.351
4	0.041	85.67	0.049	1.481	12.79
5	0.047	83.70	0.040	1.671	14.57
6	0.052	83.58	0.062	1.707	14.64
7	0.056s	84.02	0.093	1.701	14.17
8	0.061	84.40	0.113	1.706	13.77
9	0.065	84.57	0.122	1.728	13.57
10	0.069	84.62	0.127	1.756	13.49

Lastly, we inspect the variance decomposition of the output exhibited in Table 5. It is observable from the table that the contribution of other factors in output variation starts after the first period. Nevertheless, the contribution of labor in output variability is significantly small. Interestingly, the contribution of money in output variability (13.5%) is considerably higher than labor (0.13%) and capital (1.75%), reinforcing the fact that money is indeed an omitted variable from production function of the developing country. The significant output variability due to money may be explained through the cost channel of monetary policy. According to this channel, a tight monetary policy exhibited through higher interest rate reduces the short-term borrowing by the firms for working capital and consequently reduce output. Rehman and Malik (2011), in a sector-wise study for Pakistan, confirm the existence of cost channel in the country. The study finds that this channel is conspicuous in the manufacturing sector since this sector has the highest share (85%) in private sector borrowing. Similarly, Nasir and Malik (2011) surface the fact that domestic supply shock has the highest share (88%) in output variability in Pakistan. Subsequently, one may conclude that tight monetary policy, through reduction in liquidity for working capital, may transform itself into a domestic supply shock thereby having detrimental effects on output. On the other hand, the reason for lower contribution of labor in output variability may be the abundance of labor in the country. Labor supply has never been a problem for Pakistan as it is available in surplus quantity and, therefore, does not put constraint on production activities. Moreover, production technology in Pakistan is not labor intensive. Similarly, once being installed, physical capital works for many years and, hence, is not responsible much for output variability in the shorter span of time. These results are also coherent with Moghaddam (2010) for the M2 definition of money. The same outcomes for different ordering of these variables confirm the robustness of this result.

4. Concluding Remarks

The study is an attempt to investigate the validity of money as an explicit factor input in the production function of a developing country. For this purpose, data for the period 1964-2008 have been obtained for Pakistan. Using the Johansen method of cointegration, the study finds that money does play role in a cointegrated space. Money is found to be a significant input in the production function in the long-run. However, the short-run results demonstrate that none of the input factors are significant. The error correction term is significant and has expected sign. Nonetheless, its value is greater than that of a developed country showing that the convergence to equilibrium is relatively faster in a developing country. Furthermore, the forecast-error variance decomposition presents real money balances a more dominant factor than labor and capital contributing to variation in output. Therefore, in the light of these results we may conclude that money is an important factor input should be included in the production function of Pakistan. Moreover, the traditional analysis of production function has to be modified. That is, in macro model building real money balances should be included. Moreover, State Bank of Pakistan should be careful while pursuing tight monetary policy, as it is currently doing, because it can affect output adversely pushing the economy into recession.

The study also highlights some further areas for future research. For example, studies should be conducted to inquire about the optimal quantity of money for an economy. Thought the results of the study in hands show the positive effect of money on output, yet it should be inspected whether this relationship changes after a particular quantity of money. In other words, is there a non-linear relationship between money and output? This is also important in the sense that following an expansionary monetary policy to enhance output may drastically raise inflation in the country. In addition, research should also be done for separating the needs for transaction and speculating demand for money.

REFERENCES

Apostolakis, B. (1983) "Money balances as factor inputs: an empirical evidence based on translog specification" *European Economic Review* **23**, 149-160.

Bailey, M.J. (1971) "*National Income and the Price Level*, McGraw-Hill: New York.

Ben-Zion, U. and V.W. Ruttan (1975) "Money in the production function: an interpretation of empirical results" *Review of Economic & Statistics* **57**, 246-47.

Davidson, P. (1979) "Money as a factor of production: ultimate neoclassical theory or Keynesian insight: a rejoinder" *Journal of Post-Keynesian Economics* **2**, 280-282.

Fischer, S. (1974) "Money and production function" *Economic Inquiry* **12**, 517-537.

Friedman, M. (1959) "The demand for money: some theoretical and empirical results" *Journal of Political Economy* **67**, 327-351.

Johansen, S. (1988) "Statistical and hypothesis testing of cointegration vector" *Journal of Economics Dynamics and Control* **12**, 231-254.

Johansen, S. and K. Juselius (1990) "Maximum likelihood estimation and inference on cointegration with application to the demand for money" *Oxford Bulletin of Economics* **52**, 169-210.

Khan, A.H. and M. Ahmad (1985) "Real money balances in the production function of a developing country" *Review of Economics and Statistics* **67**, 336-340.

Khan, M.S. and P.J.K. Kouri (1975) "Real money balances as a factor of production: a comment" *The Review of Economic & Statistic* **57**, 144-46.

Levhari, D. and D. Patinkin (1968) "The role of money in a simple growth model" *American Economic Review* **58**, 713-753.

Mankiw, N.G. and D. Romer (1991) *New-Keynesian Economics*, MIT Press: Cambridge, MA.

Moghaddam, M. (2010) "Co-integrated money in the production function-evidence and implications" *Applied Economics* **42**, 957-963.

Moroney, J.R. (1972) "The current state of money and production theory" *American Economic Review* **62**, 335-343.

Nasir, M. and W.S. Malik (2011) "The Contemporaneous Correlation of Structural Shocks and Inflation-Output Variability in Pakistan" PIDE working paper number 70

Nguyen, H.V. (1986) "Money in the aggregate production function: re-examination and further evidence" *Journal of Money, Credit and Banking* **18**, 141-151.

Nicolli, A. (1975) "Real money balances: an omitted variable from the production function?" *Review of Economics and Statistics* **57**, 241-243.

Nourzad, F. (2002) "Real money balances and production efficiency: a panel-data stochastic production frontier study" *Journal of Macroeconomics* **24**: 125-134.

Prais, Z. (1975a) "Real money balances as variable in the production function" *Review of Economic & Statistic* **57**, 243-244.

________ (1975b) "Real money balances as variable in the production function" *Journal of Money, Credit & Banking* **7**, 535-540.

Rehman, F.Ur. and W.S. Malik (2011) "A Structural VAR (SVAR) approach to cost channel of monetary policy" MPRA paper number 32349

Sinai, A. and H.H. Stokes (1972) "Real money balances: an omitted variable from the production function?" *Review of Economics and Statistics* **54**, 290-296.

You, J.S. (1981) "Money, technology and the production function: an empirical study" *Canadian Journal of Economics* **14**, 515-524.