The Role of Money in Production Function

Jisung Yoo*

I. Introduction

Two diversified and specified(or limited) arguments on the role of money have appeared on the literatures and it still remains as a hot controversial issue among monetary economists (and non-monetary economists, also).

The neo-classical economists and Keynes-Wicksell proponents deal with the monetary growth model by starting from different bases; that is, the essential difference between the neoclassical and Keynes-Wicksell monetary growth models lies in the way the investment-savings relation is stated.

On the other hand, many econometric models, i.e., St. Louis Federal Reserve Bank model, FRB-MIT-penn. model, deal mainly with empirical researches related to monetary policy issues. And they are concerned with limited variables-mainly the monetary variables, i.e., the money supply, monetary base and non-borrowed reserves.

Therefore, neither the neoclassical and Keynes-Wicksell models, nor monetary econometric models deal with the direct effect of money on the level of output including other real variables, i.e., capital and labor. Furthermore, not many arguments appeared on the literature so far, which treated the money as a crucial input factor in aggregate production function.

The purpose of this study is to test empirically, based on existing-theoretical and empirical findings, the hypothesis that the money has positive role in determining output in aggregate production function.

*Assistant Professor, Department of Economics, Hanyang University, Seoul, Korea

Ⅱ. Theoretical Framework

A. Appraisal of Literature

Although the relating arguments are very diversified and specified, almost all of them suggest the positive role of money to the output level and treat money as a crucial variable in their applied models.

The first branch of the diversified arguments includes two distinguished approaches-Neoclassical and Keynes-Wicksell growth models, and they explicitly acknowledge the role of money on the rate of economic growth. Neoclassical approach assumed that the rate of capital formation, dK/dt, is identically equal to planned savings, sY, and that markets are always in equilibrium, regardless of the rate of price change.[1] They show, by introducing money, that the rate of price changes is the difference between the rate of increase in nominal money and the rate of growth of output. If the money stock is not changed as output increases, the price level will fall at the rate of growth of output, and real money balances, M/p, will rise. Thus the real money balances are part of the wealth, so the growth in real money balances should be added to real income. In turn, the real money balances can be considered just like any other inventory which enters into the productive process.

On the other hand, Kenyes-Wicksell approach assumed that the savings and investment are independent of each other and they are determined by the price adjustment mechanism in the market. Thus, in the simple Keynes-Wicksell model, the increase in the rate of growth of money causes the quantity of real balances per worker to increase, and hence increasing wealth and consumption. The increase in consumption, in turn, reduces savings, thus the equilibrium capital-labor ratio. Finally, in the Keynes-Wicksell model with an independent investment function, greater monetary expansion, by increasing forced savings, increases the capital-labor ratio.[2]

The second branch of the diversified argument is the monetary eco-

1) J. Stein, "Monetary Theory in Perspective," *AER*, March, 1970, p. 85.
2) D. Ott, A. Ott and J. Yoo, *Macroeconomic Theory*, McGraw Hill Book Co., 1975, p. 318.

nometric models, i.e., St. Louis model and SMP(SSRC-MIT-PENN) models. As a major analytical tools for monetary policy, those models become popularized among monetarists. Corrigan[3] applied both econometric models to the relationship between the monetary aggregate--Ml-and the output. The result of applying St. Louis model shows that the changes in nominal GNP are determined by changes in the money supply(Ml). And that of SMP model also shows the positive relationship between those variables, but not direct impact; that is, changes in the money stock influence the changes in GNP through their impact on other variables. Increases in the money supply, for example, tend to reduce interest rates and stimulate investment spending. In turn, other spending components will rise, all of which contribute to the overall increase in GNP arising from some initial monetary stimulus.

Besides those econometric models, Wallich tested each possible monetary variables one by one to the output and showed the money stock has positive impact on output level.[4]

Finally, the third branch of the diversified arguments is the direct application of money to the production function as an input factor. The study of Sinai-Stokes tested the real balances as a factor of production by including real balances to Cobb-Douglas production function directly as a variable. His testing result demonstrated again the significant relationship between the two variables.

B. Thesis of Study

Introducing the medium of exchange-money-into economy transfers the economic system from the barter to the monetary economy, and causes the dichotomized analytical difficulties-real versus money sector-as well. However, in traditional neoclassical production function, two input factors-labor and capital-are mainly considered, and output is assumed to be a linear and homogeneous function of those two physical factors.

The introduced money as a medium of exchange bears itself major

3) Gerald Corrigan, "Income Stabilization and Short-term Variability in Money," *Monetary Aggregates and Monetary Policy* FBNY, New York, 1974, pp. 92-96.
4) H. Wallich, "Money and Growth," *JMCB*, May, 1969. pp. 281-302.

roles in the economy. It solves the double-coincidence problem in barter economy, and hence decreases the search period between the traders and increases the efficiency. Pierson[5] proposed two important functions which the introduced money as a medium of exchange bears; the first is providing certain types of efficiency and utility, and the second is providing the basis for credit creation. Only the first function will be emphasized for the purpose of this study.

The efficiency of money made the market transactions easy among the trade parties, and hence it helped to increase freed labor from the tight(or hard) market transactions. In turn, the freed labor from distribution can be used for production and hence increase the output as well as consumption. This, in reality, is a reason of treating money as conusmer good or producer's good in neo-classical monetary growth model. And hence, the medium of exchange should be included in production function and the growth model. Lavahri and Patinkin[6] argue that the entrance of money into the production function reflects the fact that it frees labor and capital for the production of commodities proper. Thus, in their production function, the real money balances were considered just like any other production factors which enters into the production process. Friedman also argues by the errand boy example that the real cash balances as a substitute for other production services are at least in part a factor of production.[7]

On the other hand, Pierson argues that since the credit system, for example, makes possible a vastly more economical use of resources, the whole factors which yield the efficiency should be included in the production function like money as well.[8] And although the marginal products of

5) Gail Pierson, "The Role of Money in Economic Growth," *QJE*, 1972, p. 383.
6) D. Levehri and D. Patinkin, "The Role of Money in a Simple Growth Model." *AER*, September 1668, pp. 737-738.
7) M. Friedman, *The Optimum Quantity of Money and Other Essays*, Aldine, 1969, Chicago, p. 14.
Also see, Nadiri, "The Determinants of Real Cash Balance in the U.S. Total Manufacturing Sector," *QJE*, May 1969, p. 175.
H.G. Johnson, "Inside Money, Outside Money, Income, Wealth and Welfare in Monetary, Theory" *JMCB*, Dec. 1968, p. 40.
8) G. Pierson, *op. cit.*, pp. 392-393.

those factors are large and significant at their beginning stage, they fall rapidly. Accordingly, there are perceptible effects on production, and hence, Pierson continues, including money in production function is not proper.

Nevertheless, We believe, the rational for including the stock of money in the production function relates to the increased "economic efficiency" of a monetary economy compared with a barter economy. As Sinai and Stokes indicate, there are numerous implications of real money balances as a factor of production.

> First, money would have a marginal productivity schedule like other inputs. Second, firms' demands for real balances would be derived in the same way as other factor demand functions. Third, changes in the stock of money would affect real output, contrary to the classical dichotomy which implies the neutrality of money. Fourth, real balances might explain some of the rate of growth of total factor productivity or the "residual." Finally, traditional analyses of production would be subject to modification.[9]

Ⅲ. Methodology

A. Established Model

Any types of linear production functions are feasible for this kind of empirical studies without losing any statistical significances. The Cobb-Douglass type of production functions are relatively simple and has long been adopted as a statisfically meaningful estimating method among economists. And thus, the Cobb-Douglas production function as a basic established model, like many writers did, is chosen for this study.

The basic hypothesized production function is,

$$Y = A\ e^{\delta T}\ L^{\alpha}\ K^{\beta}\ M^{\gamma} u$$

where, A : Efficiency parameter

T : Time trends

L : Labor forces

K : Capital

9) Allen Sinai and Houston H. Stokes, "Real Money Balance: An Omitted Variable from the Production Function?" *RES*, May 1972, p. 291.

M : Nominal Money stocks

u : Residuals

Y : Gross National Products

α : Elasticity of output with respect to Labor

β : Elasticity of output with respect to capital

γ : Elasticity of output with respect to money

δ : Rate of disembodied technological change.

By taking the log-linear transformation, the equation (1) is estimated by the following model:

$$\ln Y = \ln A + \delta T + \alpha \ln L + \beta \ln K + \gamma \ln M$$

After the adjustment of data and variables, the OLS (Ordinary Least Squares) method is basically employed.

B. The Statistical Appraisal of Model

As a common phenomena, the time series analysis frequently involved with the difficulty of autocorrelation. Without proper specification of the variables it causes unreliable estimation of variables and hence less precise predicting power. For curing this possible spurious relation in the time trends, the Generalized Least Squares (GLS) method will be adopted if necessary; that is, regress on the original time series data with OLS method and then adjust the data having independent error term.

Besides adopting the GLS method, the explicit time trend variable is employed for the purpose of curing the possible autocorrelation problem[10] as well as measuring technical change.

Although it does not give any serious trouble for predicting purpose of the model, the multicollinearity is another important source of unreliable coefficients estimation. In a bird-eye view, it is impossible to eliminate completely the possibility of interrelationship among the explanatory variables, especially in production function; that is, for example, the variables-

10) P. Rao and R. Miller, *Applied Ecnoometrics*, Wadsworth Publishing Co., Belmont, California, 1971, pp. 101-102.

When the researcher suspects that 'trend' in the time series data underlies a supurious relation in the regression equation, he may abstract from this influence by introducing time as an explicit variable in the regression equation.

labor and capital-cannot be independent each other theoretically and empirically.[11] Thus, the reduction of the collinearity among the variables to the statistically acceptable level is the crucial issue for the study. One way to reduce the possibility of multicollinearity in this study is to use the adjusted data and to adopt a proxy variable which is properly specified prior to the estimation of the model, and hence those process have been proceeded.

Because of the complexity and the size of data, however, the possibility of heteroscedasticity is being neglected in this study.

C. Variables and Data

Data for output, labor, capital, and price index are taken from the *Statistical Abstract of U.S.* and data for nominal money stocks are collected from *Monetary Statistics of the U.S.* of Friedman and Schwarts.[12]

GNP: GNP is adopted for the output in production function, in order to estimate the model for economy as a whole. The functional relationship between GNP and the included explanatory variables is obvious, and hence it used to be a simplified version of economic growth model. Data-the rate of growth-for GNP are collected from the published statistics of the Commerce Department of U.S.

Labor: The Theoretical and empirical validity of labor as a major explanatory variable in production function has long been proved in economic analysis. However, because of its ambiguity in terms of definition and specification, the ratio of labor force to total population is collected first. And then the rate of increase of the ratio is calculated annually for the study.

Capital: In order to avoid the possible multicollinearity problem among the explanatory variable in the model, the proxy variable-the consumption of energy resources-is substituted for capital variable. The rational of adopting the proxy variable is based on the definition of Commerce Depar-

11) H. Kelejian and W. *Dates Introduction to Econometrics*, Harper and Row Publishers, N.Y. 1974, p. 188.

12) M. Friedman and A. Schwartz, *Monetary Statistics of the U.S.*, Columbia University Press, N.Y. 1970.

tment,[13] "...consumption of raw materials represented by the capital-goods requirement..." Hence, the annual rate of consumption of raw material is calculated and is substituted for explanatory variable-capital.

Money Stock: Based on the rational mentioned in the previous section, data for narrowly defined nominal money stock, M1, and broad money stock, M2 and M3 are hired from the study of Friedman and Schwartz. Those three monthly money stocks are averaged and deflated by the price indices, and then the rate of annual money stocks is calculated for this study.

Time: An exponential time trend, which represents the technical changes, is introduced in this model. That is, it is defined as $T=0$ in the year of 1929 and is numbered consecutively to 40 for the year 1969.

As is briefly mentioned, the collected data have been adjusted inevitably for the purpose of curing statistical difficulties. That is, all the data were recalculated as the annual growth rates.

By spending a good amount of time with computer and statistical inferences, We are convinced that it is too dangerous to deal the crude collected data directly to the model. And, as a result, our curiosity on existing similar empirical studies has been growing: how did they cope with the largely involved multicollinearity, and how did they derive such fancy and clear-cut results based on their described methods?

The non-existence of a critical standard in statistical inferences, We believe, is a crucial obstacle and it directly causes the researcher to be subjective and secret in dealing with the statistical difficulties. That is the major reason why the collected data has been completely adjusted in this study, and, by doing so, it could almost be free (compare to the previous studies) from the multicollinearity problem. However, it sets limit to the study: that is, the result could not be used directly for predicting the purpose (it is possible, of course, to use the result for predicting by converting data properly, i.e., convert the annual growth rate into the actual data). The result could be managed efficiently in determining the concerned variable whether it has positive or negative effects, and thus it is proper

13) Bureau of Census, *Historical Statistics of the U.S.: Colontal Times to 1970*, Department of Commerce, Washington, D.C., 1975, p. 812.

for the purpose of this study.

Ⅳ. Appraisal of the Results and Conclusion

A. Hypothesis

Once again, it has to be mentioned that all the collected data have been adjusted for eliminating multicollinearity problem before the estimate; that is, the rate of change of all the data is calculated and arranged based on previous year's value without changing statistical significances. As a result, the collinearity among the variables becomes almost negligible as we can see on the Table Ⅰ In other words, the estimated coefficients in this study do not show the changing output ratio by the variables, but show the intensity of variable instead.

Besides, since there is a lag in the effect of monetary policy, the several estimated equations include the lag-variables in order to clarify the dynamic aspects of money stocks.[14] Although Friedman and Schwartz predicted a fairly long period for change in money stocks to affect on general business, one year lag-variables are employed as many other monetarists and econometrics models show.[15]

Total 10 different regression equations are estimated for detailed analy-

Table Ⅰ Correlation Coefficients

	lnY	lnL	lnK	lnM1	lnM2	lnMC	lnMS	T	lnM3
lnY	1.00000	0.48450	0.37706	0.64499	0.71653	0.75080	0.42686	0.22077	0.68310
lnL	0.48450	1.00000	0.29141	0.34611	0.22436	0.33694	0.05883	−0.06038	0.23151
lnK	0.37706	0.29141	1.00000	0.00661	0.29306	0.26619	0.12885	0.17759	0.26931
lnM1	0.64499	0.34611	0.00661	1.00000	0.65321	0.75786	0.28405	−0.09126	0.76959
lnM2	0.71653	0.22436	0.29306	0.65321	1.00000	0.94431	0.76637	0.17430	0.91500
lnMC	0.75080	0.33694	0.26619	0.75786	0.94431	1.00000	0.65338	−0.06579	0.87697
lnMS	0.42686	0.05883	0.12885	0.28405	0.76637	0.65338	1.00000	0.17072	0.61152
T	0.22077	−0.06038	0.17759	−0.09126	0.17430	−0.06579	0.17072	−1.00000	0.23201
lnM3	0.68310	0.23151	0.26931	0.76959	0.91500	0.87697	0.61152	0.23201	1.00000

14) Z. Prais, "Real Money Balances as a Variable in the Production Function," *JMCB*, November 1975.

15) Micael J. Hamberger, "The Leg in the Effect of Monetary Policy: A Survey of Recent Literature," *Monetary Aggregates and Monetary Policy*, Federal Reserve Bank of New York, 1974, p. 104.

sis, and the results of estimation are aggregated on the Table Ⅱ Table Ⅱ indicates sevral findings of the study. The increased R^2 indicates that the money stocks reduces unexplained variance of the GNP, and the money stocks is a significant variable when it is included in the Cobb-Douglas production function.

The other finding is that the intensity of estimated money stocks'

Table Ⅱ

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A	0.002	−0.038	0.007	−0.011	0.000	−0.055	0.001	−0.035	−0.062	0.002
α	0.758	0.862	1.164	1.234	0.912	0.649	0.863	0.843	0.528	0.876
(s)	(0.427)	(0.391)	(0.415)	(0.415)	(0.453)	(0.410)	(0.433)	(0.405)	(0.406)	(0.457)
(t)	(1.775)	(2.781)	(2.805)	(2.973)	(2.013)	(1.583)	(1.993)	(2.081)	(1.300)	(1.967)
β	(0.827)	0.563	0.375	0.275	0.715	0.538	0.864	0.882	0.730	0.815
(s)	(0.465)	(0.434)	(0.452)	(0.454)	(0.498)	(0.426)	(0.476)	(0.445)	(0.442)	(0.512)
(t)	(1.788)	(1.216)	(0.830)	(0.606)	(1.436)	(1.263)	(1.815)	(1.982)	(1.652)	(1.592)
m1	*0.285	*0.274	.....	.....	*0.304	*0.182	**0.475	0.712	**0.470	*0.454
(s)	(0.202)	(0.184)	.....	.....	(0.228)	(0.191)	(0.219)	(0.226)	(0.246)	(0.285)
(t)	(1.411)	(1.489)	.....	.....	(1.333)	(0.953)	(2.169)	(3.150)	(1.911)	(1.593)
m_2	.....	.....	1.023	1.009	*0.551	*−0.872	**0.801	0.958	*−0.405	*0.954
(s)	.....	.....	(0.219)	(0.217)	(0.526)	(0.581)	(0.322)	(0.308)	(0.716)	(0.699)
(t)	.....	.....	(4.671)	(4.650)	(1.048)	(1.501)	(2.488)	(3.110)	(0.566)	(1.365)
m_3	.....	.....	.....	.....	.....	.....	*−0.390	**−0.846	**−0.807	*−0.416
(s)	.....	.....	.....	.....	.....	.....	(0.433)	(0.445)	(0.423)	(0.473)
(t)	.....	.....	.....	.....	.....	.....	(0.901)	(1.901)	(1.608)	(0.879)
mc	0.575	0.615	.....	.....	*0.105	*1.497	.....	.....	**−1.464	*−0.044
(s)	(0.203)	(0.185)	.....	.....	(0.475)	(0.615)	.....	.....	(0.611)	(0.506)
(t)	(2.833)	(3.524)	.....	.....	(0.221)	(2.434)	.....	.....	(2.396)	(0.087)
Ms	.....	.....	*−0.257	*−0.274	*−0.068	.....	.....	.....	*0.017	*−0.091
(s)	.....	.....	(0.209)	(0.207)	(0.239)	.....	.....	.....	(0.210)	(0.241)
(t)	.....	.....	(1.230)	(1.323)	(0.285)	.....	.....	.....	(0.081)	(0.378)
δ	.....	**0.002	.....	*0.001	.....	0.003	.....	**0.002	0.004	.....
(s)	.....	(0.001)	.....	(0.001)	.....	(0.001)	.....	(0.001)	(0.001)	.....
(t)	.....	(2.00)	.....	(1.00)	.....	(3.00)	.....	(2.00)	(4.00)	.....
R^2	0.661	0.726	0.648	0.664	0.672	0.743	0.679	0.727	0.769	0.690
d.f	36	35	36	35	35	34	34	34	32	33

*5%; **1%

coefficients is added. This can be interpreted as the strong effect of money stocks variable as a whole on output, but, more specifically, the rather weak effect of the current money stocks variable on the output level. This can be seen from the drastically increased coefficient of current money stocks variables by introducing previous year's money stocks as a lag variable.

Another finding is the related change in labor coefficient by introducing money stock variable. Since labor services are most likely to be released from distribution activities when money stocks increases, the inverse relationship support for the thesis of this study.

The coefficient of the time trend has not shown the significant value: that is, as Sinai-Stokes indicated, it might be interpreted as a neutral technological progress.[16] And hence, it can be concluded that neutral technological progress was not much different from zero over the given period of time.

C. Conclusion

By the brief discussion on the above regression results, based on the testing result of the established hypothesis, the conclusion can readily be reached: the money stocks has positively been related to the output level and has been neglected as a crucial input factor in production function. In other words, the rationale for money stocks as an input factor is related to its role in facilitating transactions, exchange and specialization, thus contributing to change in productivity. Unless the money stocks variable is included as an input factor, the traditional analysis of production inevitably brings a biased result. This conclusion, therefore, supports the money stocks as a producer's good which the study of Levhari and Patinkin directed to. And this suggests a strong doubt on the neutrality of money in the long-run as Neoclassical and Keynesian framework assumed.

16) Sinai and Stokes, *op. cit.*, p. 294.

≪BIBLIOGRAPHY≫

Bureau of Census, *Historical Statistics of the U.S.: Colonial Times to 1970*, Washington, D.C.: Department of Commerce, 1975.

Corrigan, Gerald, "Income Stabilization and Short-term Variability in Money," *Monetary Aggregates and Monetary Policy*, New York: Federal Reserve Bank of New of New York, 1974.

Friedman, M., *The Optimum Quantity of Money and Other Essays*, Chicago' Aldine, 1969.

Friedman, M., and A. Schwarts, *Monetary Statistics of the U.S.*, New York: Columbia University Press, 1970.

Hamberger M., "The Lag in the Effect of Monetary Policy: A Survey of Recent Literature," *Monetary Aggregate and Monetary Policy*, New York: Federal Reserve Bank of New York, 1974.

Johnson, H., "Inside Money, Outside Money, Income, Wealth and Welfare in Monetary Theory," *JMCB*, December 1968.

Kelejian, H. and W. Oates, *Introduction to Econometrics*, New York: Harper and Row Publishers, 1974.

Levhari, D. and D. Patinkin, "The Role of Money in a Simple Growth Model," *AER*, September 1968.

Nadiri, M.I., "The Determinants of Real Cash Balances in the U.S. Total Manufacturing Sector," *QJE*, May 1969.

Ott, D., A. Ott and J. Yoo, *Macroeconomic Theory*, McGraw-Hill Book Co., New York, 1975.

Pierson, Gail, "The Role of Money in Economic Growth," *QJE*, 1972.

Prais, Z., "Real Money Balances as a Variable in the Production Function," *JMCB*, November 1975.

Rao, P. and R. Miller, *Applied Econometrics*, Belmont, California: Wadsworth Publishing Co., 1971.

Sinai, A. and H. Stokes, "Real Money Balances: An Omitted Variable from the Production Function?" *RES*, May 1972.

Stein, J., "Monetary Growth Theory in Perspective," *AER*, March 1970.

Wallich, H., "Money and Growth," *JMCB*, May 1969.