# DEMAND FOR MONEY IN TURKEY

# 1960-1984

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A C K N O W L E D G E M E N T S

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# A B S T R A C T

The purpose of this thesis is to estimate demand for money function for Turkey.

In this study demand for money model is first explained with its mathematical properties and second applied to Turkish data.

The study covers the 1960-1984 period for Turkey. In the study, OLS estimation technique is used in the estimation of the model.

## Ö Z E T


Bu tezin amacı Türkiye için para talebi fonksiyonunu tahmin etmektir.

Bu çalışmada önce para talebi fonksiyonu mathematiksel özellikleri ile açıklanmış daha sonra Türkiye verileri kullanarak tahmin edilmiştir.

Çalışma 1960-1984 dönemini kapsamakta ve tahminde "en küçük kareler" tahmin yöntemini kullanmaktadır.

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# C H A P T E R I

## THEORETICAL FRAMEWORK OF THE STUDY

This study aims to explain the movements in the velocity of money in Turkey and this chapter provides the theoretical basis for the study. Section (1.1) studies the velocity of money and its close relation with the demand for money. Section (1.2) explains the opportunity cost of holding money and section (1.3) presents the basic hypotheses made in the real money demand model and the related studies made for the Turkish economy.

### 1.1. THE VELOCITY OF MONEY AND THE DEMAND FOR REAL MONEY

The aim of the study is to explain the velocity of money. The velocity of money is defined as the ratio of nominal income to nominal money supply (Samuelson and Nordhaus, 1985 : 323) and its significance lies in the connection made between nominal GNP and the money supply via the velocity where GNP is a flow variable and money supply is a stock variable. This connection is called the quantity equation which is $M.V=P.Y$, where M is the money supply, V the velocity of money, P the price level and Y the real income.

The quantity equation becomes the classical quantity theory of money when V and Y are assumed to be independent of changes in M and P. Hence the price level is proportional to the money supply and the theory has very strong policy implications. If we can predict the level of the velocity of money, we can predict the level of nominal income, given the money supply.

Another importance of the velocity of money is that it is a convenient way of talking about the demand for money. From the quantity equation we have $V = \frac{P.Y}{M} = \frac{Y}{M/P}$ , indicating the velocity of money as the ratio of the income to real money supply. When the real money supply is assumed to be aqual to the demand for real money, the velocity of money becomes equal to the ratio of real income to the demand for real money, $V = \frac{Y}{(M/P)_D}$ . Thus any variable that affects the demand for real money also affects the velocity of money.

In the modern quantity theory of money, which was advanced by Friedman (1956), money is taken as a capital good, and like other goods the demand for money depends on wealth and the opportunity cost of holding money.

The demand for real money is positively related to wealth, meaning that part of the increases in wealth is held as money. But there is an important problem in using wealth as a variable in the estimations. Because it is difficult to define wealth satisfactorily and to obtain the relevant data. Therefore real income is generally taken as proxy for wealth in quantitative analysis.

## 1.2. THE OPPORTUNITY COST OF HOLDING MONEY

There are many ways of holding wealth and keeping money balances is only one way of holding it. The others are generally bonds, equities and physical assets. The opportunity cost of holding money is the expected yield on bonds, equities and physical assets. These yields are the interest rate in bonds, capital gain in equities, and appreciation of physical assets, which is expressed by the expected rate of inflation. When the yields on alternatives go up, meaning that the cost of holding money has risen, the demand for real money decreases. On the other hand, if the interest income on money rises, the demand for real money increases.

This theory is generally accepted to hold in countries with developed financial intitutions and a variety of financial instruments so that individuals have alternative ways in which to hold their wealth. But Turkey does not possess these features. That is why it is important to analyze the economy precisely so as to understand the determinant(s) of the demand for real money.

First, the Turkish economy is a financially reppressed economy in which the interest rate (particularly deposit rate of interest) is held below the market rate Fry (1982). Hence the interest rate doesn't play its role attributed it in the mentioned theory (See Table 1.2).

Second, the financial institutions and instruments are in their rudimentary stage in Turkey. Table 1.1 shows that in Turkey the banking sector's share in the financial system is quite high and even higher than the less developed countries' average.

Table: 1.1.

Percentage Distribution of the Financial Assets in the Financial System

| | Years | Banking Sector | Others |
|---|---|---|---|
| Developed Countries | 1900 | 50.9 | 49.2 |
| | 1963 | 39.4 | 60.5 |
| Less Developed Countries | 1900 | 77.8 | 22.2 |
| | 1963 | 69.0 | 31.0 |
| T u r k e y | 1970-1981 | 76.0 | 27.0 |

Sources: *Goldsmith (1969), Table 5.23 ;*
*Akyüz (1984), Table 4.11.*

Another important feature that Table 1.1 shows is that the development stage of the financial system in Turkey in 1970's is approximately the same of the developed countries' level in 1900. Such an underdeveloped financial system implies that investment in physical assets is an important alternative to holding money (Ertuğrul, 1982: 114).

Table : 1.2.

| Years | Rate of Change of Prices (%) | Demand Deposit Rate (%) | Time Deposit Rate (%) |
|---|---|---|---|
| 1960 | 3.26 | 2.50 | 5.00 |
| 1961 | 3.99 | 2.50 | 5.00 |
| 1962 | 9.07 | 2.50 | 5.00 |
| 1963 | 5.58 | 2.50 | 5.00 |
| 1964 | 2.54 | 2.50 | 5.00 |
| 1965 | 4.22 | 2.50 | 5.00 |
| 1966 | 6.20 | 2.50 | 5.00 |
| 1967 | 6.32 | 2.50 | 5.00 |
| 1968 | 3.84 | 2.50 | 5.00 |
| 1969 | 5.17 | 2.50 | 5.00 |
| 1970 | 10.64 | 2.50 | 5.33 |
| 1971 | 17.09 | 2.50 | 6.00 |
| 1972 | 13.77 | 2.50 | 6.00 |
| 1973 | 21.64 | 2.50 | 6.00 |
| 1974 | 24.97 | 2.625 | 6.00 |
| 1975 | 15.01 | 3.00 | 6.00 |
| 1976 | 15.47 | 3.00 | 6.00 |
| 1977 | 21.90 | 3.00 | 6.00 |
| 1978 | 36.30 | 3.00 | 8.25 |
| 1979 | 53.70 | 3.00 | 11.00 |
| 1980 | 71.20 | 4.00 | 25.16 |
| 1981 | 34.98 | 5.00 | 49.16 |
| 1982 | 24.23 | 5.00 | 50.00 |
| 1983 | 24.71 | 20.00 | 42.50 |
| 1984 | 40.40 | 5.00 | 45.33 |

Finally, as shown in Table 1.2, Turkey was faced with a substantial inflation after 1970, especially in the period 1978-1984. In 1980, the inflation rate reached 71 percent. The average rate derived from the GNP deflator is 19.04 percent for the period 1960-1984.

What are the implications of these features of the Turkish economy relevant to the determinant(s) of the demand for real money and velocity of money? It is generally accepted that during substantial inflation the expected rate of inflation is the most important determinant of the demand for real money.* During inflation periods, nominal interest rate is dominated by the expected rate of inflation. We can clarify this by using symbols. In equilibrium, $i_N = i_R + \pi$ holds, where $i_N$ is the nominal interest rate, $i_R$ the real interest rate, and $\pi$ the expected rate of inflation. Since the interest rate is determined outside of the market because of financial repression, increases in the expected rate of inflation reduces only the real rate of interest, which affects the expenditures on physical assets. Therefore, the nominal interest rate doesn't catch up with price increases and it turns out to be inadequate in representing the cost of holding money (Akyüz, 1973: 20).

Following Friedman (1956), "physical goods ... are similar to equities except that the annual stream they yield is in kind rather than in money. In terms of nominal units,

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* Cagan (1956) is the leading study on the expected rate of inflation during hyperinflations.

this return, like that from equities, depends on the behavior of prices" and it is expressed by the expected rate of inflation. Because of this substitution between money and physical assets, the expected rate of inflation is relevant to the demand for real money.

In the absence of alternative ways of holding wealth, such as bonds and equities as a result of undeveloped financial institutions and instruments in Turkey, physical assets are the major alternative to holding money. For this reason the expected rate of inflation takes the place of the interest rate in explaining the demand for real money (Akyüz, 1973: 20).

The above discussion and the features of the Turkish economy make clear that the second important determinant of the demand for real money and the velocity of money is the expected rate of inflation. If the expected rate of inflation rises, individuals hold less money, meaning that the velocity of money rises because of the negative relation between the demand for real money and the velocity of money shown in the velocity equation $V = \frac{Y}{(M/P)_D}$

## 1.3. SOME EMPIRICAL STUDIES AND THE HYPOTHESES OF THE MODEL

It is worth mentioning two important studies that estimate this model, which will be explained in chapter II in detail, for different periods of the Turkish economy: One is Akyüz (1973) and the other Ertuğrul (1982).

In Akyüz (1973), the model is estimated for 1954-1960 period by using quarterly data. The value of the coefficient of the expected rate of change of prices is - 33.3524. Although its magnitude is very high the sign of the coefficient is negative as expected. The income elasticity of real money is 2.4871.

The value of $\beta$ which is coefficient of adaptation is 0.05. This means that economic agents have very long memory. $R^2$ is 0.6901 which is quite low. Unfortunately, DW is not given and thus it can not be concluded whether there is autocorrelation or not.

Ertuğrul (1982) covers 1970-1978 period of the Turkish economy and also uses quarterly data. At the first estimation positive autocorrelation is found and the overcome this problem Cohrane-Orcutt iteration procedure is applied.

In Ertuğrul (1982), income elasticity of real money is 1.273 and the coefficient of the expected rate of change of prices - 1.2. Both signs are as expected. $R^2$ is 0.978 which is quite high. The coefficient of adaption is 0.5, showing that economic agents have quite long memory.

Both of these studies use Ordinary Least Square in estimation of the model.

From sections I.1 and I.2 it is concluded that the expected rate of inflation and real income are the main determinants of the demand for real money and the velocity of money. It is expected that the real income elasticity of the demand for real money is greater than unity.* On the other hand, the coefficient of the expected rate of inflation can not be determined a priory but a negative relation is expected.

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(*) The real income elasticity of the demand for real money was found 0.68 for the U.S.A. economy (Dornbush and Fisher, 1984 : 266). For the analysis in which the real income elasticity of the demand for real money was found to be greater than unity in Turkey, see Akyüz (1973). In Akyüz's study this high elasticity was interpreted as a result of the Turkish economy's rapid structural change and development. Although his study covers the period 1950-1968, we think that the Turkish economy is still in structural change in 1970's and 1980's.

C H A P T E R II

# DEMAND FOR MONEY UNDER ADAPTIVE EXPECTATIONS

In the previous chapter, we gave a dominant place to expectations so as to determine the demand for real money function. But expectations include a fundamental difficulty in their nature. Because they are psychological phenomena that can not be observed directly in the way that quantities and prices can be watched (Frich, 1983: 21). Therefore we must, in one way or another, quantify the expectations. One way to get over this difficulty is to assume that expectations are formed adaptively.

The first attempt to estimate the demand for money function under adaptive expectations was carried out by Cagan (1956). His model was an instantaneous adjustment one that was based on a first-order differantial equation. In contrast to it, Dutton (1971) developed a discrete-time adjustment model that was based on a second-order difference equation. That is why, in Cagan's model, the path of prices is the solution to a first-order differential equation, while it is solution to a second-order difference equation in Dutton's.

The second important difference between these models is that the necessary and sufficient condition for the elasticity of the price level with respect to the money supply to be egual to 1 is $\alpha\beta \leqq 1$* in Cagan (1956), meaning that if $\alpha\beta=1$, the system is also in equilibrium. In contrast to this result, $\alpha\beta<1$, is the necessary and sufficient condition for the system to be in equilibrium in Dutton (1971).

What has been done in this chapter is to apply Dutton's model to Turkish data. In section (2.1) the adaptive expectations hypothesis is presented. In section (2.2) the model that will be applied to Turkish data is explained in detail

## 2.1. ADAPTIVE EXPECTATION HYPOTHESIS

One hypothesis on the formation of expectations, usually attributed to Cagan (1956), is well known as the "adaptive expectations hypothesis". According to this hypothesis, people revise their expectations each period according to the error which is the difference between the observed and the expected values of the variable in the previous period. The adaptive expectations of the price level in period t can be formalized as :

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* $\alpha$ indicates the responsiveness of real money balances to changes in the expected rate of inflation and $\beta$ is the coefficient of adaptation.

$$\pi_t = \pi_{t-1} + \beta(\dot{p}_{t-1} - \pi_{t-1}) \qquad (2.1.1.)$$

where $\pi$ is the expected rate of inflation, $\dot{p}$ is the actual rate of inflation and $\beta$ is the coefficient of expectations (or adaptations) which is between zero and unity, $0<\beta<1$. $\beta$ determines how fast people adjust their expectations in response to past errors. If $\beta=1$, then $\pi_t=\dot{p}_{t-1}$ meaning that expectations are static and if $\beta=0$, then $\pi_t= \pi_{t-1}$ meaning that expectations are independent of the actual rate of inflation.

Equation (2.1.1.) can be rewritten as

$$\pi_t = \beta\dot{p}_{t-1}+(1-\beta)\pi_{t-1} \qquad (2.1.2.)$$

Taking expectations at time t-1, we get

$$\pi_{t-1} = \beta\dot{p}_{t-2} +(1-\beta)\pi_{t-2} \qquad (2.1.3.)$$

Substituting (2.1.3) into (2.1.2), we obtain

$$\pi_t = \beta\dot{p}_{t-1} + \beta(1-\beta)\dot{p}_{t-2} + (1-\beta)^2\pi_{t-2} \qquad (2.1.4.)$$

By lagging and substituting repeatedly we arrive at the equation.

$$\pi_t = \beta\dot{p}_{t-1} + \beta(1-\beta)\dot{p}_{t-2} + \beta(1-\beta)^2\dot{p}_{t-3} + \beta(1-\beta)^3\dot{p}_{t-4}+ \cdots$$

$$= \beta \sum_{i=1}^{\infty} (1-\beta)^{i-1}\dot{p}_{t-i} \qquad (2.1.5.)$$

in which the expected rate of inflation is expressed in terms of a weighted average of all the observed rate of inflation in the previous periods.

The weights, $\beta, \beta(1-\beta), \beta(1-\beta)^2, \ldots\ldots.$, in (2.1.5) can be considered as a 'memory'. If $\beta$ is close to zero, then the weights decline slowly and the economic agent (or society at large) has a 'long' memory. In contrast, if $\beta$ is close to unity, the weights decrease quickly and the economic agent has a 'short' memory (Frisch, 1984: 25).

Though the adaptive expectations hypothesis has been used extensively in economics, it has some shortcomings. First, "it underestimates both the expected level of and changes in prices during a period of galloping inflation" (Akyüz: 1973: 48). Because of this, "adaptive expectations hypothesis appeared to work well in an environment in which change was gradual - a characteristic of the 1950's and 1960's" (Carter and Muddock, 1985: 25). Second, it incorporates only previous values of the variable under consideration. Therefore, it omits all the other variables that can influence the variable under consideration. "For example, knowledge of which party has just won a general election may be used to ignore a forecast of inflation which is otherwise based solely on past price data" (Carter-Muddock, 1985:24).

2.2. THE MODEL

The model is as follows:

$$M/P = k.y^{\eta}.\ e^{-\alpha\pi} \tag{2.2.1}$$

$$\pi_t = \pi_{t-1} + \beta(\dot{P}_{t-1} - \pi_{t-1}) \tag{2.2.2}$$

$$\dot{P}_t = \ln P_t - \ln P_{t-1} \tag{2.2.3}$$

(2.2.1) is the demand for real money function, (2.2.2) is the adaptive expectations hypothesis, and (2.2.3) is the rate of inflation in terms of logarithm. In the model, M is the nominal money, y is the real GNP, P is the price level, $\pi$ is the expected rate of inflation. $\eta$, $\alpha$, k, and $\beta$ are the constants of which $\eta$, $\alpha$ are positive and $0<\beta<1$. In addition, $\eta$ denotes the income elasticity of money, and $\alpha$ the coefficient indicating the responsiveness of real money demand to changes in expected rate of inflation. We assume that the demand for money is always equal to the supply of money so that the money market would be in equilibrium all the time. We can also express (2.2.1) in logarithmic form as:

$$\ln M_t - \ln P_t = \ln k + \eta \ln y_t - \alpha\pi_t$$

From this relation we obtain

$$\pi_t = (1/\alpha)\ (\ln k + \eta \ln y_t - \ln M_t + \ln P_t) \text{ and}$$

$$\pi_{t-1} = (1/\alpha)\ (\ln k + \eta \ln y_{t-1} - \ln M_{t-1} + \ln P_{t-1})$$

Substituting these two relations into (2.2.2) and rearranging, we get a second- order difference equation, i.e.

$$\ln P_t = [1-\beta(1-\alpha)]\ln P_{t-1} - \alpha\beta \ln P_{t-2} + \ln M_t - (1-\beta) \ln M_{t-1}$$

$$-\eta \ln y_t + \eta(1-\beta)\ln y_{t-1} - \beta \ln k \qquad (2.2.4)$$

From (2.2.4) it follows that as we increase the money supply, other things being equal, the price level also increases in the same period. Yet to analyze the effects of a permanent increase in money supply on price level over time we have to solve (2.2.4) explicitly.

The parameters and variables of (2.2.4) can be written as follows:*

| | | | |
|---|---|---|---|
| $t_1 \equiv 1-\beta\ (1-\beta)$ | $b_1 \equiv 1$ | $x_{1t} \equiv \ln M_t$ | $a \equiv -\beta \ln k$ |
| $t_2 \equiv (-\alpha\beta)$ | $b_2 \equiv -(1-\beta)$ | $x_{2t} \equiv \ln M_{t-1}$ | |
| $Y_t \equiv P_t$ | $b_3 \equiv -\eta$ | $x_{2t} \equiv \ln y_t$ | |
| | $b_4 \equiv \eta(1-\beta)$ | $x_{4t} \equiv \ln y_{t-1}$ | |

Equation (2.2.4) turns out to be

$$Y_t = t_1 Y_{t-1} + t_2 Y_{t-1} + bX_t + a$$

---

* To solve (2.2.4) and find its dynamic properties we extensively used Sargent (1979) and Gandolfo (1980) and also followed Sargent's notation.

The characteristic equation is

$$Y_t = t_1 Y_{t-1} + t_2 Y_{t-2} \qquad \text{or}$$

$$\lambda^2 - [1-\beta(1-\alpha)]\lambda + \alpha\beta = 0$$

The characteristic roots are

$$\lambda_i = \frac{t_i \pm \sqrt{t_1^2 + 4t_2}}{2} \quad \text{where } i = 1,2.$$

The solution of the second-order difference equateon is

$$Y_t = \frac{a}{\lambda_1 - \lambda_2} \quad \lambda_1 \sum_{i=0}^{\infty} \lambda_1^i - \lambda_2 \sum_{i=0}^{\infty} \lambda_2^i + \frac{\lambda_1 b}{\lambda_1 - \lambda_2} \sum_{i=0}^{\infty} \lambda_1^i X_{t-i}$$

$$- \frac{\lambda_2 b}{\lambda_1 - \lambda_2} \sum_{i=0}^{\infty} \lambda_2^i X_{t-i} + C_1 \lambda_1^t + C_2 \lambda_2^t$$

where $C_1$ and $C_2$ are constants. This equation can also be expressed as

$$Y_t = \frac{a}{\lambda_1 - \lambda_2} \quad \lambda_1 \sum_{i=0}^{t} \lambda_1^i - \lambda_2 \sum_{i=0}^{t} \lambda_2^i + \frac{\lambda_1 b}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_1^i X_{t-1}$$

$$- \frac{\lambda_2 b}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_2^i X_{t-1}$$

$$+ \lambda_1^t \quad C_1 + \frac{a \lambda_1^2}{\lambda_1 - \lambda_2} \sum_{i=0}^{\infty} \lambda_1^i + \frac{b \quad \lambda_1^2}{\lambda_1 - \lambda_2} \sum_{i=0}^{\infty} \lambda_1^i X_{0-1-i}$$

$$-\lambda_2^t \quad -C_2 + \frac{a\lambda_2^2}{\lambda_1-\lambda_2} \sum_{i=0}^{\infty} \lambda_2^i + \frac{b\lambda_2^2}{\lambda_1-\lambda_2} \sum_{i=0}^{\infty} \lambda_2^i X_{0-1-i}$$

We define $H_t = \lambda_1^t \theta_0 + \lambda_2^t \eta_0$ where

$$\theta_0 = C_1 + \frac{a\lambda_1^2}{\lambda_1-\lambda_2} \sum_{i=0}^{\infty} \lambda_1^i + \frac{b\lambda_1^2}{\lambda_1-\lambda_2} \sum_{i=0}^{\infty} \lambda_1^i X_{0-1-i}$$

$$\eta_0 = -C_2 + \frac{a\lambda_2^2}{\lambda_1-\lambda_2} \sum_{i=0}^{\infty} \lambda_2^i + \frac{b\lambda_2^2}{\lambda_1-\lambda_2} \sum_{i=0}^{\infty} \lambda_2^i X_{0-1-i}$$

$$Y_t = \frac{a}{\lambda_1-\lambda_2} \quad \lambda_1 \sum_{i=0}^{t} \lambda_1^i - \lambda_2 \sum_{i=0}^{t} \lambda_2^i + \frac{\lambda_1 b}{\lambda_1-\lambda_2} \sum_{i=0}^{t} \lambda_1 X_{t-i}$$

$$+ \frac{\lambda_2 b}{\lambda_1-\lambda_2} \sum_{i=0}^{t} \lambda_2^i X_{t-i} + H_t$$

If the characteristic roots are $|\lambda_1| < 1$ and $|\lambda_2| < 1$, $H_t$ becomes zero as $t \to \infty$. Therefore, the solution of the equation is

$$Y_t = \frac{a}{\lambda_1-\lambda_2} \quad \lambda_1 \sum_{i=0}^{t} \lambda_1^i - \lambda_2 \sum_{i=0}^{t} \lambda_2^i + \frac{\lambda_1 b}{\lambda_1-\lambda_2} \sum_{i=0}^{t} \lambda_1^i X_{t-i}$$

$$+ \frac{\lambda_2 b}{\lambda_1-\lambda_2} \sum_{i=0}^{t} \lambda_2^i X_{t-i}$$

By substituting the values of a,b's, and X's into the above equation, we get the solution of (2.2.4).

$$\ln P_t = \frac{\lambda_1}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_1^i \ln M_t - \frac{\lambda_2}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_2^i \ln M_{t-i}$$

$$- \frac{(1-\beta)\lambda_1}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_1^i \ln M_{t-i-1} + \frac{(1-\beta)\ \lambda_2}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_2^i \ln M_{t-1-i}$$

$$- \frac{\eta\ \lambda_1}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_1^i \ln y_{t-i} + \frac{\eta\ \lambda_2}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_2^i \ln y_{t-i}$$

$$+ \frac{\eta(1-\beta)\lambda_2}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_2^i \ln y_{t-1-i}$$

$$- \frac{\eta(1-\beta)\lambda_2}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_2^i \ln y_{t-1-i} - \frac{\beta \ln k\ \lambda_1}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_1^i$$

$$+ \frac{\beta \ln k\ \lambda_2}{\lambda_1 - \lambda_2} \sum_{i=0}^{t} \lambda_2^i$$

To rewrite this equation in a more simple way we define $C_m$ as:

$$C_m = \frac{\lambda_1^t}{(\lambda_1 - \lambda_2)\lambda_1^{m-1}} - \frac{\lambda_2^t}{(\lambda_1 - \lambda_2)\lambda_2^{m-2}}$$

where $\lambda_1$ and $\lambda_2$ are the roots of the characteristic equation $\lambda_2-[1-\beta(1-\alpha)]\lambda+\alpha\beta=0$ which is the homogeneous form of the second-order difference equation. As we substitute $C_m$ into the above $\ln P_t$ equation, we obtain

$$\ln P_t = \ln M_t \sum_{m=0}^{t-1} [\ C_m - (1-\beta)C_{m+1}]\ \ln M_m - C_o\ (1-\beta)\ \ln M_{0-1}$$

$$+ F_t \qquad (2.2.5)$$

$$\text{where } F_t = -\eta \sum_{m=0}^{t} C_m\ \ln y_m + \eta(1-\beta) \sum_{m=0}^{t} C_m\ \ln y_{m-1} - \beta \ln k \sum_{m=0}^{t} C_m$$

From (2.2.5) we conclude that the price level at time t is the function of the money supply and the real income as from the past to the time t.

## 2.2.A. STABILITY CONDITIONS

To analyse the stability conditions, we assume that the money supply and real income are constant over time. Thus (2.2.4) turns out to be

$$\ln P_t = [\,1-\eta(1-\alpha)\quad \ln P_{t-1} - \alpha\beta \ln P_{t-2} + (\beta \ln M - \eta\ \beta\ \ln y - \beta \ln k)$$

which is another second-order difference equation. The general solution of the this equation is

$$\ln P_t = A_1\lambda_1^t + A_1\lambda_2^t + (\ln M - \eta \ln y - \ln k)$$

where $\ln M - \eta \ln y - \ln k$ is the "particular solution" and $A_1\lambda_1^t + A_2\lambda_2^t$ is the "complementary function".

Since the roots of the equation can be either real or complex, we should find in which conditions the system will be stable.

$$\ln P_t = [1-\beta(1-\alpha)] \ln P_{t-1} - \alpha\beta \ln P_{t-2}$$

is the homogeneous part of the equation. If we define

$t_1 \equiv 1-\beta(1-\alpha)$ and $t \equiv -\alpha\beta$ as before, it turns out to be

$$\ln P_t = t_1 \ln P_{t-1} + t_2 \ln P_{t-2}$$

i- <u>If the roots are real</u>

The necessary and sufficient conditions for the system to be stable are these :

1) $t_1 + t_2 < 1$ and

2) $t_2 < 1 + t_1$

When we replace the values of $t_1$ and $t_2$, we get

1) $1-\beta + \alpha\beta - \alpha\beta < 1$ and so $1-\beta < 1$

2) $-\alpha\beta < 1 + 1-\beta + \alpha\beta$ and so $-\alpha\beta < 2 + \alpha\beta - \beta$

Therefore both conditions are satisfied by the system because we assumed that $\alpha > 0$ and $0 < \beta < 1$.

ii- If the roots are complex

The term whose square root is taken must be negative, i.e., $t_1^2 + 4t_1 < 0$. In this case, there will be oscillations. For oscillations to converge to the equilibrium level we require that $r = \sqrt{-t_2} < 1$, or equivalently $-t_2 < 1$. If we replace the value of $t_2$, we obtain the last condition, $\sqrt{\alpha\beta} < 1$ or $\alpha\beta < 1$. So we obtained three conditious for the system be stable. These are as follows :

1) $t_1 + t_2 < 1$
2) $t_2 < 1 + t_1$
3) $-t_2 < 1$

Although the first two conditions are satisfied, we can't say anything about the third one. Therefore, the system will be stable if and only if it satisfies the third condition, i.e., $\alpha\beta < 1$.

2.2.B. EFFECTS OF MONEY SUPPLY

To find out long-run effects of the money supply on the price level, we should analyse the elasticity of the price level with respect to the money supply. Suppose that the price level is determined by the equation (2.2.5)

$$\ln P_t = \ln M_t + \sum_{m=0}^{t-1} [C_m - (1-\beta) C_{m+1}] \ln M_m - C_0 (1-\beta) \ln M_{0-1} + F_t$$

Suppose also that we increase the money supply at the same rate from period -1 to t; i.e., (-1,0,1,2,...,t). The effect of the increase in the money supply is the sum of the partial derivative of ln $P_t$ with respect to $M_t$, $M_m$ and $M_{0\ 1}$. Thus, the money elasticity of price level is

$$S_t = 1 + \sum_{m=0}^{t-1} [C_m - (1-\beta)C_{m+1}] - C_0(1-\beta) \qquad (2.2.6)$$

We know from the stability condition that the necessary and sufficient condition for the system to converge to the equilibrium level is that $\alpha\beta<1$, whether the roots are real or complex.

If the roots are real:

By replacing the value of $C_m$ and $\sum_{i=0}^{t} \lambda^i = \frac{1-\lambda^{t+i}}{1-\lambda}$

into (2.2.6), we obtain

$$S_t = 1 + -1 + \frac{\beta}{\lambda_1 - \lambda_2} \quad \lambda_1 \frac{1-\lambda_1^{t+1}}{1-\lambda_1} - \lambda_2 \frac{1-\lambda_2^{t+1}}{1-\lambda_2}$$

Thus

$$S_t = \begin{cases} 0 & \text{if} \quad t = -1 \\ \beta & \text{if} \quad t = 0 \\ 1 + \quad -1 + \frac{\beta}{\lambda_1 - \lambda_2} \left[\lambda_1 \frac{1-\lambda_1^{t+1}}{1-\lambda_1} - \lambda_2 \frac{1-\lambda_2^{t+1}}{1-\lambda_2}\right] & \text{if} \quad t \geq 1 \end{cases} \qquad (2.2.7)$$

If $\lim_{t \to \infty} S_t = 1$, then 1 percent increase in the money supply produces 1 percent increase in the price level. The necessary and sufficient condition for this result is $\alpha\beta < 1$. So (2.2.7) takes the following form

$$S_t = 1 + \frac{\lambda_1 + \lambda_2 - \lambda_1 \lambda_2 + \beta - 1}{(1-\lambda_1)\,(1-\lambda_2)}$$

By applying the simple algebraic relation between the roots of a quadratic equation and its coefficients,

$$S_t = 1$$

Thus $\lim_{t \to \infty} S_t = 1$. If the roots are complex we reach the same conclusion, $S_t = 1$ (Dutton, 1971 : 1165).

Hence we conclude that, if $\alpha\beta < 1$ is satisfied, for example, a 5 percent increase in the money supply causes a 5 percent increase in the price level, so that in the long-run the quantity theory of money holds.

C H A P T E R III

# ESTIMATION AND SIMULATION RESULTS*

In this chapter estimation results of the demand for real money model is presented. In section 3.1 estimation results of the model are provided. Section 3.2 presents the simulation of the model and section 3.3 the results of the policy analysis.

## 3.1. ESTIMATION RESULTS

To estimate the model OLS is applied and the analysis uses annual data covering the period 1960-1984. In the estimation, we first constructed expected rate of inflation series, as described in Appendix A, for different values of $\beta$, starting from 0.1 to 0.9. For each of the expected rate of inflation series we estimated demand for real money function presented in Table III. 1. The value of $\beta=0.9$ which minimized sum of squared residual was chosen. Next we searched for the exact value of $\beta$. To carry out this, the expected rate of inflation series were once again constructed for different values of $\beta$, starting now from 0.85 to 0.99 on 1 percent scale. $\beta=0.99$

(*) In the estimation of the model, David M.Lilien's "Quantitative Micro Software, 1982, package program is used.

minimized sum of squared residual. The results provided in Table III. 1 show the estimated coefficients with their respective t-values in parenthesis below, R square, Durbin-Watson and F-statistics.

Table III. 1

Estimates of the Demand for Money Model

$$\ln(M/P) = \ln a + \eta \ln y - \alpha\pi$$

$$\pi = \beta \dot{P}_{-1} + (1 - \beta)\pi_{-1}$$

$$\dot{P} = \ln P - \ln P_{-1}$$

$$\ln(M/P) = -\underset{(-8.9736)}{2.6443} + \underset{(20.1021)}{1.2633} \ln y - \underset{(-6.7347)}{0.9734}\,\pi$$

$R^2 = 0.9667$ $\beta = 0.99$

$\bar{R}^2 = 0.9619$

D.W.= 1.0935

F-statistics = 203.4868

The estimated value of income elasticity equals to 1.2633 and the elasticity of the demand for real money with respect to expected inflation rate is -0.9734. Both signs are as expected and coefficients are significant at 5 % and 1 % level of significance. As D.W. statistics indicates there is positive serial correlation.

To overcome serial correlation Cohrane-Orcutt iteration procedure is applied.* The results are presented in Table III.2. In this case we obtained satisfactory results. Estimated income elasticity is 1.1284 and the elasticity of the demand for real money with respect to expected rate of inflation is -0.6879. Both coefficients carry the expected signs and are significant at 5 % level of significance. The value of $\beta$ is 0.98. This means that economic agents have very short memory, i.e., they only look at the very near past values of inflation rate in making decision about the expected rate of inflation.

Table III.2

$$\ln(M/P) = -\underset{(-2.5837)}{2.0213} + \underset{(7.1556)}{1.1284}\ \ln y - \underset{(-3.4559)}{0.6879}\ \pi$$

$R^2 = 0.9724$ $\qquad$ $\rho = 0.636$ (2.7556)

$\bar{R}^2 = 0.9667$

D.W. = 2.0467 $\qquad$ $\beta = 0.98$

F-statisties = 167.9647

(*) For serial correlation and Cochrane-Orcutt iteration procedure, see Appendix B.

## 3.2. SIMULATION RESULTS

In 3.1 we presented estimation results of the demand for real money model. To check the tracking performance of the model we carry out simulation exercise and calculate the means absolute error as an indicator of the tracking performance of the model.

We know that the price level follows the time-path of the second-order difference equation of (2.2.4). Since all the parameters of the the model have been estimated by using Cohrane-Orcutt iteration procedure not ordinary least square, these estimated values can not be inserted directly into the equation (2.2.4) and calculated for the price level.

When Cochrane-Orcutt procedure is applied the demand for real money model is written as

$$\ln(M/P) = a(1-\rho) + \eta(\ln y - \rho \ln y_{-1}) - \alpha(\pi - \rho\pi_{-1})$$
$$+ \rho \ln(M/P)_{-1} + \varepsilon_t$$

where $\varepsilon_t$ has zero mean and constant variance.* Therefore the following system of equations is solved to get the simulation result of the pirce level.

$$\pi = \beta\ (\ln P_{-1} - \ln P_{-2}) + (1-\beta)\ \pi_{-1}$$

$$\ln P = -1(1-\rho) - \eta \ln y + \eta\ \rho \ln y_{-1} + \alpha\ \pi \qquad (3.2.1)$$

$$-\alpha\ \rho\ \pi_{-1} + \ln M - \rho \ln M_{-1} + \rho \ln P_{-1} - \varepsilon_t$$

(*) For the derivation of the demand for real money and the properties of $\varepsilon_t$ see the derivation of the equation (B.1.7) and Appendix B, respectively.

TABLE III.3

ACTUAL AND PREDICTED VALUES OF INFLATION RATE

| Years | Actual Values % | Predicted Values % |
|---|---|---|
| 1965 | 4.23 | 12.85 |
| 1966 | 6.20 | 14.53 |
| 1967 | 6.32 | 11.46 |
| 1968 | 3.85 | 4.65 |
| 1969 | 5.17 | 5.04 |
| 1970 | 10.64 | 7.08 |
| 1971 | 17.09 | 16.20 |
| 1972 | 13.77 | 23.01 |
| 1973 | 21.64 | 20.54 |
| 1974 | 24.97 | 15.41 |
| 1975 | 15.01 | 10.45 |
| 1976 | 15.48 | 11.42 |
| 1977 | 21.90 | 24.05 |
| 1978 | 36.29 | 33.11 |
| 1979 | 53.71 | 47.28 |
| 1980 | 71.20 | 55.43 |
| 1981 | 34.98 | 53.10 |
| 1982 | 24.24 | 47.74 |
| 1983 | 24.72 | 27.08 |
| 1984 | 40.40 | 18.30 |

Mean Absolute Error = 7.14

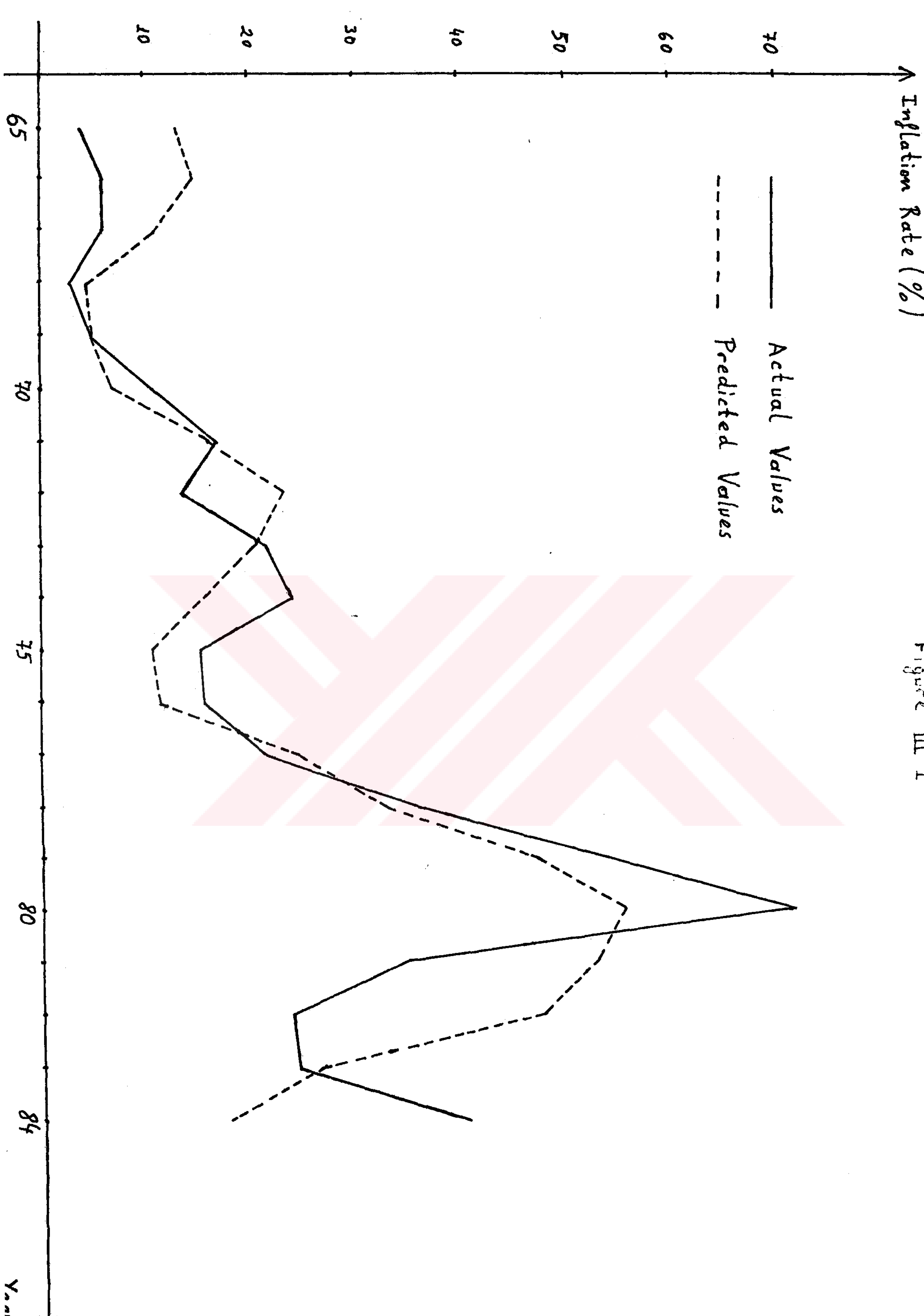
Inflation Rate (%)
Actual Values
Predicted Values
10
20
30
40
50
60
70
65
70
75
80
84

Figure III 1

Given the actual values of ln M and ln y this system gives us the time path of ln P. Denoting the simulated (predicted) value of ln P by ln PP, we determine the predicted value of the rate of inflation by $\dot{PP} = \ln PP - \ln PP_{-1}$. As an indicator of the tracking performance of the model mean absolute value was computed as

$$\text{Mean Absolute Value (MAV)} = \frac{\sum_{t=0}^{n} \left| \dot{PP}_t - \dot{P}_t \right|}{n} \qquad n = 1,3,\ldots\ldots,20$$

Actual and predicted values of inflation rate are presented in Table III.3. and Figure III.1. shows them graphically.

## 3.3. POLICY ANALYSIS

In section 3.2. we showed that the equation system of (3.2.1) determines the time path of prices. To carry out policy experiments we should make some assumptions about the variables of the system. Suppose the system is in its long-run equilibrium with $\pi = \dot{P} = 0.15$. Assume that growth rate of real GNP is 0.04 and the initial values of y and P are $y_o = 150$ and $P_o = 20$, respectively. Thus we can find ln y series by using

$$\ln y = \ln y_{-1} + 0.04 \qquad (3.3.1)$$

from demand for money function, we can obtain the initial value of $\ln M_o$ as

$$\ln M_o = \ln P_o - 2.0213 + 1.1284 \ln y_o - 0.6879\, \pi_o$$

Rate of change of money is calculated from the relation

$$\dot{M} = \dot{P} + 1.1284\ \dot{y}$$

where $\dot{y}$ and $\dot{M}$ are the rate of change of real GNP and money, respectively. It is found that the rate of change of money is 19,5137 and $\ln M_o = 4.2226$. So ln M series is derived from

$$\ln M = \ln M_{-1} + 0.195137 \qquad (3.3.2)$$

Given the time path of ln y and ln M, determined by (3.3.1) and (3.3.2), we can determine the time path of ln P by using (3.2.1). This solution, called base solution, is characterized by the fact that the rate of inflation determined by the model is 15 percent for each of the periods under consideration. The results of the base case experiment are shown in Table III.4.

In the second experiment, which we call casel, we will try to find out the effects of the increase in money supply. To perform such an exercise, suppose that the rate of growth of money supply increases from period one onwards by 10 percent from 19.5137 % to 29.5137 %. The system to be solved is the same as base case except the above assumption on the rate of change of money. The results of casel experiment are also presented in Table III.4. Following this table, although the growth rate of money is more than 25 % in the first half of the period the system converges to 25 percent inflation rate in the second half of the period. This can also be seen graphically in Figure III.2.

TABLE III.4

RATE OF INFLATION UNDER ALTERNATIVE POLICY CASES

| Years | BASE CASE (%) | CASE 1 (%) |
|---|---|---|
| 0 | 15.0030 | 15.0030 |
| 1 | 15.0007 | 25.0007 |
| 2 | 14.9977 | 31.7397 |
| 3 | 14.9973 | 29.6776 |
| 4 | 14.9993 | 23.7029 |
| 5 | 15.0011 | 20.9456 |
| 6 | 15.0010 | 20.0597 |
| 7 | 14.9998 | 26.3864 |
| 8 | 14.9991 | 27.2704 |
| 9 | 14.9994 | 25.6414 |
| 10 | 15.0001 | 23.9144 |
| 11 | 15.0004 | 23.8139 |
| 12 | 15.0002 | 24.9084 |
| 13 | 14.9998 | 25.7360 |
| 14 | 14.9997 | 25.5726 |
| 15 | 14.9999 | 24.9012 |
| 16 | 15.0001 | 24.5453 |
| 17 | 15.0001 | 24.7509 |
| 18 | 15.0000 | 25.1336 |
| 19 | 14.9999 | 25.2606 |
| 20 | 14.9999 | 25.0908 |
| 21 | 15.0000 | 24.8873 |

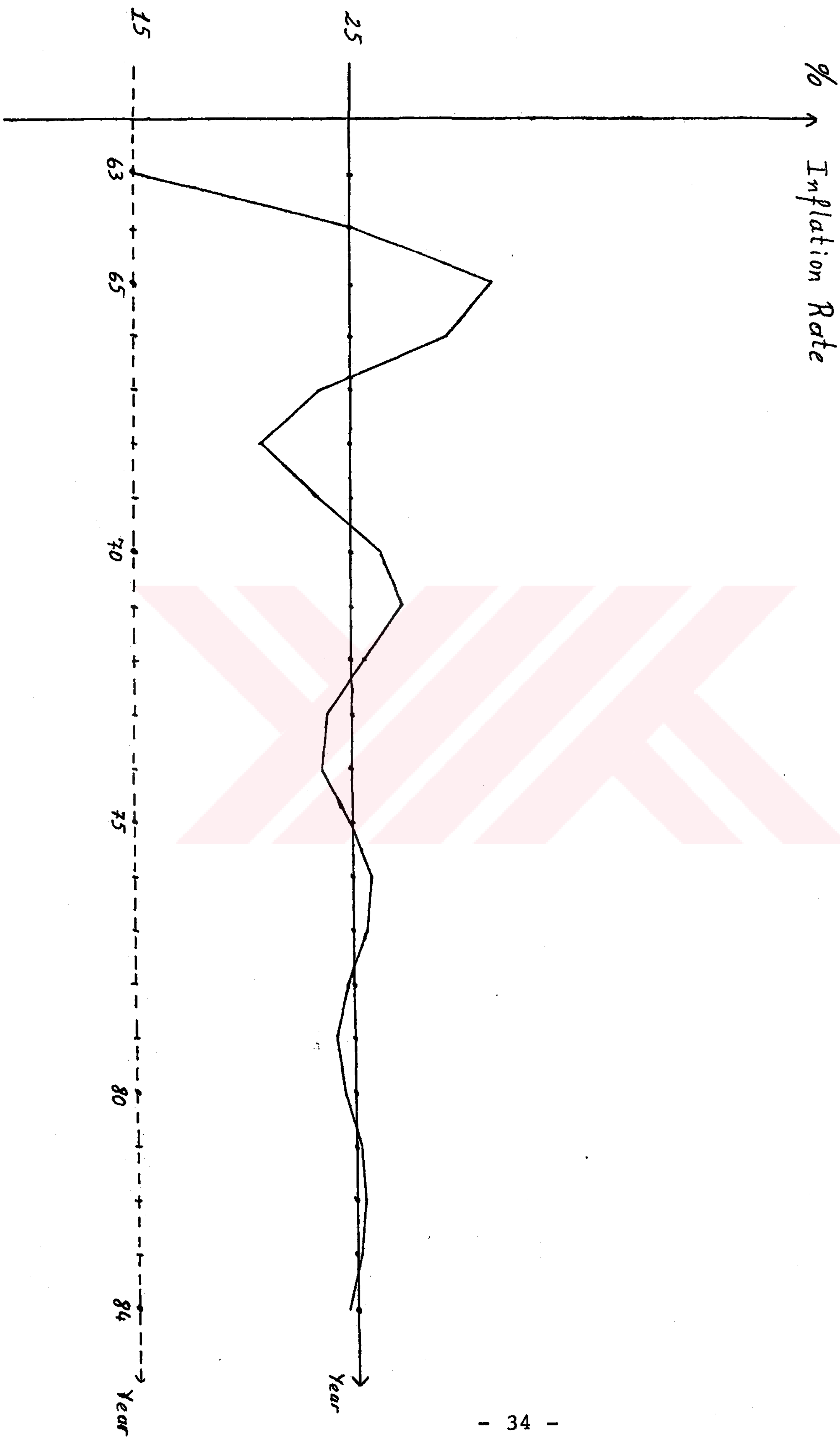


Figure III.2

# C O N C L U S I O N

It is known from the stability conditions that necessary and sufficient conditions for the model to converge to the equilibrium level is $\alpha . \beta < 1$. In the estimation of the model we found that $\alpha = 0.6879$ and $\beta = 0.98$. Hence these results satisfy the convergence conditions of the model. This means that this result verifies the basic hypothesis of the quantity theory of money that there is one to one correspondance between money supply and the price level.

We should be careful about accepting one to correspondance between money supply and the price level. First in the estimation only OLS was applied. Second we used annual data. It is worthwhile to mention and compare other studies with our results.

Esen (1986) uses montly data and covers the period january 1975 - December 1985. It tests the hypothesis of whether inflation in Turkey is purely monetary phenomenon or not by using cross-spectral method. It finds that there is a weak relation between money supply and inflation and therefore concludes that money supply is not the only variable which determines inflation in Turkey (Esen, 1986 : 40).

Another study, Neftçi (1980), which tests the relation between ɔney supply and price changes obtains the same result as Esen (1986). ɘftçi's study uses annual data and applies Sims-Causality test. He ɔncludes that money supply does affect prices but there are some price ıanges which can not be explained by past monetary expansions. He ɘntions three possible explanations for this result:

(i) Foreign price increases, the most important one being ıe jump in oil prices.

(ii) Sudden increase in agricultural support prices which ɔpear to be political in origin.

(iii) The weather conditions, which influence the agri- ıltural prices, and raise government deficit (Neftçi, 1980: 33 - 184).

On the other hand, Uygur (1983) applies Granger-causality ɘst between money supply and producer's prices in manufacturing ndustry, using quarterly data. It is found that the effect of oney supply on price changes in manufacturing industry is in- onclusive (Uygur, 1983 : 66).

All these studies' results which obtained by using different ethods show that it is difficult to accept the main hypothesis f the quantity theory of money which price changes is purely a ıonetary phenomenon.

## APPENDIX : A*

### ESTIMATION OF THE MODEL

The model is as follows :

$$M/P = k \, . \, y^{\eta} \, . \, e^{-\alpha\pi} \, . \, e^{u} \tag{A.1}$$

$$\pi = \beta \, \dot{P}_{-1} + (1-\beta) \, \pi_{-1} \tag{A.2}$$

$$\dot{P} = \ln P - \ln P_{-1} \tag{A.3}$$

Taking ln of (A.1), we get

$$\ln(M/P)_t = \ln k + \eta \ln y_t - \alpha\pi_t + U_t \tag{A.4}$$

We know that $\pi_t$ of (A.4) can be written as :

$$\pi_t = \beta \sum_{i=0}^{\infty} (1-\beta)^i \, \dot{P}_{t-1-i}$$

$$\pi_t = \beta \sum_{i=0}^{t-1} (1-\beta)^i \, \dot{P}_{t-1-i} + \beta \sum_{i=t}^{\infty} (1-\beta)^i \, \dot{P}_{t-1-i} \tag{A.5}$$

Subtituting (A.5) into (A.4), we obtain

$$\ln (M/P)_t = \ln k + \eta \ln y_t - \alpha\beta \sum_{i=0}^{t-1} (1-\beta)^i \, \dot{P}_{t-1-i}$$

$$-\alpha\beta \sum_{i=t}^{\infty} (1-\beta)^i \, \dot{P}_{t-1-i} + U_t \tag{A.6}$$

---

(*) For Appendix A we followed Maddala (1977), pp. 350-362.

The fourth term of (A.6) can be computed from the actual observations for any given value of $\beta$. The fifth term can not be computed because $x_{-1}$, $x_{-2}$, .................. are not observed. But writing $i-t=j$, it can be seen to be equal to

$$(1-\beta)^{i} \alpha\beta \sum_{j=0}^{\infty} (1-\beta)^{i} \tilde{P}_{-j-1} = (1-\beta)^{t} \gamma_{o}$$

where

$$\gamma_{c} = E(\pi_{o}) = \alpha\beta \sum_{i=0}^{\infty} (1-\beta)^{i} \tilde{P}_{-i-1}$$

Thus (A.6) can be written as :

$$\ln(M/P)_{t} = \ln k + \eta \ln y_{t} - [\alpha Z_{1t} + \gamma_{o} Z_{2t}] + U_{t} \qquad (A.7)$$

where

$$Z_{1t} = \beta \sum_{i=0}^{t-1} (1-\beta)^{i} \tilde{P}_{t-1-i}$$

$$Z_{2t} = (1-\beta)^{t} \qquad (A.8$$

In this formulation $\gamma_{o}$ is a parameter corresponding to truncation remainder. So (A.6) turns out to be

$$\ln(M/P)_{t} = \ln k + \eta \ln y_{t} - \alpha Z_{1t} - \gamma_{o} Z_{2t} + U_{t} \qquad (A.9)$$

The procedure for the estimation of (A.9) is as follows: For each value of $\beta$, $Z_{1t}$ and $Z_{2t}$ are constructed as in (A.8). Then lu(M/8) is regressed on lny , $Z_{1t}$ , $Z_{2t}$. By looking at the residual sum of squares, we choose the value of $\beta$ for which residual sum of square is minimum. Hence the coefficients of lny, $Z_{12}$ , and $Z_{2t}$ give US $\eta$, $\alpha$, and $\gamma_{o}$, respectively.

It should be noted that the estimators for, $\eta$, $\beta$ and $\alpha$ are consistent but that for $\gamma_c$ is not. This is because for large values of t, $Z_{2t}$ is almost zero. Thus as we increase the sample size we do not get any more information on $\gamma_0$. In fact for large samples we can ignore $\gamma_0$.

Although in large samples $\gamma_0$ can be ignored, following (Maddala, 1978 : 362), it has been found in practice that even for sample sizes as large as 60, it is desirable not to ignore $\gamma_0$, because this might often produce drastically different estimates for the parameters $\beta$ and $\alpha$.

APPENDIX : B

## AUTOCORRELATION AND COCHRANE - ORCUTT ITERATION PROCEDURE*

Suppose we have linear relation between y and x and have n observations on x and y, i.e.,

$$y_i = \alpha + \beta x_i + U_i \qquad i = 1,2,\ldots, n \qquad (B.1.1.)$$

where y is dependent variable, x independent variable and U residual, and want to estimate parameters $\alpha$ and $\beta$ by "method of least squares" i.e., choose $\hat{\alpha}$ and $\hat{\beta}$ as estimators of $\alpha$ and $\beta$, respectively, so that

$$Q = \sum_{i=1}^{n} (y_i - \hat{\alpha} - \hat{\beta} x_i)^2 \qquad (B.1.2)$$

is a minimum.

The estimation procedure depends on the assumptions made about the residuals $U_i$ in (B.1.1.). The least-squares estimators obtained by minimizing Q in (B.1.2) have desirable properties under the following assumptions about $U_i$ :

1. Zero mean, $E(U_i) = 0$ for al i
2. Common variance, $V(U_i) = \sigma^2$ for all i

(*) For this subject we followed Maddala (1977).

3. Independence, that is, $U_i$ and $u_j$ are independent for any $i$ and $j$ $(i \neq j)$

4. Independence of $x_j$, that is, $U_i$ and $x_j$ are independent for all $i$ and $j$. This automatically follows if $x_j$ are considered nonrandom variables.

In same cases, the third assumption which is serial independence of the residuals are not always valid, particularly in time-series data. In time-series data the successive residuals tend to be highly correlated, and this correlation is known as serial correlation or autocorrelation.

It is often found that residuals are serially correlated in time-series data. What we do about the correlation in the $U_t$ series depends on what our hypothesis is about $U_t$. The usual assumptions about $U_t$ are that they form

1. An autoregressive process (AR)
2. A moving-average process (MA)
3. A mixed autoregressive moving-average process (ARMA)

In our model our hypothesis about $U_t$ is that it follows an autoregressive process of the first-order, i.e.,

$$U_t = \theta_1 U_{t-1} + e_t \qquad (B.1.3)$$

where $e_t$ is a series with the following properties.

(i) $E(e_t) = 0$ , zero mean

(ii) $V(e_t) = \sigma_e^2$ for all $t$, same variance

(iii) $Cov(e_t, e_s) = 0$ for all $t \neq s$ , independence in the residuals.

With the assumption of first-order autoregressive process of $U_t$ the estimation procedure is as follows: Our model turns out to be

$$Y_t = \alpha + \beta x_t + U_t \qquad (B.1.4)$$

$$U_t = \rho U_{t-1} + e_t \qquad (B.1.5)$$

By lagging (B.1.4) by one time period and multiglying by $\rho$, we get

$$\rho y_{t-1} = \alpha\rho + \beta\rho x_{t-1} + \rho u_{t-1} \qquad (B.1.6)$$

Subtracting (B.1.6) from (B.1.4) and using (B.1.5), we obtain

$$y_t - \rho y_{t-1} = \alpha(1-\rho) + \beta(x_t - \rho x_{t-1}) + e_t \qquad (B.1.7)$$

Since $e_t$ are serially independent with a constant variance $\sigma_e^2$ , we can estimate the parameters in this equation by an OLS procedure.

Suppose we transform the variables $y_t$ and $x_t$ to

$$y_t^* = y_t - \rho y_{t-1} \qquad \text{(B.1.8)}$$

$$x_t^* = x_t - \rho x_{t-1} \qquad t=2,3,\ldots, T$$

and run a regression of $y^*$ on $x^*$, with or without a constant term depending on whether the original equation has a constant term or not. (In fact, in our model we have constant term). In this method we use only (T-1) observations because we lose one observation in the operation of taking difference.

In actual practice $\rho$ is not known. What is done is that we get a preliminary estimates of $\rho$ and use it in the above procedures. One way to find the estimates of $\rho$ is Cochrane - Orcutt procedure. In this procedure we estimate (B.1.7) by OLS, get the estimated residuals $\hat{U}_t$, and estimate $\rho$ by

$$\hat{\rho} = \frac{\Sigma\, \hat{U}_t\, \hat{U}_{t-1}}{\Sigma\, \hat{U}_t^{\,2}}$$

Once $\hat{\rho}$ is obtained, we transform the variables to $y^*$ and $x^*$ as defined in (B.1.8) and estimate a regression of $y^*$ on $x^*$. The only thing to note is that the slope coefficient in this equation is $\beta$ but the intercept is $\alpha(1-\rho)$. Thus, after estimating the regression of $y^*$ on $x^*$, we have to adjust the constant term appropriately to get estimates of the parameters of the original equation (B.1.4).

This procedure is called two-step procedure. The first step involves getting an estimate of $\rho$ . The second step involves getting estimates of the regression parameters. The procedure can also be iterated. After we estimate a regression of $y^*$ on $x_t^*$ , we can recompute the residuals, get a new estimate of $\rho$ , transform the variables, and recompute the estimates. We can procede with this iterative procedure till successive values of $\rho$ are approximately the same. This is called Cochrane - Orcutt iterative procedure.

APPENDIX : C

## DATA

This study covers 1960-1984 period. For this period nominal and real GNP figures are taken from various issues of "Statistical Yearbook of Turkey", State Institute of Statistics, Turkey, and from "Türkiye Milli Geliri ; Kaynak ve Yöntemler 1948-1972", State Institute of Statistics, 1973.

Price level have been obtained from GNP, using the formula $P = GNP(Nominal) / GNP(Real)$. Rate of change of prices is calculated from the relation $\dot{P}_t = \ln P_t - \ln P_{t-1}$ , where $\ln P$ denotes natural logarithm of the price level and $\dot{P}$ the rate of change of prices.

The sources for money, M2, are verious issues of "Montly Bulletin" and "Quarterly Bulletin" of Central Bank of the Republic of Turkey. M2 is not taken as end of year figure. Iustead of it, it is calculated as the average of twelve mouths.

## DATA USED IN THE ESTIMATION

| Years | GNP (Real) 1968 100 (Billion TL) | GNP (Nominal) (Billion TL) | M2 (Billion TL) |
|---|---|---|---|
| 1960 | 70.868 | 46.664 | 9.592 |
| 1961 | 72.285 | 49.535 | 10.356 |
| 1962 | 76.754 | 57.592 | 11.640 |
| 1963 | 84.188 | 66.801 | 12.722 |
| 1964 | 87.619 | 71.312 | 14.315 |
| 1965 | 90.367 | 76.726 | 17.216 |
| 1966 | 101.204 | 91.419 | 20.590 |
| 1967 | 105.460 | 101.480 | 24.019 |
| 1968 | 112.493 | 112.493 | 27.734 |
| 1969 | 118.594 | 124.892 | 32.510 |
| 1970 | 125.425 | 146.919 | 37.170 |
| 1971 | 138.185 | 192.035 | 48.139 |
| 1972 | 148.476 | 236.802 | 61.815 |
| 1973 | 156.457 | 309.829 | 78.410 |
| 1974 | 168.012 | 427.097 | 99.383 |
| 1975 | 181.383 | 535.771 | 126.242 |
| 1976 | 195.750 | 674.985 | 159.639 |
| 1977 | 203.358 | 872.893 | 210.747 |
| 1978 | 209.182 | 1290.723 | 278.225 |
| 1979 | 208.343 | 2199.520 | 417.350 |
| 1980 | 206.120 | 4435.153 | 651.550 |
| 1981 | 214.671 | 6553.596 | 1095.975 |
| 1982 | 224.542 | 8735.053 | 1885.766 |
| 1983 | 231.863 | 11549.142 | 2658.708 |
| 1984 | 245.521 | 18316.823 | 3917.483 |

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