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Testing quantity theory of money for the Turkish economy

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Abstract

In this paper, it is tried to test the main assumptions of the Quantity Theory of Money for the Turkish economy. Using some contemporaneous estimation techniques to examine the long-run stationary economic relationships on which the quantity theory is constructed, it is found that stationary characteristics of the velocitities of narrowly and broadly defined monetary aggregates cannot be rejected. However, monetary aggregates seem to be endogenous for the long-run evoluation of prices and real income. It is concluded that monetary authorities follow an accommodative monetary policy inside the period given the endogeneity of the monetary variables.

Keywords: Quantity Theory of Money, Neutrality, Co-integration, Turkish Economy.

JEL Classification: C32, E41, E52, E61

Özet - Türkiye Ekonomisi'nde Miktar Kuramının Sınanması

Bu çalışlmada, Paranın Miktar Kuramı ile ilgili temel varsayımların Türkiye ekonomisi koşullarında sınanmasına çalışılmaktadır. Miktar kuramının üzerine kurulduğu uzun dönem durağan ekonomik ilişkilerin incelenmesi amacıyla çağdaş bazı tahmin yöntemleri kullanılmak suretiyle elde edilen bulgular, dar ve geniş kapsamlı tanımlanan parasal büyüklüklere ait dolanım hızlarının durağan yapısının reddedilemeyeceğini göstermektedir. Bununla birlikte, parasal büyüklükler fiyatların ve reel gelirin uzun-dönemli gelişimi açısından içsel bir özelliğe sahip olarak görülmektedir. Sonuç olarak inceleme döneminde, parasal yetkililerin parasal değişkenlerin içsel yapılarının veri olduğu bir ortamda uyumlaştırıcı bir para politikası izlediği düşünülmektedir.

Anahtar Kelimeler: Paranın Miktar Kuramı, Yansızlık, Eş-bütünleşim, Türkiye Ekonomisi.

JEL Sınıflaması: C32, E41, E52, E61

1. Introduction

The quantity theory of money (QTM) constitutes one of the main corner-stones in the construction of economics theory. The relationship betwen the persistent changes in the price level and supply of money goes back to the earlier analysis by David Hume (1970) relating the prolonged increases in prices to the increases in nominal quantity of money. Its implications for income velocity of money and the assumptions used for the role of money in policy design process have still been highly controversial in contemporaneous macroeconomics. Resurrecting the interest upon the QTM, Friedman (1956) in his classical article considers the quantity theory mainly a theory of the demand for money and emphasizes that the main contribution of the QTM to the economics theory is to put out the stability of the functional relations affecting the quantity of money demanded. Such an assumption in turn gives rise to that variations in the velocity of money can be foreseen by the economic agents in line with a stationary economic relationship for the various phases of business cycles. Considering these fundamental theoretical issues would restrict the attention on the theory to some main economic arguments and policy issues for the construction of functional relationships.

However the QTM is based on the stable functional relations mainly affecting the quantity of money demanded, Dotsey and Hornstein (2003) in their calibrating model upon the US economy warn us that even though money communicates information on aggregate output, it is of limited use for a policy maker in the sense that it would be a useful signal in an environment driven by productivity shocks, but using it as a signal would have adverse consequences in the presence of money demand disturbances. Likewise, Estrella and Mishkin (1997) focus on the role of monetary aggregates as information variables considering a monetary policy rule perspective, however, they find that in line with the ex-post findings in their paper the monetary aggregates cannot be used in a straightforward way to signal the stance of monetary policy since they do not seem to provide adequate and consistent information.

These all bring out the importance of stability of functional relations for the QTM relationship and the critical assumptions used for this purpose must be elaborately examined to search for whether those can be supported in a way providing internal consistency of the theory.

Following Lucas (1980), this would help us to provide solutions to explicit theoretical models of idealized economies to explore why one might expect the theory to hold in reality and to exlain the conditions under which the theory might be expected to break down.

In our paper, our aim is to examine the validity of the QTM relationship for the Turkish economy in an empirical way. For this purpose, the next section is devoted to the theoretical background and a contemporaneous literature review upon the QTM relation. In section 3, the data processing methods are described and an empirical model is tried to be estimated upon the Turkish economy. The last section summarizes results and concludes.

2. Model Construction

2.1. Model

The quantity theory based on the classical book by Fisher (1911) can be described by the well-known exchange identity:

$$M\,V = P\,Y \tag{1}$$

where M is the money supply, V the income velocity of money as a function of institutional structure of the financial system ex-ante assumed as time-invariant, P the general price level and Y the measure of aggregate output level under the simplifying assumption that the economic transactions volume in the economy in a given time period would be proportional to the aggregate output.

Let us express quantity theory in terms of the growth rates:

$$m + v = p + y \tag{2}$$

where the lower case letters denote the growth rates. The QTM relationship requires that there exists a proportional relationship between the growth rates of money supply and price level and that money must be (super)neutral which is resulted from stationary velocity of money

and unaffected real output level in the long-run following the permanent changes in the growth rate of money supply.

Note here that testing a variable vector $X = (\Delta Y, \Delta M)'$, where logarithm of the money stock, M, and logarithm of the real output, Y, are assumed to follow an I(1) process, means to examine the neutrality of money, whereas if the process describing M is I(2) rather than I(1) then we test the concept of (super)neutrality by using the variable vector $X = (\Delta Y, \Delta^2 M)'$. King and Watson (1997) emphasize that long-run neutrality cannot be tested in a system in which output is I(1) and money is I(2). This is because neutrality of money refers to the hypthesis that changes in the quantity of money affect the nominal variables in the macroeconomic system and concern the relationship between shocks to the level of money and the level of output. However, if an I(2) process dominates the money supply, shocks in this case would affect the rate of money growth and there would be no shocks to the level of money. Fisher and Seater (1993) and Bullard (1999) argue various cases for long-run neutrality and (super)neutrality of money that depend on the integration of the relevant variables.

Following Ozmen (2003) and Grauwe and Polan (2005), for empirial purposes the QTM requires that each of m, p and y or their linear combination with a coefficient vector (-1 1 1) must be stationary. That is, a long-run I(0) process must dominate these variable space leading to that velocity of money (v) has been subject to a stationary long-run process. In line with the QTM assumptions explained above, Ozmen emphasizes that even if this requirement constitutes a necessary condition for the quantity theory, this is not a sufficient condition since the QTM contains also the exogeneity of money in the velocity variable system which requires that money supply must be weakly exogenous for the long-run evolution of prices and real income. Otherwise, an endogenous money supply framework for the prices and/or real income would be validated within the quantity theory variable system.

2.2. Literature Review

TIf we now briefly consider some empirical papers upon the QTM relationship for a literature review; Geweke (1986) using a century of annual US data as well as postwar monthly data supports the neutrality of money for the US economy. King and Watson (1997) investigate

various long-run neutrality propositions using postwar US data. They conclude that the data contain little evidence against the long-run neutrality of money and suggest a very steep long-run Phillips curve. Serletis and Krause (1996: 323-327) and Serletis and Koustas (1998) using a low frequency data from ten developed countries over one hundred years find supportive results of the money neutrality in the long-run. Koustas (1998) also support the money neutrality using post WWII data for the Canadian economy. Bullard (1999) examines a large review of papers upon long-run monetary neutrality and (super)neutrality propositions and emphasizes that there exist a general evidence in favor of the neutrality proposition but no clear-cut inference can be drawn from the international evidence of (super)neutrality.

Karfakis (2002) tests the predictability of income velocity and the proportionality of nominal income (or, prices) and money using Greek data. He finds that proportionality is supported by the data and that velocity does not fluctuate widely and movements in the velocity would be predictable. However, Ozmen (2003) re-examining the Greek data used by Karfakis (2002) reveals that contrary to the findings of Karfakis the Greek data strongly reject the exogeneity of money in a velocity variable system. He concludes that money and nominal income (or, prices) appear to be jointly determined in a consistent way with an endogenous money hypothesis. In reply to the Ozmen (2003), Karfakis (2004) addresses the issues raised by Ozmen and demonstrates that money can be treated as a long-run driving variable for nominal income in Greece and expresses that stationarity of the income velocity of money and validity of proportionality support the QTM by using Greek data.

Ashra et al. (2004) examine the relationship between money, output and price level for the case of a developing country, i.e. India. They emphasize that the Monetarist strategy to monitor money supply to check inflation assumes, inter alia, exogeneity of money. However, their findings indicate that there exists a bi-directional causality between money and price level and that money is non-neutral so that it is not exogenous in the long-run. Grauwe and Polan (2005) using a large panel of low- and high-inflation countries find that the QTM prediction that an expansion of the money stock does not increase output in the long-run is confirmed. Finally, starting from a quantity theoretical approach, Herwartz and Reimers (2006) analyse the dynamic relationships between money, real output and prices for an unbalanced panel of 110 economies. They support particularly for high inflation countries

homogeneity between prices and money and suggest that central banks, even in high inflation countries, can improve price stability by controlling monetary growth.

3. Estimation Results

3.1. Preliminary Data Issues

We now examine empirically the assumptions on which the QTM is constructed. We consider data for the investigation period of 1987Q1-2006Q4 using quarterly observations. All data take the form of seasonally unadjusted values in their natural logarithms and are taken from the electronic data delivery system of the Central Bank of the Republic of Turkey (CBRT). Lucas (1980) argues the importance of choosing the appropriate monetary aggregate which corresponds to the variable theoretically termed "money". Therefore, for the money supply variable two variable specifications are considered to verify the consistency of results for different monetary aggregates, represented by either narrow money supply, i.e., M1 monetary aggregate (m1) as a sum of currency in circulation plus sight deposits in the banking system, or broad money supply, i.e., M2 monetary aggregate (m2) as a sum of M1 monetary aggregate plus time deposits in the banking system. We must note that the proportion of M1 to M2 monetary aggregate steadily decreases inside the period from the maximum of 45% in 1988 to 25% in 2006. Price measures are based on the gross domestic product (GDP) deflator (p), thus the log-first difference of the deflator would be the quarterly inflation. Finally, the real GDP data are used for real income variables (y). Two impulse-dummy variables which take on values of unity from 1994Q1 till 1994Q4 and from 2001Q1 till 2001Q4 concerning the financial crises occured in 1994 and 2001 are considered as exogenous variables. In our paper, we search for a stationary long-run relation between these variables with ex-ante specified signs in order to give support to the QTM relationship.

We now investigate the time series properties of the variables. Spurious regression problem analysed by Granger and Newbold (1974) indicates that using non-stationary time series steadily diverging from long-run mean will produce biased standard errors, which causes to unreliable correlations within the regression analysis leading to unbounded variance process. In this way, the standard OLS regression will produce a good fit and predict statistically significant relationships between the variables considered however none really exists

(Mahadeva and Robinson, 2004). This means that the variable must be differenced (d) times to obtain a covariancestationary process. Therefore, individual time series properties of the variables should be considered. In our paper, the widely-used augmented Dickey-Fuller test (Dickey and Fuller, 1979) is applied to the Turkish data for testing the univariate non-stationary characteristics of the variables under the null hypothesis. We then compare the estimated ADF statistics with the MacKinnon (1996) critical values, which employ a set of simulations to derive asymptotic results and to simulate critical values for arbitrary sample sizes. For the case of stationarity, we expect that these statistics must be larger than the critical values in absolute value and have a minus sign. However, due to the low power of univariate unit root tests we will also apply below the multivariate stationarity tests yielded in a co-integrating framework. In Table 1 '$*$' and '$**$' denote the rejection of a unit root for the 1% and 5% critical values, respectively:

Table 1: Unit Root Tests

Variable	τ_C	τ_T	$\Delta\tau_C$	$\Delta\tau_T$
m1	-1.99(0)	0.78(0)	-6.79*(0)	-6.89*(1)
m2	-1.77(1)	0.29(1)	-5.00*(0)	-5.36*(0)
p	-1.72(0)	-2.16(1)	-3.11*(0)	-3.56**(0)
y	-0.06(8)	-2.39(8)	-2.98**(7)	-3.39**(7)
1% critical values	-3.52	-4.09		
5% critical vaues	-2.90	-3.47		

Above, τ_C and τ_T are the test statistics with allowance for only constant and constant&trend terms in the unit root tests, respectively. The numbers in parentheses are the lags used for the ADF stationary test and augmented up to a maximum of 10 lags. The choice of the optimum lag for the ADF test was decided on the basis of minimizing the Schwarz information criterion. 'Δ' denotes the first difference operator. Unit root test results indicate that the null hypothesis of non-stationarity cannot be rejected for all the variables in the level form both assuming only constant and constant&trend in the test equation. However, for the first differences the null hypothesis of a unit root is strongly rejected. Thus all the series are integrated of order 1, i.e., I(1), which have an invertible ARMA representation after applying to first differencing.

3.2. Econometric Methodology

Nelson and Plosser (1982) indicate that many macroeconomic time series data have a stochastic trend plus a stationary component, that is, they are difference stationary processes. It is also of great importance to discern the temporary and permanent movements in an economic time series. Economic theory in this line assumes that at least some subsets of economic variables do not drift through time independently of each other and some combination of the variables in these subsets reverts to the mean of a stable stochastic process.

Granger (1986) and Engle and Granger (1987) indicate that even though economic time series may be non-stationary in their level forms, there may exist some linear combination of these variables that converge to a long run relationship over time, which also requires the existence of Granger causality in at least one direction in an economic sense as one variable can help forecast the others. Following Johansen (1988) and Johansen and Juselius (1990), let us briefly assume a z_t vector of non-stationary n endogenous variables and model this vector as an unrestricted vector autoregression (VAR) involving up to k-lags of z_t:

$$z_t = \Pi_1 z_{t-1} + \Pi z_{t-2} + \ldots + \Pi_k z_{t-k} + \varepsilon_t \qquad (3)$$

where ε_t follows an i.i.d. process $N(0, \sigma^2)$ and z is (nx1) and the Πi an (nxn) matrix of parameters. Eq. 3 can be rewritten leading us to a vector error correction (VEC) model of the form:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2} + \ldots + \Gamma_k \Delta z_{t-k+1} + \Pi_{t-k} + \varepsilon_t \qquad (4)$$

where

$$\Gamma_i - I + \Pi_1 + \ldots + \Pi_i \,(i = 1, 2, \ldots, k\text{-}1) \text{ and } \Pi - I - \Pi_1 - \Pi_2 - \ldots - \Pi_k \qquad (5)$$

Eq. 4 can be arrived by subtracting zt-1 from both sides of Eq. 3 and collecting terms on z_{t-1} and then adding $-(\Pi_1 - 1)X_{t-1} + (\Pi_1 - 1)X_{t-1}$. Repeating this process and collecting of terms would yield Eq. 4 (Hafer and Kutan, 1994). This specification of the system of variables

carries on the knowledge of both the short- and long-run adjustment to changes in z_t, via the estimates of Γi and Π. Following Harris (1995), $\Pi = \alpha\beta'$ where a measures the speed of adjustment coefficient of particular variables to a disturbance in the long-run equilibrium relationship and can be interpreted as a matrix of error correction terms, while β is a matrix of long-run coefficients such that $\beta'z_{t-k}$ embedded in Eq. 4 represents up to (n-1) cointegrating relations in the multivariate model which ensure that z_t converge to their long-run steady-state solutions. Note that all terms in Eq. 4 which involve Δz_{t-i} are I(0) while Πz_{t-k} must also be stationary for $\varepsilon_t \sim$ I(0) to be white noise of an N(0, σ_ε^2) process. Gonzalo (1994) reveals that this method performs better than other estimation methods even when the errors are non-normal distributed or when the dynamics are unknown and the model is over-parameterized by including additional lags in the error correction model.

We now construct two unrestricted VAR models:

$$\beta'z_t : (m1, p, y) \sim I(0) \qquad\qquad (6)$$

$$\beta'z_t : (m2, p, y) \sim I(0) \qquad\qquad (7)$$

For the lag length of unrestricted VARs, we consider various information criterions to select appropriate model between different lag specifications, i.e., sequential modified LR statistics employing small sample modification, minimized Akaike information criterion (AIC), final prediction error criterion (FPE), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ). Considering the maximum lag of 5 for the unrestricted VAR models of quarterly frequency data and using the model with M1 monetary variable, LR, AIC, FPE and HQ criterions suggest to use 3 lag orders, while SC information criterion suggests 1 lag order. For the model with M2 monetary variable, LR, AIC, FPE and HQ criterions suggest to use 4 lag orders, while SC information criterion again suggests 1 lag order. Thus we choose the lag length of unrestricted VAR model with M1 monetary variable as 3 and with M2 monetary variable as 4. We add a set of centered seasonal dummies which sum to zero over a year as exogenous variable as well (Johansen, 1995). We must express that including any dummy or dummy-type variable will be able to affect the underlying distribution of test statistics so that the critical values for these tests are different depending on the number of dummies included (Harris, 1995). As a next step, we estimate the long run co-integrating

relationships by using two likelihood test statistics known as maximum eigenvalue for the null hypothesis of r versus the alternative of r+1 co-integrating relations and trace for the null hypothesis of r co-integrating relations against the alternative of n co-integrating relations, for r = 0,1, ..., n-1 where n is the number of endogenous variables.

3.3. Results

Table 2 and Table 3 below give the results in which a constant and long-run deterministic trend are restricted but no deterministic trend is assumed for dynamic VEC model:

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Table 2: Co-Integration Test (using M1 monetary aggregate)

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Null hypothesis	r=0	r≤1	r≤2
Eigenvalue	0.32	0.19	0.08
λ trace[1]	50.81*	22.00	6.26
5% critical value	42.92	25.87	12.52
λ max	28.81*	15.74	6.26
5% critical value	25.82	19.39	12.52

Unrestricted Co-integrating Coefficients

m1	p	y	trend
4.688591	-4.885396	-15.20693	0.188034
12.70363	-7.600178	7.973348	-0.774255
1.289271	0.481731	17.78630	-0.343653

Unrestricted Adjustment Coefficients (alpha)[2]

D(m1)	-0.014819	-0.017901	0.003302
D(p)	-0.027763	0.001773	-0.009082
D(y)	0.013048	-0.007721	-0.003892

1 Co-integrating Equation (t-stat. in parentheses): Log likelihood   399.1460

m1	p	y	trend	constant
1.000000	-1.041975	-3.243391	0.040105	22.92111
		(-6.52816)	(-2.99219)	(1.62838)

Adjustment coefficients

D(m1)	D(p)	D(y)
-0.069482	-0.130169	0.061178
(-2.37463)	(-4.10954)	(3.40257)

Multivariate Statistics for Testing Stationarity

	m1	p	y
$\chi^2(2)$	12.52520	11.21898	9.611451
Probability	0.001906	0.003663	0.008183

Homogeneity and Symmetry Restrictions on Co-integrating Coefficients

b(1,1) = 1, b(1,2) = -1, χ^2 (1) = 0.014567 Probability 0.903933

b(1,1) = 1, b(1,2) = -1, b(1,3) = -1, $\chi^2(2)$ = 3.881631 Probability 0.143587

1 '*' denotes rejection of the hypothesis at the 0.05 level.

2 'D' indicates the first difference operator

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Table 3: Co-Integration Test (using M2 monetary aggregate)

Null hypothesis	r=0	r≤1	r≤2
Eigenvalue	0.33	0.18	0.13
λ trace[1]	54.29*	24.94	9.99
5% critical value	42.92	25.87	12.52
λ max	29.35*	14.95	9.99
5% critical value	25.82	19.39	12.52

Unrestricted Co-integrating Coefficients

m2	p	y	trend
3.045462	-4.718991	-22.16688	0.416581
-9.079620	7.850534	-9.832335	0.348789
4.461430	-3.660320	-18.08751	-0.050724

Unrestricted Adjustment Coefficients (alpha)[2]

D(m1)	-0.016135	0.007808	-0.010327
D(p)	-0.023894	0.008499	0.010101
D(y)	0.014317	0.008191	0.000433

1 Co-integrating Equation (t-stat. in parentheses): Log likelihood 411.6727

m2	p	y	trend	constant
1.000000	-1.549516	-7.278659	0.136787	61.18190
		(-5.41828)	(-3.84917)	(3.06418)

Adjustment coefficients (alpha)

D(m2)	D(p)	D(y)
-0.049138	-0.072769	0.043602
(-2.89130)	(-3.63543)	(3.77921)

Multivariate Statistics for Testing Stationarity

	m2	p	y
$\chi^2(2)$	12.52520	11.21898	9.611451
Probability	0.002177	0.003663	0.008183

Homogeneity and Symmetry Restrictions on Co-integrating Coefficients

b(1,1) = 1, b(1,2) = -1, χ^2 (1) = 4.099696 Probability 0.042891
b(1,1) = 1, b(1,2) = -1, b(1,3) = -1, χ^2(2) = 7.481780 Probability 0.023733

[1] '*' denotes rejection of the hypothesis at the 0.05 level.
[2] 'D' indicates the first difference operator

From Table 2 and Table 3, both LR tests verify the existence of 1 potential co-integrating vector lying in the long-run variable space. Rewriting the normalized QTM upon the money supply variable m1 under the assumption of r = 1 and applying to the homogeneity and symmetry restrictions in line with the quantity theory yield below:

$$\beta'm1z_t = m1 - p - 2.955746y + 0.031482\text{trend} + 20.14965 \sim I(0) \tag{8}$$

$$\beta'm1z_t = m1 - p - y + 0.013470\text{trend} + 1.039779 \sim I(0) \tag{9}$$

The restrictions are well-accepted by the χ^2 tests. In Table 2, we accept the homogeneity restriction for only price level variable with $\chi^2(1) = 0.014567$ and for both price and output variables with $\chi^2(2) = 3.881631$ under the null hypothesis. Likewise, the normalized equation inclusive of m2 money supply variable can be given below:

$$\beta' m2z_t = m2 - 1.549516p - 7.278659y + 0.036787trend + 61.18190 \sim I(0) \qquad (11)$$

however, the symmetry and homogeneity restrictions here cannot be accepted under the usual significance levels which yield prob. values under 5%. Besides, both co-integrating vectors fit well with the data generating process in the VEC models using $LM_{m1}(4) = 8.339960$ (prob. 0.5003), $LM_{m2}(4) = 13.92969$ (prob. 0.1248), $Skew_{m1}(3) = 3.985083$ (prob. 0.2631), $Skew_{m2}(3) = 2.588502$ (prob. 0.4595), $Kur_{m1}(3) = 5.381375$ (prob. 0.1459), $Kur_{m2}(3) = 6.814683$ (prob. 0.0780), $JB_{m1}(6) = 9.366458$ (prob. 0.1540), $JB_{m2}(6) = 9.403185$ (prob. 0.1521), where LM is the 4th order VEC system residual serial correlation lagrange multiplier statistic under the null of no serial correlation, Skew the skewness, Kur the kurtosis, and JB is the Jarque-Bera VEC residual normality statistics assuming Cholesky orthogonalization of Lütkepohl (1991) under the null hypothesis that system residuals are multivariate normal thus indicating no significant outliers in the model. For the VEC system residual serial correlation test, probs. come from $\chi^2(9)$, and the values in parentheses for the system normality tests are the degrees of freedom (d.o.f) values considered. As for the non-stationarity of the variables, multivariate statistics for testing stationarity are in line with the univariate unit root test results obtained above in the sense that no variable alone can represent a stationary relationship in the co-integrating vector.

In Table 2 and Table 3, we find that estimation results are consistent with quantity theory for the signs of the variables in a significant way and long-run exclusion of the each variable from the stationary variable space can also be rejected. We are unable to reject the symmetry and homogeneity restrictions of the proportionality assumption for the model using M1 monetary aggregate. For the model using M2 monetary aggregate, we support a case of near-proportionality of money and prices but now not in a one-to-one way. Thus, these results yield a strong support to the ex-post stationary characteristic of the velocity of money leading to a stable functional relationship in line with the quantity theory.

However, we are unable to find both money supply variables as weakly exogenous in the long-run variable space. In both Table 2 and Table 3, all adjustment coefficients indicating feedback effects of disturbances from the steady-state functional forms and carrying the long-run knowledge from co-integrating vectors into the VEC models are found highly different from zero in a statistically significant way. Such a finding requires that VEC models upon all these endogenous variables can be constructed through error-correction mechanism. Following Ozmen (2003), no variable alone can be interpreted as the uni-directional forcing variable for the long-run evoluation of the other variables, and this imposes them an endogenous characteristic in the QTM long-run variable space. Ozmen attributes such a result to that this would contradict the QTM assumption that money is the sole forcing variable in the multivariate co-integrating system and he gives support to an endogenous money creation framework conditioned upon long-run courses of prices and real income. Thus, rejecting the weak exogeneity of both real income and money supplies considering a positive relationship does not support the neutrality hypothesis embedded in the quantity relationship. For the design of monetary policy, a possible explanation can be brought out such that monetary authority seems to follow an accommodative monetary policy inside the period given the endogenous characteristics of the monetary variables. These all would weaken the discretionary policy role of money in the conduct of future stabilization policies.

Given that Johansen methodology of extracting co-integrating relationships does not suffer from normalization problems, we below re-normalize the co-integrating equations upon the real income variable to examine the knowledge of money (non-)neutrality more explicitly in a long-run stationary relationship (t-stats. in parenthesis):

$$y = 0.308319m1 - 0.321261p + 0.012365trend + 7.067020 \qquad (10)$$
$$(1.71384) \qquad (2.84503) \qquad (1.01937)$$
$$y = 0.137388m1 - 0.212885p + 0.018793trend + 8.405655 \qquad (11)$$
$$(1.94353) \qquad (2.33529) \qquad (3.42313)$$

As can be seen from Eq. (10) and Eq. (11), a 1% increase in the M1 and M2 money supplies would lead significantly to a 0.31% and 0.14% increase in the real output, respectively. Having established the main theoretical model and tested assumptions on which the theory is

constructed, we now try to test the (super)neutrality of money. Following Grauwe and Polan (2005), for the (super)neutrality condition to hold, a permanent increase in the growth rate of money must leave output unaffected in the long-run. If there is a positive effect of money growth on output, it only holds in the short run. To test this proposition, we estimate the following equation:

$$\Delta y = \alpha + \delta ec\text{-}1 + \beta \Delta m + \varepsilon \tag{12}$$

where, Δy is the growth rate of real output and Δm the growth rate of money supply, both expressed in log differences, and e is again $N(0, \sigma^2)$ white-noise error term. The OLS results including stationary knowledge of long-run relationship yielded in co-integration analysis with one period lagged error correction term (ec_{-1}) are given below:

Table 4: Ols Estimation Results For (Super) Neutrality Of Money

White HCSE&Covariance		Included observations: 78 after adjustments		
Variable	Coefficient	Std. error	t-statistic	p-value	Wald tests (β = 1) (p-value = 0.0954)
Constant	-0.164063	0.045066	-3.640532	0.0005	
ec_{-1}	-0.652662	0.079150	-8.245883	0.0000	
Δ_{m1}	1.535477	0.316854	4.846011	0.0000	
Adj. R^2	0.388192	D-W stat.		2.200296	
S.E. of reg.	0.202600	F-stat. (prob.)		24.15920 (0.000000)	

Results in Table 4 and Table 5 reveal that we reject the (super)neutrality condition for both M1 and M2 money supply measures. Changes in the growth rate of money supply lead to a significant increase in the real output growth rate. We must note that we have just the same results for the model using M1 money supply when we exclude the lagged error correction term from the regression, but for the model using M2 money supply we find highly insignificant results in an econometric sense.

Table 5: Ols Estimation Results For (Super) Neutrality Of Money

White HCSE&Covariance Included observations: 78 after adjustments

Variable	Coefficient	Std. error	t-statistic	p-value	Wald tests ($\beta = 1$) (p-value = 0.8871)
Constant	-0.101773	0.047114	-2.161065	0.0341	
ec_{-1}	-0.733359	0.085929	-8.534517	0.0000	
Δ_{m2}	0.954181	0.321647	2.966542	0.0041	
Adj. R^2	0.312469	D-W stat.		2.155180	
S.E. of reg.	0.217776	F-stat. (prob.)		16.13402 (0.000002)	

4. Concluding Remarks

One of the main fundamental building blocks of the economics theory is the quantity theory of money (QTM) relating the prolonged increases in prices to the increases in nominal quantity of money. Based on an a priori assumption of stability of the functional relations affecting the quantity of money demanded, the basic postulate of the QTM is that the variations in the velocity of money can be foreseen and explained by the economic agents considering a stationary economic relationship for the various phases of business cycles.

In this paper, we examined the validity of the QTM relationship for the Turkish economy and applied to an empirical model testing whether the assumptions related to the quantity theory can be supported by the Turkish data. Employing some contemporaneous estimation techniques such as multivariate co-integration analysis of the same order integrated variables, our ex-post findings indicate that a stationary long-run QTM relationship can be constructed in the long-run variable space, verifying the stationary characteristics of the velocities of narrowly and broadly defined monetary aggregates leading to a stable functional relationship in line with the quantity theory. Besides, we are unable to reject the symmetry and homogeneity restrictions of the proportionality for the model using M1 monetary aggregate

and support a case of near-proportionality of money and prices for the model using M2 monetary aggregate.

However, we cannot find both money supply variables as weakly exogenous in the long-run variable space. This requires that money should be taken endogenous for the long-run evolution of prices and real income, thus money cannot be considered the only forcing variable in the multivariate co-integrating system. For the design of monetary policy, a possible explanation can be brought out such that monetary authority seems to follow an accommodative monetary policy inside the period given the endogenous characteristics of the monetary variables. These all would weaken the discretionary policy role of money in the conduct of future stabilization policies. Finally we examined briefly the (super)neutrality condition of money assuming unaffected real output level in the long-run following the permanent changes in the growth rate of money supply. Our estimation results revealed that changes in the growth rate of M1 and M2 money supplies lead to a significant increase in the real output growth rate.

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