Quantity theory of money: the hypothesis of the dichotomy between relative prices and absolute prices

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Abstract: This paper aims to investigate the impact of a change in the quantity of money on relative prices based on quarterly time-series for the period 1959-2013 of the U.S. economy. The econometric results show evidence that a change in the money supply affects the relative prices. This result does not corroborate the assumption that changes in relative prices only occur due to changes in real variables, but changes in relative prices also occur via changes of the money stock. In this sense, there is no empirical evidence that the hypothesis of the dichotomy between relative prices and absolute prices is valid.

Key Words: Quantity theory of money, relative prices, absolute prices, dichotomy.

JEL: E51, E52

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Teoria quantitativa da moeda: a hipótese da dicotomia entre preços relativos e preços absolutos

Resumo: *Este artigo investiga o impacto de uma mudança na quantidade de moeda sobre os preços relativos com base em dados trimestrais no período de 1959 a 2013 na economia americana. Os resultados econométricos mostram evidencias de que mudanças na quantidade de moeda afetam os preços relativos. Este resultado não corrobora a hipótese de que mudanças de preços relativos ocorre somente devido a mudanças em variáveis reais, pois também ocorre devido a variações no estoque de moeda. Nesse sentido, não há evidencias empíricas de que a hipótese da dicotomia entre preços relativos e absolutos é validada.*

Palavras chave: *Teoria quantitativa da moeda, preços relativos, preços absolutos, dicotomia.*

JEL: E51, E52

Introduction

One of the postulates of the quantity theory of money is the dichotomy between relative prices and absolute prices, which postulate that changes in real variables such as GDP, employment level, etc. explain changes in relative prices, while changes in the money supply, in a stationary fully employed economy, cause the absolute price movements. This dichotomy means that given the stock of money, the velocity of money and given the level of trade in goods, changes induced by a real shock in the relative prices, produce compensatory changes in other relative prices, so that the absolute level of prices remain unchanged (Humphrey,1997 and Fisher ([1911] 1963).

Using quarterly data from 1952:2 to 2013:02, we perform an econometric analysis to evaluate the direct effect of the change in the stock money on the change in the relative prices.

1. Methodological aspects

In this section, we introduce the empirical models that evaluate if a change in the quantity of money really produces effects on change in the relative prices. For that, we estimate systems of simultaneous equations.

Let us assume a Cobb-Douglas production function, which the real output q is function of a fixed capital stock $\overline{k}$ and the quantity of labor l such as $q = l^{\alpha}\overline{k}^{1-\alpha}$. Taking logarithms of both sides of this function and, after that, derivative it with respect to time, we obtain $Y_t = \alpha L_t$, where Y_t is growth rate of real production and L_t is growth rate of labor. We can express this deterministic equation in form of stochastic equation as shown below

$$Y_t = \beta_0 + \sum_{i}^{m} \phi Y_{t-i} + \beta_1 L_t + v_t \tag{1}$$

where *m* is the number of lags of the dependent variable and v_t is the residual term. We estimate the second equation such as

$$\begin{aligned}(P_i/P_j)_t &= \gamma_0 + \sum_{i}^{n} \alpha_i (P_i/P_j)_{t-1} + \gamma_1 M_t + \gamma_2 Y_t + \gamma_3 U_t \\ &+ \gamma_4 D(60,70) + \gamma_5 D(60,70) + \gamma_5 D(60,70) * M_t + u_t\end{aligned} \tag{2}$$

where *n* is the number of lags of the dependent variable, M_t is the change in the money supply, Y_t is the change in the real GDP, U_t is the unemployment rate and $(P_i/P_j)_t$ identifies the change in the relative prices and u_t is the error term. Observe that if γ_1 or γ_5 are statistically significant, then the hypothesis of dichotomy between relative prices and absolute prices is not valid.

The parameters ϕ and α in the autoregressive components tries to capture the inertia in the dynamics of the dependent variable. The basic hypothesis behind the equation (2) shows that the relative price change only suffers directly influence from the change of the quantity of money and from the real sector of the economy that is given by the change of real output and unemployment rate. Besides, there is the indirect effect which the variations in the employment level on the change of real output according to equation (1), which in turn affect the change of relative prices via equation (2). This effect occurs by interactive term $\beta_1\gamma_2$. We also assume that $c(u_t, v_t) \neq 0$.

Regarding inflation control, Romer and Romer (2004) consider two schemes for the conduction of monetary policy from the year of 1950 on. The fifties and from 1980 onwards are considered periods in which the monetary regimes adopted by Fed are associated to a monetary policy with low tolerance to accommodate inflation. On the other side, the period between 1960 to the late seventies are associated to a regime with high tolerance to inflation. In this context, we use a dummy for the period 1960 - 1970, $D(60,70)$ and also an interactive variable that shows the impact of changes in the money supply during the period of greater tolerance for inflation $(D(60,70)*M)$.

The equations (1) and (2) define a simultaneous equations model. Due to a possible endogeneity problem, we apply the generalized method of moments (GMM). Needless to say that GMM requires the employment of instrumental variables (IV). For the appropriate use of the IV method, it is necessary that the instruments are "good instruments" in order to be relevant and valid.

This implies that the instruments must be not only correlated with the endogenous regressors but also orthogonal to the disturbance. Our econometric specification apply the following tests: The test of underidentification (Cragg and Donald, 1993), the test of over-identifying Sargan-Hansen also known as J-statistic, and the Stock-Yogo test (Stock and Yogo, 2005) to verify the hypothesis of weakness of instruments.

Finally, when the variables are not stationary, specific problems arise in conventional inference based on ordinary last squares (OLS) regressions. Johnston and DiNardo (1997) stress the importance of knowing whether similar problems occur in the context of two-stage least squares regressions. Notwithstanding, Hsiao (1997a,b) analyses this issue and concluded that the inference with two-stage last square estimators using instrumental variables remains valid, even when time series are non-stationary or non-co-integrated. In that context, Hsiao's conclusions also are valid when GMM is applied.

In order to take into account the two problems of unknown heteroskedasticity and the serial correlation of the residuals, we use the procedure of Newey and West (1987a,b) for all estimated models. The authors have proposed a more general covariance estimator that is consistent in the presence of both heteroskedasticity and autocorrelation of an unknown form. Table 1 displays the description of variables.

TABLE 1 – DESCRIPTION OF AGGREGATE VARIABLES

Series ID	Acronym	Title	Units
GDPC1	GDP	Real Gross Domestic Product	Billions of Chained 2009 Dollars
M2SL	$M2$	M2 Money Stock	Billions of Dollars
CPITRNSL	P_i	Consumer Price Index for All Urban Consumers: Transportation	Index 1982-84 =100
CPIMEDSL	P_j	Consumer Price Index for All Urban Consumers: Medical Care	Index 1982-84 =100
CUUR0000SEHA	P_i	Consumer Price Index for All Urban Consumers: Rent of primary residence	Index 1982-84 =100
PPIFGS	P_j	Producer Price Index: Finished Goods	Index 1982 =100
CEU0500000001	l	All Employees: Total Private	Thousands of Persons
LNS14000024	U	Unemployment Rate - 20 years and over	Percent
GDPPOT	$\tilde{Y}$	Real Potential Gross Domestic Product	Billions of Chained 2005 Dollars

Source: FRED

2. Econometric results

This section presents the econometric results of the estimated model defined by equations (1)-(2). For that, we used estimated through generalized method of moments (GMM). As we pointed out in last section, we have four systems of equations each one composed by two equations. Table 2 displays the regressions according to equation 1, i.e., the models 1A, 2A, 3A and 4A.

The results show that for any of these models all variables are statistically significant at the 5% level. The J-statistics, based on p-values higher than 0.99, do not provide evidence to reject the hypothesis of overidenfication. Hence, the model specification is not rejected.

Tables 2 also shows the Stock-Yogo test. The F statistic indicates evidence for the rejection of the null hypothesis of weak instruments. The value of Cragg-Donald F-statistic is 62.33 and the Stock-Yogo critical values TSLS at 5% level of significance is 21.42.

TABLE 2 – ESTIMATION METHOD: GMM (EQUATION 1)

Dependent variable: $Y\%$ (real GDP)				
	Model 1A	Model 2A	Model 3A	Model 4A
Variables	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)
Constant	0.004933* (0.000182)	0.004905* (0.000177)	0.004795* (0.000259)	0.004758* (0.000194)
Y_{t-1} %	0.308677* (0.021139)	0.307712* (0.021225)	0.313248* (0.028052)	0.296930* (0.021706)
E_t %	0.087857* (0.013820)	0.086935* (0.013892)	0.090330* (0.017177)	0.098420* (0.014196)
Adjusted R-squared	0.139092	0.139189	0.138741	0.137762
J-Statistics [p-value]	0.190464 [0.995]	0.187452 [0.995]	0.189573 [0.995]	0.213980 [0.997]
Included obs.	207	207	207	207
Weak Instrument Diagnostics				
Stock-Yogo test	Cragg-Donald F-statistic	62.33	Critical values (relative bias) 5%	21.42

Note 1: * p-value $\leq$ 0.01; ** p-value $\leq$ 0.05; *** p-value $\leq$ 0.10; (SE) = Standard Error. Note 2: Instruments $Y(-1 to -10), E(-1 to -10), U(-1 to -6), \tilde{Y}$

Table 3 shows the estimates of the Models 1B, 2B, 3B and 4B according to equation (2). The basic model 1B shows that the dependent variable is explained by the lag of changes in relative prices and by the rates of change in the money supply and of real product. The other models have other additional variables in order to observe the consistency of the estimated results. The model 2B includes to the unemployment rate, while the 3B model adds the monetary regime dummy and the interactive variable D(60.70)*M and disregards the rate of unemployment. The 4B model includes all variables.

The empirical results presented in models 1B to 4B show that all explanatory variables are statistically significant at the 5% level, except the growth rate of the money supply of the 1B model. The estimated coefficients of the intercepts of the equations 2B and 3B are not statistically significant as well.

The empirical results show that real variables such as the rates of change in the real product and unemployment rate partially explain the rates of change in the relative prices, since the monetary variables also explain.

The coefficients of the rates of change in the money supply is positive in model 2B and negative in models 3B and 4B. The difference between these models is that the last two models include the dummy of monetary regimes and the interactive variable $D(60,70)*(M)$.

The dummy variable, $D(60,70)$, and the interaction variable $D(60,70)*(M)$ show negative and positive signs, respectively, for specifications presented in tables 3B and 4B. Based on elasticity coefficients, this means that in periods that the Fed was more tolerant to high inflation rates, the positive effect was higher on the variation of this specific relative price than in period of lower tolerance to inflation.

We can also analyze the indirect effects of real variables shown in Table 2 on the relative prices via systems of equations shown in tables 2 and 3 $(\beta_1\gamma_2)$.

TABLE 3 – ESTIMATION METHOD: GMM (EQUATION 2)

Dependent variable: $(P_i / P_j)_t$ % = (Consumer Price Index for All Urban Consumers: Transportation / Consumer Price Index for All Urban Consumers: Medical Care)

	Model 1B	Model 2B	Model 3B	Model 4B
Variables	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)
Constant	-0.007860* (0.001544)	0.005502 (0.006940)	-0.001044 (0.001973)	0.016447* (0.006008)
P_{t-1} %	0.232816* (0.042232)	0.226620* (0.042005)	0.263709* (0.049486)	0.246042* (0.035369)
M_t %	0.098984 (0.069501)	0.152251** (0.060702)	-0.344781* (0.060702)	-0.344435* (0.087800)
Y_t %	0.296274* (0.032815)	0.308243* (0.037834)	0.245788* (0.059047)	0.214176* (0.049747)
U_t %	–	-0.002508* (0.001186)	-	-0.003072* (0.001042)
D(60,70)	–	–	-0.012303* (0.004094)	-0.014102* (0.002998)
D(60,70)*M	–	–	0.768070* (0.236689)	0.908819* (0.175521)
Adjusted R-squared	0.032253	0.016496	0.085920	0.076992

Note: * p-value $\leq$ 0.01; ** p-value $\leq$ 0.05; *** p-value $\leq$ 0.10; (SE) = Standard Error

We also estimate systems of simultaneous equations for other relative price according to Tables 4 and 5. The results confirm that monetary variables affect relative prices.

TABLE 4 – ESTIMATION METHOD: GMM (EQUATION 1)

Dependent variable: $Y\%$ (real GDP)				
	Model 1A	Model 2A	Model 3A	Model 4A
Variables	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)
Constant	0.005086* (0.000347)	0.004944* (0.000178)	0.005068* (0.000291)	0.005085* (0.000295)
Y_{t-1} %	0.310372* (0.036140)	0.314553* (0.015293)	0.296333* (0.034399)	0.296921* (0.034469)
E_t %	0.079938* (0.022491)	0.091568* (0.014065)	0.085732* (0.018797)	0.085957* (0.018784)
Adjusted R-squared	0.138937	0.138445	0.139263	0.139208
J-Statistics [p-value]	0.160600 [0.975]	0.211296 [0.998]	0.127828 [0.900]	0.127387 [0.950]
Included obs.	207	207	207	207
Weak Instrument Diagnostics				
Stock-Yogo test	Cragg-Donald F-statistic	62.33	Critical values (relative bias) 5%	21.42

Note 1: * p-value $\leq$ 0.01; ** p-value $\leq$ 0.05; *** p-value $\leq$ 0.10; (SE) = Standard Error. Note 2: Instruments $Y(-1to-10), E(-1to-10), U(-1to-6), \tilde{Y}$

TABLE 5 – ESTIMATION METHOD: GMM (EQUATION 2)

Dependent variable: $(P_i / P_j)_t$ % = (Consumer Price Index for All Urban Consumers: Rent of primary residence / Producer Price Index: Finished Goods)

Model 1B	Model 1B	Model 2B	Model 3B	Model 4B
Variables	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)	Coefficient (S.E)
Constant	0.005201* (0.001361)	-0.000431 (0.002480)	0.009437* (0.002210)	0.005936 (0.005728)
P_{t-1} %	0.592029* (0.064378)	0.609572* (0.038515)	0.535920* (0.077172)	0.548217* (0.083744)
M_t %	-0.224031* (0.078029)	-0.296236* (0.021804)	-0.500624* (0.152162)	-0.527806* (0.162071)
Y_t %	-0.154031* (0.030984)	-0.125387* (0.012631)	-0.194193* (0.031733)	-0.190047* (0.032519)
U_t %	–	0.001164* (0.000414)	-	0.000698 (0.001073)
D(60,70)	–	–	-0.011567** (0.004546)	-0.011459** (0.004537)
$D(60,70)*M_t$%	–	–	0.673458** (0.265638)	0.664696** (0.265112)
Adjusted R-squared	0.196253	0.170908	0.114695	0.102187

Note: * p-value $\leq$ 0.01; ** p-value $\leq$ 0.05; *** p-value $\leq$ 0.10; (SE) = Standard Error

Conclusions

The quantity theory of money assumes that relative price changes are caused only by real variables. The empirical results show that changes in relative prices stem not only from changes in real variables, but also from changes in the money stock. In this sense, there is no empirical evidence that the hypothesis of the dichotomy between relative prices and absolute prices is valid.

If monetary policy generates changes in relative prices, we can infer that it also alters the allocation of production factors. In this sense, the money cannot be neutral in long run and further studies should be conducted into the impact of the changes in relative prices on real variables de long run. Furthermore, this finding has serious implications that must be considered in the transmission mechanisms of monetary policy. In other words, if money affects relative prices, policymakers have a major complicating factor to manage monetary policy.

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