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STOCK PRICES AND MONETARY POLICY: AN IMPULSE RESPONSE ANALYSIS

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Abstract

This paper analyses the relationship between monetary policy and the stock market with the aim of gaining new insights into the transmission mechanism of monetary policy. The empirical findings shed light on the importance of stock prices for money demand and therefore provide useful information to monetary authorities deciding on policy actions. A technique developed by Wickens and Motto (2001) for identifying shocks by estimating a VECM for the endogenous variables is employed. The reported evidence suggests that stock markets play a significant role in the money demand function.

Key words: *Asset Prices, Stock Market, Monetary Policy, Impulse Response Analysis, VECM, VAR*

JEL classifications: *E41, E52*

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1. Introduction

Asset price movements can affect the real economy significantly. For instance, from the late 1990s until the beginning of the "Credit Crunch" in 2007, households felt wealthier as their stock portfolio increased in value. This "wealth effect" boosted their consumption expenditure, which accounts for about two thirds of GDP in some advanced economies such as the US and the UK.

Many central banks aim to keep inflation low while promoting sustainable real growth. Given the fact that swings in asset prices can affect both goals, some economists have argued that monetary authorities can improve macroeconomic performance by responding directly to them (Lansing, 2003). In the macroeconomic literature there is a wide consensus that monetary policy can influence the real economy. For instance, Taylor (1995) and MacLennan et al. (1998) reported that monetary policy actions can cause real output movements lasting for over two years. However, there is less agreement on the relationship between stock price movements and monetary policy, and in particular on the impact of the former on money demand and in turn on economic activity. Is the demand for money independent from asset price movements? Should central banks react directly to stock price movements, especially at times of very volatile stock prices? Some economists (e.g., Bernake and Gertler, 1999, Ioannidis and Kontonikas, 2006) are in favour of inflation targeting and argue that, by focusing on inflationary or deflationary pressures, a central bank effectively minimises the negative side effects of short-run, extremely volatile stock price movements, without having to target them directly. The interest rate should therefore be set on the basis of the difference between actual and forecast inflation, and monetary policy should react to stock prices only if they influence expected future inflation, otherwise it may induce higher inflation volatility and macroeconomic instability. As Bernanke and Gertler (2001, p. 253) put it, "Inflation targeting central banks automatically accommodate productivity gains that lift stock prices, while offsetting purely speculative increases or decreases in stock values whose primary effects are through aggregate demand".

Several studies have analysed the relationship between asset price movements and economic activity and treated the former as exogenous, arguing for an inflation targeting framework with monetary authorities reacting to asset price fluctuations only to the extent that they affect the central bank's inflation forecast. Mishkin (2001) surveyed the transmission mechanisms of monetary policy other than the standard interest rate channel by focusing on how monetary policy affects the economy through other asset prices, such as stock prices. He found that these play an important role, but targeting them might increase inflation volatility. However, in a more recent study, Bernanke and Kuttner (2005) argued that the stock market is an independent source of macroeconomic volatility to which policy makers might need to respond in order to reduce inflation volatility.

By contrast, Cartensen (2004), Cecchetti et al. (2000) and Masih and De Mello (2009) took the view that policy makers should give more consideration to asset price movements to reduce the risk of economic instability resulting from boom and bust in business cycles. Cecchetti et al., (2000), for example, argued that monetary authorities should take into account asset price movements with the aim of achieving macroeconomic stability. Carstensen (2004) in his study of the relationship between the stock market downswing and the stability of EMU money demand found that the persistently high money growth rates in EMU countries since 2001 led to instability of money demand functions neglecting stock market influences, implying a possible relationship between stock price movements and money demand. Alexander (2002) argued that reacting to non-fundamental (e.g. fluctuations in stock prices due to irrational behaviour by investors) shocks to stock prices leads to more stability in macroeconomic variables such as investment and output. Filardo (2004) suggested that monetary policy should step in only when asset price bubbles have negative macroeconomic implications.

Masih and De Mello (2009) estimated a money demand function including real stock prices for Australia. They found that stock prices have a positive income effect: higher stock prices imply higher portfolio risk and return, thereby increasing the demand for money. Choudhry (1996) investigated the relationship between stock prices and the long-run money demand function in Canada and USA during 1955 - 1989, finding that stock prices play a significant role in the determination of stationary long-run demand functions in both countries. Finally, Caruso (2001) analysed a panel of 25 countries and also time series data for six developed countries (France, USA, UK, Japan, Switzerland and Italy) and found that periods of asset inflation and deflation have systematic influences on money demand.

This paper aims to shed further light on the relationship between stock price movements, demand for money and monetary policy in the UK, the US and Germany by investigating the links between stock price movements and demand for money. We employ a method recently developed by Wickens and Motto (2001) for identifying shocks. Their approach is based on adopting for the endogenous variables a VECM specification, which incorporates long-run restrictions derived from economic theory, and estimating a VAR model in first differences for the exogenous variables. Impulse responses to the *structural* shocks can then be estimated without requiring any arbitrary restrictions other than those necessary for identifying the shocks to the exogenous variables. Such impulse responses lend themselves to economic interpretation and are suitable for policy analysis, in contrast to alternative methods used in the earlier empirical literature.

The layout of the paper is as follows. Section 2 discusses the identification of demand shocks and outlines the econometric approach taken in the present study. Section 4 presents the empirical findings. Section 5 offers some concluding remarks and highlights the policy implications of our findings.

2. Methodology

Recent studies such as Caruso (2006), Carstensen (2004) and Masih and De Mello (2009) have employed cointegrated VAR models to examine the long-run relationship between stock price movements and demand for money. However, serious objections can be raised against the standard VAR methodology used to analyse demand shocks. Firstly, there is the issue of misspecification because of the omission of important variables. Previous results could be misleading because they ignored the significance of stock prices in the conduct of monetary policy. The second issue is the identification of the structural parameters. It is standard practice to achieve it by assuming that there is simultaneous feedback only from the interest rate, prices and real per capita income (or wealth) to money demand (and not *vice versa*), which is consistent with a number of theoretical models, and by imposing restrictions on the interest rate, prices and income block. To compute the impulse response functions the disturbances from the moving average (reduced form) representation of the model are then orthogonalised using the Choleski decomposition. Forecast error variance decomposition is also routinely carried out. There are two obvious problems with this approach (see Pesaran and Smith, 1998). Firstly, the impulse responses are obtained using *orthogonalised* errors, not the *structural* or even *reduced form* errors. Secondly, this procedure involves choosing a particular ordering of variables. Consequently, different estimates of the impulse responses will be obtained depending on what ordering is adopted. In fact, the assumptions needed in this context to identify the responses are equivalent to traditional identification assumptions. A possible alternative is to impose *a priori* restrictions on the covariance matrix of the structural errors and the contemporaneous and/or long-run impulse response functions themselves, as in the *Structural VAR* approach. However, this method typically involves assuming that the structural errors are uncorrelated, which is not plausible in many cases, and requires a high number of restrictions, which makes its implementation possible only in the case of very small systems.

Recent methodological developments aim at addressing the issues highlighted above. In particular, Garratt, Lee, Pesaran and Shin (2003) have attempted to tackle the identification problem, namely the fact that in the presence of multiple cointegrating vectors the estimated vectors cannot be interpreted as identifiable long-run relations unless additional restrictions are imposed. Their approach is to restrict the cointegrating space and then use a constrained maximum likelihood estimator instead of the standard Johansen estimator. However, this leaves the problem of identifying the shocks unsolved. Pesaran and Shin (1998) have advocated *generalized impulse response* analysis for unrestricted vector autoregressive (VAR) and cointegrated VAR models. This has two major advantages, namely: (i) it does not require orthogonalisation of the shocks; (ii) it is invariant to the ordering of the variables in the VAR. The derived impulse responses are unique, and also take into account the historical patterns of correlations observed amongst the different shocks. They coincide with the orthogonalised responses only in the special case when the variance/covariance matrix is diagonal – usually, they are substantially different.

However, as pointed out by Wickens and Motto (2001), it is not possible to give an economic interpretation to the "persistence profiles" (i.e. the response of the error correction terms to shocks to the disturbances of the cointegrating VAR - CVAR) estimated in this way. This would require imposing restrictions on the disturbances of the CVAR, so as to be able to compute impulse responses to the structural shocks. They suggest, therefore, an alternative methodology. Specifically, this involves adopting for the endogenous variables a VECM specification, which incorporates long-run restrictions derived from economic theory, and estimating a VAR model in first differences for the exogenous variables. The full system then includes both sets of equations, and can be used to compute impulse responses to the *structural* shocks, without requiring any arbitrary restrictions other than those necessary for identifying the shocks to the exogenous variables. The estimated impulse responses then have an economic interpretation and are suitable for policy analysis.

The method relies on the assumption that it is possible to decide which variables are endogenous and which are exogenous. The endogenous ones are determined by a structural simultaneous equation model (SEM):

$$B(L)\gamma_t + C(L)\chi_t + Rd_t = e_t \qquad (1)$$

where γ_t is a $\rho \times 1$ vector of endogenous variables, χ_t is a q $\times$ 1 vector of exogenous variables, both being I(1), and d_t represents a vector of deterministic variables.

If s_t is an r $\times$ 1 vector of stationary endogenous variables, equation (1) becomes

$$F(L)s_t + B(L)\gamma_t + C(L)\chi_t = e_t \qquad (2)$$

Assuming that the equation for the stationary variables takes the form

$$J(L)\Delta s_t + G(L)\Delta y_t + H(L)\Delta\chi_t + M_{s_{t-1}} + K\beta' z_{t-1} = \varepsilon_t \qquad (3)$$

and assuming that the exogenous variables are generated by

$$D(L)\Delta x_t + E(L)\Delta y_{t-1} = Sd_t + \varepsilon_t \qquad (4)$$

Defining the vectors $y_t^* = (s_t' y_t')'$ and $Z_t^* = (s_t' y_t' x_t')'$ allows (2) to be written as

$$\left[F(0)B(0)C(0)\right]\Delta z_t^* = \left[F(1)I\right]\beta' z_{t-1}^* + \left[\widetilde{F}(L)\widetilde{B}(L)\widetilde{C}(L)\right]\Delta z_{t-1}^* + e_t \qquad (5)$$

where the roots of $\left[j(L)(1-L)+ML\right]=0$ lie outside the unit circle.

The complete system is given by combining (4) and (5), and can be written as a CVAR, namely

$$\Delta z_t^* = -\alpha^* \beta^{*\prime} z_{t-1}^* + A^*(L)\Delta z_{t-1}^* + v_t^* \tag{6}$$

Note that equation (6) is not a standard cointegrated VAR, as it contains equations for the stationary as well as the non-stationary variables.

The sub-system of equations for the combined stationary and non-stationary endogenous variables can then be written as

$$\Delta y_t^* = -B^*(0)^{-1} C^*(0)\Delta x_t - B^*(0)^{-1} w_{t-1}^* + B^*(0)^{-1}\left[\widetilde{B}^*(L)\widetilde{C}^*(L)\right]\Delta z_{t-1}^* + e_t^* \tag{7}$$

Both equation (7) and the equations for the exogenous variables can then be estimated by OLS, and impulse response functions can be calculated from equation (6).

3. Data and Empirical Results

The selected countries are the UK, the US and Germany. Following the work of Choudhry (1996) we specify the money demand function as:

$$\left(\frac{M}{P}\right)^d = f(i, y, sp)$$

The demand for real money balances is being modelled as a function of the interest rate, real income and stock prices. The model is estimated using quarterly data for the period 1992Q1 to 2008Q3. We use broad measures of the nominal money stock, namely M2, M3 and M4 respectively, and nominal GDP, all deflated using the CPI.

Following the work of Gottschalk (1999) and Clausen and Kim (2000) we include both short-term rates (3-month money market) and long-term rates (10-year Treasury bond yield) as a measure of the opportunity cost. The stock price indices used are the FTSE 100 for the UK, the DAX 100 index for Germany and the Dow Jones 100 for the US. The data sources are Datastream, and publications of the ONS, the OECD, the Bank of England and the Bundesbank. Real stock prices are constructed using the CPI. All variables are in (natural) logarithms, except the interest rates, which are in levels. A cointegrated VAR is estimated as a vector error-correction model (VECM) to identify impulse response functions. ADF tests indicate that interest rates are stationary (or I (0)) series whilst the other variables are non-stationary or I (1) (see Unit Root results, Table 1). We employ the Johansen (1988) and Johansen and Juselius (1990) cointegration tests to check if the logs of stock index, 3-month Treasury bills, 10-years government bonds and money demand are cointegrated. The test results (see Table 2) do not reject the null hypothesis of one cointegrating relationship among the variables. We estimate a VECM in each case (see Tables 3, 4, and 5) to analyse both the long- and short-run relationships among the variables of interest. The model is specified with Δmp_t as the dependent variable and the following explanatory variables: $\Delta mp_{t-1}, \Delta y, \Delta st, \Delta lt, \Delta ms, and \Delta \upsilon_t$, which stand respectively for lagged demand for real money balances, the first difference of real income, the short-term interest rate, the long-term interest rate and the first difference of real stock prices.

Figures 1 displays the estimated impulse responses. Following a one standard deviation shock to the long-term interest rate money demand appears to decline, though this varies across countries (it falls more sharply in Germany than in the UK and the US). It falls immediately in the UK and Germany and in the short run (i.e. for 8 quarters) in the US. In both the UK and the US the economy reaches a lower steady state after 8-10 quarters, whilst in Germany this takes around 24 quarters. High debt levels of the corporate sector may explain this strong sensitivity to interest rates. The influence of monetary policy on firms depends on their liabilities. High debt levels can cause high negative cash-flow effects and intensify credit constraints. Given the high level in Germany, German firms should suffer comparatively more than those in the UK and the US. These results are also consistent with the fact that credit is indexed using short-term interest rates in the UK and the US (for example, 73% of all credit is short-term in the UK - see Borio, 1995), and long-term interest rates instead in most of the other EU countries including Germany.

As for the effect of a one standard deviation shock (increase) to the short-term interest rate, the demand for money decreases rapidly in all countries, all of them moving to a lower steady-state within the first 3 quarters, this being lower in the UK compared with the US and Germany. For the UK this is a common finding, in line with monetarist and Keynesians theories, suggesting that a monetary contraction leads to a decline in asset prices. High yields are expected from bonds when interest rates are high, which leads to a fall in bond prices.

The same money demand function was used to assess the effects of shocks to real stock prices on the money stock. A one standard deviation shock (increase) is again considered. This is found to result in a rise in money demand in the three countries examined, all reaching the new steady state at a fast rate, 15 quarters in the UK and only 6 in Germany. In the US, real stock price movements have been the dominant variable influencing money demand, which is evidenced by the higher steady state compared with the UK and Germany. These findings support the existence of a wealth effect in the demand for money, which is influenced positively by real stock price movements in all countries under study: therefore, stock markets play a significant role. A possible explanation is that higher stock prices with higher trading volume may require larger amounts of money for transactions and consequently increase demand for money. Moreover, Caruso (2006) argues that as the trading volume raises both market volatility and uncertainty more will have to be traded in order to rebalance portfolio risks resulting in a higher demand for money, mainly for precautionary purposes.

The impulse response analysis, again based on a one standard deviation shock (increase) to the short-term interest rate, shows that stock prices move to a new equilibrium, lower in the US and the UK, but higher in Germany. On the one hand higher interest rates, due to their positive relationship with the inflation rate, should adversely affect stock prices. On the other hand, it may be the case that they signal a recovery in the economy resulting in higher corporate earnings and stock prices. Furthermore, with rising inflation households tend to invest some of their income in the stock markets to alleviate the effects of inflation.

4. Conclusions

This study has provided evidence on the significant role played by stock price movements in the demand for money in three developed economics (Germany, the US and the UK). The analysis distinguishes carefully between the role of short-term and long-term interest rates. It finds that as a result of a one standard deviation shock (increase) to the latter, money demand declines everywhere but with differences across countries. The findings also indicate, in line with monetarists and Keynesian theories, that a decrease in the short-term interest rate (monetary contraction) leads to a decline in asset prices and in the demand for money in all countries under study.

Our results, therefore, suggest that incorporating stock price movements into money demand models is important for understanding the transmission mechanism of monetary policy. Therefore, central banks should pay more attention to stock market movements. If these significantly affect the demand for money, then stock prices should be used as leading indicators of future economic activity, and in particular demand for money, at least in the three developed economics examined here. There are also lessons to be learned for developing economies, namely the importance of a well developed financial system and well functioning stock market for estimating the demand for money accurately.

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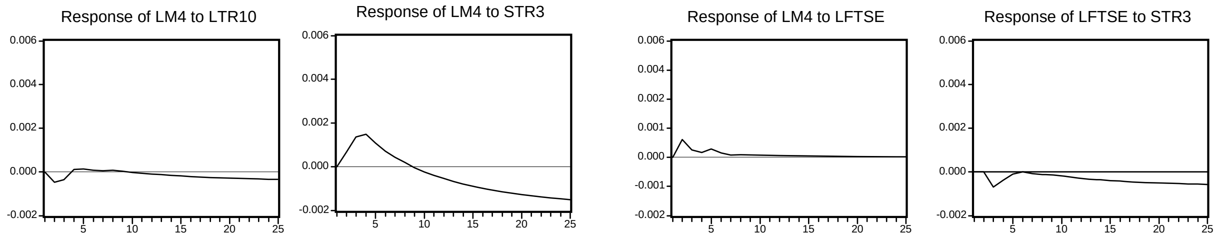
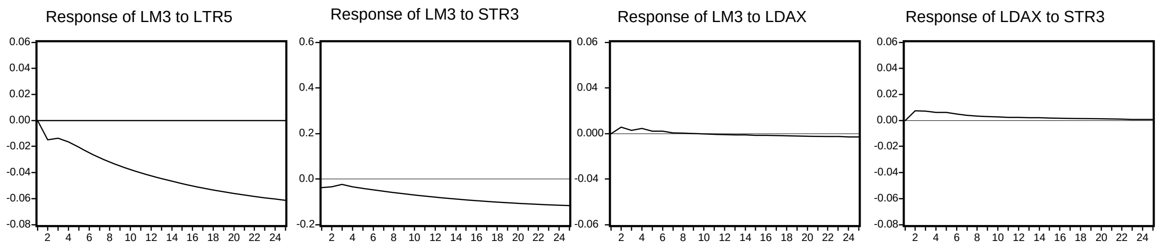
Figure 1

UK



Germany



USA

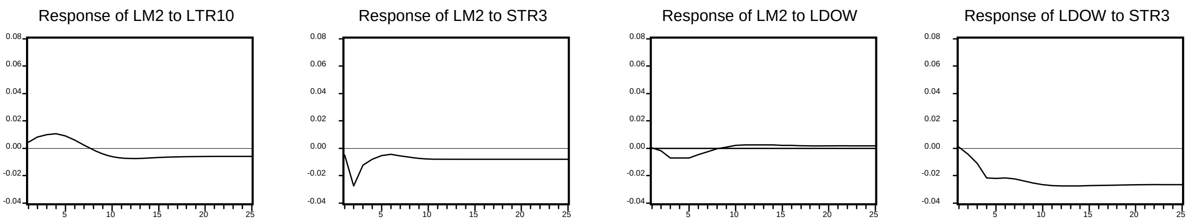


Table 1 Unit root tests

Countries/Test	ADF with trend				Phillips-Perron			
	M/Index	M3	STR3	LTR5	M/Index	M3	STR3	LTR5
UK	-1.26	-0.35	-4.62	- 3.20	-1.21	-1.13	-2.91	-3.45
Germany	-1.38	-1.01	-4.03	-3.81	-1.89	-1.54	-3.93	-5.62
USA	-2.14	-1.71	-3.82	-3.18	-2.26	-2.85	-3.27	-4.28

- ADF is the augmented Dickey-Fuller test for unit root
- Lag lengths in the ADF tests were determined by minimising the Akaike Information Criterion.

Table 2 Cointegration Test results

COUNTRIES		LMP/LY/LST3/LRT10/LSI	
		Eigen Value	Trace
UK	r=0	36.24*	45.21*
	r<=1	15.12	14.41
	r<=2	4.91	4.82
Germany	r=0	41.34*	43.11*
	r<=1	12.15	15.12
	r<=2	3.17	5.36
USA	r=0	56.66*	58.22*
	r<=1	28.23	17.61
	r<=2	8.28	6.41

Note: an asterisk indicates statistical significance at the 5% level. The AIC and SIC were used for selecting the lag length.

Table 3 Error Correction Model for the UK

		STR3	FTS	M3	Y
Error Correction Term:		-0.062* (-2.89)	-0.041* (-2.62)	-0.069* (-3.01)	-0.031* (-2.41)
Short-Run Dynamics	ΔM3	0.472 (3.27)	0.621 (3.34)	0.518 (1.71)	0.861 (2.15)
	ΔSTR3	0.641 (2.61)	0.723 (3.42)	- 0.193 (-3.72)	0.236 (2.35)
	ΔFTS	0.043 (2.81)	-0.232 (-1.27)	0.612 (1.42)	0.541 (2.11)
	ΔY	0.531 (1.83)	0.626 (1.72)	0.238 (1.64)	0.461 (1.83)
		LTR5	FTS	M3	Y
Error Correction Term:		-0.563* (-2.43)	-0.072 (3.31)	-0.057* (-2.73)	-0.0463* (-2.62)
Short-Run Dynamics	ΔM3	0.652 (1.61)	0.769 (1.45)	0.893 (1.93)	0.461 (0.91)
	ΔLTR5	-0.198 (-0.032)	0.921 (1.75)	0.391 (0.75)	0.184 (0.65)
	ΔFTS	0.642 (2.82)	- 0.765 (-2.64)	0.571 (2.17)	0.814 (3.26)
	ΔY	0.324 (1.74)	-0.072 (0.51)	-0.372 (2.52)	0.182 (1.87)

- - LM – tests for autocorrelation were performed to choose lag lengths

Table 4 Error Correction Model for Germany

		STR3	DAX	M3	Y
Error Correction Term:		-0.054*	-0.027*	-0.083*	-0.073*
		(-2.93)	(-1.54)	(-3.86)	(-3.65)
Short-Run Dynamics	ΔM3	0.641	0.863	0.634	0.732
		(3.21)	(3.61)	(2.89)	(3.05)
	ΔSTR3	0.832	0.872	1.093	0.682
		(3.72)	(3.91)	(4.32)	(2.87)
	ΔDAX	0.043	0.232	0.612	0.541
		(1.23)	(1.72)	(2.78)	(3.21)
	ΔY	-1.621	1.921	0.913	0.671
		(-0.91)	(0.82)	(0.021)	(0.081)
		LTR5	DAX	M3	Y
Error Correction Term:		-0.421*	-3.291	-0.051*	-0.0418*
		(-2.01)	(0.06)	(-3.81)	(-3.12)
Short-Run Dynamics	ΔM3	0.153	0.512	0.059	0.728
		(0.017)	(0.16)	(0.12)	(1.82)
	ΔLTR5	0.047	- 0.721	0.419	1.218
		(0.081)	(-0.012)	(0.16)	(0.48)
	ΔDAX	0.071	0.26	0.72	0.61
		(1.73)	(0.11)	(1.52)	(0.052)
	ΔY	-0.053	0.062	0.021	0.067
		(-.003)	(1.22)	(0.92)	(1.41)

- LM – tests for autocorrelation were performed to choose lag lengths

Table 5 Error Correction Model for the UK

		STR3	DOW	M3	Y
Error Correction Term:		-0.053* (-2.17)	-0.063* (-2.54)	-0.042* (-2.08)	-0.081* (-3.11)
Short-Run Dynamics	ΔM3	0.16 (1.73)	0.082 (0.043)	0.54 (2.26)	0.065 (1.62)
	ΔSTR3	0.22 (2.54)	0.38 (1.87)	0.005 (0.035)	0.04 (0.52)
	ΔDOW	1.97 (0.07)	1.43 (0.81)	2.56 (4.26)	5.82 (0.67)
	ΔY	0.32 (1.71)	0.062 (0.002)	0.57 (0.091)	2.24 (0.22)
		LTR5	FTS	M3	Y
Error Correction Term:		0.003* (-1.19)	-0.024* (-1.64)	-0.056* (-2.23)	-1.67 (1.83)
Short-Run Dynamics	ΔM3	-5.72 (0.83)	0.782 (0.061)	3.137 (0.23)	0.586 (0.023)
	ΔLTR5	-2.316 (0.33)	0.923 (1.21)	-0..913 (-1.71)	0.521 (0.05)
	ΔDOW	-0.283 (-1.36)	3.723 (0.023)	2.921 (3.171)	0.023 (0.065)
	ΔY	1.023 (2.91)	2.917 (0.001)	6.183 (-1.98)	2.705 (0.078)

- LM – tests for autocorrelation were performed to choose lag lengths