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EFFECT OF MONEY SUPPLY ON THE STOCK MARKET

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Abstract

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This paper observes effect of money supply on the stock market through the portfolio balance channel as a transmission mechanism of monetary policy. National *flow of funds* accounts, specifically assets from US households' portfolios, represent a key data source. Johansen's cointegration methodology is employed in the empirical part of the paper to analyze both short term and long term relationships among researched variables. Estimates of vector error correction model help to reliably quantify intensity of the effect. Results show money supply excercises influence on valuation of S&P 500 index with 6 months lag. The impact is also distinguishable in the long run, whereas all observed asset classes can positively influence price of S&P 500. Findings are then contextualized in the concluding part of the paper using a monetary policy framework.

Keywords: Stock market, money supply, transmission mechanism, portfolio balance, flow of funds, cointegration, VECM

INTRODUCTION

After financial crisis, the US economy found itself on the lower bound of short term interest rates. The Board of Governors of FED decided to employ large-scale asset purchases (further referred to as LSAP) in order to both affect long term interest rate and rejuvenate real estate market (FED, 2008). Efficiency of unconventional monetary policy therefore became an essential topic for central banks and related researchers. The worldwide economic conditions induced the need for reinvention of functional transmission channels of monetary policy.

D'Amico *et al.* (2012) assume LSAP has an effect on long term interest rates through three transmission channels. First, signaling channel explains the relationship via expectations. If the rate of short term notes decreases, investors usually expect bond rates to disproportionally decrease as well. By definition, the signaling channel cannot help to clarify effects of monetary policy on the lower bound. Cochrane (2012) proposes an alternative version identifying short term debt with reserves. He further derives that investors interpret an increase in reserves as a signal of longer lasting low interest rate environment. Second, interest rate of bonds depends on relative quantity of privately held bonds according to scarcity channel (Modigliani and Sutch, 1966; D'Amico, 2012). Therefore, purchases of debt assets cause an increase in demand for this asset class which results in rising bond prices while simultaneously reducing interest rate. The third transmission channel is predominantly called portfolio balance channel or less often duration channel. According to this theoretical approach, efficiency of LSAP can be explained with duration (see Thornton, 2012). Large scale purchases restrain the supply of high duration bonds to private sector, and expand the supply of zero duration, zero convexity assets (Gagnon *et al.*, 2010). As Brian Sack (2009) of the Fed stated in one of the most important crisis speeches „By purchasing a particular asset, the Fed reduces the amount of the security that the private sector holds, displacing some investors and reducing the holdings of others. In order for investors to be willing to make those adjustments, the expected return on the security has to fall. Put differently, the purchases bid up the price of the asset and hence lower its yield." A theoretical background of portfolio balance channel stems from modern portfolio theory (see Markowitz, 1952; Sharpe, 1964, 1966, 1994), segmented debt market (e.g. Riefler, 1930; Vayanos, Vila, 2009), imperfect asset substitution (Tobin, 1969; Andres *et al.*, 2014) and term structure of interest rates (Culbertson, 1957). There is empirical evidence of existing portfolio balance transmission channel on both national and international level (see Neely, 2010; Bauer, Neely, 2014; Gagnon *et al.* 2010; Wright, 2012). Opponents of the channel emphasize three critical domains. First, although numerous empirical works acknowledge occurrence and efficiency of portfolio balance, they differ in opinions on how it works (Cochrane, 2012). Moreover, the term premium is not defined precisely because standard deviation of returns contains both market risk and default risk. However, it is advisable to measure term premium only with market risk. Second, the preferred-habitat models as a part of segmented markets hypothesis are usually employed to rationalize the effects of portfolio balance channel. In order to explain the efect, preferred-habitat model presumes that investors are not willing to change their maturities and they stick to their preferred maturities (Vayanos, Vila, 2009). However, debt market finds its equilibrium only if investors can substitute between their preferred maturities. The third domain of criticism reflects doubts about the strength of the aforementioned transmission channel. Bauer and Rudebusch (2011) doubt the scale of Fed's asset purchases to be sufficient to impact the bond market. Although Thornton (2012) acknowledges portfolio balance channel as a part of transmission mechanism, he suggests its quantitative effect is insignificant. Christensen and Rudebusch (2012) similarly impugn importance of portfolio balance channel as they consider the signaling channel more significant. Insufficient segmentation of debt market might be one of the key reasons for limited effect of LSAP on economic activity via portfolio balance channel (Cúrdia and Ferrero, 2013). According to Thornton (2012), discussed transmission channel also lacks empirical evidence on low frequency data as timeframe of the study plays a role in consistency of results (see Hancock and Passmore, 2011; Stroebel and Taylor, 2009).

All the transmission channels help central banks to understand and quantify how their tools of monetary policy affect real economic activity. In this paper we discuss the connection between monetary policy tools and stock market that can be perceived as an intermediary to real economic variables. From monetarist point of view, surge in money supply leads to surplus of money balance which can be spent on stocks. Increased demand for stocks eventually raise their prices (Fisher, 1911). Keynesian perspective draws the same conclusion as expansionary monetary politics make stocks more attractive investment than bonds which drives up the prices in accordance with the liquidity preference theory. Alternatively, Tobin's q can explain rising prices of stocks in response to monetary expansion (Tobin, 1969). Empirical evidence revealed that both money supply and M1 aggregate can impact stock prices (Rozeff, 1974; Flannery, Protopapadakis, 2002). Also, Homa and Jaffee (1971) acknowledged "*significant and systematic relationship*" between money supply represented by deposits and currency, and stock prices. On the contrary, Black (1987) deduces that changes in money supply do not influence stock prices. The evidence of Campbell and Ammer (1993) shall be interpreted similarly as they claim money supply has minimal effect on stocks prices. Furthermore, Thorbecke (1997) estimates stock prices decline for 0.8 % if federal funds rate increases unexpectedly for 1 %. Rigobon and Sack (2004) expect stock index S&P 500 to lose 1.7 % if 3-month rate increases for 0.25 %. The effect is even more significant for Nasdaq index (2.4 % decrease for the same magnitude of change). Similar estimation applies for monetary aggregate M1. Stocks fall off 2.4 % if M1 is limited by 1 % (Lastrapes, 1998). Effects of monetary policy on stocks also depends on economic environment. Conventional monetary policy tools are capable to cause greater change in stock price compared to a policy tool for lower bound economy (Kiley, 2014). Connection between interest rates and stock performance constitute a challenge for contemporary monetary policy. Portfolio balance channel of monetary transmission appears to be a convenient framework for observation of monetary policy's impact on the real economy as Gagnon *et al.* (2010) state, "These portfolio balance effects should not only reduce longer-term yields on the assets being purchased, but also spill over into the yields on other assets. With lower prospective returns on agency debt, agency MBS, and Treasury securities, investors should bid up the prices of other assets such as corporate bonds and equities." Investors are therefore motivated to rebalance their portfolios in response to the change of yield. As long as investors are willing to substitute among asset classes, effects could spill over to stocks.

The main objective of this paper is to quantify the effect of money supply on US stock market through portfolio balance channel of monetary transmission. The paper is organized as follows. The section Materials and Methods outlines vector error correction model and specifies data sources. The next section describes the results of the model. Results are discussed and put in context of the US and European monetary policy in last sections of the paper.

MATERIALS AND METHODS

Quantitative part of this paper was based on the publicly available Financial Accounts of the United States issued by the Board of Governors of the Federal Reserve System. We concentrated on specific statistical accounts so called flow of funds. It is assumed that every personal portfolio comprises

I: *Tab. I. Descriptive statistics of the variables*

Variable	N	Mean	Maximum	Minimum	Std. Dev.
sp500	256	500.55	2099.29	23.27	562.11
depcurr	256	315337	1222244	60701	252381
treasury	256	342637	1271664	65904	309708
equities	256	3239251	14403003	133430	3685870

cash, bonds, stocks and other asset classes. Flow of funds provides us with levels of these asset classes on quarterly basis across the US economics. Since flow of funds are usually used to research savings or economic cycles (see Terzi, 1986; Christiano *et al.*, 1994), this paper derives benefit from innovative utilization of the data. Long period of quarterly data from 1952 to 2015 is used as an input. Money supply is represented by the variable deposits and currency (coded as *depcurr*). The two most common asset classes in the US personal portfolios stand for bonds (coded as *treasury*) and stocks (coded as *equities*). Values of input time series are stated in millions of US dollars. Results are then multiplied by one thousand due to interpretability. Performance of stocks is represented by a time series of S&P 500 (coded as *sp500*) available publicly at prof. Robert Schiller's online library. The whole dataset contains four variables and 256 observations of each variable. Descriptive statistics of the data is available in Tab. I.

Stationarity of time series is tested with augmented Dickey-Fuller test (see Dickey, Fuller, 1981) and KPSS test (see Kwiatkowski *et al.*, 1992). Minimization of Akaike information criterion (AIC) helps to set appropriate lag order. Since applying linear regression model could result in spurious correlation, cointegration is employed in this paper. It is assumed that although time series are nonstationary, there can exist at least one linear combination of the time series that is stationary. We would call these time series cointegrated. Cointegrated time series carry an important information on their long term relationship, so called cointegration vector. It can be estimated with Johansen's cointegration test. The test is formally derived from general formula:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + \varepsilon_t \quad (1)$$

where y_t represents a vector of variables and p is lag order. Basic vector error correction model is then used to determine cointegration vectors as follows:

$$\Delta y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \\ + \ldots + \Gamma_{p-1} \Delta y_{t-(p-1)} + \varepsilon_t \quad (2)$$

$$\Pi = \left(\sum_{i=1}^{p} A_i \right) - I \quad (3)$$

$$\Gamma_i = -\left(\sum_{j=i+1}^{p} A_j \right) \quad (4)$$

where Π represents a matrix of parameters, which enables to test more than two time series together. Rank of the matrix Π is then essential for detection of cointegration vectors. If the matrix Π has zero rank, there are no cointegration vectors among the time series. On the contrary, if Π is a full rank matrix, the time series can not be considered as cointegrated because the unit root is missing. Otherwise, rank of the matrix Π confirms existence of r cointegration vectors. It can always be estimated less cointegration vectors than the number of cointegrated time series. Trace statistics of Johansen's test follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln\left(1 - \breve{\lambda}_i\right) \quad (5)$$

where Π stands for the number of cointegration vectors and T represents number of observations. Null hypothesis that there is up to r cointegration vectors is tested against alternative hypothesis that there is more than r cointegration vectors. Trace test is evaluated for each rank of given matrix. In accordance with Johansen (1991), vector error correction model (VECM) is then estimated:

$$\Delta y_t = \alpha\left(\beta' y_{t-1}\right) + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \\ + \ldots + \Gamma_{p-1} \Delta y_{t-(p-1)} + \varepsilon_t \quad (6)$$

where α stands for the speed of adjustment and β′ is a representation of cointegration vectors. Estimates of α and β′ tell us both the short term correction and long term dynamics that attracts variables to equilibrium. Since the model includes lagged variables, AIC minimization is utilized to determine the appropriate order of lag. Last but not least, choosing the adequate specification of the vector error correction model is essential to obtain interpretable results. The model can be enriched by constant or trend (possibly both) in either restricted, or unrestricted version (Johansen, 1991). Vector error correction model with unrestricted constant and trend follows:

$$\Delta y_t = u + \alpha\left(\beta' y_{t-1} + c\right) + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \\ + \ldots + \Gamma_{p-1} \Delta y_{t-(p-1)} + \varepsilon_t \quad (7)$$

where u is a representation of a trend and c stands for a constant, whereby $u = u_0 + u_1 t$ and $c = c_0 + c_1 t$. If constant or trend is included in both error correction and long term structure, the model specification is unrestricted. Restricted versions of the model contain constant or trend only in the long term part of the formula. Vector error correction models with restricted and unrestricted trend are estimated in this paper.

RESULTS

All four time series were tested for stationarity. ADF test with appropriate lag showed all variables are nonstationary, null hypothesis of nonstationarity was not rejected, see Tab. II. Conversely, first differences of all variables were reported as stationary on the 1 % significance level. Time series are considered to be integrated in the first order $I(1)$, and thus a condition for correct estimation of the final models was met.

KPSS test was carried out as a second unit root test (see Tab. III.). Despite the fact that results of ADF test and KPSS are often different, observed variables were not the case. Variables were tested in the same order of lag as in the case of ADF. Null hypothesis of KPSS test was rejected for all four variables on the 1 % significance level and the time series were confirmed to be nonstationary. First differences of time series sp500, equities and treasury were identified as stationary because the null hypothesis cannot be rejected. However, depcurr variable was reported as nonstationary on the 10 % significance level. The result might stem from a used lag that was intentionally the same as for ADF test. Since both tests generally confirmed the assumption of integrated time series, further adjustment of lag is not desirable.

Time series were then subjected to a test for a number of cointegration vectors. Both lag and version of the model were chosen according to economic theory and interpretability of results. The model containing restricted trend with second order of lag approved existence of one cointegration vector on the 5 % significance level (see Tab. IV.). The model with unrestricted trend remained without identifiable cointegration vector. Alternatively, models with the fourth order of lag were also tested for cointegration vectors (see Tab. V.). Though both lagged models confirmed existence of one cointegration vector, the model with lower order of lag and restricted trends was chosen to enter the estimation of vector error correction model. Final VECM should be considered as a basic fit for further optimization. Moreover, an interpretation of such a model is closer to the reality of monetary policy.

Cointegration vectors (see Tab. VI.) and speed of adjustment coefficients (see Tab. VII.) were estimated from the final VECM. Estimated cointegration vector

II: *Tab. II. ADF test results*

Variable	Level value		First difference		Integration
	ADF statistics	Lag	ADF statistics	Lag	
sp500	−0.9608	2	−9.5728***	1	1
depcurr	−2.0648	4	−9.6283***	1	1
equities	−1.7415	2	−9.5689***	1	1
treasury	−2.2714	2	−8.6279***	1	1

III: *Tab. III. KPSS test results*

Variable	Level value		First difference		Integration
	KPSS statistics	Lag	KPSS statistics	Lag	
sp500	1.5409***	2	0.0479	1	1
depcurr	3.3859***	4	0.489*	1	1
equities	1.4916***	2	0.0299	1	1
treasury	0.4398***	2	0.0531	1	1

IV: *Tab. IV. Trace test for cointegration vectors*

	Trace test	
Lag	**2**	**2**
r < = 3	1.40	2.19
r < = 2	14.40	16.10
r < = 1	32.49**	34.51
r = 0	85.93***	88.16***
Version	With restricted trend	With unrestricted trend

V: *Tab. V. Trace test for cointegration vectors*

Trace test		
Lag	**4**	**4**
r < = 3	1.66	2.14
r < = 2	15.22	15.70
r < = 1	43.66***	45.95**
r = 0	79.82***	82.12***
Version	With restricted trend	With unrestricted trend

VI: *Tab. VI. Estimate of cointegration vectors*

Cointegration vectors				
	sp500	**depcurr**	**treasury**	**equities**
sp500.l2	1	1	1	1
depcurr.l2	–0.14484	–0.26538	0.61261	–0.34413
treasury.l2	–0.11072	0.61438	–0.31897	–0.07716
equities.l2	–0.14952	–0.17849	–0.15847	–0.09596

VII: *Tab. VII. Estimate of speed of adjustment coefficients*

Speed of adjustment				
	sp500.l2	**depcurr.l2**	**treasury.l2**	**equities.l2**
sp500.d	–0.16402	0.07447	0.02229	–0.01561
depcurr.d	–0.81046	0.33380	0.10791	0.10977
treasury.d	–0.25820	–0.44071	1.08466	–0.03167
equities.d	–0.42162	0.85802	0.32280	–0.09757

display a long run relationship among observed variables. The vector is demonstrated as follows:

$$sp500 = 0.144\,depcurr + 0.11\,treasury + 0.149\,equities \quad (8)$$

In accordance with expectations, volume of deposits and currency and volume of equities in the US personal portfolios have an impact on stock index performance in the long run. Increase in both variables (independently of each other) leads to higher S&P 500 price. Specifically, if the volume of deposits and currency among US households increases for $1 billion, S&P 500 then rises for 0.144 points in the long run. If the volume of equities in personal portfolios increases for $1 billion, S&P 500 can be expected to add 0.149 points over a period of time. However, results for treasury were not consistent with expectations. If the volume of bonds in the US personal portfolios increases for $1 billion, S&P 500 index should rise for 0.11 points. It can be presumed that highs and lows in prices of stocks and bonds vary depending on the phase of business cycle. The contradictory result can stem from the nature of interest rate. If the interest rate declines, bond prices advance and stock prices probably rise as well because future cash flows are discounted with the lower rate.

Speed of adjustment is stated as follows:

$$\breve{\alpha}' = \left(-0{,}164; -0{,}810; -0{,}258; -0{,}421\right) \quad (9)$$

Speed of adjustment enlightens the short run relationship among variables as it indicates how quickly variables offset shock changes. Generally, the larger is speed of adjustment coefficient, the quicker is the adjustment of a variable while coefficients are expected to fall in (–1,0) interval. Estimated coefficient –0.164 for lagged variable of S&P 500 index indicates how intensively the shock change is emended back to equilibrium during half a year. Relatively low speed of adjustment is consistent with high price efficiency of the US stock market. It can be presumed that higher orders of lag would return even lower speed of adjustment because the majority of price adjustment takes place in much shorter periods of time. The most dynamic speed of adjustment (–0.81) was quantified for deposits and currency. Shocks are absorbed relatively quickly in S&P 500, and the result confirms the hypothesis about the effect of money supply on stock indices. The coefficient of –0.258 was estimated for volume of treasury, respectively –0.421 for the volume of equities. The results for both variables are consistent with theoretical expectations.

DISCUSSION

Relationship between money supply and asset prices is widely covered topic, whereas the research works predominantly infer that significance of the relationship differs among various asset classes. Belke *et al.* (2010), for example, focused on the effect of global liquidity growth on real estate, commodity and stock prices. While the impact of a shock change on commodity prices and real estate prices was assessed as statistically significant, stock prices seemed to be inert to monetary policy expansion. It is worth mentioning that real estate prices rose for 55 % in the USA (respectively 41 % in the Eurozone) from 2001 to 2006, and stocks almost doubled on major markets (Belke *et al.*, 2010). Fischer *et al.* (2008) confirm these findings in case of the Eurozone. Authors predominantly argue that the evidence stems from price elasticity of asset supply. While supply of real estate is limited and bustling construction is often legally restricted, quantity of stocks can accommodate increased demand. Therefore, monetary expansion should have a considerable impact on assets with limited supply elasticity.

On the contrary, Baks and Kramer (1999) provided evidence of money supply on stock market. They observed the effect on panel data from 1971 to 1998 among G-7 countries and found significant empirical evidence. Conover *et al.* (1999) and Marshall (1992) also published affirmative research works. There are more theoretical foundations for aforesaid empirical evidence. Increase in money supply may lead to rise in overall value of assets in personal portfolios, and individuals then reallocate excessive cash balance to other (e.g. stocks). Better stock performance can also evoke substitution effect and further attract investors to stocks. The relationship between money supply and stock prices is usually confirmed by researches of long time period. If the research is based on a case study or a shorter time period, it generally indicates weak or even missing relationship. Credit crunch, bursting asset price bubble or monetary policy on the lower bound may overshadow the effect in short run. Since this paper reflects 63 years long time period, results are positive about the observed effect.

Last but not least, the efficiency of money supply stimulus may differ among institutional environment. If interest rates hit the lower bound, financial institution find it difficult to get appropriate return from interbank market. They can make a decision to place their assets into stock market which further facilitate access to funding for listed companies. Increasing investment activity of companies leads directly to economic growth. Stable role of financial and capital markets thus reinforce efficiency of transmission channels. However, bank-based economies (e.g. the Eurozone) cannot expect the efficiency of transmission channels in such extent because private companies rely largely on debt financing.

CONCLUSION

In this paper we attempted to quantify an effect of money supply on the stock index. Portfolio balance channel of monetary transmission was used to clarify how monetary stimulus can affect real economy. Relatively long period of time (1952 to 2015) was studied on the *flow of funds* data set. The data set consisted of four variables – deposits and currency, value of equities in the US households' portfolios, value of treasury in the US households' portfolios and performance of S&P 500. Vector error correction model was then employed to estimate the short term dynamics and long term equilibrium of the relationship. One cointegration vector and speed of adjustment coefficients were estimated as a result. In the long run, increase in any variable leads to advance in S&P 500. If a money supply increases for $1 billion, S&P 500 rises for 0.14 points according to results. In the short run, deposits and currency variable shows the highest speed of adjustment of all variables (–0.81). It indicates that S&P 500 reacts intensively to changes in money supply during observed order of lag (6 months). Equities and treasury in the US personal portfolios show moderate speed of adjustment (–0.421, respectively –0.258). Stimulus in money supply as an instrument of monetary policy therefore penetrate through individual portfolios while affecting risk and return of given asset classes. Investors reallocate their portfolios accordingly and bring new demand to stock market.

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