Abstract

Among the monetary policies that the Fed adopts in intervening the US economy, Open Market Operation is the one which is most frequently used due to its easily observable effect and relatively low cost during operation. Via buying and selling US Treasuries the Fed adjusts the money supply in the market and manipulates the economy. In recent years, a modern practice of this policy is used by the Fed which targets the federal funds rate to control the money supply.

Following a brief introduction on the Federal Reserve and its monetary policy making mechanism this paper studies the relationship between money supply and the economic output from theoretical and statistical perspectives. An equation indicating this relationship, focusing on *d(GDP)* and *d(M2)*, is estimated by OLS by SAS in statistical analysis section. Based on the research, we conclude that lagged changes in GDP play a significant role in estimating the change in M2.

1 Introduction

Since the Federal Reserve has been playing an essential role in affecting or even controlling the US economy system through implementing monetary policies and targeting a stabilized economy system, attention of economists is attracted to follow the fed's policy behavior and implication behind. The three main tools of the Fed in influencing the market are open market operations, discount rate and reserve requirement. The importance of the function of Fed cannot be overemphasized because of its irreplaceable responsibility for the management of aggregate demand via total spending as well as inflation.

Several researches have attempted to figure out the rules of policy choices made by the Federal Reserve that influenced interest rates and other economic indicators (Feldstein & Stoc, 1994). Inspired by them, this study mainly focuses on the relationship between M2 and GDP of the United States.

2 Literature Review

A substantial number of empirical researches have examined the mechanism of how the Fed operates as an independent private organization. These days, the Federal funds rate, which has gained growing focus from the Federal Reserve, is acting as the primary indicator of the tendency of monetary policy. The federal funds rate target is publicized at every FOMC meeting since more than a decade ago. The federal funds rate can be influenced by the changes in the three monetary policy tools—open market operations, reserve requirement, and discount rate. Despite the latter two, which are determined by the board of governors, it is the FOMC that directs the open market operations of buying and selling US government securities to control the federal funds rate targeting the two key objectives of the US monetary policy: price stability and maximum sustainable economic growth. The observation of the decision changes determined by FOMC has strategic meaning as an operational indicator of how the direction of monetary policy has impact on the economic system in a macro aspect. "At the meeting itself, staff officers present oral reports on the current and prospective business situation, on conditions in financial markets, and on international financial developments. In its discussions, the Committee considers factors such as trends in prices and wages, employment and production, consumer income and spending, residential and commercial construction, business

investment and inventories, foreign exchange markets, interest rates, money and credit aggregates, and fiscal policy." (Anon., 2011)

Feldstein and Stock (1994) studied the possibility of using M2 to target the quarterly rate of growth of nominal GDP in their paper in 1994. The study evidenced that the Federal Reserve could probably make use of M2 that reduces both the long-term average inflation rate and the variance of annual GDP growth rate. Similarly, our project would examine the potentially existing relationship of how the monetary directions eventually affect the output by applying econometrical models.

The research from Bernanke in 1990 stated that federal funds rate was a good indicator of monetary policy. A tight monetary policy would result in a short-run sell off of banks security holdings, as well as the impact of tautened bank loans that would depress the economy. In addition, the response of unemployment and loans in respect of monetary policy changes are more or less similar in time manner.

Lang and Lansing (2010) stated that 'the economy recession ended in June 2009, since when the U.S. economy has recorded four consecutive quarters of positive real GDP growth'. By reducing interest rate to zero and buying bad assets, the Fed has implemented a series of accommodative monetary policy to stabilize asset price and the whole economy. Regardless of the controversy aroused by spending tax revenue to save Fannie Mae and Freddie Mac, the reaction of the Fed during this unique period and its impact was not to be ignored. Indication 3 from this would be the consideration of policy behavior differences before, during and after the recession.

One study of Fed's policy behavior by Fair (2001) estimated the implicit rules relating to interest rate and a set of economic variables, and pointed out that there was a structural change of policy behavior of Fed between 1979 and 1982. By including the structural change factor, the author was able to carry out stable coefficient estimates. The rules derived from the regression interpreted interest rate into a disciplinary changing indicator influenced by other major economic factors.

3 Theoretical Analysis

Open Market Operations - the most frequently used instrument of monetary policy – works with the idea that by adjusting the money supply in the market, the economic output will consequently alter toward particular directions. In this section, the influence to the economy triggered by the change in money supply will be analyzed by adopting the IS-LM curve and AD-AS curve from the aspect of macroeconomics. Then, two approaches of the transmission of monetary policy's impact on output will be explained. Thereafter, the modern view of its monetary policy of Fed and its tight and loose practices of the implementation will be introduced. Finally, based on the observation on the economic environment of recent years and the actions that the Fed has taken in fighting against recession and pulling back the economy from decreasing, we would suggest the Fed continuing implementing the loose monetary policy. The possible aftermath will be concluded based on the theoretical conclusion.

3.1 AD-AD, IS-LM Model

According to Keynesian structural model approach, in the money market, when there is an increase in money supply from MS^1 to MS^2 with a constant price level P_1 which leads to a drop in interest rate from r_1 to r_2, LM curve shifts downward from LM_1 to LM_2. In IS-LM model, the downward-shifted LM curve intersects with IS curve at equilibrium with an increased output, Y_2. In AD-AS model, the new output level shifts AD curve up from AD_1 to AD_2.

In short run, as we assume that the price is sticky, the upward-shifted AD curve intersects SRAS at a new equilibrium at the higher output level Y_2. In the long term, since the price is flexible and the output will ultimately return to the assumed-full-employment level Y_1, the upward-shifted AD curve will intersect with LRAS curve at Y_1, but at a higher price level P_2. Due to the return in the output, and the rise in price, LM curve will then shift back to the initial position LM^1, and the interest rate reduces back to the original level r_1. In summary, the increase in money supply will decrease the interest rate and increase output in short run. In the long run it has no effect on the interest rate or output, but results in inflations. On the other hand, the influence of the economy from decreasing money supply is the opposite, which will increase the short run interest rate, decrease the output, but lower the price in the long term.
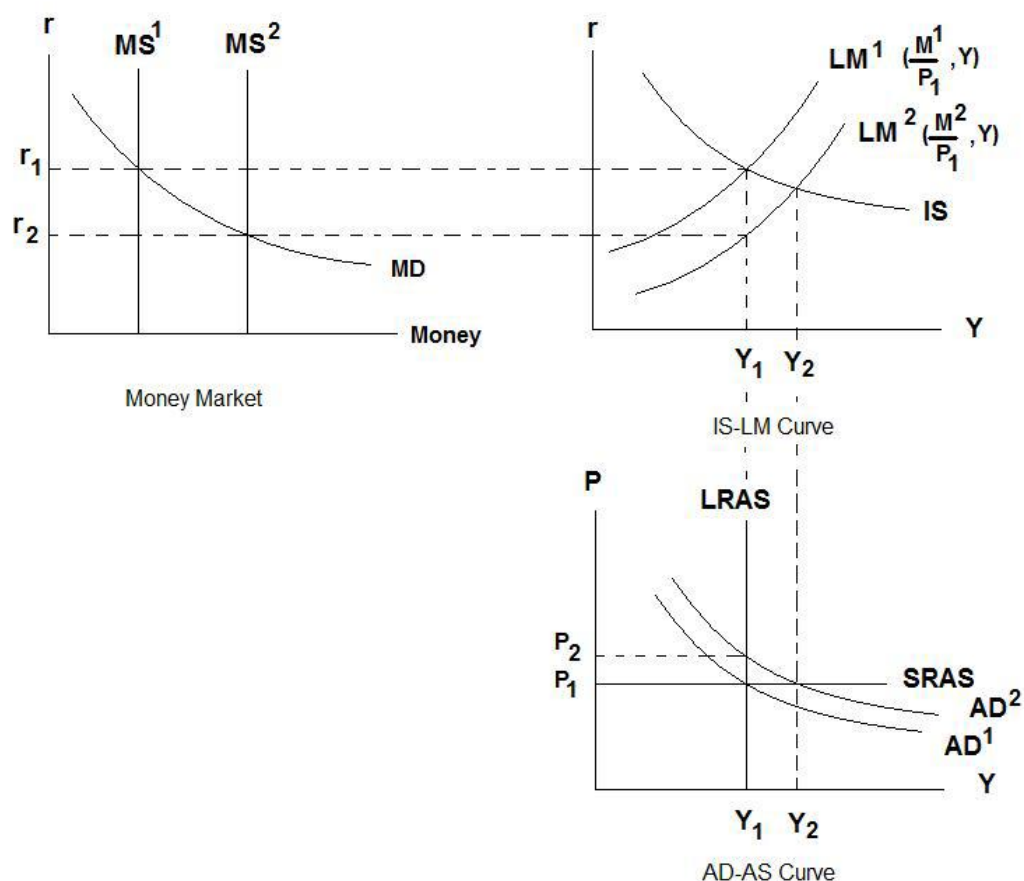
Figure 1 illustrates the shifts of AD and LM curve

3.2 The mechanism of M2

According to Frederic S (2007, p.603-607), the traditional Keynesian structural model exams the channels of interest rate effects through which the monetary policy eventually has impact on aggregate demand. After Keynesian, researchers attempt to pursue a much more detailed structural model approach by viewing the monetary transmission mechanism through various channels (Appendix I, figure 2). Other than the traditional interest-rate monetary transmission mechanisms, those channels are separate into two basic categories: operating

through asymmetric information effects on credit markets and operating through asset prices. Examples of each are provided as follow.

For credit view transmissions, we use the cash flow channel to elaborate the mechanism of expansionary monetary policy. The increased money supply results in lowered nominal interest rate. This leads to an improvement of firms' balance sheet since the rising liquidity enables investors to gain confidence of the firms' pay back ability. The consequences lessen moral hazard and adverse selection, and therefore, enhance the economic activities as well as the output. The schematic for the transmission through cash flow channel is:

$$M\uparrow \Rightarrow i\downarrow \Rightarrow \text{cash flow}\uparrow \Rightarrow \text{adverse selection}\downarrow \Rightarrow \text{moral hazard}\downarrow,$$
$$\Rightarrow \text{lending}\uparrow \Rightarrow I\uparrow \Rightarrow Y\uparrow$$

For asset prices transmissions, one of the examples is the channel of wealth effects, through which the changes in consumers' balance sheets might affect their spending decisions. As money supply is increased, the rise in stock price indicates a boost in financial wealth as consumers' lifetime resources. Consequently, the consumption, which stands for the spending by consumers on nondurable goods and services, should increase and eventually cause the output expansion. Schematically, the monetary policy effect is:

$$M\uparrow \Rightarrow Ps\uparrow \Rightarrow \text{wealth}\uparrow \Rightarrow \text{consumption}\uparrow \Rightarrow Y\uparrow$$

Hence, to simplify all the monetary transmissions, a behavioral equation provides the description of the structural approach:

$$M \rightarrow \boxed{\alpha \rightarrow \beta \rightarrow \mu} \rightarrow Y$$

The rectangular represents the structural model evidence of monetary influence from money supply to output. The structural approach emphasizes the procedure of operation in different sectors in the economy. It has the advantage of a better understanding of how the economy works, and enables more precise prediction according to monetary or fiscal policy change.

Besides, as opposite to structural model, the other direction of research moves toward a more sophisticated monetarist reduced-form model to examine the substance of money supply to the economic system. Instead of studying the reaction of separated economic sectors, the reduced-form approach directly views the impact of money supply on the output. Monetarists regard the economic activities as a black box between money supply and output in which the behaviors are invisible.

$$M \rightarrow \boxed{ ? } \rightarrow Y$$

It is believed that the channels through which the monetary policy affects output are continually changing. And it might be too complex to identify all the transmissions of mechanisms in the economic system. In addition, the model avoids the potential missed out of

any transmission channels. Therefore, to make this research simple and clear, this approach will be adopted in the statistical analysis.

3.3 Presumptions

In the economic markets, the federal funds rate has the essence of being an indicator of monetary policy. As the most important control method of federal funds rate, money supply can directly influence the behavior of federal funds rate. It is the equilibrium of demand and supply for reserves that determines the federal funds rate, which will decrease due to the increase of money supply, or say, open market purchase (figure 3).

Nevertheless, when intervening the market, instead of targeting money supply to boost the output, the Fed targets the *ffr* or the interest rate to a particular amount while conducting its monetary policy. With an interest rate target, the Fed then acts in the market by buying and selling certain amount of government securities, such as Treasuries, to achieve this target, and to reach the objective of increasing output.
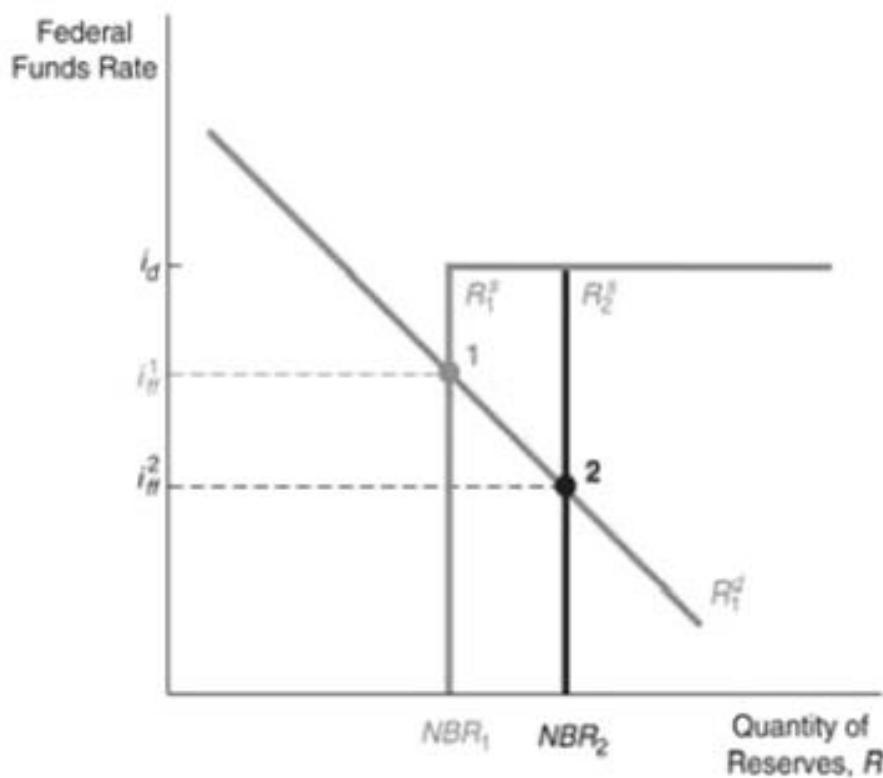
Figure 3 illustrates shift of money supply curve

When the Fed applies its Open Market Operations in buying and selling government securities, two practices are usually involved - tight monetary policy and loose monetary policy. Theses monetary policies represent different dimensions of the Fed in achieving the *ffr* target and interest rate target.

While conducting the loose monetary policy, in the short run, the Fed increases money supply by purchasing Treasuries to inject money to the market. This increase in money supply decreases the *ffr* and consequently lowers the short run interest rate. Since the price of borrowing declines, more consumer and business are willing to borrow money from

commercial banks, and it will result in an increase in investment, GDP and employment, however, an inevitably permanent increase in price level.

The tight monetary policy, on the other hand, decreases the money supply by selling Treasuries, and withdraws the money from the market. With a declined money supply, there is an upward pressure on the *ffr* as well as the short run interest rate. As it becomes more expensive to borrow money, less consumers and businesses will borrow money from the commercial banks, and it will lead to a decrease in GDP and an increase in unemployment.

After the Fed has maintained the *ffr* at nearly to zero for two years to fight against the economic recession began in 2008, the GDP growth started picking up from negative in late 2009, and the US GDP maintained a positive growth during 2010. Although the economy has started to grow and the unemployment has begun to drop, the current unemployment is still dramatically higher than the normal rate. To draw the unemployment down to the safe range, more jobs need to be created, and consumers and businesses should continue being encouraged to borrow money and to increase the output. Therefore at the early stage of economic recovering, the loose monetary dimension should continue being the preferred direction to the tight monetary dimension at the FOMC meetings when monetary policies are made. Based on the analysis above, by implementing the loose monetary policy and remaining the *ffr* at the 0-.25%, the unemployment will continue declining, GDP growth will remain at a positive and stable rate, and the economy will keep recovering steadily.

4 Statistical Analysis

In section 3 we have theoretically analyzed the mechanism of how monetary policies have impacts on the US economy. To generate a more precise relationship between money supply and the reaction of the economy, an empirical study of the presumed reasoning becomes a necessity. In this section, we conduct a quantitative research based on the real time data from the Federal Reserve Banks. We divide this statistical analysis section into two main segments. In part one, we first introduce the research objective, data collection. Then, statistical models are adopted to test the econometrical attributes of the data. We estimate a simple VAR model which involves M2 measuring the money supply, and real GDP presenting the economic output. Afterward, we conduct the OLS and estimate the coefficient of each variable. In the second part, we interpret the results and probabilities, as well as provide further explanation of the method behind.

4.1 Research Objective

In section 3, all the theories evidence that it is the money supply that eventually causes GDP to increase or decrease through a variety of transmission channels, so we focus the study of the economic output on real GDP. To measure the money supply in the market, Norman Frumkin (1990, p.179) introduces four measures – M1, M2, M3 and L, with a declining liquidity in assets involved. Abel, Bernanke, and Croushore mentioned in Macroeconomics that the two monetary aggregates used to measure the US currency circulation now are M1 and M2.

Furthermore, because of the broader definition of M2 which includes components of M1, saving deposits, small-denomination time deposits, and MMMFs, it is usually used to quantify the money supply in the economy. Therefore, we include M2 as the variable reflecting money supply in the model.

Hence, based on the theoretical analysis, our primary research objective is to examine the statistical relationship between M2 and GDP.

4.2 Data Collection

Based on the research objective, the suitable data set chosen consists of quarterly time series of M2 and nominal GDP of the US over the sample period from the beginning of the first quarter in 1976 to the beginning of the third quarter in 2013. To clarify each variable, here M2 represents the sum of notes and coins (currency) in circulation, traveler's checks of non-bank issuers, demand deposits, other checkable deposits, savings deposits, and time deposits less than $100,000 and money-market deposit accounts for individuals. Real GDP refers to the market value (adjusted for price changes) of all final goods and services produced within a country in a given period in the US.

4.3 Vector Autoregressive Model

Inspired by the paper of Feldstein and Stock (1994) which indicated that an optimal M2 rule generated from a simple Vector Autoregressive Model (VAR) reduced GDP variance by 20%, we structure our model by adopting VAR.

$$[Y]_t = [A][Y]_{t-1} + \ldots + [A][Y]_{t-k} + [e]_t \text{ (model 1)}$$

Where k is the number of lag terms, [Y], [Y]$_{t-1}$, ... [Y]$_{t-k}$ are the 1 x p vector of variables, and the [A], ... and [A'] are the p x p matrices of coefficients to be estimated, [e], is a 1 x p vector of innovations that may be contemporaneously correlated but are unrelated with their own lagged values and uncorrelated with all of the right-hand side variables.

4.3.3 OLS: Equation Estimation

Then, we conduct OLS by using SAS to estimate the equation. The results are in appendix I. While inputting data to SAS, we select d(M2) and d(RGDP) with lag terms equal to 1, 2, 3 (i = 1, 2, and 3), which means, for instance, the d(M2) of 2010Q4 might be influenced by d(M2) of 2010Q3, 2010Q2, 2010Q1 and 2009Q4, and d(GDP) of 2010Q4, 2010Q3, 2010Q2 and 2010Q1. With the selecting criteria of C(p), SAS then generates one best model including d(M2)$_t$ as dependent variable, d(GDP)$_t$, d(GDP)$_{t-1}$, d(GDP)$_{t-2}$, d(GDP)$_{t-3}$, d(M2)$_{t-1}$, d(M2)$_{t-2}$ and d(M2)$_{t-3}$ as independent variables.

In the result, R-square is 0.9998. The t-statistics of d(GDP)$_t$, d(GDP)$_{t-1}$, and d(M2)$_{t-1}$ are -4.22, 2.87, and 15.35 which indicate that the estimated parameters of these variables are statistically significant. However, the coefficients of d(GDP)$_{t-2}$, d(GDP)$_{t-3}$, d(M2)$_{t-2}$, and d(M2)$_{t-3}$ with t-statistics of 0.63, -1.62, -1.41, and -0.99 are slightly statistically insignificant.

The estimated equation is

$$d(M2)_t = 6.79167 - 0.20848*d(GDP)_t + 0.23994*d(GDP)_{t-1} + 0.05418*d(GDP)_{t-2} -$$

$$(0.33) \qquad (-4.22) \qquad (2.87) \qquad (0.63)$$

$$0.08626*d(GDP)_{t-3} + 1.28861*d(M2)_{t-1} - 0.19264*d(M2)_{t-2} - 0.08509*d(M2)_{t-3}$$

$$(-1.62) \qquad (15.35) \qquad (-1.41) \qquad (-0.99)$$

*() t-value, critical t value = 2.0

In order to find the optimal equation, we also estimate an alternative equation by adapting variables in the format indicating the percentage change of *M2* and *GDP*, which is denoted as, *d[log(M2)]* being the depend variable, and lagged *d[log(M2)]*'s and *d[log(GDP)]*'s being independent variables. We then estimate the equation in SAS. (Detailed SAS results are in Appendix II.) The new equation can be denoted as

$$d[log(M2)]_t = 0.51323 - 0.19938*d[log(GDP)]_t + 0.12513*d[log(GDP)]_{t-1}$$

$$(2.72) \qquad (-2.19) \qquad (1.33)$$

$$+ 0.1619*d[log(GDP)]_{t-2} - 0.032*d[log(GDP)]_{t-3} + 0.38321*d[log(M2)]_{t-1}$$

$$(1.71) \qquad (-0.35) \qquad (4.52)$$

$$+ 0.07467*d[log(M2)]_{t-2} + 0.19767*d[log(M2)]_{t-3}$$

$$(0.83) \qquad (2.28)$$

*() t-value, critical t value = 2.0

The best results of difference-formed variables and difference-log-formed variables are compared below in table 1.

d(M) is dependent variable

| | Intercept | Independent variables in model | | | | | | |
		d(GDP1)	d(GDP2)	d(GDP3)	d(GDP4)	d(M2)	d(M3)	d(M4)
t-value	0.33	-4.22	2.87	0.63	-1.62	15.35	-1.41	-0.99
Pr > |t|	0.7417	<.0001	0.0047	0.531	0.1067	<.0001	0.1609	0.3233
standard error	20.56616	0.04939	0.08356	0.08625	0.05312	0.08392	0.13668	0.08583
Variance inflation	0	2152.28896	6142.2116	6527.037	2470.23586	4020.46279	10336	3951.34638
R-Square	0.9998							
Adj R-Sqr	0.9998							
AIC	1099.01							

d[log(M)] is dependent variable

| | Intercept | Independent variables in model | | | | | | |
		d[log(GDP1)]	d[log(GDP2)]	d[log(GDP3)]	d[log(GDP4)]	d[log(M2)]	d[log(M3)]	d[log(M4)]
t-value	2.72	-2.19	1.33	1.71	-0.35	4.52	0.83	2.28
Pr > |t|	0.0073	0.03	0.1857	0.0893	0.7272	<.0001	0.4093	0.0242
standard error	0.18852	0.09094	0.09408	0.09461	0.09152	0.08476	0.09022	0.08673
Variance inflation	0	1.23003	1.31663	1.32974	1.22194	1.35113	1.49483	1.37056
R-Square	0.2939							
Adj R-Sqr	0.2581							
AIC	-64.4992							

critical t value= 2.0 and critical p value = 0.05

Table 1

After comparing the results from the best equations selected by SAS, we find that the

difference-log-formed equation is more preferable than the difference-formed equation in terms of

the values of Pr, standard error, variance inflation, and t-statistics of all the parameters.

Based on the observation of standard error, it is obvious that the standard error of the

intercept of difference-formed equation are greater than the standard error value of the difference-

log-formed equation, which intimates that the model with difference-log-formed variables is more

representative and accurate than the model consisting of difference- formed variables.

Furthermore, by considering t-statistics of every independent variable in each equation, we notice

that difference-log-formed equation includes more variables with t-values greater than 2 comparing

with the difference-formed equation. It means the difference-log-formed equation has more

significant variables, and this model is statistically preferred to the model of difference-form.

Moreover, the variables in the difference-log-formed have much smaller variance inflation than the

variables in difference-formed model, which indicates that the difference-log-formed equation has

no multicollinearity problem. Therefore, on the ground of the statistic indicators discussed above,

we regard difference-log-formed equation as the optimal equation estimated.

4.4 Interpretation

Since d(GDP) and d(M2) indicate the difference of GDP's and M2's between two

adjacent quarters, the estimated equation can be implicated as the change in M2 is affected by

the changes of GDP of 1, 2 and 3 quarters ago as well as influenced by the changes of M2 of the

last second, third and fourth quarters simultaneously. Furthermore, with other variables

constant, if the GDP growth of the same quarter was 100 percent, the M2 growth this quarter

will fall by 19.938 percent; if the GDP growth of the previous quarter was 100 percent, M2 growth this quarter will increase by 12.513 percent; if the GDP growth three quarters ago before the previous one was 100 percent, M2 growth this quarter will increase by 16.19 percent; if the GDP growth three quarters ago was 100 percent, M2 growth this quarter will decrease by 3.2 percent; when M2 growth of the previous quarter reached 100 percent, current M2 will increase by 38.321 percent; if M2 growth in the quarter before the previous one was 100 percent, M2 will go up by 7.467 percent; and M2 of three quarters ago raised by 100 percent, the M2 in this quarter will raise by 19.767 percent.

Alternatively, it can also be understood as that the targeted money supply is determined by previous money supply and economic behavior. More precisely, Fed's percentage change of M2 this quarter is influenced by the percentage change of M2 growth of last second, third and fourth quarters and GDP growth of 1, 2 and 3 quarters ago.

As mentioned in section 3, we apply reduced form approach to evaluate the relationship between M2 and GDP. The result indicates that it is the lagged change in GDP and lagged change in M2 that affect actual money supply. However, the previous theoretical analysis highlights the transmission from the change of money supply to the output. In fact, Frederic S. (2007, p.606) states that "If most of the correlation between M and Y occurs because of the Fed's interest-rate target, controlling the money supply will not help control aggregate output, because it is actually Y that is causing M rather than the other way around." The structural approach, which studies every channel that money supply has impact on output, only considers the natural market reaction to the change in money supply. Nevertheless, in the US the fed targets the federal funds rate to control the economy by adjusting money supply. When the

FOMC is determining the money supply, the decision process usually takes the performance of output into consideration, as well as the statistics of other economic indicators. Therefore, despite what the structural approach tries to argue, with the intervention of targeting federal funds rate by the Fed, the change in money supply is actually affected by the change in GDP.

6 Conclusion and limitation

6.1 Conclusion

In this paper we discuss the relationship between money supply and GDP in the US. Through FOMC, the Fed comes out monetary policies and fiscal policies to control the economy. Among its monetary policies, the most effective policy is to control the money supply via interest rate (ffr) in its Open Market Operations. By targeting an ffr in the fund market, the Fed controls the amount of fund circulating in the money market and further controls the economic performance.

To further study this relationship between money supply and economy, we conduct qualitative and quantitative analysis in this paper by adopting M2 measuring money supply and real GDP measuring economic performance. The theoretical analysis indicates that the change of M2 will lead to a change of GDP. Traditionally, IS-LM, and AD-AS results shows that the change of money supply in money market will lead to the change of interest rate and a shift of LM curve. Consequently, the new intersect of IS and LM curves indicates the new equilibrium of output. In goods market, this change in output results in a shift of AD curve which changes the price level in the long term, but the price stays constant in the short run due to its stickiness in the short term. Hence, theoretically, it is obvious that the change of money supply leads to the

change in output in the same direction. In reality, by applying its tight and loose monetary policies, the Fed controls the money supply and achieving the target interest rates by buying and selling Treasuries and other government bonds in money market, and then to control the whole economy.

Based on the conclusion in the theoretical section, in statistical analysis section we then try to generate a more precise relationship of money supply and the economy by estimating an equation of the relevant indicators. According to the theoretical conclusion in theoretical analysis, in this section we firstly apply statistical tests to examine the causality between M2 and GDP, and then estimate an equation of money supply and the output using data from website of St. Louis Federal Reserve Bank. Inspired by the paper of Feldstein and Stock (1994), we apply a simple VAR as the original model in estimating the quantitative relationship of M2 and GDP. After examining the t-test result in OLS, we select d(M2), d(GDP) and their lagged terms as the optimal variables. We simplify the model with d(M2) as dependent variable and lagged d(M2) and lagged d(GDP) as independent variables, and conduct OLS in SAS, and obtain the optimal result.

This estimated equation indicates that the change of M2 in current quarter is influenced by the fluctuation of GDP in the current quarter, the last quarter, the last second quarter and the last third quarter, as well as affected by the variation of M2 in the last second, third and fourth quarters.

6.2 Limitations

To bring the conclusion to a dialectically completion, in this section, we will discuss the endogenous limits of the models and tests we have adopted in statistical analysis. One problem in our study is the limitation of Granger Causality that it does not perfectly indicate the causality. Albeit the Granger Causality test results show that $d(M2)$ does not Granger Cause $d(GDP)$ and $d(GDP)$ Granger Causes $d(M2)$, it does not necessarily prove that $d(M2)$ does not cause $d(GDP)$ or $d(GDP)$ does cause $d(M2)$. Dr. Roland Füss in his lecture on Vector Autoregressive Models mentioned that "Granger Causality is a much weaker argument than normal causality." Instead of stating that $d(GDP)$ and its lags determine the change of M2, the Granger Causality result of $d(GDP)$ Granger Causing $d(M2)$ could be more properly understood as that $d(GDP)$ and its lag terms influence the change of M2 in a certain degree, which could be either significant or insignificant.

Besides Granger Causality, another pitfall in the statistical analysis section is that in the estimated equation of $d(GDP)$ and $d(M2)$, the t-values of $d[log(GDP2)]$, $d[log(GDP3)]$, $d[log(GDP4)]$, and $d[log(M3)]$ are slightly smaller than 2 which makes these coefficients of corresponding variables not statistically significant in explaining the relationship of the variables. To find out a reasonable explanation to this flaw, we first examine the existence of multicollinearity, which could cause insignificant t-test results, by checking the VIF of each variable. Nevertheless, the VIF of every variable is smaller than 2 which is less than the benchmark of a critical value of 5 in defining whether multicollinearity being high. Therefore the multicollinearity is not high among the selected variables in the estimated equation, and the insignificant t-values are not caused by multicollinearity. After considering the study of Hoover and the others on "the causes and effect of U.S. M2" we conclude that this

insignificance is likely to be caused by other indicators not included in the estimated equation whose change would also contribute to the change in M2, such as inflation, unemployment and price-earnings ratio (Hoover, Demiralp and Perez 2008).

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Appendix I

The REG Procedure
Model: MODEL1
Dependent Variable: D_M2_1

Number of Observations Read	147
Number of Observations Used	147

Obs	_MODEL_	_TYPE_	_DEPVAR_	Intercept	D_RGDP_1	D_RGDP_2	D_RGDP_3	D_RGDP_4	D_M2_2	D_M2_3	D_M2_4	D_M2_1
1	MODEL1	PARMS	D_M2_1	6.79167	-0.20848	0.23994	0.054176	-0.08626	1.2886	-0.193	-0.09	-1
2	MODEL1	PARMS	D_M2_1	6.30572	-0.21117	0.2702	.	-0.05953	1.3014	-0.219	-0.07	-1
3	MODEL1	PARMS	D_M2_1	8.42624	-0.20359	0.23882	0.033648	-0.06974	1.3135	-0.301	.	-1
4	MODEL1	PARMS	D_M2_1	7.94207	-0.20585	0.25888	.	-0.05378	1.3194	-0.308	.	-1
5	MODEL1	PARMS	D_M2_1	6.65758	-0.21359	0.22779	0.090837	-0.10561	1.193	.	-0.18	-1

Obs	_P_	_EDF_	_RSQ_	_CP_	_AIC_
1	8	139	0.99976	8	1099.01
2	7	140	0.99976	6.39453	1097.42
3	7	140	0.99976	6.9827	1098.04
4	6	141	0.99976	5.14419	1096.21
5	7	140	0.99976	7.98659	1099.09

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	9.86E+08	140886261	84129.7	<.0001
Error	139	232774	1674.63087		
Corrected Total	146	9.86E+08			

Root MSE	40.9223	R-Square	0.9998
Dependent Mean	4554.28	Adj R-Sq	0.9998
Coeff Var	0.89854		

Parameter Estimates						
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	1	6.79167	20.56616	0.33	0.7417	0
D_RGDP_1	1	-0.20848	0.04939	-4.22	<.0001	2152.289
D_RGDP_2	1	0.23994	0.08356	2.87	0.0047	6142.2116
D_RGDP_3	1	0.05418	0.08625	0.63	0.531	6527.037
D_RGDP_4	1	-0.08626	0.05312	-1.62	0.1067	2470.2359
D_M2_2	1	1.28861	0.08392	15.35	<.0001	4020.4628
D_M2_3	1	-0.19264	0.13668	-1.41	0.1609	10336
D_M2_4	1	-0.08509	0.08583	-0.99	0.3233	3951.3464

The REG Procedure
Model: MODEL1
Dependent Variable: D_LOG_M2_1

Number of Observations Read	147
Number of Observations Used	146
Number of Observations with Missing Values	1

Obs	MODEL	_TYPE_	DEPVAR_	_RMSE_	Intercept	D_LOG_RGDP_1	D_LOG_RGDP_2	D_LOG_RGDP_3	D_LOG_RGDP_4	D_LOG_M2_2	D_LOG_M2_3	D_LOG_M2_4
1	MODEL1	PARMS	D_LOG_M2_1	0.78075	0.51323	-0.19938	0.12513	0.1619	-0.031995	0.38321	0.074668	0.19767
2	MODEL1	PARMS	D_LOG_M2_1	0.77828	0.50202	-0.20165	0.12148	0.15269	.	0.37997	0.072177	0.20332
3	MODEL1	PARMS	D_LOG_M2_1	0.77986	0.55404	-0.19977	0.122	0.15231	-0.026014	0.40866	.	0.22337
4	MODEL1	PARMS	D_LOG_M2_1	0.7773	0.54376	-0.20162	0.1191	0.14504	.	0.40531	.	0.22729
5	MODEL1	PARMS	D_LOG_M2_1	0.7829	0.56379	-0.16506	.	0.19504	-0.018474	0.37178	0.06984	0.20112

Obs	_IN_	_P_	_EDF_	_RSQ_	_CP_	_AIC_
1	7	8	138	0.29388	8	-64.4992
2	6	7	139	0.29325	6.12223	-66.3699
3	6	7	139	0.29037	6.68503	-65.7762
4	5	6	140	0.28996	4.76634	-67.6907
5	6	7	139	0.28483	7.76904	-64.6395

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	35.0094	5.00134	8.2	<.0001
Error	138	84.1198	0.60956		

Root MSE	0.78075	R-Square	0.2939
Dependent Mean	1.55603	Adj R-Sq	0.2581
Coeff Var	50.1754		

Parameter Estimates						
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Variance Inflation
Intercept	1	0.51323	0.18852	2.72	0.0073	0
D_LOG_RGDP_1	1	-0.19938	0.09094	-2.19	0.03	1.23
D_LOG_RGDP_2	1	0.12513	0.09408	1.33	0.1857	1.3166
D_LOG_RGDP_3	1	0.1619	0.09461	1.71	0.0893	1.3297
D_LOG_RGDP_4	1	-0.032	0.09152	-0.35	0.7272	1.2219
D_LOG_M2_2	1	0.38321	0.08476	4.52	<.0001	1.3511
D_LOG_M2_3	1	0.07467	0.09022	0.83	0.4093	1.4948
D_LOG_M2_4	1	0.19767	0.08673	2.28	0.0242	1.3706