An Analysis of the Exit Problem Facing the Fed from Quantitative Easing on Inflation

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I. Introduction

Quantitative Easing (QE) is an unconventional monetary policy used by a central bank to stimulate an economy when standard monetary policy has become ineffective. Standard central banking monetary policies, focus on the buying and selling of government bonds to reach a desired target for the interbank interest rate. However, if a central bank has lowered interest rates to nearly zero, it can no longer lower interest rates or it has to attain negative rates. The central bank may then need to implement QE: purchasing bonds or other financial assets from private financial institutions or the government. The goal of QE is to expand private banking lending, which raises the money supply.

However, the effectiveness of QE is hard to assess quantitatively. Even assuming QE has helped economic recovery, the amount of bank reserves on Fed's balance sheet (about 4.5 trillions) has become a huge number. The potential explosive increase in the money supply will cause huge inflation if the Fed cannot bring down the bank reserves or if the money multiplier returns its nominal level before the 2008 financial crisis. Although the latest QE3 was halted in October 2014, the Fed's balance sheet is still not shrinking.

Even though the former Fed's Chairman Bernanke outlined some major components of the exit strategy on QE during Congressional testimonies in 2010, he did not quantify it thus leaving it vague. I want to examine the potential consequence of QE: the exit problem. This topic should be very interesting to the readers because QE has become a popular unconventional monetary policy after 2008 financial crisis. The most recent case is the European Central Bank (ECB) when it unveiled a massive QE boost for the Eurozone in January 2015. It appears that major developed countries have recently used this policy to boost their economies. It is likely QE would continue to be one of the popular monetary policies. However, QE has led us to an unfamiliar territory. For example, the U.S. has never held so many assets on its Fed's balance sheet. No one really knows exactly how to solve this exit problem.

The outcomes of QE could affect future public policy considerably because we have arrived at an uncharted territory. The public policy implications of QE include its impact, effectiveness, risks and how to exit. Particularly, how to exit from QE policy has become the central issue of QE. Understand how big the exit problem is would help policymakers understand the potential problems when it tries to use QE as well as the possible practical exit strategies (if there is one). There are relatively few literature on the exit problem due to its short history and complexity. Most of the literature was done qualitatively and only a few of them was analyzed quantitatively indirectly on this exit problem. This paper would be addition to the quantitative side of the exit issue; it is done by analyzing how certain hypothetical percent of excess reserve, if leaked to the market, would affect inflation quantitatively.

The hypothesis I would examine is that the Federal Reserve's Quantitative Easing program could lead to significant inflation in the United States. While there are many mechanism that the Federal Reserve has at its disposal as it claimed, I am certainly concerned that no matter how hard the Federal Reserve tries to limit the leakage of reserves into the economy that some of reserves will enter circulation and trigger inflation.

The remainder of this paper is broken into four sections: Literature Review, Economic Model, Empirical Analysis, and Conclusion. In the Literature Review section, it first gives an introduction to monetary policy. Next, it discusses conventional monetary policy and unconventional monetary policy including its history and recent trends. It then discusses in details about why implementing unconventional policy measures, main characteristics of unconventional measures, and the two main implementations of unconventional measures. Finally, it would discuss in details how big the exit problem is in the U.S. as well as the potential exit strategies in the existing literature.

In the Economic Model section, it logically discusses what economic model and theory are used to assess the effects of excess reserves on inflation, and how the hypothesis is going to be examined. In the Empirical Analysis section, it shows all the regression models and why they are chosen for the economic model given in previous section. It also provides an out-of-sample scenario analysis to forecast the how leaked excess reserves affect inflation.

Finally, in the Conclusion it summarizes results in non-technical terms and discuss potential new research questions as well as policy implications.

II. Literature Review

2.1 Introduction to Monetary Policy (conventional and unconventional)

Monetary policy is a process by which the monetary authority of a country controls the supply of money, often targeting an inflation rate or interest rate to ensure price stability and general trust in the currency[1]. Other goals of a monetary policy are to contribute to economic growth and stability, to low unemployment, and to predictable exchange rates with other currencies. Monetary policy is referred to as either being expansionary or contractionary. An expansionary policy increases the total supply of the money in the economy more rapidly than usually, and contractionary policy expands the money supply more slowly than usual or even shrinks it. Expansionary policy is traditionally used to combat unemployment in a recession by lowering interest rates in the hope that easy credit (increased supply of money) will stimulate business into expanding. Contractionary policy is intended to slow inflation to avoid resulting distortions and deterioration of asset values.

Monetary policy can also be divided into conventional and unconventional monetary policy. Conventional monetary policy mainly acts by setting a target for the overnight interest rate in the interbank money market, and adjusting the supply of central bank money to that target through open market operations. An open market operation is an activity by a central bank to buy or sell government bounds on the open market. By steering the level of key interest rates, the central bank effectively manages the liquidity condition (an asset's liquidity is the asset's ability to sell quickly without having to reduce its price very much) in the money markets and pursues its primary objective of maintaining price stability. This has proved to be a reliable way of providing sufficient monetary stimulus to the economy during downturns, of containing inflationary pressures during upturns, and of ensuring the sound functioning of money markets.

In abnormal times conventional monetary policy tools may prove insufficient and achieve the central bank's objective. Generally, there may be two reasons for this. First, the economic shock (e.g. recession) is so powerful the nominal interest rate needs to be brought down to zero. At this level, cutting policy rates further is not possible, so any additional monetary stimulus can be undertaken only by resorting to unconventional monetary measures. Second, unconventional monetary measures may be warranted even when the interest rate is above zero if the monetary policy transmission process (the process by

[1] http://en.wikipedia.org/wiki/Monetary_policy. accessed on Feb 23, 2015.

which a central bank's monetary policy decisions are passed on, through financial markets, to businesses and households) is significantly impaired.

2.2 Main characteristics of unconventional measures

In general, unconventional measures can be defined as those policies that directly target the cost and availability of external finance (funds that firms obtain from outside of the firm) to banks, households, and non-financial companies. Unconventional measures can be seen as an attempt to reduce the spreads between various forms of external finance, thereby affecting asset prices and the flow of funds in the economy. There are usually two possible measures.

One way to affect the cost of financing would be to influence real long-term interest rates by impacting on market expectations. Expectations may work through several channels. For example, the central bank can lower the real interest rate if it can induce the public to expect a higher price level in the future.[2] If expected inflation increases, the real interest falls, even if the nominal rate remains unchanged at the lower bond. Alternatively, policy makers can influence expectations about future interest rates by resorting to a conditional commitment to maintain policy rates at the lower bound for a significant period of time.[3] In either cases, if the management of expectation is successful, it would, *ceteris paribus,* reduce the real long term rate and hence foster borrowing and aggregate demand.

Another way to affect the cost of financing is to affect market conditions of assets at various maturities such as government bonds and corporate debt. Two different type of policies can be considered. The first aims at affecting the level of the longer term interest rate of financial assets across the board, independently of their risk. This policy would operate mainly affecting the market for risk free assets, typically government bonds. This policy is typically known as "*Quantitative easing*" (QE). The second policy is to affect the risk spread across assets, between these whose markets are impaired and those that are functioning. This policy is usually referred as "*credit easing*" (CE). Both policies affect differently the composition of the central bank's balance sheet.[4] Another difference is that "credit easing" can generally conducted also at above zero level of the short-term nominal interest rate, while QE should make sense only when the interest rate is at zero or very close to zero. However, both operations aim at increasing the size of the central bank balance sheet, and therefore expanding its monetary liabilities.

2.3 Implementation of Unconventional Measures

The central bank can change the size and composition of its balance sheets by directly purchasing assets in the relevant markets through two main unconventional measures: Direct Quantitative Easing and Direct Credit Easing. Another unconventional measure (indirect Quantitative/Credit Easing) is not discussed here due to its complexity.

2.3.1 Direct Quantitative Easing

When the central bank decides to expand the size of its balance sheet, it has choose which assets to buy. In theory, it could purchase any asset from anybody. In practice, QE has traditionally focused on buying longer-term government bonds from banks. There are two aspects of this idea: first, government bonds

[2] This is the type of policy analyzed by Krugman (1998),
[3] See Eggertsson and Woodford (2003).
[4] See Bernanke (2009).

serve as a benchmark for pricing riskier privately issued securities. When long-term government bonds are purchased, the yields on privately issued securities are expected to decline in parallel with those on government bonds. Second, if long-term interest rates were to fall, this would stimulate longer-term investments and hence aggregate demand, thereby supporting price stability.

Banks play a critical role in the success of any QE policy. If the goal is to ensure that new loans are provided to the private sector, central banks should mainly purchase bonds from the banks. The additional liquidity would then be used by the banks to extend new credit. However, banks may choose to hold the liquidity received in exchange for the bonds in their reserves at the central bank as a buffer. In this case, the liquidity provided by the central bank remains within the financial sector; it does not flow out of it. This risk can be minimized if the central bank conducts this type of operation at the lower bound. At the lower bound the payment of deposits is null, and there is hence little or no incentive for banks to park excess reserves with the central bank. Deploying a policy QE at a policy rate different from the lower bound necessitate a larger expansion of the central bank's balance sheet and thus increase the risk exposure of the monetary authority.

The soundness of the financial system is critical to the success of quantitative easing. When bank stop lending loans, this policy no longer works. QE is successful if it narrows the market spreads between rates paid on selected credit instrument and policy rates, thereby limiting the risks of a liquidity shortfall and encouraging banks to extend credit to higher interest-pay parties.

2.3.1 Direct Credit Easing

Credit easing is a policy that directly addresses liquidity shortages and spreads in certain market segments through purchase of private assets. The effectiveness of measures depends on their importance in the financing of households and firms, which varies considerably from country to country. Two things need to be noted. First, buying privately issued securities is not fundamentally different from buying government bonds in terms of the impact on the money supply or the monetary base. Second, buying privately issued securities implies that the central bank interacts directly with the private sector and is stepping into the realm of credit risk. Outright purchases of privately issued securities affect the risk profile of the central bank's balance sheet. In order not to compromise the financial independence of the central bank, policymakers need to carefully assess all the assets on account of the implications they could have for the risk exposure of the central bank's balance sheet.

In sum, a simple way to distinguish between the two is that direct QE involves purchasing government assets, while crediting easing involves buying or lending private-sector assets.

2.4 History of Quantitative Easing from Japan and the U.S.

Quantitative Easing was first used by the Bank of Japan (BOJ) to fight domestic deflation in the early 2000s.[5] Under QE, the BOJ flooded commercial banks with excess liquidity to promote private lending, leaving them with large stocks of excess reserves. As a result of the QE, the BOJ's assets significantly increased from ¥91 trillion in 1998 to a peak of about ¥155 trillion in 2006, or from 18 to more than 30 percent of GDP (Syed, Kang & Tokuoka 2009). The BOJ claimed later that QE is not effective and rejected its use for monetary policy[6]. In July 2007, the BOJ entered the exit stage. In an extensive research on

[5] http://en.wikipedia.org/wiki/Quantitative_easing, accessed on Feb 23, 2015.

[6] See Hiroshi Fujiki et al. (2001)

lessons from the Japanese experience, Yamaoka and Syed (2010) conclude that, a smooth exit from QE, without overshooting of inflation, undermining economic recovery, or disrupting financial markets, is possible. However, the authors pointed out a possible exit strategy requires central banks to have sufficient instruments to exit and can convince market participants of their intentions. In reality, this is never easy to accomplish, given the scale of the required unwinding and the relatively untired nature of many of the tools.

In the United States, Federal Open Market Committee (FOMC) controls the supply of credit to banks and the sale of treasury securities. The FOMC meets and makes any changes it sees as necessary, notably to the federal funds rate (the interest rate that borrowing bank pays to the lending bank to borrow the funds) and the discount rate (the interest rate that the Fed charges banks when it lends the bank money). Facing the financial crisis in 2008, the Fed started the unconventional measures in order to simulate the economy. The Fed first launched QE in December 2008, and it lasted until October 2014. All those QE program raised Federal Reserve Balance sheet from under $1 trillion at middle of 2008 to about $4.5 trillion in February 2015.

2.5 Current exit problem in the U.S.

The Federal Reserve, until September 2008, engaged in qualitative easing (balance-sheet policies that deteriorate the average quality of central-bank assets[5]) with an almost constant balance-sheet total. The current $4.5 trillion on Federal Reserve's balance sheet has become a big problem. This huge amount of bank reserves plus the total currency circulating in the public is called monetary base. QE essentially has increased substantially the monetary base. The product of monetary base and money multiplier is called the money supply. The potential explosive increase in the money supply will cause huge inflation if the Fed cannot bring down the bank reserves or if the money multiplier (currently at 0.736 for M1) returns to its level (1.6 for M1) before the 2008 financial crisis. Although the latest QE was halted in October 2014, the Fed's balance sheet is still not shrinking.

Many people are worrying about when interest rates will rise, but that's not the big question. Of course interest rates will rise; they are currently at zero. What the Fed isn't saying is how it plans to get rid of the enormous number of bonds it has bought. By ending QE, the Fed is not filling up the financial hole left by its stimulus. It has only stopped digging itself deeper.

The exit problem lies in restoring a central bank balance sheet without harming the financial system. Unwinding QE by reversing the balance-sheet policies is easy only from a technical point of view. In order to reduce the size of its balance sheets, the Fed could simply sell the government bonds and mortgage-backed securities. However, the reduction of the balance sheet would probably undo policies enacted in order to support the financial systems. For example, by selling securities, the Fed would reduce the amount of banks reserves and thereby reduce liquidity in the interbank loan market. In sum, quantitative tightening would decrease interbank and overall liquidity and could lead to a stronger, deflationary credit tightening. The financial crisis could become aggravated again with destabilizing effects.

There has been considerable debate about whether the Fed should unwind QE at all. Some have suggested that they may not be able to, because selling off all those bonds will cause yields to spike, causing distress to asset holders and the U.S. government[7]. Other have argued that they shouldn't, because having excess reserves improves the liquidity of banks and protects them from runs[8]. However, the Fed has made its intention eventually to unwind QE clearly after September 2014 meeting. Hence the question is not whether, but how the Fed will go about unwinding QE: the method they will use, the timing (how fast/slow, before or after interest rate rises), and the approach to monetary policy.

The former Fed Chairman Ben Bernanke has suggested that the Fed might use alternative means of tightening monetary conditions, not involving securities sales. Bernanke has provided two tightening monetary policies. The first is to move a portion of bank's excess monetary reserves held at the Fed to term deposits (similar to CDs), which would lock up that money for a fixed period. The second is to use "reverse repos", in which the Fed continuously borrows money from the banks, using its treasury securities as collateral. Both tools are functionally identical; they reduce the amount of funds banks have available to loans out, which serves the Fed's purpose of restraining credit growth and inflation. But the hidden catch is that the Fed will lose control over interest rates. The Fed must choose between managing the level of reserves and managing rates. It cannot do both. Yet the Fed is unlikely to be willing to allow rates to rise as far and as fast as the market may demand in a term deposit auction.

Some has suggested the Fed could sell Mortgage backed Security (MBS) portfolio to the Treasury at face value in exchange for Treasury securities. The Fed swapping its MBS with the Treasury in return for Treasury securities is better for U.S. taxpayers. It preserves the value of the securities. It also better for sustaining the recovery of the U.S economy. However, this is still not the ultimate solution to QE problem; the Fed balance sheet still remains unchanged.

Another aspect of the exit problem is the resentment from public that banks have benefited extraordinarily from the Fed's stimulus. While banks made billions in profits from low interest rates, ordinary Americans lost out. Furthermore, the Fed's exit from QE will benefit banks even more. A large part of unwinding QE involves paying banks high interest rates to behave the way the Fed wants to them to behave. The Fed has to find a way to sell over $3 trillion worth of bonds, and the buyers are the same group of banks and hedge funds that first sold them to the Fed.

All the current literature mentioned above about exit problems are all qualitative analyses; they do not have any empirical studies backing it up. They are simply just opinions at the most. The only study has done empirically on the U.S. exit problem is in the article of "When and How to Exit Quantitative Easing" by Yi Wen from Federal Reserve Bank of St. Louis Review[9]. The author constructed a general equilibrium model featuring explicitly large-scale private asset purchases as well as the two exit strategies (a one-time exit and a gradual exit). The author concluded several key points: first, there is an optimal timing to exit with respect to maximizing the mitigating effect of QE. Second, an unanticipated exit works better than an anticipated exit, everything else equal. Third, a one-time exit is likely to work better than a gradual exit provided the timing of the exit is not too early compared with the optimal timing. However, this paper's model is based on a lot of assumptions. Also the model itself is very complex and it's hard to convince general public.

[7] See Comstock Partners Team (2014).
[8] See WSJ by John Cochrane (2014).
[9] See Yi Wen (2014).

In the following sections, I will be mainly analyzing quantitatively the effects of QE with exit on inflation. I will use an economic model (quantity theory of money) learned in class to approach this issue. I will explore all the important assumptions made in the previous quantitative studying on the exit problem. However, I will not address whether or not QE has worked for the economy because the main problem currently is how to exit.

III. Economic Model

M2 is a board measure of money supply and consists of M1 (Cash, demand deposits, travelers' checks, and other checkable deposits) plus saving deposits, small time deposits, and money market mutual funds. During Quantitative Easing (November 2008 – October 2014) M2, according to data from the Federal Reserve Bank of St. Louis's FRED system, increased by over US $ 3.5 trillion (estimate) or 45%. This can be Figure 1.

The money multiplier theory equation is:

$$\Delta D = (\frac{1}{r})\Delta R \qquad (1)$$

In this equation, ΔD represents changes in reservable deposits, r represents required reserve ratio, and ΔR refers to changes in total reserves. The inverse of the reserve requirement in this equation, 1/r, equals the money multiplier m. In the United States there is a required reserve ratio of 10%. Thus, if r is 0.1 (10%), the money multiplier is 10. This means an initial deposit of $1 could result in a maximum of a $10 expansion of the money supply. This has led many to fear that the rapid expansion of the money supply will lead to inflation and further threaten the recovery of the U.S. economy.

The logic behind this reasoning comes to us from the quantity theory of money. Known as the Fisher's equation of exchange as following:

$$MV = PQ \qquad (2)$$

It states that when an economy is in equilibrium and at full employment equation where: M is average amount of money in circulation, V is velocity of money, average frequency with which a unit of money is spent in a specific period of time, P is price level, and Q is real value of all transactions. The theory postulates that V and Q are constant in the long term thus leading to the conclusion that an increase in M will lead to an increase in P or in other words that the expansion of M2 during QE will lead to inflation. However, if we take a close look at the data in Figure 2 from the two most common measure of inflation: CPI and GDP deflator, we do not see a spike in inflation during the period QE.

In fact, using the monthly percentage changes for both the Consumer Price Index and M2 since the beginning of 2006 in a simple correlation reveals that the two variables (either CPI and M2, or deflator and M2) have been negative correlated. The simulative effect on prices from an infusion of dollars into the U.S. economy that was expected by many has not been seen. The reason that we have not experienced a strong recovery, even though trillions of dollars have flowed into financial system from the Fed, is that large portions of the funds have not been utilized by financial institutions and sitting idly as excess reserves. Figure 3 illustrates that since beginning of the QE in November of 2008, the excess reserves of depository institutions has increased astronomically to a total of nearly $2.75 trillion. Compared to the historical amount of excess reserves held by banks in the U.S., which is next to zero,

$2.75 trillion is an astounding amount. The potential inflationary effect of these excess reserves being pushed through financial system is extremely large.

Over time if these large amounts of excess reserves are not drawn down, there could be large amount of price inflation in the U.S. Nevertheless, it appears that the Fed believes it can maintain the excess reserves on the balance sheets of the nation's banks for the time being without this leading to increased inflation. Whether or not the Fed is able to counteract the massive amount of excess reserves, only time will tell. Looking at the inflation forecast taken from Bloomberg's Contributor Composite Average, consisting of 86 domestic and international financial institutions, we can see that the inflation forecasts through 2016 are moderately low (CPI YOY% 2.1% for 2015, 2.3% for 2016[10]). This indicates a level of confidence in the Fed to draw down reserves and tighten monetary policy. However, forecasts are not always accurate and over confidence in the ability of the Fed to manage such a massive issue may render these forecasts irrelevant.

Also, Eq. (2) implies the following is also true:

$$m + v = p + q \tag{3}$$

Eq. (3) states that the sum of money growth and velocity growth is equal to the sum of the price level growth and real output growth. Since V can be treated as a constant, therefore v is zero. From AD-AS framework, a change in m is believed to affect q first, and then p. Perhaps this is why we have not seen huge inflation. I will use Eq. (3) as my model basis to explore my hypothesis in the introduction.

To analyze the potential impact of the excess reserves of depository institution on inflation in the U.S., several regressions will be utilized. Based on Eq. (3), I believe m is going to affect p or inflation. I will first analyze how m affect inflation. Then I will analyze how m and v jointly affect inflation. Those regressions will provide an estimate of this potential inflationary effect and help to understand the magnitude and consequence of QE that has occurred in the United States.

IV. Empirical Analysis

4.1 Data

The following data listed in the Table 1 were collected from St. Louis Federal Reserve Bank FRED system for the empirical analysis. All the data were drawn quarterly from 1985 to 2014, which means there are only 120 observations. One of the potential issues would be the sample size might be small. This was constrained because only quarter data on Velocity of M2 is provided by the FRED system. One solution would be using data from earlier years, but I believe those additional data are not going to affect the results too much. Also, M2 was chosen instead of M1 because M2 is a broader measure of the money supply for the U.S. economy that includes not only the assets directly used for transactions (currency and checkable deposits), but also highly liquid bank accounts used for short-term savings.

4.2 Regression model

4.2.1 Model 1

[10]Source:http://www.bloombergbriefs.com/content/uploads/sites/2/2014/07/G20_Economic_Forecasts_June2014.pdf. . Accessed on February 28, 2015.

The Quantity Theory of Money states that there is a direct relationship between the quantity of money in an economy and the level of prices of goods and services sold. If the amount of money doubles, price levels also double, causing inflation. This is to say that inflation is a monetary phenomenon. In other words, when too much money pursues few goods we experience general price level increases, which lead to inflationary pressures and to inflation. Therefore, first I want to analyze how M2 only affects inflation. The model I will run a regression on is the following:

$$CPI\ \%\ change_t = a + \sum_{i=1}^{2} \varphi_i\, CPI\ \%\ change_{t-i} + \theta \cdot QE_{dummy} + \sum_{i=1}^{4} \beta_i\, M2_{t-i} + \varepsilon_t \qquad (4)$$

This model was chosen for several reasons. This model is combination of an AR (2) model and an unrestricted finite distributed lag model[11]. First, an autoregressive model – AR (2) was included in the model to counteract serial correlation from CPI % change. AR (1) was analyzed initially, but it was shown not enough to fix autocorrelation problem. The lag model used on M2 was because a change in money supply is believed to have lagged effects on price level and real output. As Milton Friedman famously argued lags can be "long and variable." Four lag terms (to mimic 1 year lag effect) were used on M2 to show the lagged effects. Notice a dummy variable is included for the QE policy. QE is 0 from 1985 to the 3rd quarter of 2008 (No QE implementation). QE is 1 from 4th quarter of 2008 to the end of 2014 (QE implementation). Also, two periods were analyzed: 1985 to 2014 and 1985 to 2005. Notice the dummy variable was not used in the short period because there was no QE during 1985 to 2005. Two periods were used for analyses because I believe the model might not capture the effects of increase of money supply on inflation after QE was initialized. This huge amount of money created by the Fed might have changed the entire structure of the market.

The Results from the regression and Durbin Watson test statistic are listed in Table 2 and Table 3. The Durbin Watson statistics were 1.8723 and 1.9821 for both periods respectively, which means no autocorrelation in the residuals is valid. Notice the coefficient on the money supply is negative and significant for the period of 1985 to 2014. This means if the money supply increases, the inflation decreases, which contradicts quantity theory of money. Also the sum of the coefficients on money supply terms (M2 and its lag terms) is negative, which is not desired. The coefficient of the money supply for the short period also negative and insignificant. This means model 1 is not appropriate to show the essence of Quantity Theory of Money.

4.2.2 Model 2

In order to adjust the model, I used real GDP deflator for inflation instead of CPI in the following regression shown in Eq. (5). GDP deflator is not identical with the CPI but provides an alternative to each other as measure of inflation. The CPI is usually used to measure how the prices of a typical market basket of good changes over time. Consumption goods are the main priority of the CPI measure. The GDP deflator takes accounts goods that are produced domestically. In the GDP deflator, the so-called basket in a year is weighted by the market value of all the consumption of each good, therefore it is allowed to change with people's investment and expenditure patterns since people do respond to varying prices. I believe this alternative measure of inflation may catch positive effects of money supply on inflation, and provide some ideas what is happening to the model.

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[11] AR(2) and unrestricted finite distributed lag model are referred from Econometric Analysis 5th by W. Greene.

$$Deflator\ \%\ change_t = a + \sum_{i=1}^{2} \varphi_i\ Deflator\ \%\ change_{t-i} + \theta \cdot QE_{dummy} + \sum_{i=1}^{4} \beta_i\ M2_{t-i} + \varepsilon_t \quad (5)$$

The results from model 2 are shown in Table 4 and 5. All the variables were the same as model 1 except CPI (real GDP deflator was used instead). Interestingly, although all the coefficients on money supply and its lag terms are still insignificant, the sum of the coefficients on those terms is closer to zero comparing to the sum from model 1. This means the deflator may have reduced the negative effect of money supply on inflation. However, model 2 failed to predict quantity theory of money once again.

4.2.3 Model 3

Puzzled by this troubling problem, I revisited the assumptions of Quantity Theory of Money. There are three theoretical assumptions. First V is fixed with respect to the money supply. Second, the supply of money is exogenous. Third, the direction of causation runs from left to right. The story of the Quantity Theory of Money then states that since V is fixed and M is exogenous, then an increase in the supply of money will lead exactly to a proportionate increase in the price level. Therefore, money supply expansions only cause price inflation. However, the regressions above showed otherwise. Money supply may not be the only factor in the current economy. Note Quantity Theory of Money was started in the 16^{th} century, there were not many things to be considered. In fact, prior to the 1990s, one could speak of the U.S economy as a closed economy since trade between the U.S. and other nations was essentially nonexistent, relative to current global economic realities. In the paper "Import Response and Inflationary Pressures in the New Economy[12] (2008)," it suggested that inclusion of the values of imports of goods and services and the value of oil imports on the right-hand side of the equation of exchange can accurately measure the presence of inflationary pressures. Hence I incorporated the contributions of imports of goods and services to percent change in real GDP to see if that would have effects on the previous model. The following Eq. (6) is the regression model I ran. Again, the regression was run on two different periods for comparison. The results are listed in Table 6 & 7.

$$Deflator\ \%\ change_t = a + \sum_{i=1}^{2} \varphi_i\ Deflator\ \%\ change_{t-i} + \theta \cdot QE_{dummy} + \sum_{i=1}^{4} \beta_i\ M2_{t-i} + (IM/GDP)_t + \varepsilon_t \quad (6)$$

Interestingly, the coefficient on the supply of money became positive but still insignificant even though the sum of the coefficients from all the money supply term is still a negative number (-0.018). The coefficient on the new term, percent contribution of imports of goods and services to real GDP is positive and significant for the short period, which means imports of goods and services will reduce inflation. This makes sense because as domestic demand tends to outpace domestic supply, foreign goods and services flow in to augment the shortage in domestic supply, thereby reducing or even eliminating the possibility of general price level increases and/or inflation. However, this did not happen to the coefficient on IM/GDP over the long period. I believe the recent QE implementation may have skewed the market, so the model failed to predict both effects of money supply and the percent contribution of imports of goods and services as expected. There must be an omitted variable that is causing the problem.

As mentioned above, the V is assumed to be fixed over long period. Whether or not this still applies the current economy, no one is certain. Therefore, I believe velocity could correct all the previous models.

[12] Ajuzie, Edoho, Kang, Uwakonye, Keleta (2008).

4.2.4 Model 4

The following regression model in Eq. (7) included addition two terms: Velocity of M2 and its first lag. Only one lag term was used because velocity in general is not a long variable. Indeed, more regressions were run with more lag terms on Velocity (results are not shown in the paper), but the coefficients on those lag terms appear to be insignificant.

$$Deflator\ \%\ change_t = a + \sum_{i=1}^{2} \varphi_i\, Deflator\ \%\ change_{t-i} + \theta \cdot QE_{dummy} + \sum_{i=1}^{4} \beta_i\, M2_{t-i} + \left(\frac{IM}{GDP}\right)_t + \sum_{i=1}^{2} \varphi_i\, V2_{t-i} + \varepsilon_t \quad (7)$$

The results are listed in Table 8 and 9. Shockingly, the coefficient on money supply became positive and significant for the long period. The sum of the all the coefficients from money supply is also positive (0.1091). The coefficient of Velocity is positive and significant for the long and short periods. The coefficient on IM/GDP are positive for both periods, but only significant for the short period. The results from this regression seem to be able to capture the essence of Quantity Theory of Money: Increasing the supply of money would cause inflation.

4.3. Scenarios Analysis

In order to get a better idea of how the excess reserves of depository institutions as reported by the FRED system could affect inflation, I created a scenario analysis to forecast what would happen if banks started using part of those newly created excess reserves. First, I calculated the expansion of the M2 measure of money supply if certain level of excess reserves were to enter the economy. I used data from the FRED system to calculate the expansion of the M2 money supply by multiplying the excess reserves by a hypothetical percentage that could leak into the M2 measure of money supply. I then calculated a historical M2 money multiplier (M2/ monetary base) using data from 1985 to 2014 and a QE-affected money multiplier (from 2008 to 2014). Following this I calculated the percentage increase that the excess reserves would cause in the M2 measure of money supply. I did this by taking the money multiplier and multiplying by the amount reserves then adding it the current amount M2 before dividing by the current amount of M2. This is showed in Eq. (8).

$$M2\%\ Increase = \frac{current\ M2 + Excess\ Reserves \cdot Money\ Multiplier}{current\ M2} \times 100\% \quad (8)$$

I then plugged these values for M2 percent increase, and hypothetical V2 % change into the Eq. (7) to determine potential inflationary effects given various scenarios. I assumed the percent contribution of imports of goods and services to GDP is zero. I also assumed there was no inflation from previous quarters, therefore the two lag terms don’t contribute. QE dummy variable was set to zero. Those results are listed in Table 10 and 11.

Looking at the results of the scenario analysis from Table 10 and 11, it becomes apparent the excess reserves of depository institution could certainly cause high levels of inflation in the U.S. For example, if the velocity percent change is zero, even leaking 1% of excess reserve would cause a 20% inflation at least.

In the Figure 4, it shows a graphic representation of how inflation increases linearly with increase of percent of leaked excess reserve. If the money multiplier returned to historical average, which is shown in the blue line, it would have much bigger effect on inflation.

V. Conclusion

Understanding the exit problem of Quantitative Easing is extremely important because it gives me a sense of how severe the problem is. It might not be obvious to the American public at the current state, but it would affect the economy drastically if the Fed cannot manage it cautiously. In this paper, I was able to quantify the consequence of Quantitative Easing. I accomplished this by showing how certain hypothetical percent of excess reserve, if leaked to the market, would affect inflation quantitatively. The results were shocking. Even 1% percent of excess reserve leaked to the market, it would push inflation up at least to 20%, which is unimaginable in the U.S. That's probably why the Fed is so cautious about how to keep the excess reserve in the banks as long as possible by paying higher interest to the banks. However, the Fed paying banks higher interests would certainly increase the burden on itself. It is going to be a fraught process for Fed to move on from this point.

Another interesting finding through this paper is that we no longer can rely on the old conclusions from Quantity Theory of Money. Analyzing money supply only is certainly not enough to examine inflation. The assumptions of the theory should be reconsidered carefully. The QE policy has pushed our economy into an uncharted territory. The data from the market are so skewed that it is more difficult than ever to make accurate predictions using old models and theories.

If I were to study this issue again, I would look into possible solutions to the exit problem. Perhaps starting with all the Fed's purposed solutions. I would like to quantify them to see if they are feasible. For policy implications, I also think quantitative easing have not solved our problem, but only delayed the solution. The problem can only be solved by acknowledging it. The Fed has to figure out how to exit from QE without causing public outrage. Perhaps this is the biggest challenge the Fed has ever encountered. I believe there will be significant challenges throughout the process of reversing excess reserves from the balance sheets of banks and there will be a fine line between successfully removing reserves and causing economic turbulence.

My studying is different from the most of study done out there for the exit problem. Not only did I argue qualitatively why the exit problem is severe, but I was also able to quantify the problem and capture the essence without making the model too complicated. I also provided some insightful comments on Quantity Theory of Money by critiquing its dated assumptions. I believe my paper would help other people understand and move forward with this exit issue. It has generated some new research questions such as what other possible factors would contribute to inflations, and how to solve exit problem.

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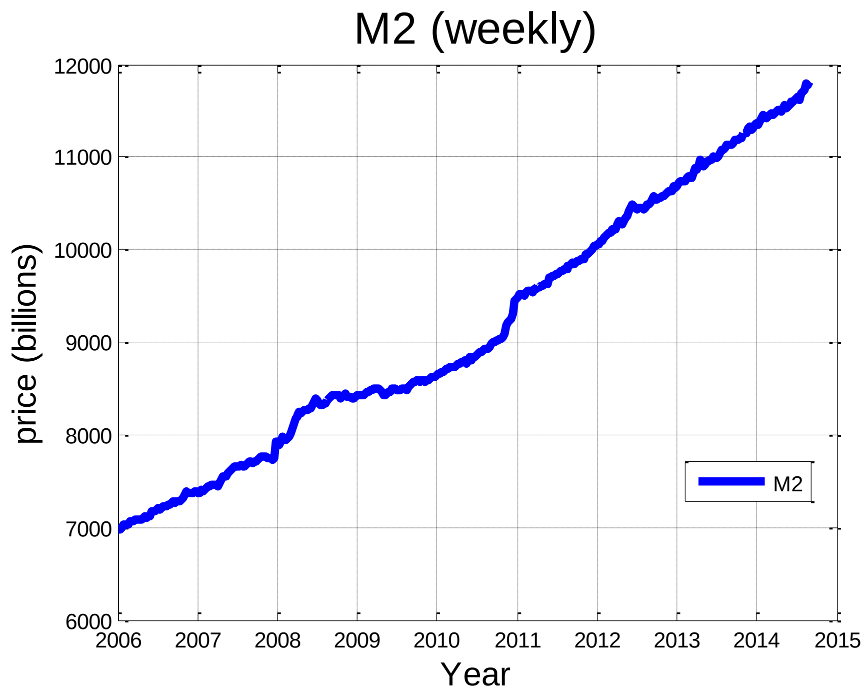

Figure 1. M2 from 2006 to 2015 (Source: St. Louis Federal Reserve Bank FRED system[13]

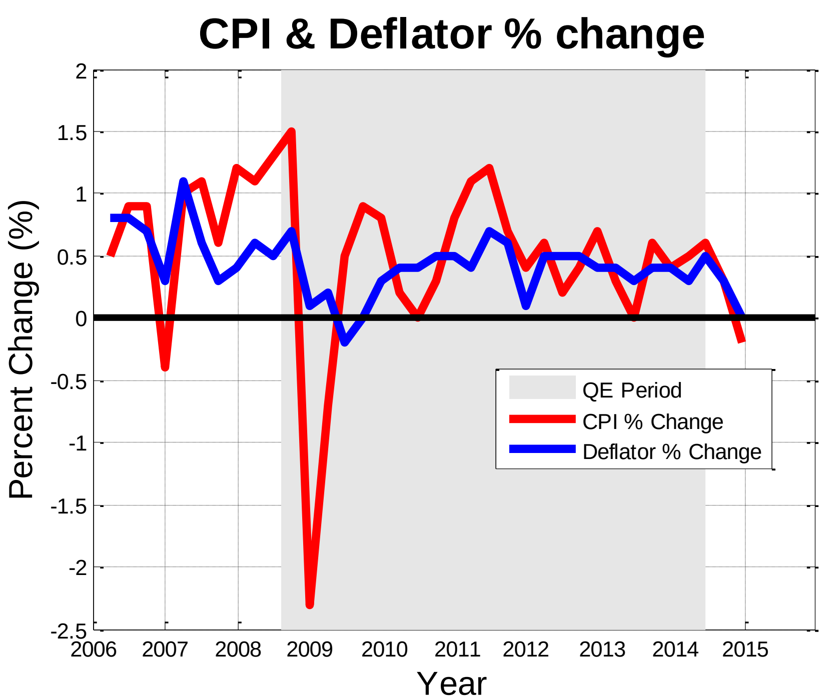

Figure 2. CPI and real GDP deflator % Change from 2006 to 2015 (Source: St. Louis Federal Reserve Bank FRED system.[14]

[13] Source: http://research.stlouisfed.org/fred2/series/M2V/downloaddata. Accessed on February 28, 2015.
[14] Source: http://research.stlouisfed.org/fred2/series/CPIAUCSL/downloaddata. Accessed on February 28, 2015.

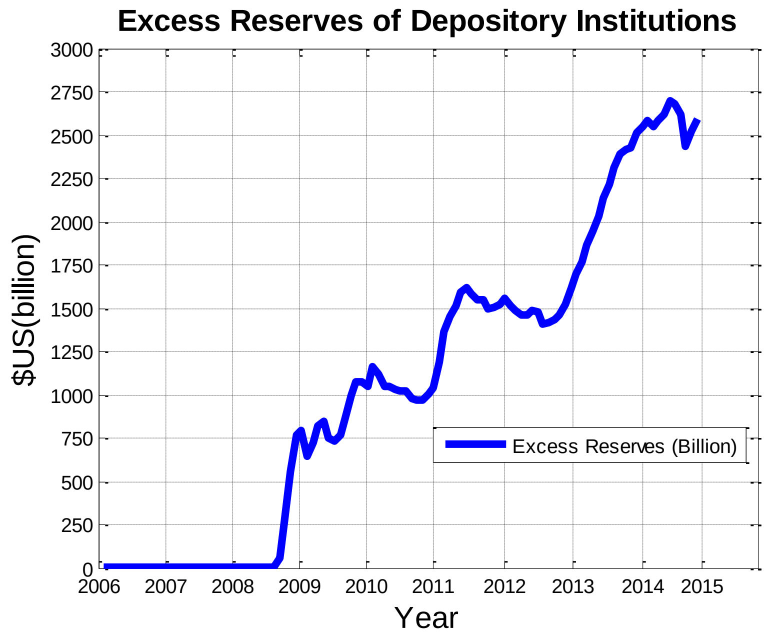

Figure 3. Excess Reserves of Depository Institutions from 2006 to 2015 (Source: St. Louis Federal Reserve Bank FRED system).[15]

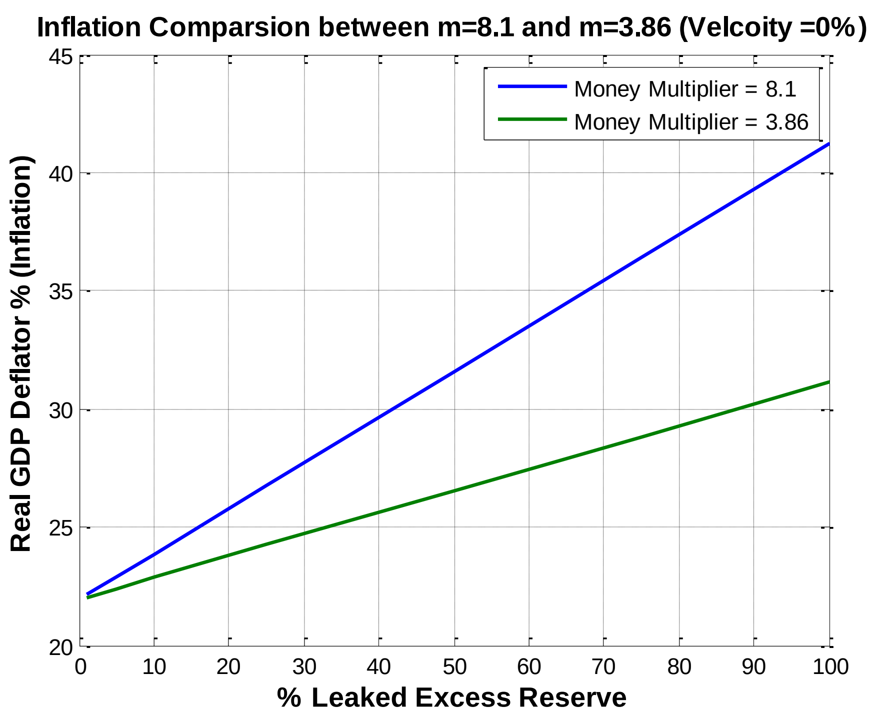

Figure 4. Inflation Forecast with Different Money Multiplier.

[15] Source: http://research.stlouisfed.org/fred2/series/EXCSRESNS/downloaddata. Accessed on February 28, 2015.

Table 1. Data Selection from St. Louis Federal Reserve Bank FRED system.

Variable	Description	Frequency	Measurement
CPI	U.S. Consumer Price Index	Quarterly from 1985 to 2014	% Change
V2	Velocity of the M2 Money Stock	Quarterly from 1985 to 2014	% Change
M2	M2 Money Stock	Quarterly from 1985 to 2014	% Change
Deflator	Real GDP Deflator	Quarterly from 1985 to 2014	% Change
IM/GDP	Contributions to % change in real GDP: imports of goods and services	Quarterly from 1985 to 2014	Change, percentage Points at Annual Rate
M2	M2 Money Stock	Quarterly from 1985 to 2014	Billions of Dollars
B	Monetary Base	Quarterly from 1985 to 2014	Billions of Dollars

Table 2. Results from 1st Regression.

Variables	Estimate		t value		P value	
	1985-2014	1985-2005	1985-2014	1985-2005	1985-2014	1985-2005
Intercept	0.77147 (0.15796)	0.42096 (0.15316)	4.884	2.748	3.66e-06 ***	0.00761 **
CPI_{t-1}	0.24001 (0.09610)	0.29971 (0.11692)	2.498	2.563	0.01403 *	0.01252 *
CPI_{t-2}	-0.07034 (0.09788)	0.18995 (0.11868)	-0.719	1.601	0.47393	0.11397
QE_{dummy}	-0.32721 (0.11117)		-2.943		0.00398 **	
M2	-0.16498 (0.07013)	-0.12084 (0.07295)	-2.352	-1.656	0.02048 *	0.10210
$M2_{t-1}$	0.02021 (0.08116)	-0.01220 (0.08677)	0.249	-0.141	0.80386	0.88862
$M2_{t-2}$	0.06084 (0.07980)	0.07424 (0.08396)	0.762	0.884	0.44749	0.37964
$M2_{t-3}$	-0.07599 (0.07849)	-0.07198 (0.08484)	-0.968	-0.848	0.33514	0.39910
$M2_{t-4}$	0.05034 (0.06651)	0.08803 (0.06818)	0.757	1.291	0.45081	0.20092

Signif. codes: 0 '*' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. () is Standard Error.**

Table 3. Statistics from 1st Regression & Durbin-Watson Test.

Results from Regression		
	1985-2014	**1985-2005**
Residual Std. Error	0.4508 on 107 DF	0.3345 on 70 DF
Multiple R-squared	0.2462	0.2609
Adjusted R-squared	0.1898	0.187
F-statistic	4.368 on 8 and 107 DF	3.53 on 7 and 70 DF
p-value	0.0001371	0.002654
Durbin-Watson test		
DW	1.8723	1.9821
p-value	0.1938	0.4112

Table 4. Results from 2nd Regression.

Variables	Estimate		t value		P value	
	1985-2014	1985-2005	1985-2014	1985-2005	1985-2014	1985-2005
Intercept	0.251392 (0.077330)	0.31459 (0.12399)	3.251	2.748	0.00154 **	0.0134 *
Deflator$_{t-1}$	0.426856 (0.095158)	1.71156 (0.18708)	4.493	9.149	1.79e-05 ***	1.41e-13 ***
Deflator$_{t-2}$	0.219336 (0.095158)	1.86204 (0.18854)	2.305	9.876	0.02310 *	6.69e-15 ***
QE$_{dummy}$	-0.102455 (0.046286)		-2.214		0.02898 *	
M2	-0.001548 (0.027523)	-0.08251 (0.05479)	-0.056	-1.506	0.95524	0.1366
M2$_{t-1}$	-0.057225 (0.031779)	0.11378 (0.06506)	-1.801	1.749	0.07456 .	0.0847 .
M2$_{t-2}$	0.001271 (0.031820)	-0.08619 (0.06298)	0.040	-1.368	0.96822	0.1755
M2$_{t-3}$	0.014185 (0.031817)	0.06543 (0.06364)	0.446	1.028	0.65663	0.3074
M2$_{t-4}$	0.013064 (0.026770)	-0.04253 (0.05140)	0.488	-0.827	0.62654	0.4108

Signif. codes: 0 '*' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. () is Standard Error.**

Table 5. Statistics from 2nd Regression & Durbin-Watson Test.

Results from Regression		
	1985-2014	**1985-2005**
Residual Std. Error	0.1815 on 107 DF	0.252 on 70 DF
Multiple R-squared	0.4925	0.9036
Adjusted R-squared	0.4546	0.894
F-statistic	12.98 on 8 and 107 DF	93.76 on 7 and 70 DF
p-value	6.247e-13	< 2.2e-16
Durbin-Watson test		
DW	2.015	2.0238
p-value	0.4513	0.472

Table 6. Results from 3rd Regression.

Variables	Estimate		t value		P value	
	1985-2014	1985-2005	1985-2014	1985-2005	1985-2014	1985-2005
Intercept	0.2072739 (0.0885750)	0.48161 (0.14627)	2.340	3.292	0.0212 *	0.00157 **
$Deflator_{t-1}$	0.4254910 (0.0950027)	1.67882 (0.18368)	4.479	9.140	1.9e-05 ***	1.66e-13 ***
$Deflator_{t-2}$	0.2468355 (0.0988804)	1.77021 (0.18981)	2.496	9.326	0.0141 *	7.64e-14 ***
QE_{dummy}	-0.0936656 (0.0470709)		-1.990		0.0492 *	
M2	0.0053018 (0.0283242)	-0.10378 (0.05459)	0.187	-1.901	0.8519	0.06147
$M2_{t-1}$	-0.0509741 (0.0323572)	0.09972 (0.06401)	-1.575	1.558	0.1182	0.12382
$M2_{t-2}$	0.0005471 (0.0318217)	-0.08580 (0.06298)	0.017	-1.393	0.9863	0.16814
$M2_{t-3}$	0.0121455 (0.0318734)	0.07762 (0.06253)	0.381	1.241	0.7039	0.21869
$M2_{t-4}$	0.0148480 (0.0268218)	-0.04518 (0.05030)	0.554	-0.898	0.5810	0.37217
IM/GDP	-0.0178201 (0.0174571)	0.07811 (0.03825)	-1.021	2.042	0.3097	0.04495 *

Signif. codes: 0 '*' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. () is Standard Error.**

Table 7. Statistics from 3rd Regression & Durbin-Watson Test.

Results from Regression		
	1985-2014	**1985-2005**
Residual Std. Error	0.1815 on 106 DF	0.2465 on 69 DF
Multiple R-squared	0.4975	0.9091
Adjusted R-squared	0.4548	0.8986
F-statistic	11.66 on 9 and 106 DF	86.28 on 8 and 69 DF
p-value	1.448e-12	< 2.2e-16
Durbin-Watson test		
DW	2.0587	2.0835
p-value	0.5237	0.5562

Table 8. Results from 4th Regression.

Variables	Estimate		t value		P value	
	1985-2014	1985-2005	1985-2014	1985-2005	1985-2014	1985-2005
Intercept	0.110243 (0.090001)	0.37186 (0.16363)	1.225	2.273	0.223375	0.0263 *
$Deflator_{t-1}$	0.372981 (0.096584)	1.63650 (0.18774)	3.862	8.717	0.000196 ***	1.23e-12 ***
$Deflator_{t-2}$	0.223592 (0.094660)	1.77834 (0.18638)	2.362	9.541	0.0141 *	4.15e-14 ***
QE_{dummy}	-0.046951 (0.047339)		-0.992		0.323594	
M2	0.119717 (0.042804)	0.01992 (0.08069)	2.797	0.247	0.006149 **	0.8058
$M2_{t-1}$	-0.041390 (0.045282)	0.09972 (0.08346)	-0.914	0.915	0.362807	0.3635
$M2_{t-2}$	0.006813 (0.030459)	0.07636 (0.06298)	0.224	-1.280	0.823435	0.2050
$M2_{t-3}$	0.015810 (0.030502)	-0.07758 (0.06062)	0.518	1.162	0.605341	0.2493
$M2_{t-4}$	0.008182 (0.025723)	-0.04005 (0.04948)	0.318	-0.809	0.751070	0.4212
V2	0.109508 (0.032228)	0.12558 (0.05863)	3.398	2.142	0.000964 ***	0.0358 *
$V2_{t-1}$	0.021541 (0.034120)	-0.01714 (0.06426)	0.631	-0.267	0.529205	0.7906
IM/GDP	0.021679 (0.021237)	0.10335 (0.04259)	1.021	2.426	0.309728	0.0180 *

Signif. codes: 0 '*' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. () is Standard Error.**

Table 9. Statistics from 4th Regression & Durbin-Watson Test.

Results from Regression		
	1985-2014	**1985-2005**
Residual Std. Error	0.1733 on 104 DF	0.242 on 67 DF
Multiple R-squared	0.5504	0.915
Adjusted R-squared	0.5028	0.9023
F-statistic	11.57 on 11 and 104 DF	72.1 on 10 and 67 DF
p-value	8.218e-14	< 2.2e-16
Durbin-Watson test		
DW	2.0457	2.1555
p-value	0.4962	0.6675

Table 10. Scenario Analysis: Money Supply and Velocity % Increase on Inflation using m=8.1.

Real GDP Deflator % (inflation) using money multiplier 8.1							
V%	% of leaked Excess Reserves						
	100%	75%	50%	25%	10%	5%	1%
6%	42.03%	37.20%	32.37%	27.55%	24.65%	23.69%	22.92%
5%	41.89%	37.07%	32.24%	27.42%	24.52%	23.56%	22.79%
4%	41.76%	36.94%	32.11%	27.29%	24.39%	23.43%	22.65%
3%	41.63%	36.81%	31.98%	27.16%	24.26%	23.30%	22.52%
2%	41.50%	36.68%	31.85%	27.03%	24.13%	23.16%	22.39%
1%	41.37%	36.54%	31.72%	26.89%	24.00%	23.03%	22.26%
0%	41.24%	36.41%	31.59%	26.76%	23.87%	22.90%	22.13%
-1%	41.11%	36.28%	31.46%	26.63%	23.74%	22.77%	22.00%
-2%	40.98%	36.15%	31.33%	26.50%	23.61%	22.64%	21.87%
-3%	40.85%	36.02%	31.20%	26.37%	23.47%	22.51%	21.74%
-4%	40.72%	35.89%	31.06%	26.24%	23.34%	22.38%	21.61%
-5%	40.58%	35.76%	30.93%	26.11%	23.21%	22.25%	21.48%
-6%	40.45%	35.63%	30.80%	25.98%	23.08%	22.12%	21.34%

Table 11. Scenario Analysis: Money Supply and Velocity % Increase on Inflation using m=3.86.

Real GDP Deflator % (inflation) using money multiplier 3.86							
V%	% of leaked Excess Reserves						
	100%	75%	50%	25%	10%	5%	1%
6%	31.92%	29.62%	27.32%	25.02%	23.64%	23.18%	22.82%
5%	31.79%	29.49%	27.19%	24.89%	23.51%	23.05%	22.68%
4%	31.66%	29.36%	27.06%	24.76%	23.38%	22.92%	22.55%
3%	31.53%	29.23%	26.93%	24.63%	23.25%	22.79%	22.42%
2%	31.40%	29.10%	26.80%	24.50%	23.12%	22.66%	22.29%
1%	31.27%	28.97%	26.67%	24.37%	22.99%	22.53%	22.16%
0%	31.14%	28.84%	26.54%	24.24%	22.86%	22.40%	22.03%
-1%	31.00%	28.71%	26.41%	24.11%	22.73%	22.27%	21.90%
-2%	30.87%	28.57%	26.27%	23.97%	22.60%	22.14%	21.77%
-3%	30.74%	28.44%	26.14%	23.84%	22.46%	22.00%	21.64%
-4%	30.61%	28.31%	26.01%	23.71%	22.33%	21.87%	21.51%
-5%	30.48%	28.18%	25.88%	23.58%	22.20%	21.74%	21.37%
-6%	30.35%	28.05%	25.75%	23.45%	22.07%	21.61%	21.24%