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THE EFFECT OF EXCESS RESERVES ON U.S REAL GROSS DOMESTIC PRODUCT

Submitted by

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ABSTRACT:

The recent financial crisis has triggered questions regarding the role of the Federal Reserve Bank and the effectiveness of its intervention in the financial markets, post the crisis. This paper investigates the impact of huge spikes in excess reserves on the U.S. real gross domestic product. U.S. Federal Reserve in an effort to deal with the 2008 financial crisis instituted a series of programs aimed at taming the impact of the crisis. Through its emergency lending activities and Quantitative Easing (QE) programs, the Federal Reserve created a huge spike in excess reserves to levels not seen before.. The empirical findings of this research show that a negative correlation exist between excess reserve and U.S. real gross domestic product. In fact the results show that a 5% increase in excess reserves results in a 0.1% reduction in real GDP activity. The analysis also indicates that an increase in excess reserves negatively impact full employment and asset prices. Additionally, Federal funds rate show a significantly positive association to real gross domestic product, possibly evidencing the Feds payment of interest on excess reserves.

1. Introduction

With increasing levels of Excess Reserve being held by the Federal Reserve on behalf of depository institutions, this research investigates the effect of excess reserve on U.S. economic output measured in real GDP terms. Available research has shown a direct link between regulatory enforcement actions and the contraction of bank loans to sectors likely to be credit dependent (Peek, J. and E.S. Rosengren, 1995a). According to the recent H.3 release from the Board of Governors of the Federal Reserve System, depository institutions are holding significant amounts of balances in excess of their required reserves. The H.3 report shows that an excess reserve of about $2,212 trillion (data as of August, 2017). The current level of excess reserves is one of the highest in recent times and the available data points to the fact that the rising levels started in the aftermath of the 2008 Financial Crisis, which saw the collapse of the banking giant Lehmann Brothers; ushering in the present day regulatory actions.

Excess reserves are the surplus of the reserves banks hold against deposits and certain other liabilities that depository institutions (commonly called "banks") hold above the amounts that the Federal Board requires within ranges set by federal law. The general rule is that covered institutions maintain reserves at least equal to ten percent of liabilities payable on demand, (Todd (2013). The 2008 Financial Crisis has changed the trade-off that banks normally make when determining their desired level of excess reserves. Recently, banks now operate in an atmosphere in which holding reserves seem much more attractive due to the lower cost of holding them compared to pre-crisis times. Craig and Koepke (2015) further argued that the Fed created this phenomenon in which it has embarked on policies designed to mainly pump large amount of reserves into the banking system creating conditions that made it easier and attractive for banks to rather hold a significant amount of cash in excess reserves. More balances in reserves points to the

truth of less funds in the banking system for lending or rather, with such dramatic increase in excess reserves, liquidity needs for businesses and households is restrained.

Several literature exist that point to the fact that lending activities by banks have a real impact on economic growth, but limited work has been done on assessing the impact of excess reserves on economic activity. When banks are able to lend to businesses and households alike, it contributes positively to Gross Domestic Product (GDP). Banks are able to extend credit when they have enough funds to do so, and when the expected return on lending activity is at least more than the return on risk-free asset such as Treasury Bills, (Todd (2013).

In 2008, the Federal Reserve, in an attempt to deal with the Financial Crisis introduced a significant amount of reserves into the U.S. banking system through a set of programs that basically changed the trade-offs that banks make when determining their level of excess reserves. In 2008, the Federal Reserve announced that it would start paying interest of 25 basis points on all reserves which made it more attractive for banks to hold reserves than lending such amount towards activities that have the propensity to spare the growth of the economy. This phenomenon has resulted in a reduction in additional cost of excess reserve when measured by the opportunity cost of other uses for the reserves, (Todd (2013). Before the crisis, banks commonly parked their cash in the Federal funds market for short periods. The interest rate in this market, hovering between seven and twenty basis points since the crisis, has lagged the interest rate paid by the Federal Reserve for excess reserves (Craig and Koepke, (2015), as depicted in Figure 1.

Figure 1. Federal Funds Target Rate
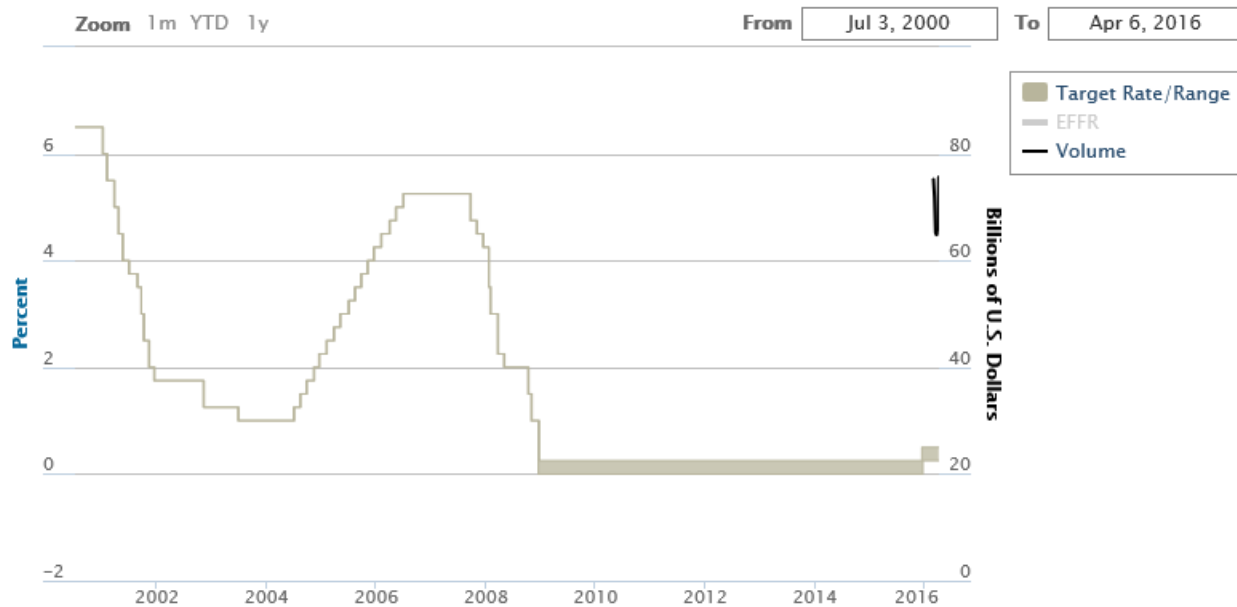
Source. Federal Reserve Board.

The paper's contributions to the literature are several. First, the study provides direct evidence that excess reserve negatively impacts U.S Real Gross Domestic Product. The results indicate that a 5% increase in excess reserves results in a 0.1% reduction in real gdp. This confirms McKinnon (1973), Shaw (1973) theories of financial development and economic growth. In their theory they established that government actions through monetary maneuvers aimed at restricting banking system functioning (such as interest rate ceilings, high reserve requirements and directed credit program) impede financial development and, hence, reduces economic growth. Since the acted in a way to constrained banking activity by way of creating massive uptick in excess reserves, it directly put restrictions in the banking that effectively led to the reduction in real U.S gdp as evidenced in the research. The results also indicate that the subsequent reduction in real gdp sets off a feedback loop which negatively impacts both employment as well as inflation, which will ultimately result in an economic slowdown. If policy makers' intention is to drive an increase in

economic output while simultaneously ensuring that banks are well capitalized to withstand an economic downturn, then critical consideration is needed to determine the optimal level of excess required reserves. The study also shows that an increase in TED Spread leads to a positive outcome in U.S Real Gross Domestic Product, signifying availability of credit needed to expand activities that will lead to positive economic output. The study also shows that Chicago Fed National Activity Index – CFNAI_MA3, is good predictor of economic activity in the U.S. An increase CFNAI_MA3 shows a positive relations U.S Real Gross Domestic Product. A 2% increase in CFNAI_MA3 is associated with a 0.32% increase in U.S Real Gross Domestic Product.

This research fills a gap that exist in empirically testing the impact of excess reserve on U.S Real Gross Domestic Product.

The remainder of the paper is organized as follows: Section 2 provides background information about excess reserves; Section 3 discusses various literature on the subject of excess reserves; and Section 4 discusses the data. In Section 5, the study present empirical analysis along with results and Section 6 concludes the paper.

2. Background on U.S. Excess Reserves

In the history of banking, there has been the assumption that banks may hold reserves against deposits they receive from households and businesses. The level of reserves that banks are expected to hold against deposit has been a subject for debate over a long period of time and still there's no consensus on the appropriate level that is adequate. Historically, reserves in most banking systems include gold, silver, coins, currency and in the case of the U.S. full faith and credit of the US Government Treasury suffices for reserves. In other cases, deposit accounts that banks hold with central bank and in the U.S. banking system for example, deposit accounts held at the Federal Reserve Banks account for most of the reserve in the system, Todd (2013).

Before the 2008 Financial Crisis, banks, both large and small reserve were mostly in Vault cash which was mainly used to cover wire transactions as well as check settlements. Recent regulations, especially Federal Reserve Board's Regulation D (12 CFR Part 204), requires banks to hold reserves equal to ten percent of their checking and other accounts which are subject to third party withdrawals, collectively known as their demand liabilities. At the inception of the Federal Reserve banks in the 1914s most financial institutions that were members of the Federal banking system deposited their reserves, which was about 13% of the demand liabilities, at the Federal Reserves banks. The Fed instituted a discount window system that helps member banks meet their reserve requirement, (Meulendyke, 1992).

Available data shows that the Fed's monetary balance sheet has expanded from about $900+ billion before the 2008 financial crises to recent levels of about $4+ billion, this includes about $2.2 billion in excess reserves. The Fed created this huge excess reserve through a series of policy actions which were intended to transmit the Federal Reserve's monetary policy. First, in an attempt to address the fallout of the financial crises, the Fed engaged in emergency lending

activities which saw excess reserve move from less than $2 billion to $767 billion by the end of 2008 (Todd 2013). Secondly, the Fed's program known as Quantitative Easing (QE), which involved the purchases of government agency debt and agency-guaranteed mortgage-backed securities, contributed to the increase. For example between 2009 and late spring of 2010, excess reserve went over $1 Trillion. A further QE program in 2011 resulted in creation of additional $581 billion in excess reserve. Further QE's in 2012 and 2013 all resulted in the creation of excess reserve in the banking systems. Orlowski (2015) pointed out that even with all the increase in excess reserve which has provided banks with massive liquidity injections, there's still no spark in credit extension that would have been expected.

3. Literature Review

Several prior studies and empirical findings complement my research (see for instance Driscoll (2004), Fuerst (1992)). A number of earlier work have identified a link between monetary policy or regulatory actions such as the Federal Reserve's emergency lending and Quantitative Easing programs that effectively resulted in the creation of excess reserves and the quantity of loans banks make to households and industries (see for instance Gertler and Gilchrist (1994), McKinnon (1973), Shaw (1973)). According to Kashyap and Stein (1994), the mix of commercial-paper/loans varies after creative and innovative monetary policy was introduced for a sample of small manufacturing firms. Similarly, Morgan (1992) finds that bank loans that are not under commitment decline with innovations in monetary policy. Regulatory actions affect banks in different ways; work by Peek and Rosengren (1995a) and Cappiello el at. (2010) show that regulatory actions on banks leads to a decrease in bank lending and hence economic growth. Kashyap and Stein (2000), find that small and less liquid banks have a larger lending reaction than larger, better and well capitalized banks.

Gertler and Gilchrist (1994) find that there appears to be enough evidence that at the microeconomic level, small firms turn to suffer most when banks lend less.

Oliner and Rudebusch (1996) argue that this is a result of a "broad credit channel", and not a bank lending channel. In a series of papers, Peek and Rosengren (1995b, 2000) and Peek, Rosengren and Tootell (2000) use regulatory actions and shocks to the parent banks of foreign-owned subsidiaries as measures of shocks in loan supply. Survey by Kashyap and Stein (1994) and the further comment by Eichenbaum (1994) provide evidence that lending channel at the aggregate level is more mixed.

Bernanke and Lown (1991), tried to answer the question of whether contraction in bank lending during the credit crunch in 1990 has had any macroeconomic impact. They find that although it is likely that a bank credit crunch (or capital crunch) has occurred and has imposed costs on some borrowers, they were somewhat skeptical that the credit crunch played a major role in worsening the 1990 recession. However, they established that the subdued lending activities of banks had a somewhat macroeconomic impact especially in real GDP. Fuerst (1990) finds that monetary injections cause changes in asset prices for the non-Fisherian reasons and that monetary injections have increased both current and future real activity. They further conclude that the Federal Bank actions has the ability to dampen and or cause changes in real activity. This result complements my findings that the recent monetary policy moves by the Federal Reserve banks which ended up creating significant rise in excess reserves, had a negative impact on the U.S. real gdp.

This research complements work by Fawley and Neely (2013) which suggest that invested liquidity may limit banks' credit expansion that has been otherwise historically known to contribute positively to economic growth and job creation. Orlowski (2015) finds that massive liquidity injected by the Fed into the banking system, particularly in the aftermath of the financial crisis, has restrained bank credit.

4. Data Analysis and Model

To examine the effect of excess reserve on U.S Real Gross Domestic Product, this research use data on excess reserve, U.S Real Gross Domestic Product data, Federal Funds Rate, TED Spread, Employment Rate data and Chicago Fed Economic Activity Index. A write up on each variable is presented below.

4.1 Variable Definitions

4.1.1 U.S Real Gross Domestic Product

The dependent variable in this research is U.S Real Gross Domestic Product. Real Gross Domestic Product (real GDP) is a macroeconomic term that measure of the value of economic output adjusted for changes in inflation or deflation. This adjustment transforms nominal GDP, which is a money-value measure, into an index for quantity of total output. Although GDP is total output, it is useful because it closely approximates the sum of consumer spending, investment made by industry, excess of exports over imports, and government spending. GDP does not actually reflect the true growth in an economy because of increases in inflation. To tame the impact of inflation, GDP must be divided by the inflation rate to get the growth of the real GDP. Quarterly data on real GDP was downloaded from the website of Federal Reserve Bank of St. Louis – FRED. The dataset spans from second quarter of 1986 – third quarter 2017. U.S Real Gross Domestic Product is computed as:

$$\mathbf{RGDP} \ = \ \frac{ngdp}{gdpd} \tag{1}$$

where rgdp = Real Gross Domestic Product

ngdp = Norminal Gross Domestic Product

gdpd = Gross Domestic Product Deflator

4.1.2 Excess Reserve of U.S Commercial Banks

In order to determine the effect of Federal Reserve's monetary policy initiatives that created the massive excess reserves, this research attempt to find the effect of excess reserves on economic output or business cycle, using real GDP as the measure of economic output. Excess reserves are capital reserves held by a bank or financial institution in excess of what is required by regulators, creditors or for internal controls. For commercial banks, excess reserves are measured against standard reserve requirement amounts set by Federal Reserve. The Federal Reserve set out a portion of depositors balances that U.S commercial banks must have on hand as cash, this is referred to as the reserve ratio. For this research excess reserve is the main independent variable been tested considering its massive uptick in recent years. Quarterly data on Excess reserves was downloaded from the website of Federal Reserve Bank of St. Louis – FRED. The dataset spans from second quarter 1986 – third quarter 2017. In basic form, excess reserve is computed as follows:

$$\text{Excess Reserve} = \text{Legal Reserve} - \text{Required Reserve} \qquad (2)$$

Where legal regal reserves represent cash held by banks to effect daily transactions and deposits held at anyone Federal Reserve regional banks; Required Reserve represent the reserves that the Federal Reserve requires banks to hold in anticipation of withdrawals

4.1.3 Effective Federal Funds Rate

Federal funds rate is the rate at which depository institutions lend their reserve balances to other depository institutions overnight. Federal Reserve requires banks to keep a certain percentage of their customer's money on reserve, where the banks earn no interest on it. Federal Reserve uses federal funds rate to control the supply of available funds and thus, have bearing on inflation and

other interest rates. Raising the rate makes it more expensive to borrow, that lowers the supply of available money, which increases the short-term interest rates and helps keep inflation in check. According Anderson (June 2017), since the Federal Open Market Committee (FOMC) has increased the target range for the federal funds rate by 25 basis points three times, bringing the target range from 0 to 25 basis points in late 2015 to 75 to 100 basis points in March 2017, the overnight money market rates have moved up smoothly with each of the FOMC's increases in the target range for the federal funds rate. In particular, both unsecured and secured overnight interest rates have risen in line with each change in the target range with little volatility. Lowering the rate has the opposite effect, bringing short-term interest rates down. Considering its impact on borrowing and production activity, Federal Funds Rate is included as control variable in this research to account for any impact of interbank borrowings and how that may have a likely effect on economic output. Quarterly data on effective Federal Funds Rate was downloaded from the website of Federal Reserve Bank of St. Louis – FRED. The dataset spans from second quarter 1986 – third quarter 2017.

4.1.4 TED Spread

Ted Spread measures the difference between the interest rates on interbank loans and short-term government debt such as T-Bills). TED Spread is included in the model to gauge the level of liquidity in the system and determine the prevalence of counterparty risk. TED is an acronym where T stands for Treasury bill and ED is the ticker symbol for a Eurodollar futures contract sold on the Chicago Mercantile Exchange. Eurodollars are U.S. dollars on deposit in commercial banks outside the United States, and prices for CME Eurodollar futures contracts are determined by the market's forecast of the 3-month London Interbank Offered Rate (LIBOR). One key measure of perceived risk and volatility in markets is TED Spread and its included in this research model to

accounts for it possible impact on economic activity. Quarterly data on effective TED Spread was downloaded from the website of Federal Reserve Bank of St. Louis – FRED. The dataset spans from second quarter 1986 – third quarter 2017.

4.1.5 U.S Employment Rate

Employment rate is defined as a measure of the extent to which available labor resources (people available to work) are being used. It is calculated as the ratio of the employed to the working age population. Employment rate is sensitive to the economic cycle, but in the longer term it is significantly affected by government policies. Employment rate is included in the research model since it's also an indication of the health of the economy. Quarterly data on effective U.S Employment Rate was downloaded from the website of Federal Reserve Bank of St. Louis – FRED. The dataset spans from second quarter 1986 – third quarter 2017.

4.1.6 Chicago Fed National Activity Index (CFNAI)

The Chicago Fed National Activity Index (CFNAI) is an index designed to gauge overall economic activity and related inflationary pressure. The CFNAI is a weighted average of 85 existing monthly indicators of national economic activity. It is constructed to have an average value of zero and a standard deviation of one. Since economic activity tends toward trend growth rate over time, a positive index reading corresponds to growth above trend and a negative index reading corresponds to growth below trend. The 85 economic indicators that are included in the CFNAI are drawn from four broad categories of data: production and income; employment, unemployment, and hours; personal consumption and housing; and sales, orders, and inventories. Each of these data series measures some aspect of overall macroeconomic activity. The derived index provides a single, summary measure of a factor common to these national economic data. To control for variables that measure economic activity, CFNAI is included in the model for this

research. Additional data on CFNAI is included in the appendix. Quarterly data on effective CFNAI was downloaded from the website of Chicago Federal Reserve Bank. The dataset spans from second quarter 1986 – third quarter 2017.

4.2 Empirical Model and Hypothesis

4.2.1 Persistence of Data Variables

Quite recently, several researchers have started to question the validity of the significance of a number of predictors used in various models in the finance literature. For example, Goyal and welch (2008) have found that persistence contributed mainly contributor to the significance found in several equity returns models. Similarly Stambaugh et al (2012), have also found similar evidence regarding the validity of a number of earlier findings. A persistent series can be defined as one where the value of the variable at a certain date is closely related to the previous value. Persistence is also the extent to which events that occur today have an effect on the whole future history of a stochastic process. This is certainly a central issue in macroeconomic theory and policy. In their seminal paper, Nelson and Plosser (1982) argued that the presence of unit roots meant that shocks were persistent, and that the data were consistent with Real Business Cycle (RBC) models, in which most shocks to GNP were mostly technology shocks. Campbell and Mankiw (1987a, 1987b), however, suggested that an ARMA (2, 2) model provided the best description of the data for US real GDP, and that this is generated by a difference-stationary (DS) (or unit root) process. They went further to conclude that the long-run response of US GDP to a unit shock, given by the cumulative response function A (1), is greater than 1, which implies that there is no trend-reversion, (Caporale 2001).

De Long and Summers (1988) claimed that stabilization policies proved to be were much more effective in the post-war era, when a larger portion of the delta of US GNP could be explained by

a stochastic trend. Several research attributed the high degree of persistence shown by GDP to supply factors (see e.g. King et. al. (1991), Shapiro and Watson (1988), and Blanchard and Quah (1989)), although West (1988) proved that persistence is also consistent with Keynesian models of business cycles. Similarly, a lot of effort was aimed at estimating the degree of persistence of unemployment and to determining its causes (see e.g., Blanchard and Summers (1986), and Alogoskoufis and Manning (1988)).

A lot of statistics have been proposed to capture the persistence of macroeconomic time series. Cochrane (1991a) argued that, because any time series with a unit root can be separated into a stationary series and a random walk, and the latter can have an arbitrarily small variance, persistence should be measured as the ratio of the variance of the change in the random walk component to the variance of the actual change (see Cochrane (1988)). Furthermore, unit root tests do not give much information about persistence (see Cochrane (1991b)). Firstly, the argument that series which are more likely to reject unit root tests are also those that are "less persistent" shocks has no much theoretical justification. Secondly, the persistence of univariate prediction error shocks can be absolutely different from that of multivariate prediction error shocks, (Caporale 2001).

In a different context, Cavaglia (1992) showed how a measure of persistence may be determined through the use of Kalman filtering. Finally, rescaled range statistic (R/S), an alternative test statistic, was first introduced by Hurst (1951) and then later refined by Mandelbrot (1972, 1975), and Lo (1991), whose abbreviated rescaled range statistic converges to a well-defined random variable under the null hypothesis of short-term dependence, and can show the difference between short-run and long-run dependence. All the studies outlined so far derived measures of persistence in the form of univariate models. The question that needs answering, however, is whether estimates of persistence are invariant to a model selection; would we make

the same inference if a multivariate framework was adopted? In Cochrane and Sbordone (1988), research for example, they provided a measure of persistence for GNP and stock prices using multivariate information. Their statistic, however, relied on strong identifying restrictions that are non-testable. Lupi (1993) also suggested that persistence measures are not invariant to the information set, and that probabilistic framework are inadequate to capture persistence in terms of non-mixing properties.

There are two basic measures of persistence - autocovariance and the autocorrelation coefficient. The correlation of a time series with its own past and future values- is known as Autocorrelation. This is normally also known as "lagged or series correlation". Positive autocorrelation indicate a specific form of persistence, which is the tendency of a system to remain in the same state from one observation to the next. Future values of the samples probabilistically will depend on the current & past samples if a time series shows correlation. There the existence of autocorrelation can be captured in prediction as well as time series modeling. Normally an economic time series can often be seen as a noisy proxy for an underlying economic variable. Measurement errors will influence the dynamic properties of the observed process and may hide the persistence of the underlying time series, (Caporale 2001).

This research used a multivariate model to assess the effect of excess reserves on U.S real GDP. To investigate the existence of possible persistency in the data, an autocorrelation function (ACF) was used. From figure 2, ACF plot summarizes the correlation of a time series at various lags at their levels. It plots the correlation co-efficient of the series lagged by 1 delay at a time in the sample plot. Plotting the ACF for the output from the models (equation 4), the study show that autocorrelation exist in the most of the variable at their levels. U.S Real GDP, Excess Reserves, Federal Funds Rate and Employment Rate are persistent through-out the lags tested. Only TED

Spread and CFNAI show autocorrelation dissipating after about lag ten of the tested lag horizon. This observation of persistence with general understanding that most macroeconomic variable have autocorrelation.

To tame the effect of autocorrelation and to address persistency, the data used in the research was differenced. Both table 3 and figure 3 show the disappearance of autocorrelation. The results validate the model because ACF disappears with the differencing of the data. Plots for U.S Real Domestic Gross Product, Federal Funds Rate and U.S Employment Rate, show a significant correlation at lag 1 that decreases after a few lags. Plots for Excess Reserves, TED Spread and Chicago Fed National Activity Index show a large spike at lag 1 followed by a decreasing wave that alternates between positive and negative correlations.

4.2.2 Hypothesis and Model

To test the hypothesis that excess reserves significantly predict the changes in real gdp, Eqn (3) is fitted to the data. Next the study extends the model by controlling for a number of popular predictors in the literature which is represented by equation 4.

For the purposes of this research base model (I) is presented as:

$$RGDP = \beta 0 + \beta Ex\_Res + \varepsilon \qquad\qquad (3)$$

To check the impact of excess reserves on U.S. Real Gross Domestic Product, model I is used as base model before controlling for other variables to test the real effect on excess reserve on U.S real GDP before controlling for other variable.

To control for other variables, an expanded model as Model II as presented below:

$$indp_{i,t+1} = \beta_{i,0} + \beta_b Ex\_Res + \beta_d ffr + \beta_m Ted_t + \beta_c cfnai_t + \beta_{oi} emp_t + \varepsilon_{t+1} \qquad \textbf{(4)}$$

where *rgdp* denotes real gross domestic product, *Ex_Res* represents excess reserve, *ffr* denotes effective funds rate, *Ted* represents ted rate, Emp represent U.S employment rate and CFNAI is an economic activity index provided by Chicago Fed.

Since this research is investigating how Real Gross Domestic Product (real GDP), which is a macroeconomic measure of the value of economic output adjusted for price changes (i.e., inflation or deflation) is impacted, is adjusted. This adjustment transforms the money-value measure, nominal GDP, into an index for quantity of total output and I present both Real GDP and GDP Deflator as:

$$\textbf{RGDP} = \frac{ngdp}{gdpd} \qquad (5)$$

and

$$gdpd = \frac{ngdp}{\text{rgdp}}$$

where rgdp = Real Gross Domestic Product

ngdp = Norminal Gross Domestic Product

gdpd = Gross Domestic Product Deflator

The relevant measure of variables for this model includes those components which affect the ability of banks to make loans and hence hampers real economic growth. This consists of all U.S. commercial banks excess reserve, effective funds rate, TED Spread, U.S employment rate and Chicago Fed economic activity index.

4.2.3 Summary Statistics and Data Analysis

Time series summary statistics of data is presented in table 1. This represent a quick simple

description of the data used in this research.

Table I

Summary statistics of Quarterly Time Series of U.S. real GDP, Excess Reserves, TED Spread, Federal Funds Rate, Employment Rate and Chicago Fed National Activity Index, 1986:Q1 to 2017:Q3

Table I reports summary statistics for the quarterly data on U.S. Excess Reserves, Real GDP, TED Spread, the Fed Funds rate and Chicago Fed National Index covered in the study. The average quarterly values range from _-0.31_(CFNAI) to _15,314_ (Real GDP). The standard deviations and maximum/minimum values clearly indicate the high volatility of variable Real GDP, with Excess Reserves displaying the greatest volatility (9.71%) over the sample.

Variable	Units	Symbol	Mean	Std. Dev	Min	Max
Real GDP	Billions of 2009 Chained U.S. Dollars	RGDP	15,314	840	14,099	17,031
Excess Reserves	Billions of U.S. Dollars	EXReserve	1,236	971	2	2,677
Effective Federal Funds Rate	Percentage	FedRate	1.35	1.88	0.07	5.26
TED Spread	Percentage	TED	0.51	0.51	0.13	3.15
Employment Rate	Percentage	Employment_Rate	69.01	1.98	66.5	72.2
Chicago Fed National Activity Index	Index	CFNAI_MA3	-0.31	0.84	-3.87	0.5

Figure 1: Plots depict quarterly Time Series of U.S. real GDP, Excess Reserves, Ted Spread, and Federal Funds Rate from Federal Reserve Bank of St. Louis FRED. Chicago Fed National Activity Index from Chicago Fed. Show stationarity of the variable used in this research.
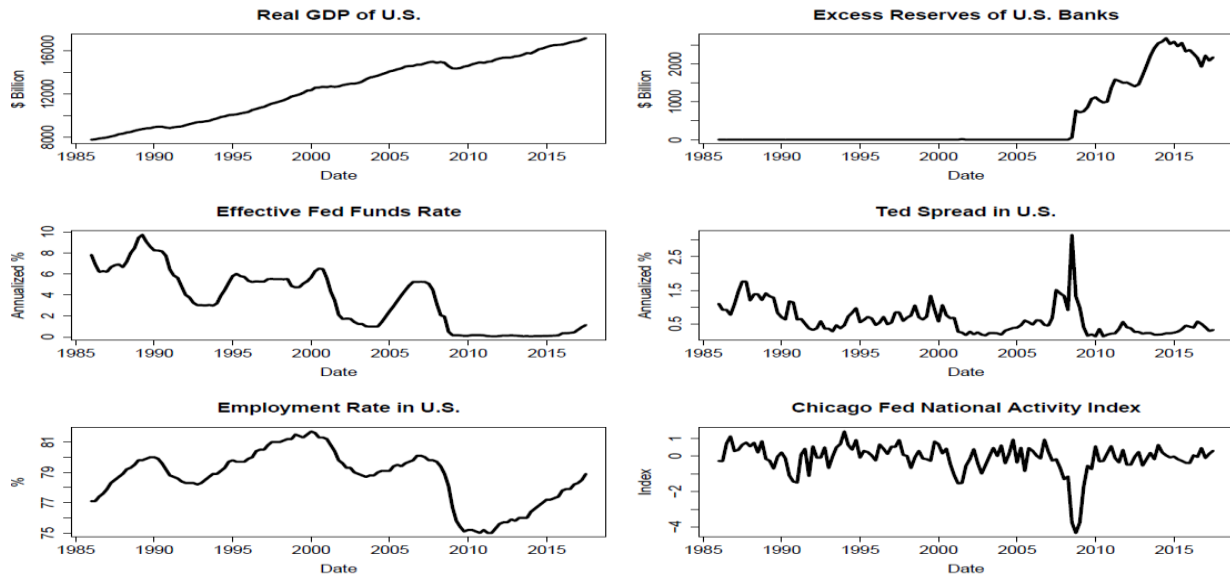
4.8 ACF Function Test

Autocorrelation function (ACF) test is performed on the data variables to test the persistency of data used. Autocorrelation exist among the variables at their level as depicted below.

Figure 2: depict level ACF (graph) of U.S. real GDP, Excess Reserves, Commercial Banks Deposits, Ted Spread, Federal Funds Rate and Employment Rate from Federal Reserve Bank of St. Louis FRED. Chicago Fed National Activity Index from Chicago Fed.
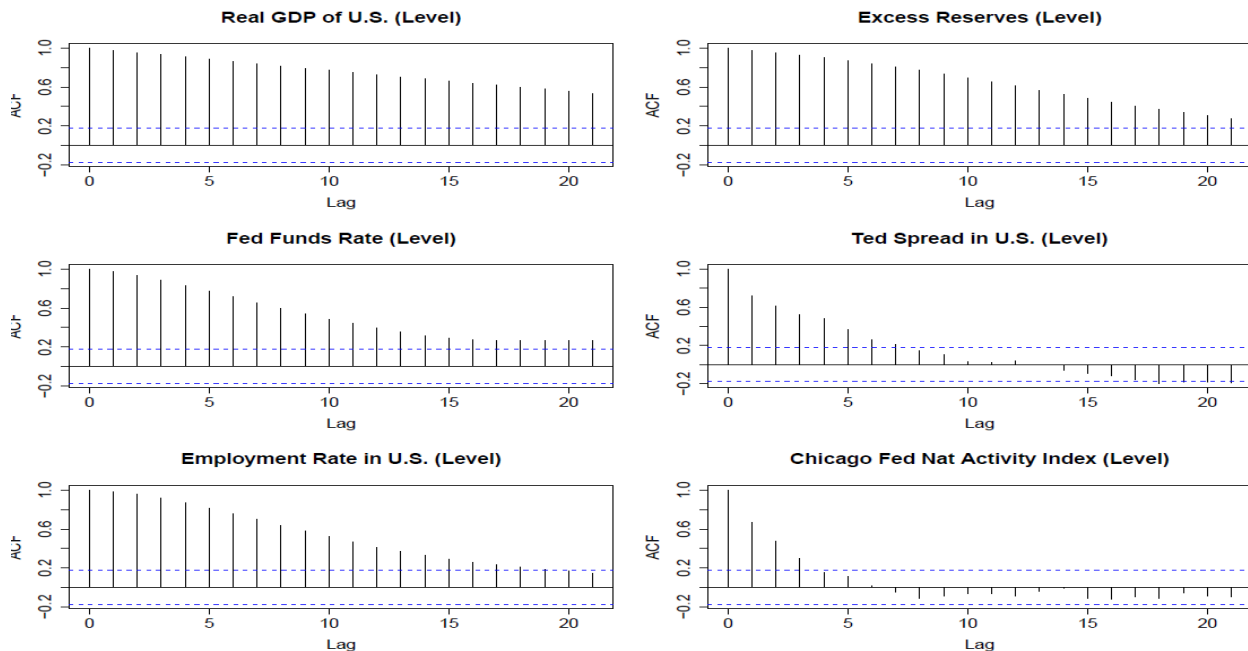
Table 2: depict level ACF (table) of U.S. real GDP, Excess Reserves, Ted Spread, Federal Funds Rate and Employment Rate from Federal Reserve Bank of St. Louis FRED. Chicago Fed National Activity Index from Chicago Fed.

Table II

Summary of *Autocorrelation Function test (ACF) of level* **Quarterly Time Series of U.S. real GDP, Excess Reserves, TED Spread, Federal Funds Rate, Employment Rate and Chicago Fed National Activity Index, 1986:Q1 to 2017:Q3**

Lag	RGDP	EXReserve	FedRate	TED	Employment_Rate	CFNAI_MA3
1	0.98	0.98	0.97	0.72	0.99	0.67
2	0.95	0.95	0.94	0.62	0.96	0.47
3	0.93	0.93	0.89	0.52	0.92	0.30
4	0.91	0.90	0.83	0.48	0.87	0.15
5	0.89	0.87	0.78	0.37	0.82	0.11
6	0.86	0.84	0.71	0.26	0.76	0.02
7	0.84	0.81	0.65	0.21	0.70	-0.05
8	0.82	0.77	0.59	0.14	0.64	-0.11
9	0.79	0.74	0.54	0.10	0.58	-0.09
10	0.77	0.70	0.49	0.03	0.52	-0.06

To minimize the presence of autocorrelation in the variables, the variables are differenced and the results are displayed in Figure 3. The results show that the ACF disappears at their difference. Plots for U.S Real Domestic Gross Product, Federal Funds Rate and U.S Employment Rate, show a significant correlation at lag 1 that decreases after a few lags. Plots for Excess Reserves, TED Spread and Chicago Fed National Activity Index show a large spike at lag 1 followed by a decreasing wave that alternates between positive and negative correlations.

Figure 3: graph depict differenced ACF of U.S. real GDP, Excess Reserves, Commercial Banks Deposits, Ted Spread, Federal Funds Rate and Employment Rate from Federal Reserve Bank of St. Louis FRED. Chicago Fed National Activity Index from Chicago Fed.
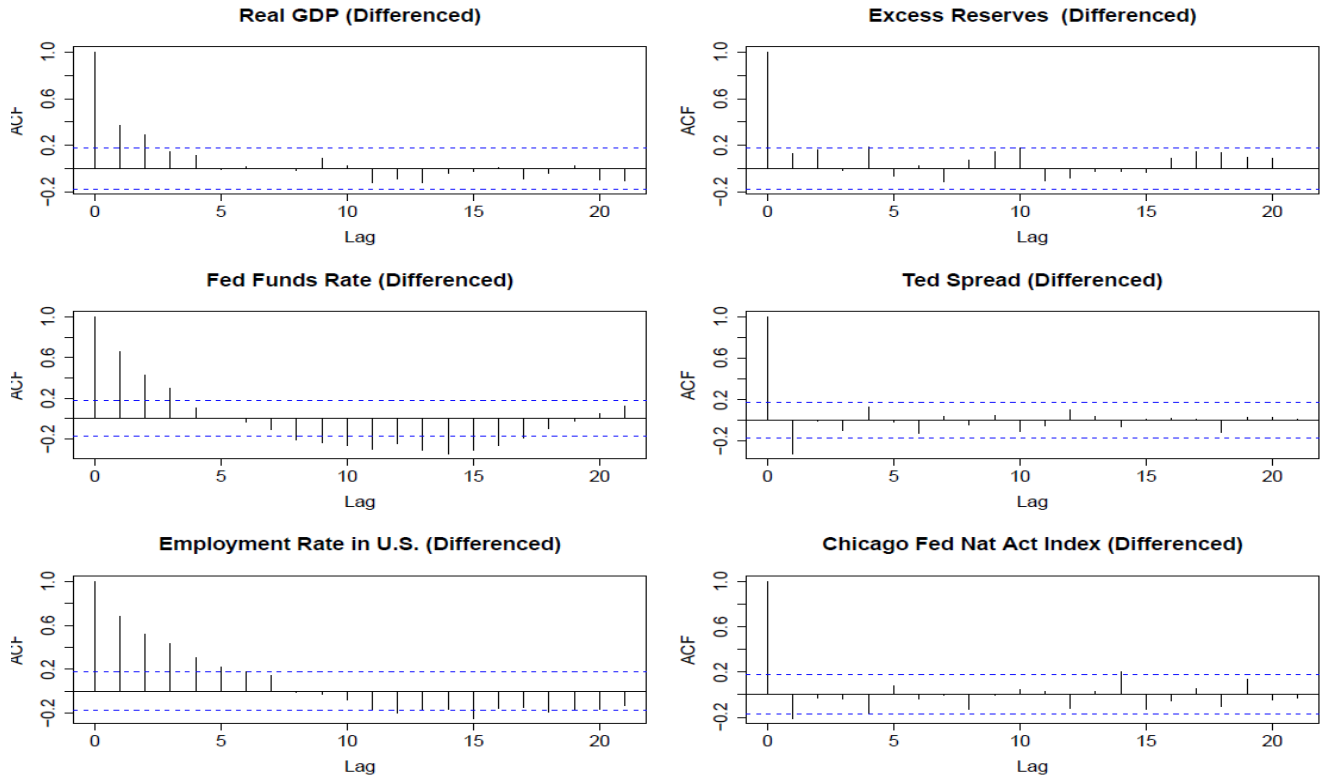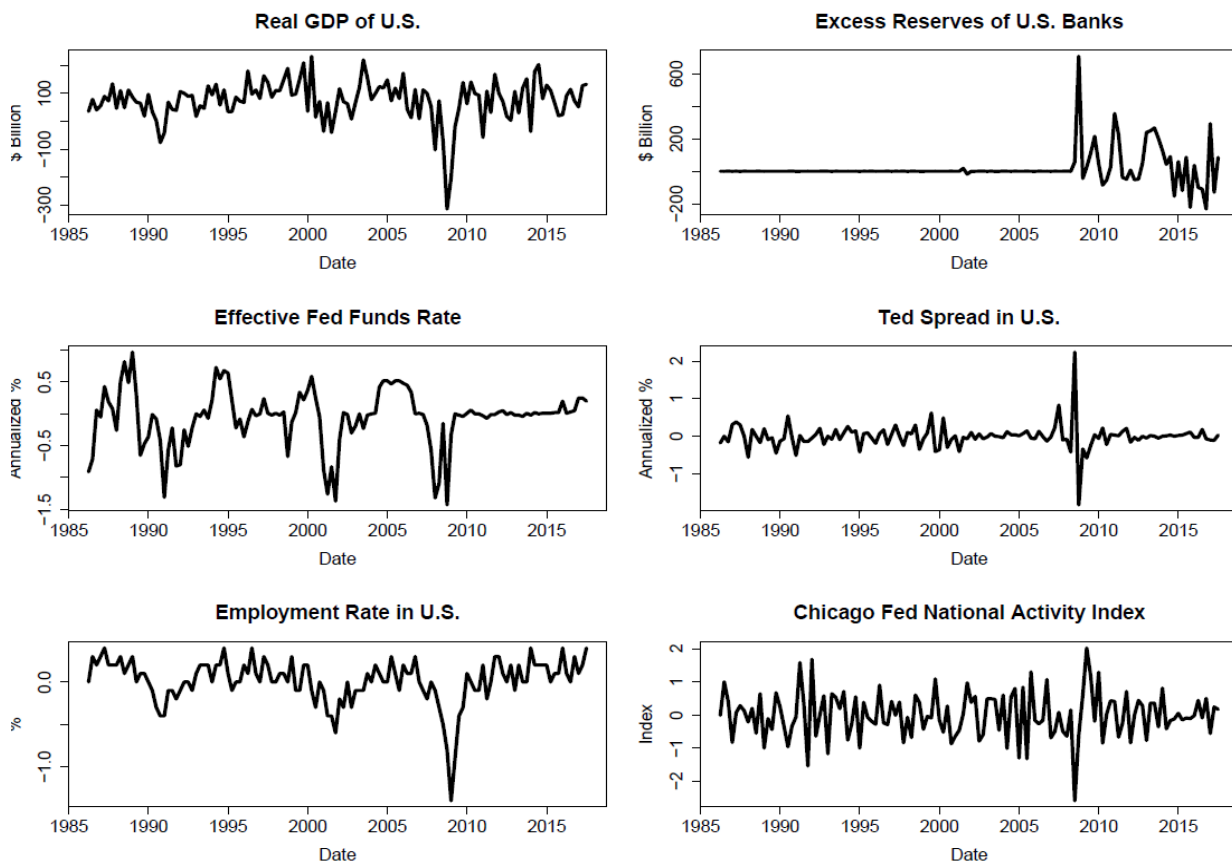

Table III

Summary of *Autocorrelation Function test (ACF) of first differenced* **Quarterly Time Series of U.S. real GDP, Excess Reserves, TED Spread, Federal Funds Rate, Employment Rate and Chicago Fed National Activity Index, 1986:Q1 to 2017:Q3**

Lag	RGDP	EXReserve	FedRate	TED	Employment_Rate	CFNAI_MA3
1	0.37	0.13	0.65	-0.32	0.68	-0.21
2	0.29	0.16	0.43	-0.01	0.52	-0.03
3	0.14	-0.02	0.30	-0.10	0.43	-0.03
4	0.12	0.19	0.11	0.13	0.30	-0.16
5	-0.01	-0.06	0.01	-0.02	0.22	0.08
6	0.02	0.02	-0.04	-0.12	0.18	-0.04
7	0.00	-0.12	-0.10	0.04	0.15	0.00
8	-0.01	0.07	-0.20	-0.04	-0.02	-0.13
9	0.08	0.14	-0.23	0.04	-0.03	-0.01
10	0.03	0.18	-0.27	-0.10	-0.08	0.04

With the random walk nature of the data presented in Figure 1 and to tame the effect of the quick

spike in excess reserves within the time series, an effort is made to transform the data to enable

the effective analysis of the hypothesis. To achieve this, the study transformed the data at first

difference and present that result in Figure 4.

Figure 4: Plots depict differenced Time Series of U.S. real GDP, Excess Reserves, Ted Spread, and Federal Funds Rate from Federal Reserve Bank of St. Louis FRED. Chicago Fed National Activity Index from Chicago Fed.

5. The empirical results

Table IV presents the results of the summary statistics of the study's variables. The results indicate

a negative correlation between excess reserves and real GDP. Figure 5 below show the correlation

among the variables:

Table IV

Summary statistics for Variable Correlations, 1986:Q1 to 2017:Q3

The table displays correlation coefficients for differenced Quarterly Time Series of U.S. real GDP, Excess Reserves, TED Spread, Federal Funds Rate, Employment Rate and Chicago Fed National Activity Index, 1986:Q1 to 2017:Q3

Variables	RGDP	EXReserve	FedRate	TED	Employment_Rate	CFNAI_MA3
RGDP	1	-0.32	0.41	-0.20	0.50	0.64
EXReserve		1.00	-0.16	-0.02	-0.19	-0.28
FedRate			1.00	0.03	0.47	0.48
TED Spread				1.00	-0.05	-0.24
Employment_Rate					1.00	0.72
CFNAI_MA3						1.00

Prior to performing empirical test of the stated equation (1), this research tested the

variables to help determine the right testing methodology to employ. Tests of stationarity and

normality for all variables were performed and reports are shown the figure V.

Table V: Skewness, Kurtosis, Jarque-Bera & Unit Root Tests

Variables	skewness	Kurtosis	Jarque-Bera	ADF Unit Root
Real Gross Domestic Product	-0.13	1.65	9.96	-0.26
	(-1.59)	(9.22)	(255.83)	(-7.46)
Excess Reserves	1.38	3.306	41.02	0.66
	(3.19)	(20.96)	(1907.38)	(-9.72)
Effective Federal Funds Rate	0.18	1.83	7.87	-1.92
	(-0.94)	(4.58)	(31.56)	(-5.18)
TED Spread	1.96	9.70	319.46	-3.33
	(1.19)	(24.37)	(2427.31)	(-15.47)
Employment Rate	-0.51	2.47	7.04	-2.04
	(-1.87)	(9.46)	(292.28)	(-4.64)
CFNAI_MA3	-2.33	11.44	491.98	-4.97
	(-0.14)	(4.10)	(6.81)	(-13.69)

Notes: upper numbers present variables at levels, lower numbers represent variables at first difference. Augmented Dickey Fuller (ADF) test.
Data source: Federal Reserve Bank of St. Louis FRED, Chicago Fed.

5.1 Unit Root and ADF Process

Diebold and Kilian, (2000) indicated that difference stationary and trend stationary models of the same time series may show very different predictions (e.g., Diebold and Senhadji, 1996). Deciding which model to use is therefore very important for applied forecasters. Rather than employing one or the other model by default, a unit root test may be use as a diagnostic tool to guide the decision.

Studies has shown that one of the early motivations for unit root tests was precisely to help determine whether to use forecasting models in differences or levels in particular applications (e.g., Dickey, Bell, and Miller, 1986). Several of the recent econometric unit root literature has focused on how unit root tests is unable to distinguish in finite samples the unit root null from nearby stationary alternatives (e.g., Christiano and Eichenbaum, 1990; Rudebusch, 1993). Diebold and Killian, (2000), point out that low power against nearby alternatives, which are mainly the relevant alternatives in econometrics, has not been much of a concern for forecasting. It has long been demonstrated, for example, that forecasts accuracy may be improved by employing a model in differences rather than a model in levels, especially if the root of the process is close to but less than one (e.g., Box and Jenkins, 1976, p. 192). Most importantly, the question of interest for forecasting is not necessarily whether unit root pretests select the "true" model, but rather whether models that will produce superior forecasts is selected. Diebold and Kilian, (2000) documented that little is known about the efficacy of unit root tests for this purpose. The comparative advantage of strategies such as "always difference," "never difference," or "sometimes difference, according to the results of a unit root pretest" will in general depend on the level of persistence of the true process, the forecast horizon of interest, the sample size, and the properties of the pretest.

Diebold and Killian, (2000), pointed out that difference stationary and trend stationary models of the same series may imply very different predictions. Deciding on the right model to use thus is very important for applied forecasters, and unit root pre-tests may provide a formal criterion for deciding whether to difference the data or not. However, very little is known about how useful unit root tests is as diagnostic tools for selecting a forecasting model. In an effort to deal with the situation, Diebold and Killian, (2000), conducted a Monte Carlo study in which they systematically explored the extent to which pretesting for unit roots leads to improvement in

forecast accuracy in a canonical AR(1) model with trend, for a different set of sample sizes, forecast horizons, and level of persistence. Diebold and Killian, (2000), found strong evidence indicating that pre-testing leads to forecast accuracy compared to routinely differencing the data. They also documented the conditions under which pre-testing is likely to improve forecast accuracy compared to forecasts from models in levels.

In keeping with literature and to improve on the accuracy of this research, pre-tests of unit roots were done. The augmented Dickey-Fuller tests reveal that the variables have a unit root at their levels and they become stationary at their first difference and the differenced values are used in the model. The variable seem to have a heavy-tailed distribution (Orlowki, 2012).

5.2 Test of Normality

5.2.1 Jarqua-Bera Test

The Jarqua-Bera test was originally proposed by Bowman and Shenton (1975). They combined squares of normalized skewness and kurtosis in a single statistic as follows

$$JB = [n / 6] [2 2 S + (K -3) / 4] (5)$$

This normalization is based on normality since S = 0 and K = 3 for a normal distribution and their asymptotic variances are 6/n and 24/n respectively. Hence under normality the JB test statistic follows also a chi-squared distribution with two degrees of freedom. A significantly large value of JB leads to the rejection of the normality assumption.

5.2.2 Skewness

In probability theory and statistics, skewness is defined as a measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. The skewness value can be positive or negative, or undefined. The qualitative interpretation of the skew is complicated and unintuitive. Skew however does not refer to the direction the curve appears to be leaning; in fact, the opposite is true. For a unimodal distribution, negative skew indicates that the tail on the left side of the probability density function is longer or fatter than the right side – this does not distinguish these two kinds of shape. On the other hand, a positive skew indicates that the tail on the right side is longer or fatter than the left side. In cases where one tail is long but the other tail is fat, skewness is said to not obey a simple rule. For instance, a zero value means that the tails on both sides of the mean balance each other out overall; this is normally the case for a symmetric distribution, but is also be true for an asymmetric distribution where the asymmetries even out, such as one tail being long but thin, and the other being short but fat.. Importantly, the skewness does not determine the relationship of mean and median. In cases where it is necessary, data might be transformed to have a normal distribution.

As evidenced in the coefficients of skewness test suggests that excess reserves, Federal Funds Rate and Ted spread are right-skewed. However, all the variables tested in model at their first difference do not follow normal distribution.

5.2.3 Kurtosis

Kurtosis is defined a measure of whether the data are heavy-tailed or light-tailed relative to a normal distribution. That is, data sets with high kurtosis will tend to have heavy tails, or outliers. Data sets with low kurtosis will tend to have light tails, or lack of outliers. A uniform distribution would be the extreme case. The kurtosis of a distributions can fall in one of three categories of

classification: Mesokurtic - A distribution that has tails shaped in roughly the same way as any normal distribution, not just the standard normal distribution, is said to be mesokurtic. The kurtosis of a mesokurtic distribution is neither high nor low, rather it is considered to be a baseline for the two other classifications; Leptokurtic - A leptokurtic distribution is one that has kurtosis greater than a mesokurtic distribution. Leptokurtic distributions are sometimes identified by peaks that are thin and tall. The tails of these distributions, to both the right and the left, are thick and heavy; and Platykurtic distributions are those that have slender tails. Many times they possess a peak lower than a mesokurtic distribution. The results in table V points to the fact our data is leptokurtic nature since kurtosis is greater than three for the tested variable. For this empirical testing identity link function with Pearson-Chi-square predictor was used.

Table VI presents the empirical results of the OLS model depicted by Eqn 3, with variables stationary at their first difference. The results show a strong and significant negative relationship between excess reserves and U.S. Real Gross Domestic Product.

Table VI

Base Regression Model Estimation Results 1986:Q1 to 2017:Q3

Independent Variable	Beta Co-efficient
Excess Reserve	-0.23
	(-3.69)
	Diagnostic Statistics
	R-squared 0.099
	F-stats. 13.66
	Akaike info crit. 11.37
	Log likelihood -714.34

Table VII presents the empirical results of the OLS, represented by Eqn. 4, and tests with all

variables stationary at their first difference.

Table VII

Regression Model Estimation Results 1986:Q1 to 2017:Q3

Independent Variables	Beta Co-efficient
Excess Reserve	-0.12
	(-2.10)
Fed Rate	27.58
	(-1.91)
TED Spread	33.59
	(-1.81)
Employment Rate	102.98
	(-4.42)
CFNAI_MA3	15.86
	(-1.92)

Diagnostic Statistics

R-squared 0.361

F-stats. 13.55

Akaike info crit. 11.09

 Durbin-Watson 2.01

Log likelihood -692.72

Note: t-statistics for OLS are in parentheses
.

The OLS estimation based on the study's model II (Equation 4) shows a significantly negative association between real Gross Domestic Product for the study period; this significant support the hypothesis of this research.

$$indp_{i,t+1} = \beta_{i,0} + \beta_b Ex\_Re\,s + \beta_d ffr + \beta_m Ted_t + \beta_c cfnai_t + \beta_{oi} emp_t + \varepsilon_{t+1} \qquad (4)$$

Column (2) of Table VII presents the coefficient estimates of the instrument predictor variables for the predictability of movements in industrial production, in equation 4. The t-statistics given in parentheses below the OLS estimates are based on heteroskedasticity autocorrelation-robust standard errors (White (1980)).

The results show that movements in excess reserves predict changes in real gdp, a measure of economic activity. The results also show that the fed funds rate and the Ted spread were insignificant predictors. The employment rate returned a significant coefficient of 102.98. The coefficient on Chicago Fed's National Activity Index, a measure of related inflationary pressure, was found to be. The positive coefficients on the CFNAI is consistent with the existing literature which suggests that industrial production is pro-cyclical.

The results presented in Table VII are consistent with the view that excess reserves and Chicago Fed's National Activity Index play a significant role in determining future economic activity. For example, economists have long recognized that monetary shocks are important drivers of price fluctuations, which in turn can have significant real effects on the economy. Hamilton (1983) for instance shows that disruptions to oil supply and dramatic oil price increases preceded almost all of the U.S. economic downturns after World War II. Given that commodities are central to the productive sector, indications of a potential change in the demand for commodities should be very informative about future economic activity.C.CN

The results of the OLS estimates show that there is a negative relationship between U.S real gross domestic product and excess reserve. A $1 billion increase in excess reserves is associated with a $.12 billion contraction in real domestic gross product. It is evidenced that the negative relationship points to a harmful effect of Feds policy that resulted in the spike in excess reserve and hence its effect on real GDP growth. Federal funds rate show a significantly positive association to real gross domestic product, possibly evidencing the Feds payment of interest on excess reserves.

5.3 Robustness Analysis and Impulse Response Functions

To check for robustness of the OLS tests and also to examine any causal effects that may exist between my model variables, the study verify the results by using an Unrestricted Vector Auto regression (UVAR) model along with impulse response functions. The UVAR model is made up of a set of linear functions in which individual variable is explained by its lagged values and that of the lagged values of the remaining variables. The VAR test is made up of the set of variables included in Equation (4), all in their first differences.

The Impulse response functions generated from VAR assume a Monte Carlo distribution of error terms, and the responses are shown over ten quarters. Only a select set of impulse reactions that provide meaning to my results for the analysis in Figure 5.

Response to Cholesky One S.D Innovations ± 2 S.E

Figure. 5. Impulse Responses of Changes in Individual Variables to Cholesky One Standard Deviation Shocking Real GDP

NB: Impulse responses generated from a multivariate VAR with 4 lagged terms, Monte Carlo distribution of errors, accumulated over 10 quarters, based on 1986Q1 – 2017Q3 quarterly data.

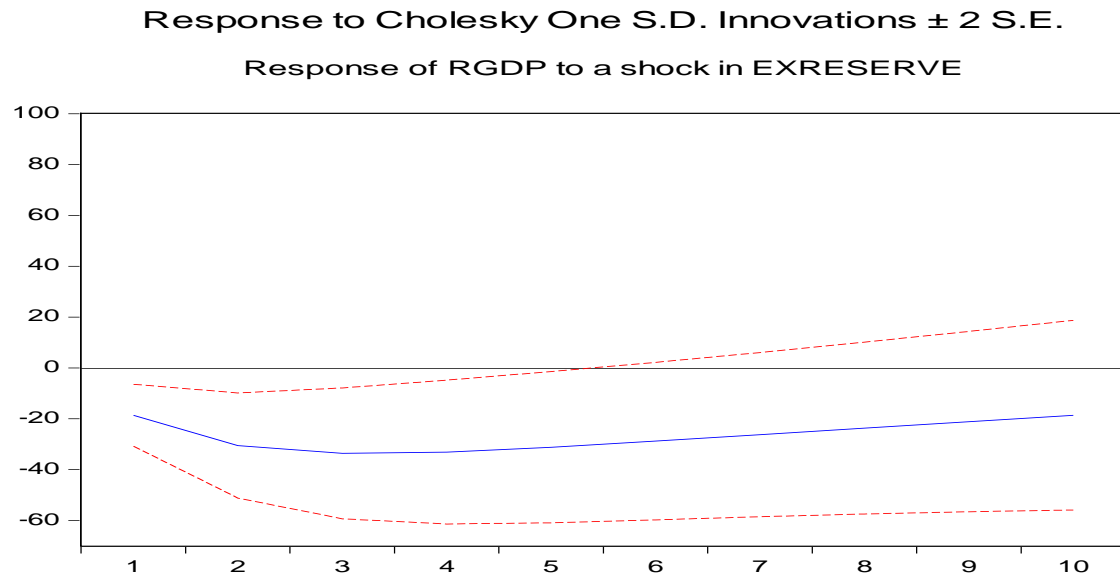*Data Source: Federal Reserve Bank of St. Louis FRED* and Chicago Fed.

Figure 5a.

Response to Cholesky One S.D. Innovations ± 2 S.E.

Response of RGDP to a shock in EXRESERVE

Figure 1 displays a response of U.S. Real Gross Domestic Product to a shock in excess reserves. The impulse response is significant. The impulse response shows that a negative relationship exists between U.S. Real Gross Domestic Product and Excess Reserves of commercial banks. An increase in Excess Reserves leads to an initial significant decrease in U.S. Real Gross Domestic Product which gets to a positive turning point by the fourth quarter. The implication is that when the Federal Reserve requires commercial banks to increase their reserve holdings to levels well above the required reserves, it leads to a significant decline in U.S. Real Gross Domestic Product.

Figure 5b

Response to Cholesky One S.D. Innovations ± 2 S.E.

Response of RGDP to a shock in FEDRATE
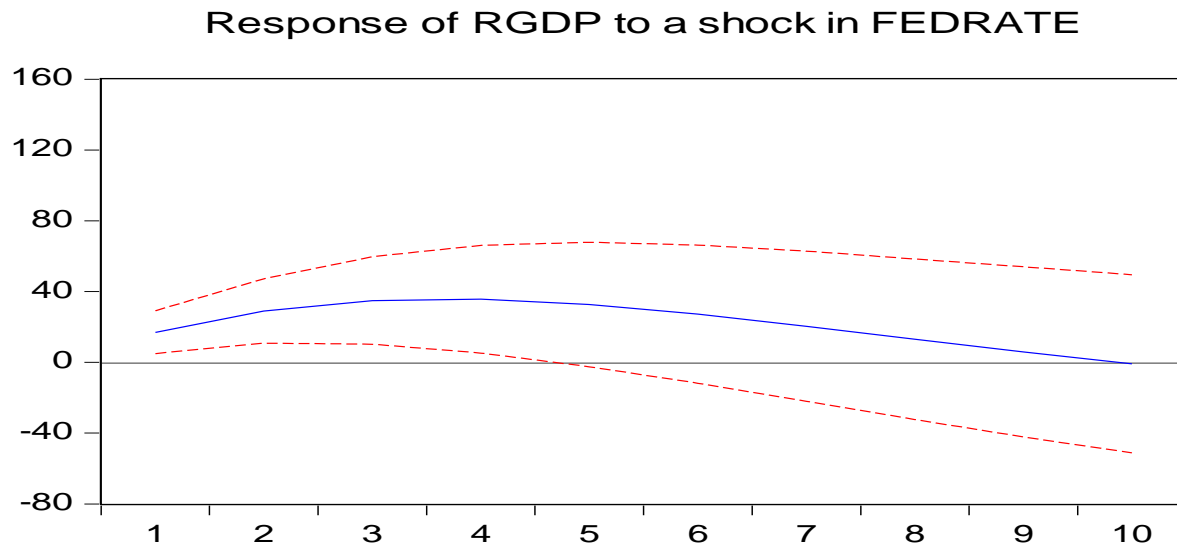
It is significant to note the positive relationship between Fed Funds and U.S. Real Gross Domestic Product. As shown in the figure above, an increase in Fed Funds leads to an increase in U.S. Real Gross Domestic Product until it hits a level and then it becomes insignificant after five quarters. Very important to note that the increase in excess reserve appears to be much more impactful than fed funds rate because of the policy intent associated with each. An increase in fed funds is designed to slow the economic growth

Figure 5c

Response to Cholesky One S.D. Innovations ± 2 S.E.

Response of EMPLOYMENT_RATE to a shock in RGDP
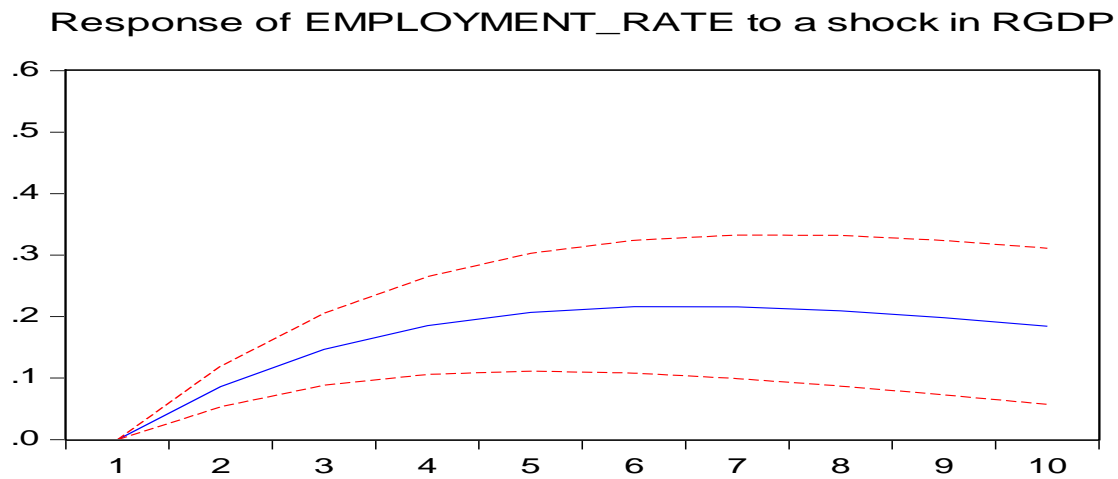
The impulse response for employment rate and U.S. Real Gross Domestic Product show a positive and significant relationship. An increase in U.S. Real Gross Domestic Product leads to increase in employment rate. Whiles the main independent variable in this research shows a negative relationship with U.S. Real Gross Domestic Product, employment rate moves in positive direction with U.S. Real Gross Domestic Product.

The analysis show that a positive shock in the excess reserve results in a decline in real GDP, consistent with my hypothesis. The OLS tests and the impulse reaction functions generated from UVAR show that increases in the excess reserves are associated with decrease in real GDP and has positive impact to effective fed funds rate.

6. Conclusion

The study shows that the massive spike in depository institutions holdings of excess reserves with Federal Reserve Banks, has had negative effect on U.S. real GDP. The study empirically tested a model using 1986Q1 – 2017Q3 quarterly data from Federal Reserve Bank of St. Louis FRED and Chicago Fed. An OLS and a number of UVAR tests with impulse response functions optimized for lags were used and the results presented response functions relevant to the study.

The results indicate that a 5% increase in excess reserves results in a 0.1% reduction in real gdp. The results also indicate that the subsequent reduction in real gdp sets off a feedback loop which negatively impacts both employment as well as inflation, which will ultimately result in an economic slowdown. If policy makers' intention is to drive an increase in economic output while simultaneously ensuring that banks are well capitalized to withstand an economic downturn, then critical consideration is needed to determine the optimal level of excess required reserves. The study also shows that an increase in TED Spread leads to a positive outcome in U.S Real Gross Domestic Product, signifying availability of credit needed to expand activities that will lead to positive economic output. The study also shows that Chicago Fed National Activity Index – CFNAI_MA3, is good predictor of economic activity in the U.S. An increase CFNAI_MA3 shows a positive relations U.S Real Gross Domestic Product. A 2% increase in CFNAI_MA3 is associated with a   0.32% increase in U.S Real Gross Domestic Product.

A $1 billion increase in excess reserves is associated with a $.12 billion contraction in real domestic gross product. It is evidenced that the negative relationship points to a harmful effect of Feds policy that resulted in the spike in excess reserve and hence its effect on real GDP growth.

Federal funds rate show a significantly positive association to real gross domestic product, possibly evidencing the Feds payment of interest on excess reserves.

Based on the result of the analysis, it's recommended that the Federal Reserve Banks should take bold steps to discourage the continuous amassing of excess reserves. This action when taken will cause depository institutions to desist from the current practice and rather channel such funds toward productive activities that will spur economic growth. Active steps by the Fed will signal to the banks that the Fed is confident they are capitalized enough to avoid penalties that are usually imposed by the Fed for holding low level of reserves.

Additionally, the study agree with Todd (2013), that the Fed could retire a certain percent of excess reserve each year by open-market sales of Treasury securities or, if feasible, government agency securities for the next ten to 15 years.

In wake of the financial crisis and post crisis monetary policies of the Federal Reserve, many central banks in emerging countries are considering Federal Reserve type crisis era monetary policies to shore up their banking sectors of the economy. Based on the results of this study, care must be taken to not dampen economic growth through the implementation of capital adequacy/liquidity rules that may appear to be too aggressive and hence resulting in unintended results of such policies. Liquidity and or capital adequacy policies must be reasonable to achieve a balance of economic growth and banking sector soundness.

Any future research work should investigate the hypothesis using monthly data and performing regime study with structural breaking points at 2007 global pre-financial crisis and 2010 post financial crisis.

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Appendix

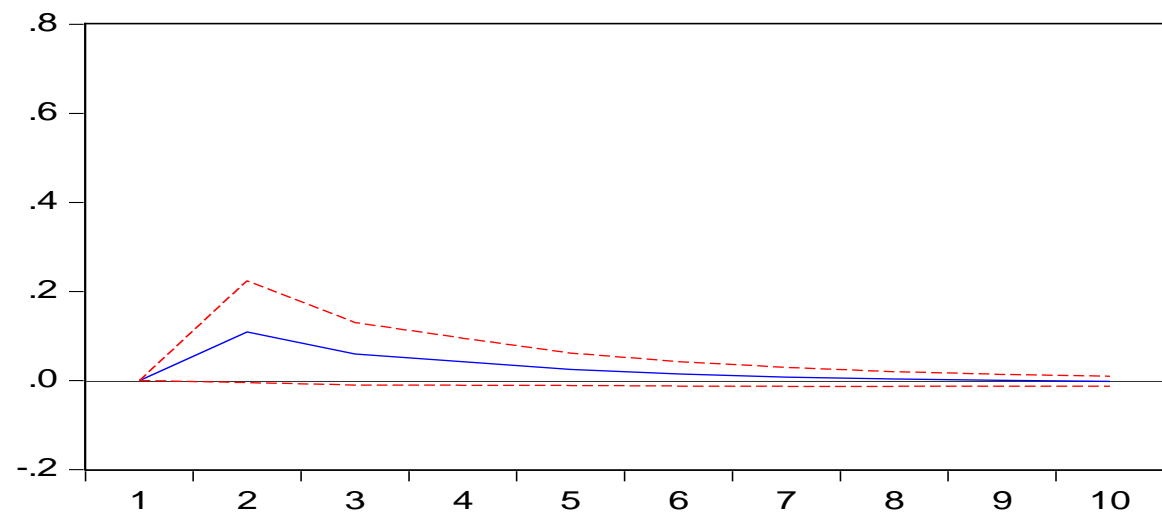Impulse Response of variable considered not to be significant to be included in the main body of the paper.

Response to Cholesky One S.D. Innovations ± 2 S.E.

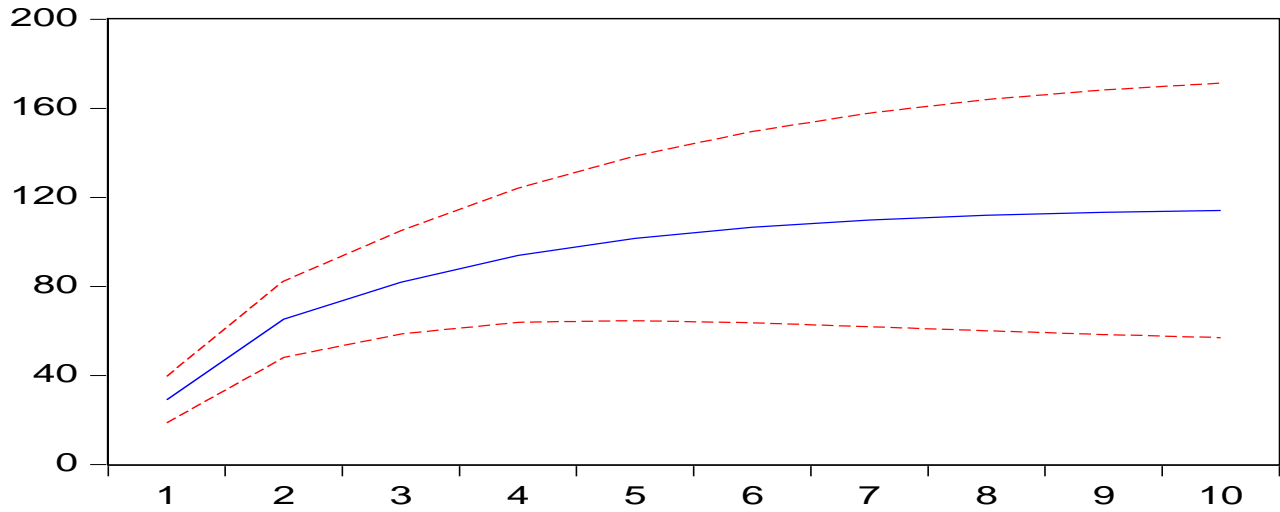### Response of RGDP to a shock in EMPLOYMENT_RATE
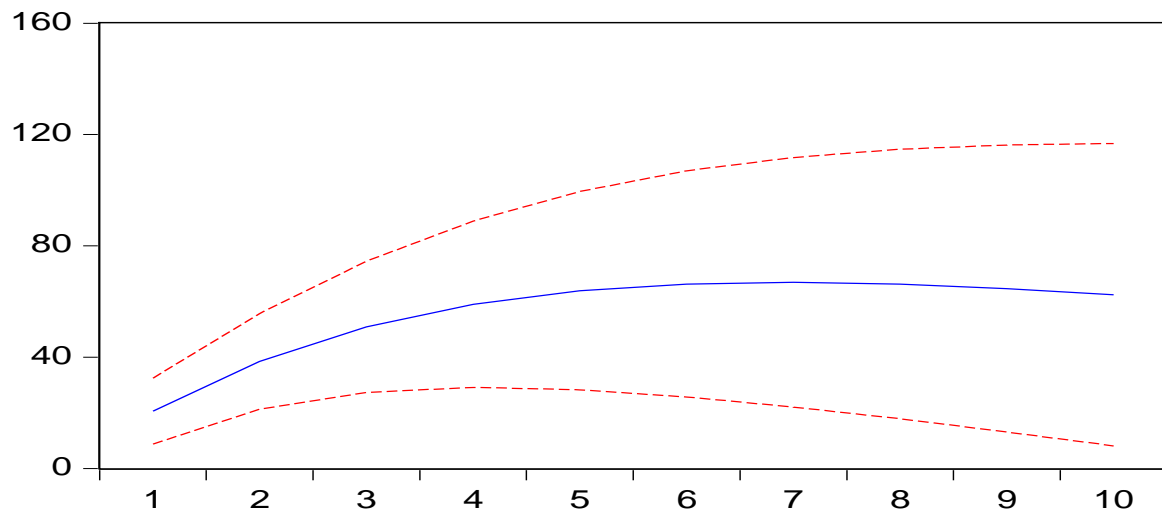
Response to Cholesky One S.D. Innovations ± 2 S.E.
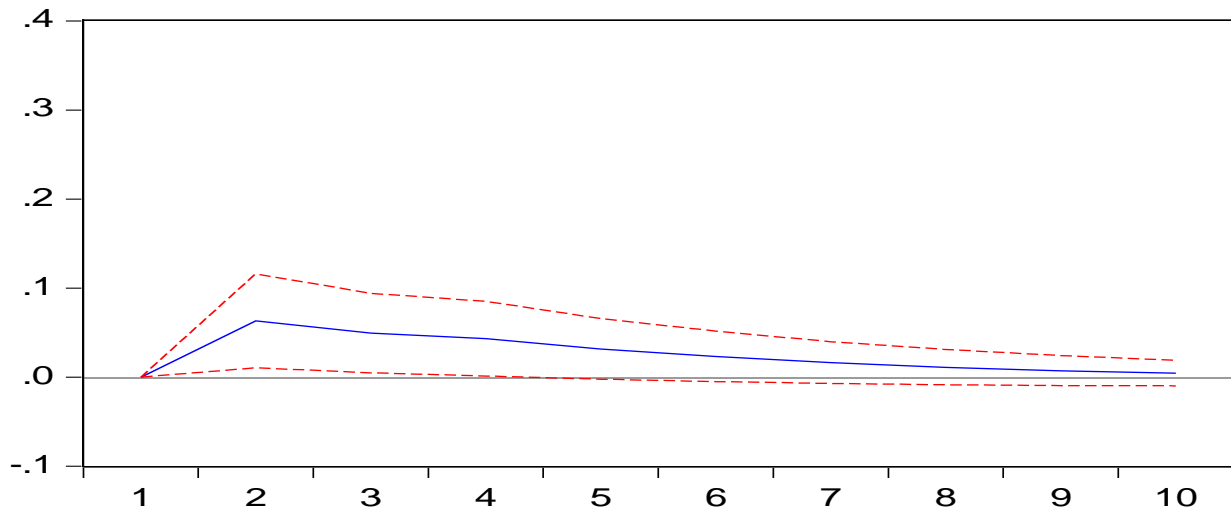
Response of CFNAI_MA3 to a shock in RGDP

Response to Cholesky One S.D. Innovations ± 2 S.E.
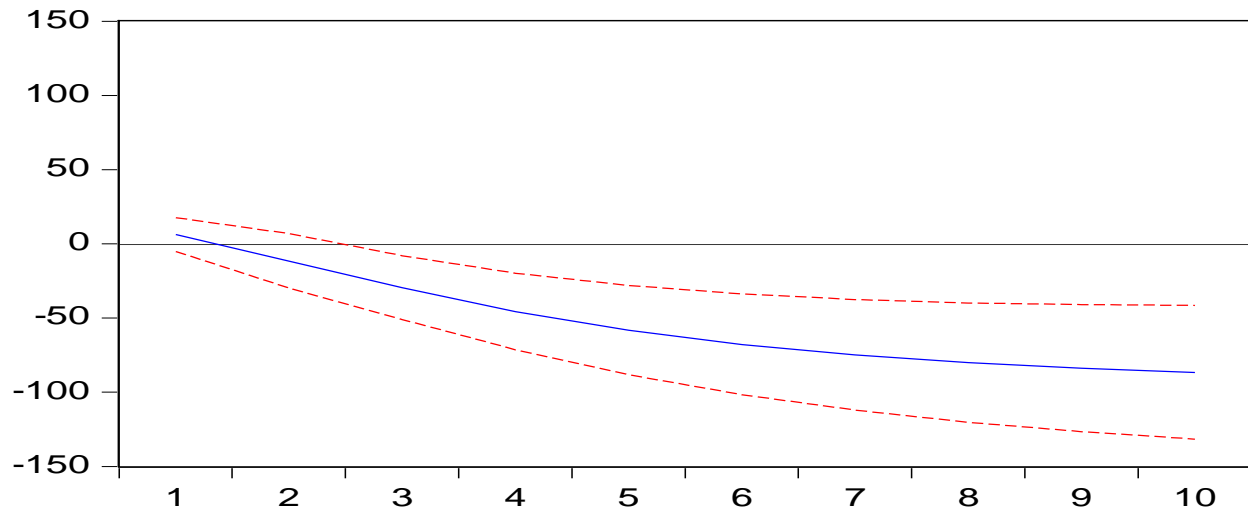
Response of RGDP to a shock in CFNAI_MA3

Response to Cholesky One S.D. Innovations ± 2 S.E.

Response of TED to a shock in RGDP

Response to Cholesky One S.D. Innovations ± 2 S.E.
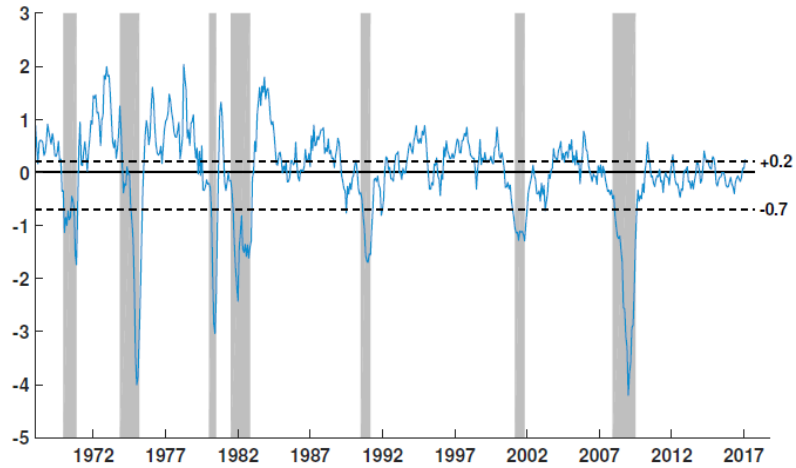
Response of RGDP to a shock in TED
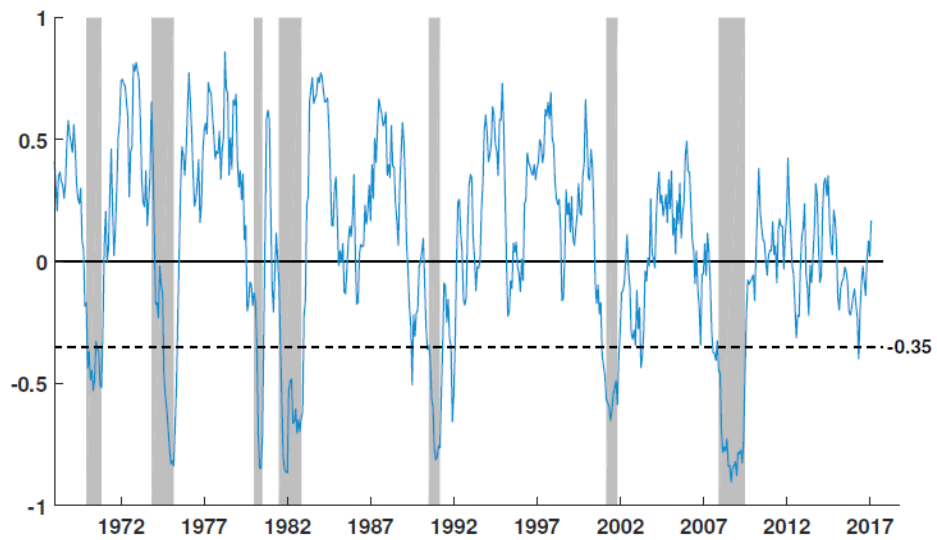

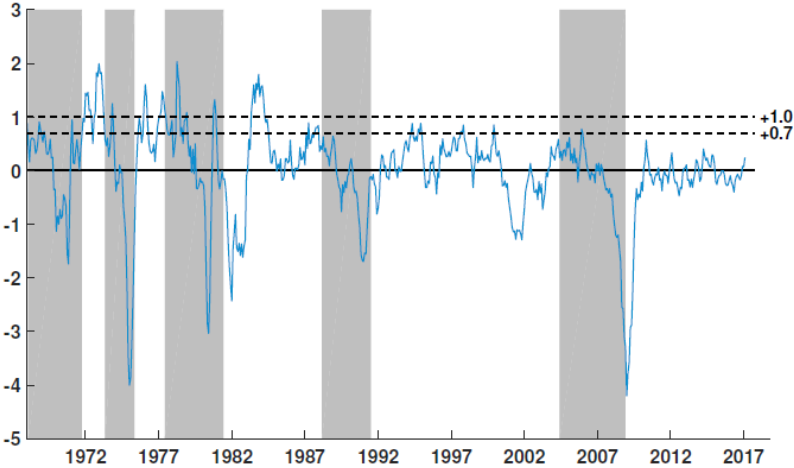## The CFNAI and its Components
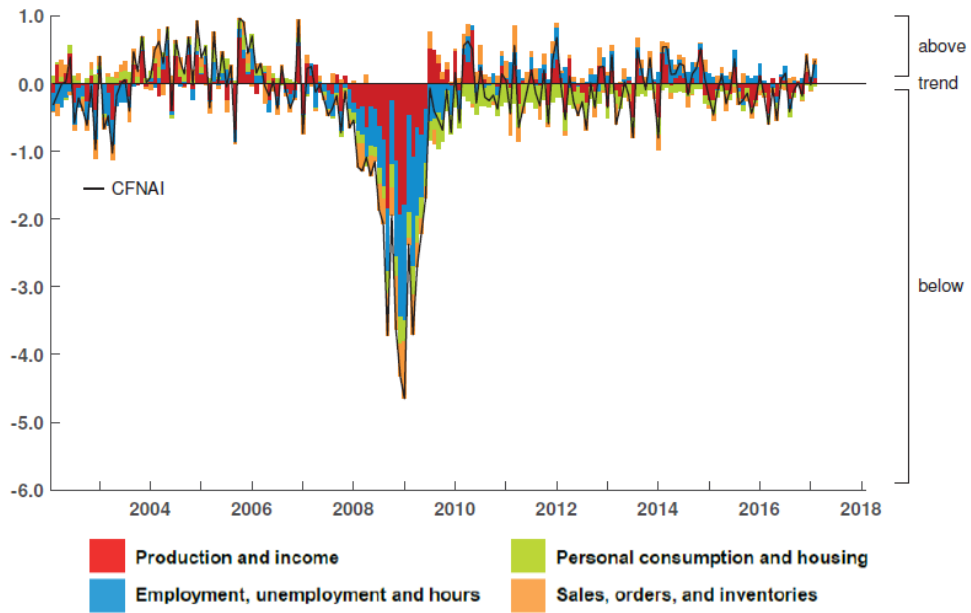
CFNAI-MA3 and Business Cycles

Above −0.7 characteristic of periods of economic expansion
Below −0.7 increasing chance of *recession* | Above +0.2 significant chance of *recovery*

CFNAI Diffusion Index

Above −0.35 characteristic of periods of economic expansion

CFNAI-MA3 and Inflation Cycles

More than 2 years into an economic expansion
Above +0.7 increasing chance of *sustained rising inflation* | Above +1.0 substantial