The Shadow Rate and its Relationship with Lender and Borrower Variables

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THE SHADOW RATE AND ITS RELATIONSHIP WITH LENDER AND BORROWER VARIABLES

by

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ABSTRACT

Since the federal funds rate reached the zero lower bound in late 2008, economists have been struggling to adapt their models to a long-term zero rate. Wu and Xia built upon previous research by Fischer Black to create a model for how the federal funds rate behaves during the ZLB period. In their model, the rate actually dips into the negative digits, which the actual federal funds rate does not do. The logic behind the model is that a negative shadow rate is a much better indicator of true economic conditions while the current zero rate merely masks the actual economic reality. It is also easier to use the shadow rate for trend analysis purposes, since the shadow rate is flexible and changes while the federal funds rate remains artificially fixed at zero. Thus, this paper seeks to provide a comparison between the Shadow Rate, as defined by Wu and Xia, and how three key banking variables (leverage, profitability, and non-performing loans to total loans) react in response to the shadow rate, along with three control variables: real GDP growth, inflation, and the current account to GDP ratio. Regression will also be used to determine how three key borrower variables (S&P 500 Index, Credibility Consumer Distress Index, and the ratio of nonfinancial corporate business debt securities to total assets) interact with the shadow rate and the three control variables previously mentioned.

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INTRODUCTION

This thesis will employ regression to determine how three key banking variables (leverage, profitability, and non-performing loans to total loans) react in response to the shadow rate, along with three control variables: real GDP growth, inflation, and the current account to GDP ratio. Regression will also be used to determine how three key borrower variables (S&P 500 Index, Credibility Consumer Distress Index, and the ratio of nonfinancial corporate business debt securities to total assets) interact with the shadow rate and the three control variables previously mentioned.

The independent effects of the interaction between lenders and borrowers have an important impact on the economy as a whole, and do influence the direction of monetary policy, as told by Bernanke and Gertler (1995) and Bernanke and Blinder (1988). The reason this research is important is because of importance of the credit channel, which is outlined by the academics previously noted.

Since the US entered the ZLB period, credit channel literature has seen a decline, however, it is the opinion of the author that much of the literature on the credit channel can still be highly useful in determining macroeconomic effects of monetary policy even during the ZLB period, and should not be ignored. To the knowledge of this author, this is one of the first theses at the undergraduate level that attempts to measure the effect of the Wu-Xia (2009) shadow rate against borrower and lender variables to determine if there exists any correlation. However, prior to getting into the exact methodology and formal analysis of this paper, a brief discussion regarding the Fed and how it operates is necessary.

For many individuals, the day-to-day operations of the United States Federal Reserve Bank belong to the realm of the unknown. Actions that this formidable institution takes are supposedly only understood by a small handful of economists and bankers who, through their superior knowledge of the system, are able to manipulate it in order to conduct what is known as monetary policy. What can perhaps make things even more confusing for someone just beginning a study of economics is how something called the federal funds rate (FFR) dictates inflation, along with other macroeconomic conditions.

This work thus seeks to act as a brief introduction into the nuts and bolts of monetary policy related to the FFR, with a particular emphasis on something known as the "shadow rate," which those familiar with the topic know, is an estimated rate that some argue is a better indication of true economic conditions during the zero-lower bound period (ZLB).

It was initially believed that a central bank that could control money supply would also be able to control boom-bust cycles.[1] The manipulation of monetary policy was believed to give policy makers an additional weapon for fighting recessions and run-away inflation. To some extent, the Federal Reserve has done its job, with the Great Depression being a formidable exception to the rule.[2]

In recent years, the financial news has been filled with speculation in regards to whether or not the Federal Reserve will end up raising interest rates.[3] This sort of speculation has not

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[1] Sowell, Thomas. *Basic Economics: A Common Sense Guide to the Economy*. 1st ed. Vol. 5. New York: Basic, 2015. Print.

[2] Bernanke, Ben. *The Courage to Act: A Memoir of a Crisis and Its Aftermath*. New York, NY: W. W. Norton, 2015. Print.

[3] Hilsenrath, John. "Fed Sets Stage for Rate Hikes in 2015." *Wsj.com*. Wall Street Journal. 10 Feb. 2016

been unique only to the US. Central banks in Europe and Canada have also lowered their rates into the zero-lower bound (ZLB), prompting many economists to question the long-term benefits of such an action.[4]

In the initial period of the 2008 financial crisis (now aptly titled "The Great Recession"), economists were all unanimous in calling for lower interest rates coupled with increased government spending in order to stimulate the economy.[5] The rationale behind this idea made sense: if interest rates were lowered, people would be willing to borrow more, and thus invest more. This of course, is a very simplistic way of looking at the situation, especially since many people became so risk-averse to borrowing during this period that lower rates would have little impact on their outlook.

Since lowering interest rates were only a first step in tackling the economic problems facing the US in 2008, the Fed had to resort to a combination of unconventional monetary policy tools. These included the use of forward guidance, targeted-asset purchases (TARP), and quantitative easing (QE).[6] The Fed lowered rates in December 2008, and then in their first 2009 FOMC statement stated that the rates would remain low for the foreseeable future.[7]

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[4] Burnham, Terry. "The Real Financial Monster: Low Interest Rates." *The Huffington Post*. TheHuffingtonPost.com. Web. 9 Feb. 2016.

[5] Chidley, Joe. "A voice in the wilderness: Paul Krugman on why Economists Misread the Financial Crisis and why the US still needs more Stimulus." Canadian Business 2009: 48. Academic OneFile. Web. 10 Feb. 2016.

[6] Cecchetti, Stephen G., and Kermit L. Schoenholtz. *Money, Banking, and Financial Markets*. McGraw Hill, 2014. Print.

[7] Hilsenrath, John. "Fed Cuts Rates Near Zero to Battle Slump." *Wsj.com*. Wall Street Journal, 17 Dec. 2008. Web. 04 Nov. 2015.

This is important to note because once the federal funds rate reached the ZLB, the Fed still continued its buying up of toxic assets from failing institutions. The economy also began a slow, but steady rebound. However, this recovery presented a relatively unique problem for economists studying monetary policy. Since the rates reached zero, many macroeconomic models failed to accurately predict future economic conditions in the country.

It must also be noted that keeping rates at such a low threshold for extended periods of time can be dangerous for an economy. Such a policy does not work if banks borrow form the Fed but then refuse to lend the money out, or if not enough people continue to borrow from banks. This can ultimately cause deflation and a lack of spending, which can hurt the economy.

Furthermore, because the rate is in the ZLB, economic empirical models that rely on the federal funds rate as an input variable are no longer accurate. To draw a parallel, think of having to solve complex mathematical equations, but possessing a calculator on which only the number zero worked. You would not be able to solve any complex calculation using that calculator if you could only input one variable.

To solve for this apparent conundrum, economists began using what is now known as a "shadow rate." This was essentially a statistical estimate, based on current economic conditions, of what the federal funds rate *ought* to be. Wu and Xia (year), formulated the basis for the shadow rate that will be used in this thesis, they based their rate on a wide array of macroeconomic indicators and found that for the past several months, the rate has actually been in the negative digits. If the actual rate were so low, it would mean that you would actually be paying to keep your money in a bank, as opposed to receiving an interest on your deposit.

Since empirical models that study the impact of monetary policy require a variable for the federal funds rate that is not zero, Wu and Xia's shadow rate will be used as opposed to the FFR when comparing it to the lending and borrower aspects of the credit channel. The next step lies in determining whether using an artificial rate can actually tell us anything about changing economic conditions.

LITERATURE REVIEW

Building upon previous research on the credit channel, this thesis seeks to determine how lenders (banks) and borrowers are affected under the Wu-Xia (2009) shadow rate. According to Bernanke & Gertler (1995), the credit channel is something of a misnomer because it is not necessarily an independent channel, but rather a "set of factors that amplify and propagate conventional interest rate effects."[8] This means that throughout this thesis we will not be discussing the credit channel as an independent channel of the monetary transmission mechanism, but rather as the enhancer that Bernanke & Gertler spoke about.

It has been argued by researchers that it is difficult to measure monetary policy shocks to the economy using conventional interest rate models, and it is here that the credit channel can help fill in the gaps, so to speak. The conditions of banks in accordance to bank variables as well as the relative well-being of borrowers, can also help fill in these gaps.

According to Gertler and Gilchrist (1994), short term borrowing rises subsequently to a monetary policy tightening. This is interesting to point out, because in the case of this particular thesis, low interest rates have been coupled with an expansionary monetary policy, which does not fall in line with traditional economic theory. However, during the start of the 2008 recession, short term borrowing decreased, which is exactly what Gertler and Gilchrist predicted. However, the 2008 housing crash helped economists better understand the fragile relationship between lenders and borrowers, which was previously not as emphasized in Credit Channel literature.

[8] Bernanke, Ben S., and Mark Gertler. "Inside the Black Box: The Credit Channel of Monetary Policy Transmission." *Journal of Economic Perspectives* 9.4 (1995): 27-48. Web. 10 Nov. 2015.

It is important to note that the Credit Channel as we know it, and the literature that seeks to understand it, has undergone important changes since Bernanke and others initially wrote about it in the 1990s. Other newer studies that were performed in the aftermath of the Great Recession are noteworthy because they account for the large housing market shock that occurred in 2008. For example, prior to the 2008 housing crisis, it was assumed that bank lending was not one of the key factors affecting the monetary transmission mechanism.[9] A recent working paper for the Bank of International Settlements (BIS) found that banks "with weaker core capital positions…restricted the loan supply more strongly during the crisis period."[10] It was also argued that this action further exacerbated the recessionary effects of the period.

The paper further used this evidence to support the idea that the Basel III Accords were correct in focusing on bank capital, on "funding liquidity risks," and utilizing a more forward looking approach when creating new macroprudential regulation.

Another 2015 paper by Ciccarelli, Maddaloni, and Peydro found that:

> "the credit channel amplifies a monetary policy shock on GDP and prices through the balance-sheets of households, firms and banks. For corporate loans, amplification is highest through the bank lending and the borrower's balance sheet channel; for households, demand is the strongest channel."[11]

[9] Gambacorta, Leonardo, and David Marques-Ibanez. "The Bank Lending Channel: Lessons from the Crisis." *BIS Working Papers* (2014). Web. 05 Apr. 2016.

[10] Gambacorta, Leonardo, and David Marques-Ibanez. "The Bank Lending Channel: Lessons from the Crisis." *BIS Working Papers* (2014). Web. 05 Apr. 2016.

[11] Ciccarelli, Matteo, Angela Maddaloni, and Jose-Luis Peydro. "Trusting the Bankers: A New Look at the Credit

This is quite a shift in tone from previous academic papers, as both lenders and borrowers are now seen as being potential sources of monetary policy shocks, whereas previously, they were only seen as risk-enhancers.

Lenders and borrowers themselves operate within the Credit Channel. Since interest rates are known to affect borrowers and lenders, and in turn, loans the frequency of their repayment, I am interested in finding out if the shadow rate can be substituted for the Federal Funds rate during the ZLB.

When creating the framework for their model of the shadow rate, Wu and Xia used the shadow rate term structure model (SRTSM) which was first proposed by economist Fisher Black (1995).[12] In his research, the idea was to extract shadow rates which can become negative and were "driven by the dynamics of the term structure of interest rates."[13] His shadow rate model was unconstrained by the ZLB and appeared to mirror market expectations of short term nominal interest rates. However, many other factors besides changes in interest rate policy can affect the outcome of expectations, such as "longer-term growth prospects and changes in short-run market sentiments."[14]

Channel of Monetary Policy*." Review of Economic Dynamis* 18.4 (2015): 979-1002. EconLit. Web. 15 Apr. 2016

[12] Xia, Fan. "The Term Structure of Interest Rates, Monetary Policy, and Macroeconomy." Order No. 3630527 University of California, San Diego, 2014. Ann Arbor: *ProQuest.* Web. 10 Nov. 2015.

[13] Lombardi, Marco, and Feng Zhu. "A Shadow Policy Rate to Calibrate US Monetary Policy at the Zero Lower Bound." *BIS Working Papers*. Web. 05 Apr. 2016.

[14] Lombardi, Marco, and Feng Zhu. "A Shadow Policy Rate to Calibrate US Monetary Policy at the Zero Lower Bound." *BIS Working Papers*. Web. 05 Apr. 2016.

The Wu-Xia shadow rate, although not perfect by any means, does attempt to account for some of these non-interest rate policy factors in their rate, which was a major factor in my decision to use it in my own model.

Wu-Xia built on the Black (1995) model by using a simple factor-augmented vector autoregression (FAVAR), which showed that the calculated shadow rate exhibited dynamic correlations with both the federal funds rate and key macro variables, which included variables relating to the dissemination of credit.[15] This essentially means that the shadow rate in their model could be estimated using both traditional macroeconomic indicators (such as GDP and inflation) and consequently was directly related to both: this was different than the Black (1995) SRTSM which almost focused exclusively on interest rate policy when computing the shadow rate. Thus, when the funds rate was artificially stuck at zero, the Wu-Xia shadow rate still moved in response to other macro variables.

Another key aspect to note about the Wu-Xia shadow rate is that the shadow rate will not be accurate in the ZLB unless the data set spans the pre-ZLB period. This is an important distinction, because it implies that any numerical value of the shadow rate is dependent on a slew of data that occurred before a ZLB period. This will means that future researchers will not be able to use Wu and Xia's model during an isolated ZLB period.[16]

Despite its inability to be examine the ZLB period in isolation, Wu and Xia's model made a great contribution to the field of economics in presenting a long-term estimate of the

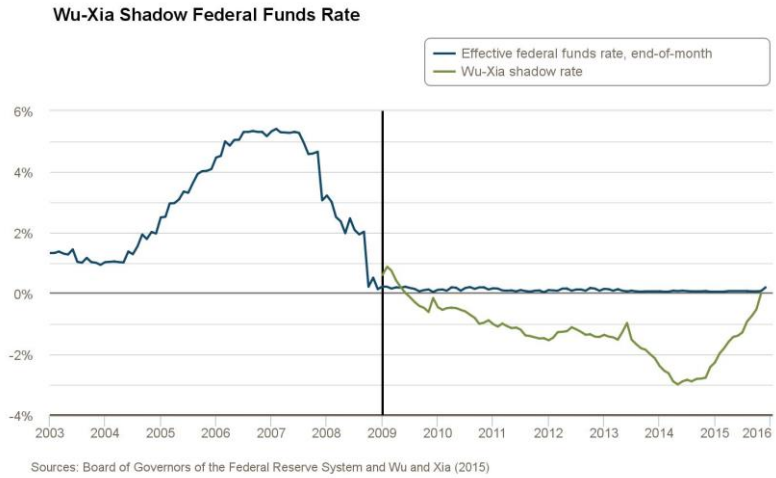
[15] Wu, Jing Cynthia and Xia, Fan Dora. "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound. May 18, 2015. *Chicago Booth Research.* Paper No. 13-77.

[16] Wu, Jing Cynthia and Xia, Fan Dora. "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound. May 18, 2015. *Chicago Booth Research.* Paper No. 13-77.

shadow rate that, unlike other works in the field did not have unexplained gaps. For example, Bauer and Rudebusch (2013) do not account for the ZLB period, but do provide better forecasts and better interest rate fit than Wu-Xia, according to a 2014 BIS working paper.[17] In other words, the Wu-Xia rate model did not have to readjust its parameters during consecutive time periods in order to retain its accuracy. The trend of the shadow rate is fairly consistent with economic conditions and can thus act as a suitable replacement for the federal funds rate when using other empirical economic models. This is exactly the reason why I will be using the rate by Wu and Xia as opposed to other models.

Below is a visual representation of what the shadow rate, according to Wu and Xia, is estimated to be from 2003 to 2016.

Figure 1: Wu-Xia Shadow Federal Funds Rate



One can clearly see that the shadow rate (represented by the green line) perfectly mirrors the federal funds rate (represented by the blue line) until approximately the end of 2008. This is

[17] http://www.bis.org/publ/work452.pdf

precisely when monetary policy entered the so-called zero-lower bound: the exact date is Tuesday, December 15, 2008.[18] Here, we see economic conditions indicating the shadow rate being higher than the federal funds rate. Then, midway through 2009, when the Federal Reserve stated in their FOMC report that rates would remain near zero for the foreseeable future, the shadow rate dipped into negative territory.

It is interesting to note that the shadow rate behaved like traditional economists predicted the federal funds rate should have behaved under similar economic conditions. If the Fed were to conduct monetary policy solely mirroring current economic conditions, they would inadvertently have lowered rates into negative territory midway through 2009 in order to stimulate spending. The rationale is that in an economy suffering from excess saving (people are afraid of losing their money so they save instead of spend) is in danger of entering what Bernanke called a "savings glut." This in turn can lead to what Paul Krugman termed a "liquidity trap," where monetary policy fails to have any effect on the economy, and thus policy makers lose their ability to combat worsening conditions.[19]

Yet, none of those things happened despite the Fed pursuing a highly aggressive monetary policy. Strangely enough, the money supply increased, debt to GDP increased significantly (from 41% in 2008 to 74% today), but inflation remained relatively constant.[20] This

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[18] Hilsenrath, John. "Fed Cuts Rates Near Zero to Battle Slump." *Wsj.com*. Wall Street Journal, 17 Dec. 2008. Web. 04 Nov. 2015.

[19] Summers, Larry. "The Age of Secular Stagnation: What It Is and What to Do About It." *Foreign Affairs* 95.2 (2016): 2-9. Web. 03 Mar. 2016.

[20] Summers, Larry. "The Age of Secular Stagnation: What It Is and What to Do About It." *Foreign Affairs* 95.2 (2016): 2-9. Web. 03 Mar. 2016.

is surprising because according to traditional monetary policy, an increase in money supply should drive inflation up. Yet, the US has kept interest rates near zero for nearly 7 years now, and inflation has remained constant the entire time!

This lack of growth seems to have been expected by the Fed. The last FOMC report of 2008 traditionally recognized the second pillar of the dual mandate in regards to maximizing employment, but "chose to eschew the equivocal reference to stable economic growth."[21] This shows that the Fed was privy to not referencing growth as a precursor to stability, because they knew it would not be achieved in the near future.

This thesis will also show that as expected, bank balance sheet assets also increased during this time period. However, consumer assets, although they increased, did not increase by nearly the same amount as those assets held by banks. Consumer propensity to borrow has also significantly declined. This is interesting to point out because it shows that large banks benefitted more from the zero rates than regular individuals have. The newly imposed mortgage regulations, particularly on those seeking to refinance their mortgages, have become so stringent in the wake of the 2008 crisis that even former Fed chairman Ben Bernanke was denied an application to refinance his mortgage in 2014![22]

This is the sort of thing one cannot make up. Yet, this further leads credence to the old maxim that too much of a good thing (in this case regulation) is indeed bad (over-regulation). In

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[21] Jackson, Laura E. "Monetary Policy in a Zero Lower Bound Environment." *University of North Carolina Phd Submission* (2014): 1-91. Web. 10 Nov. 2016.

[22] Campbell, Elizabeth, and Lorraine Woellert. "You Know It's a Tough Market When Bernanke Can't Refinance." *Bloomberg.com*. Bloomberg, 3 Oct. 2014. Web. 20 Mar. 2016.

this particular case, excess regulation in regards to receiving real estate loans actually harmed the every-day consumer more than the largest real estate conglomerates.

METHODOLOGY

The main scope of this thesis is to determine how lenders and borrowers react to changes in the Wu-Xia (2009) shadow rate. This section will cover the methodology used in creating a model that will allow for comparison between these variables, as well as a description of each of the variables and why they are significant.

The shadow rate will act as the main variable studied, and is significant because it allows us to look at the ZLB period without having an artificially fixed rate. The shadow rate data was acquired from the Federal Reserve Bank of Atlanta website on a monthly basis. To adjust the rate to fit the model, the mean for every three months was found and then adjusted to a quarterly rate. The difference between each quarter was then found in order to give the quarterly change and it is these variables that are used in the regression analysis. For the pre-2009 period, since there was no shadow rate provided in the data, the ratio of the quarterly federal funds rates was compared to the ratio of the shadow rate, and the unknown shadow rate variables were solved for. This is how I was able to craft a shadow rate for the pre-ZLB period.

All the data used in the study was obtained from the Federal Reserve Bank of St. Louis website. As mentioned previously, variables related to banks and variables related to borrowers are contrasted with the shadow rate in this model. The three control variables used in this study are Real GDP Growth, inflation, and the current account to GDP ratio. Control variables are variables that are held constant and used in the model in order to clarify the relationship between two principal variables.

As such, the regression will take on the following format:

$$x_t = \beta_0 + \beta_1 (\text{Shadow Rate})_t + \lambda C_t + \varepsilon_t$$

Where x_t is the lender or borrower variable being regressed, β_1 (Shadow Rate)$_t$ is the shadow rate, the control variables are shown here by the λC_t, while ε_t is the error term.

The control variables are shown here by the λC_t. Historically the Federal Reserve has acted in response to GDP and inflation, because of their dual mandate targeting both growth and inflation. Fed policymaking is also affected by exchange rates, trade, and foreign borrowing, which is why I used the current account to GDP ratio, because I want to control for all of these things in my regression.

Real GDP Growth is significant because it offers a broad look at how the United States economy has performed in recent years: it was calculated as a percent change from the preceding quarter. Inflation, also a good indicator of economic conditions because it directly relates to purchasing power and prices of goods, was found using the Consumer Price Index. The CPI Index is a measure of the average change (over time) in the prices paid by consumers for a market basket of consumer goods and services.[23] The CPI numbers were then presented as a percent change from the previous quarter. The current account to GDP ratio measures the current account surplus or deficit as a percentage of GDP, and then presented as the change from previous quarter.

The banking variables used were leverage, profitability, and non-performing loans to total loans. According to Beltratti and Palladino (2015), bank leverage is a key determinant of bank profitability, and in their work have formed a GMM-econometric model that determined that equity is positively related to residual income. They also show how liquidity is positively

[23] "Consumer Price Index." *Bureau of Labor Statistics*. Web. 6 Apr. 2016.

related to equity, and thus prove there exists a relationship between the two.[24] Bank leverage is also impacted by the shadow rate, because interest rate changes affect a bank's ability to lend. If the shadow rate goes up, then it is expected that a bank's leverage will increase, because it becomes harder for them to find funding.

The traditional manner of calculating leverage (debt/equity) was eschewed because equity is more volatile, and total assets includes equity in its calculation and is thus a better indicator. Leverage was then presented as a change from the previous quarter. Profitability was calculated as the Return on Average Assets. It is expected that the shadow rate is inversely related to bank profitability because the cost of funding goes up with the shadow rate, and thus banks make less in the process of lending out money.

The ratio of non-performing loans to total loans is the "ratio of defaulting loans (payments of interest and principal past due by 90 days or more) to total gross loans (total value of loan portfolio)."[25] It is important to note that it doesn't include only the unpaid portion of the loan, but rather the gross loan as a whole. This is a significant variable because it is a good indicator of the health of the commercial banking system: loan repayment is central to bank solvency and is thus critical to understanding the financial well-being of the banking system. It is expected that the shadow rate is positively related to the ratio of non-performing loans to total loans, because as interest rates rise, the borrower's ability to pay back loans diminishes.

[24] Beltratti, Andrei, and Giovanna Paladino. "Bank Leverage and Profitability: Evidence From a Sample of International Banks." *Review of Financial Economics* (2015): 46. *Academic OneFile*. Web. 6 April 2016

[25] "Bank Non-Performing Loans to Gross Loans for United States." *FRED*. Web. 6 Apr. 2016.

Now that the banking variables used have been outlined, it is time to move on to the borrower variables. The borrowing variables that will be used in the regression analysis are the S&P 500 index, the credibility consumer distress index, and the ratio of nonfinancial corporate debt securities to assets.

The S&P 500 index tracks the largest 500 companies in the United States, which also collectively make up 75% of the total equity in the country.[26] The fact that they take up such a large portion of the market makes these companies and the index that tracks them a good measure for my analysis. This is the widest spanning measure that we have for the overall health of the economy, which is in large part, the reason for my using it in this analysis. The strength of the S&P 500 is an excellent indicator of the health of the nationwide economy, and by extension, the health of borrowers. This index will be presented as a quarterly percent change. The S&P 500 should display an inverse relationship with the shadow rate, as firm's health is negatively impacted by an increase in the shadow rate, because as bond prices go up, people tend to invest less. This in turn may negatively impact the health of the firms in the S&P 500, thus lowering the overall value of the S&P 500.

The Credibility Consumer Distress Index (CCDI) measures the 5 categories of personal finance that are purported to reflect or lead to a secure and stable financial life. These are: employment, housing, credit, household budget and net worth, all measured equally. The aggregate of these five components is then calculated and presented as a score on the index, with scores above 80 being stable, 70-79 indicating financial risk, and under 70 indicating instability

[26] "S&P 500©." *FRED*. Web. 6 Apr. 2016.

and potential recession.[27] The CCDI is important because if offers a glimpse into regular borrower households' economic actions and motivations. In regards to the shadow rate, the CCDI should display a positive correlation, because if the shadow rate is a surrogate for the FFR, and we are not in a recessionary gap (which currently we aren't) then an increase in the shadow rate would mean that economic conditions are improving, which consequently means that that the CCDI is increasing.

The final component of the borrower variables included is the ratio of nonfinancial corporate business debt securities to total assets. According to the FRED website, this variable presents "a sequence of accounts that relate production, income and spending, capital formation, financial transactions, and asset revaluations to changes in net worth between balance sheets for the major sectors of the U.S. economy."[28] This is shown as a ratio with assets in order to get a more comprehensive picture. It is expected that the ratio of nonfinancial corporate business debt securities to total assets would have an inverse relationship with the shadow rate because net worth goes down (S&P 500 goes down and leverage increases) when the shadow rate increases.

Each of the borrower and lender variables described in this section will be regressed against the shadow rate in order to determine if there is any statistical correlation between the two. The shadow rate will be available for the 2000-2015 period, as will all the other variables with the exception of the S&P 500 and the Consumer Credibility Distress Index, as data was not

[27] "Credibility Consumer Distress Index (DISCONTINUED)." *FRED*. Web. 6 Apr. 2016.

[28] "Nonfinancial Corporate Business; Debt Securities; Liability, Level." *FRED*. Web. 6 Apr. 2016.

available for the entire period covered. As a result, these two variables will have fewer observations present in the regression analysis.

RESULTS.

There are four tables below: one encompassing the shadow rate and its relationship with the borrower and lender variables in the 2000-2015 period, and another encompassing the 2009-2015 period. Afterwards, there are two more tables: on encompassing the 2000-2015 period, including a quarterly lag on the shadow rate variable, and another encompassing the 2009-2015 period, including dummy variables (dummy variable was named "dumsr" in STATA) in order not to lose any of the pre-2009 data when regressing the results.

Figure 2: 2000-2015 Regression Results

	Leverage	Profitability	Non-Performing Loans to total Loans	S&P 500	CCDI	Security/Assets Ratio
Shadow Rate	6.587 (7.330)	-8.526 (26.203)	-6.491 (4.360)	1.874 (3.119)	-0.687 (0.493)	-11283.09 (12462.25)
Real GDP	0.276 (0.804)	6.612 (12.141)	-5.938* (2.020)	3.845* (1.145)	0.515** (0.231)	-2748.761 (5774.207)
Inflation	1.141 (1.118)	-8.561 (20.138)	4.274 (3.351)	0.486 (1.729)	-0.102 (0.382)	1981.879 (9577.793)
CA/GDP	1.747 (3.663)	-64.266 (43.453)	28.245* (7.231)	-9.039** (4.248)	-1.802** (0.814)	45028.36** (29509.39)
Observations	60	60	60	27	53	60
R2	0.199	0.062	0.536	0.6416	0.391	0.205

Note; ( ) represent the standard error, the numbers on top of the numbers in ( ) represent the coefficients

Figure 3: 2009-2015 Regression Results

	Leverage	Profitability	Non-Performing Loans to total Loans	S&P 500	CCDI	Security/Assets Ratio
Shadow Rate	-0.187	404.8842	17.791	-10.352	-2.010	15869.04
	(2.851)	(455.8549)	(53.984)	(18.166)	(5.948)	(104590)
Real GDP	0.448	5.577*	-0.269	-0.353**	-0.116**	-3390.932
	(0.427)	(41.074)	(4.864)	(1.637)	(0.457)	(9423.844)
Inflation	-0.340	-64.345	-4.488**	1.692	0.153	-9843.204
	(0.593)	(66.884)	(7.921)	(2.665)	(0.749)	(38391.99)
CA/GDP	-1.606	-213.621*	43.295	-13.678	-5.493*	-26485.73
	(1.944)	(167.928)	(19.816)	(6.668)	(2.372)	(38391.99)
Observations	24	24	24	24	20	24
R2	0.132	0.250	0.617	0.668	0.738	0.048

*Note; ( ) represent the robust standard error, the numbers on top of the numbers in ( ) represent the coefficients. * represents a statistical significance of 0.01, ** of 0.05, and *** of 0.10*

Figure 4: 2000-2015 Regression Results (Lagged)

	Leverage	Profitability	Non-Performing Loans to total Loans	S&P 500	CCDI	Security/Assets Ratio
Shadow Rate	-0.542	-18.944	-0.719**	-10.352	-2.010	-6236.186
	(0.501)	(32.282)	(4.171)	(18.166)	(5.948)	(14255)
Real GDP	0.116	6.84	-5.398*	2.126**	-0.538*	-5734.661
	(0.201)	(12.945)	(1.672)	(0.923)	(0.228)	(5716.117)
Inflation	-0.310	-11.799	11.618*	1.142	-0.652	867.7019
	(0.387)	(24.963)	(3.225)	(1.633)	(0.443)	(11022.83)
CA/GDP	-1.264***	-85.018***	35.231*	-3.338	-2.41*	58896.33*
	(0.803)	(51.727)	(6.683)	(4.04)	(0.9)	(22841.16)
Observations	60	60	60	60	27	60
R2	0.08	0.21	0.726	0.668	0.487	0. 48

*Note; ( ) represent the robust standard error, the numbers on top of the numbers in ( ) represent the coefficients. * represents a statistical significance of 0.01, ** of 0.05, and *** of 0.10*

Figure 5: 2009-2015 Regression Results (with Dummy Variable)

	Leverage	Profitability	Non-Performing Loans to total Loans	S&P 500	CCDI	Security/Assets Ratio
Shadow Rate	-0.055	-15.584	-6.481	4.817	0.547	-19862.76
	(0.435)	(26.09)	(4.462)	(3.253)	(0.493)	(10295.13)
Real GDP	0.077	10.786	-5.944*	2.977*	0.608*	2324.582
	(0.37)	(12.187)	(1.672)	(1.15)	(0.234)	(4808.917)
Inflation	0.04	-9.94	4.275	-0.79	-0.159	306.781
	(0.561)	(19.806)	(3.388)	(1.732)	(0.377)	(7815.499)
CA/GDP	1.303	-89.788**	28.281*	-17.703*	-2.274*	14005.69
	(0.803)	(59.121)	(7.752)	(8.674)	(0.851)	(17886.02)
dumsr Shadow Rate	-0.723	-11.414	-9.766	7.881	1.251	-22736.822
	(0.342)	(30.19)	(6.452)	(5.782)	(1.562)	(12475.148)
dumsr Real GDP	0.865	12.472	-11.453**	3.210	2.221*	4745.531
	(0.421)	(22.933)	(3.774)	(5.631)	(0.873)	(6064.21)
dumsr Inflation	0.09	-10.234	8.275	-1.241	-2.45	417.31
	(0.43)	(20.547)	(8.933)	(2.318)	(0.854)	(8860.849)
dumsr CA/GDP	0.927	-8.725***	34.762**	-20.441	-4.451	17138.097
	(1.629)	(61.332)	(8.301)	(13.308)	(1.134)	(21365.443)
Observations	60	60	60	60	27	60
R2	0.04	0.11	0.536	0.70	0.42	0.48

*Note; ( ) represent the robust standard error, the numbers on top of the numbers in ( ) represent the coefficients. * represents a statistical significance of 0.01, ** of 0.05, and *** of 0.10*

The above table represents the results discovered when computing the regressions outlined in the Methodology section, only by also adopting a lag on the shadow rate, in order to achieve better results. The coefficients shown imply that with a one-point change in the shadow rate, the response variable moves x amount either up or down in response. For example, when looking at the leverage ratio, it is observed that for every 1 point change in the shadow rate, leverage goes down by 0.542. The standard error shown in brackets measures the accuracy with

which a sample represents a population. R2 is a statistical method which explains exactly how much of the variability of a factor is caused or explained by its relationship to another factor.[29]

The p-value (denoted in the graph by the * symbol) shows whether or not a sample tests as being statistically significant. Traditionally, a hypothesis is rejected if the p-value is greater than 0.05. Inevitably, it must come to the attention of anyone reading this that none of the chosen lender and borrower variables actually test as being statistically significant in regards to the shadow rate. The closest values that appear to have some correlation to the shadow rate are non-performing loans to total loans and the CCDI: although in the lagged 200-2015 regression, Non-Performing Loans to total Loans tests as being statistically significant at the 5% level.

On the other hand, there are several variables which do indeed test as being significant to other control variables. The current account to GDP ratio is the most consistently statistically significant control variable of those chosen for this study.

There are various reasons for this result. First, the number of observations taken is relatively small (with the most being 56 per sample). Second, the variables chosen may be affected by too many other factors besides the shadow rate in order for there to appear any correlation in the regressions.

For example, an index like the S&P 500 can be triggered to move by something like an oil crisis in Europe, or a conflict in the Middle East, or even a domestic crisis in the US (like a real estate crash, or high unemployment). The fact that this index is so susceptible to so many other variables provide some justification for why it would have little correlation with the shadow rate.

[29] "What Is Coefficient of Determination (r2)? Definition and Meaning." *BusinessDictionary.com*. 7 April 16

However, that is not to say that all of the predictions outlined in this thesis were erroneous. For example, the regression results did indeed show that the shadow rate has an inverse relationship with profitability, the ratio of nonfinancial corporate debt securities to assets and a positive correlation with the CCDI. Consequently, it was found that the Wu-Xia shadow rate and the S&P 500 were actually positively correlated, but that the shadow rate was inversely related to the non-performing loans to total loans ratio as well as to leverage. This is unexpected, but perhaps due to the small number of observations included in the regression analysis.

CONCLUSION

Ultimately, the findings of this thesis do not support the idea that the lender and borrower variables chosen exhibit a direct correlation with the Wu-Xia (2009) shadow rate. However, this does not necessarily imply that there is no direct correlation between such variables and the shadow rate at all. In one of their recent working papers, Wu and Xia (2014) outline their use of impulse responses of six economic variables (policy rate, industrial production, consumer price index, capacity utilization, unemployment, and housing starts) to a shock by the FFR, and subsequently a shock to the shadow rate, and discover that there is indeed a correlation between macroeconomic variables, the FFR, and the shadow rate.[30]

Furthermore, through the use of simple factor-augmented vector autoregression (FAVAR), they plot impulse responses, and ultimately discover they have 90% confidence intervals for their data.[31] Their model makes use of more advanced regression techniques, as well as more raw data, than what is presented in this thesis. Even though Wu and Xia do not focus on the credit channel in their work, the variables that they do contrast to the shadow rate appear to have a direct correlation, and their work does objectively show that the shadow rate moves in direct response to the macrovariables chosen.

As such, this work does not ultimately disprove that the shadow rate is unrelated to lender and borrower variables; this thesis merely shows that in the experiment outlined at the start of

[30] Wu, Jing Cynthia, and Fan Dora Xia. "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound." *Journal of Money, Credit and Banking* 48.2-3 (2016): 253-91. Web. 9 Nov. 2015.

[31] Wu, Jing Cynthia, and Fan Dora Xia. "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound." *Journal of Money, Credit and Banking* 48.2-3 (2016): 253-91. Web. 9 Nov. 2015.

this work, there does not appear to be any correlation between the variables chosen and the shadow rate.

In the Formal Analysis section, some of the reasons for this were outlined, however, a deeper discussion is warranted. One of the biggest reasons for the unobservable correlation has to do with the fact that there are a limited number of observations used in the study. The main database used was the Federal Reserve Bank of St. Louis' website, and many of the variables used did not come with an option for monthly intervals. As such, even the Wu-Xia (2009) shadow rate, which did come on a monthly basis, had to be converted to a quarterly result so that it could be accurately used in the regression analysis.

The variables picked were also susceptible to changes in factors not related to the shadow rate, in fact, as mentioned in the Formal Analysis section, some of the variables (like the S&P 500) were even moved by non-economic shocks, such as wars, or domestic unrest. The two variables that appeared to have the closest relationship with the shadow rate were non-performing loans to total loans and the CCDI. It is also important to note that these two variables were not as susceptible to non-economic factors as something like the S&P 500, and as such appeared to be more closely correlated with the shadow rate.

This thesis would have benefitted from choosing better regressor variables, and undertaking deeper research to seek lender and borrower variables that were more closely tied to monetary policy. On the other hand, this thesis is still unique in its approach to attempting to relate credit channel variables (those related to lenders and borrowers) and attempting to contrast them to the Wu-Xia shadow rate. Thus, despite its shortcomings, the research here can still be built upon in the future, albeit with better adjusted models, and better-chosen variables. Although

this work did not prove that there exists a direct correlation between lenders, borrowers, and the shadow rate, hopefully, it at least raised an interest in the relationship of the credit channel variables and the shadow rate, an interest that future academics will explore in their own works.

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