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Testing *a Simple Model of Spreads and Policy Interventions* with Empirical Data

Abstract

This paper uses Christiano and Zha's (2010) *A Simple Model of Spreads and Policy Interventions* to test several of the assumptions within their paper. This paper also explores the relationship between the banking system's net worth and yield spreads. This paper collects data, constructs the variables proposed in Christiano and Zha's paper, and tests the validity of the assumptions made in the paper. In particular, this paper uses data to test the predictive qualities of the incentive compatibility constraint, an inequality identified by Christiano and Zha that serves as a proxy for discretionary behavior by a bank against its depositors. The regressions indicate that spreads have no significant relation to θ and θ^{max}, the propensity for banks to cheat and the maximum possible propensity for banks to cheat in an economy. Also, the data does not support any relationship between banks net worth N and spreads which is intimated by the Christiano and Zha paper.

Introduction

The role of government intervention in the financial market is hotly disputed in the arenas of politics and economics. Following the 2008 financial crisis, pundits and politicians praised the Dodd-Frank Wall Street Reform and Consumer Protection Act for regulating banks in a way that would minimize the likelihood of future bank failures. A bank failure occurs either when the bank cannot meet its obligations to pay depositors or when the bank becomes too insolvent or illiquid to account for its liabilities. Not enough time has passed for us to see whether these regulations actually helped prevent future crises, but refining a simplified model could help illuminate what regulations or market conditions are optimal for preventing bank defaults.

In *A Simple Model of Spreads and Policy Interventions*, Lawrence Christiano and Tao Zha (2010) construct a two-period model to study the properties of an equilibrium with a positive spread of interest rates. In this paper, the authors model a market with a financial friction equilibrium such that banks are able to earn a rent. In their model, a bank chooses not to default whenever its net returns exceed some arbitrary fraction of its gross returns. That specific fraction is represented by θ in the equation below. This inequality is then referred to as the incentive compatibility constraint.

$$(N + db)R^k - d^b R^d \geq \theta (N + d^b) R^k.$$

Figure 1.

In the constraint, if θ is 1, then cost of deposits would be greater than what would be available to the bank and the bank would have an incentive to default.

$$- d^b R^d \geq \theta (N + d^b) R^k - (N + db) R^k .$$

$$- d^b R^{\,d} \geq \ 0.$$

At the other extreme, if θ is zero, then the return on total liabilities will exceed the cost of deposits and there will be no incentive to default.

$$(N \ + \ db\ )R^k \ \geq \ d^b R^{\,d}.$$

The above equation tells us that a bank will not default as long as bank profits remain sufficiently high. The question then becomes what should be the role of the government to counteract such rent-seeking behavior. In this paper the authors argue it is possible to develop a model for government policy interventions However, under normal legal circumstances, it is worth considering the fact that the FDIC insures all deposits up to $250,000. So, a bank will always pay its depositors' claims before it could ever embezzle (Glazov 2009). On the bank's balance sheet, depositor claims fall under the scope of liabilities. So, in the case of a failure, the "FDIC, acting in its corporate capacity, pays depositors the amount of their insured deposits, and is subrogated to the depositor's claims against the failed bank's estate" (Ragalevsky and Ricardi 2009). In other words, the FDIC will first take away from the bank's estate to compensate depositors before giving funds to depositors through pooled insurance. l. However, if we somehow assume that banks are indeed able to embezzle, it is necessary to particularize what exactly it would mean to do so. . Christiano and Zha offer the following equation to symbolize the maximum amount a bank could embezzle in an economy:

$$\theta^{max} = \frac{N}{N+y}(1 + R^k(\beta R^k)^{-\frac{1}{\gamma}})$$

Figure 2.

On the left-hand side of this equation, θ^{max} represents the maximum threshold of which a bank would be willing to embezzle in case of a default. On the right-hand side of this equation, N represents the banks net worth, y represents income from the household's problem, R^k represents the return on capital, β represents the discount factor from the household's problem, and γ represents the coefficient of risk aversion from the household's problem.

Christiano and Zha use this equation to describe the threshold level θ^{max} the highest fraction where banks can default without triggering a positive premium. If the actual fraction θ exceeds θ^{max}, the interest rate spread will widen so that $R^k - R^d > 0$ t. The authors state, "If the actual fraction is beyond the threshold, interest rate spreads widen and the equilibrium becomes inefficient."

Therefore, according to Christiano and Zha's paper, we can take away that if the θ^{max} could be made high enough, the interest rate spread will equal (or at least approach) 0. Likewise, lower values of θ^{max} ought to widen the spread. Accordingly, if the government were to take action to raise equity, in effect it would narrow yields in the market by increasing the supply of loanable funds, which will have long term beneficial effects, absent other opportunity costs in the system.

In this paper, I create the time series θ^{max} using the capital asset ratio for N, real median household income for y, Moody's Seasoned Baa Corporate Bond R^k, discount factor $\beta = 0.99$ and risk aversion coefficient $\gamma = 0.9$ as constants proposed by Christiano and Zha. The relationship between θ^{max} and yield spread φ roughly demonstrates the relationship between three primary variables: N bank worth, y household income, and R^k yield on capital. I also plot these variables to show this model applied to the real economy. Furthermore, I regress θ^{max} with the yield spread of R^k and R^d = 3-month Treasury Bill where the spread $\varphi = R^k - R^d$. According to the theoretical model proposed by Christiano and Zha, as θ^{max} increases, the spread should decrease. Also, I regress relationship between spread φ and net worth N to see whether net worth could possibly carry any relationship to profits.

Literature review

Christiano and Zha's paper is based on a 2010 paper by Mark Gertler and Nobuhiru Kiyotaki titled *Financial Intermediation and Credit Policy in Business Cycle Analysis*. In their paper, the authors outline the simple idea that bankers are able to steal from their depositors in the default condition. Their paper models an agency problem whereby there is a limit an intermediary can borrow from depositors. As a result, spread between loan and deposit rates is produced. This aspect of the paper lays the groundwork for the θ^{max} found in Christiano and Zha's paper.

Financial friction is an idea that has been linked to financial crises and bank defaults. In *Financial Frictions,* Robert Hall (2013) contends that the financial friction rose to an extreme level after the financial crisis in late 2008 and remained high for four years. Hall uses a calculation of a comprehensive spread to confirm the hypothesis that some combination of factors incorporated in the spread create a drag on the economy. Furthermore, he cites his 2010/2011 paper that offers an explanation why the spread has a negative effect on output and employment using standard macroeconomic principles.

Unfortunately, there is not much literature that tests the assumptions made in Christiano and Zha's model. However, in *Default Risk and Unconventional Monetary Policies,* Cheol Soo Park (2013) argues that a positive premium reflects the structure of the incentive compatibility restraint and the size of the net worth.[3.] Furthermore, Parks' paper reinforces the idea that decreases in net worth increases the rate in spreads.

Despite the mathematical rigor of the model, Christiano and Zha's paper is not the first to suggest that net worth affects the rate of spreads. In the paper *The Determinants of Bank Interest Spread in Brazil* Tarsila Afanasieff, Priscilla Lhacer, and Marcio Nakane (2001) seek to identify the roles played by the inflation rate, risk premium, required reserves, and the bank's CELS/CAMELS rating. Their paper defines an empirical model that defines a vector of bank characteristics that includes the number of bank branches, the ratio of deposits to operational assets, operating costs, liquidity, the/ services to revenues ratio, the bank's net worth, and the bank leverage. The paper expects the net worth to have a negative effect on the interest spread; they state that a large net worth provides a cushion for banks to better face risks and thereby reduces the interest spread. Despite the inclusion of net worth as a factor of a bank's observable characteristics, the authors conclude that macroeconomic conditions remain the primary determinants of bank interest spread in Brazil.

Data and Methodology

All data used for this project can be found at the following URL:
https://github.com/areibman/Research/blob/master/Economics/ESFAED.dta

In constructing the experimental model, I gather data from the Federal Reserve Economic Database (FRED). First, I construct a time series for θ^{max} as a function of N, where y, R^k, β and γ. Additionally, I construct θ. According to Christiano and Zha's paper, "A necessary and sufficient condition for the spread, Rk − Rd > 0, to exist in equilibrium is $\theta > \theta^{max}$." Hence, I test whether the necessary condition $\theta > \theta^{max}$ is true for the positive spread to exist. If this inequality is not true, then the model fails to explain the spread. Net worth N is represented by the capital to assets ratio[7]. Income y is represented as real median household income in the United States[8]. R^k is represented as Moody's Seasoned BAA corporate bond yield, and R^d is represented as Moody's Seasoned AAA corporate bond yield [9]. Moody's includes bonds with maturities as close as possible to 30 years and drops bonds with less than 20 years remaining or if the rating changes. In accordance with Christiano and Zha's paper, I assign the values of 0.99 and 0.9 to β and γ accordingly.

In order to maintain consistency in developing θ and θ^{max}, some data preprocessing is necessary. First, data on the capital asset ratio is only available from 1984 onwards, so previous data is ignored. Additionally, data on AAA and BAA corporate bond yields is only given as monthly, so it is converted to annual by benchmarking January 1st of each year as defined year's rate. I also divide the corporate bond yields and add 1 in order to maintain consistency with Christiano and Zha's model.

In order to create $\theta,$ the following formula is used:

$$\theta = \frac{N}{N+y}(1 + \frac{y}{N}\left(1 - \frac{R^k}{R^d}\right) + R^d(\beta R^k)^{-\frac{1}{\gamma}})$$

Figure 3.

Furthermore, Equation 2 is used to calculate θ^{max}. Using Microsoft Excel, an If statement is used to test the $\theta > \theta^{max}$ condition, and given the data I used, this case holds true.

The formula $\varphi = R^k - R^d$ is used to calculate the spread between BAA and AAA bonds. Finally, I run a regression between φ and θ^{max} to determine the strength of the relation of θ^{max} and φ. I also run a regression between φ and θ.

Results

Given the input data, for all values of θ and θ^{max} the inequality $\theta > \theta^{max}$ held true. This was tested by using an If-statement comparing whether items in Theta were greater than Theta Max.

Theta Max Estimates 1998-2013

Observation Date	ThetaMax	Theta	Inequality
1-1-1998	0.000003017	0.0000206	TRUE
1-1-1999	0.000002909	0.0000201	TRUE
1-1-2000	0.000002948	0.0000203	TRUE
1-1-2001	0.000003192	0.0000208	TRUE
1-1-2002	0.000003302	0.0000211	TRUE
1-1-2003	0.000003305	0.0000210	TRUE
1-1-2004	0.000003715	0.0000211	TRUE
1-1-2005	0.000003677	0.0000208	TRUE
1-1-2006	0.000003719	0.0000207	TRUE
1-1-2007	0.000003599	0.0000204	TRUE
1-1-2008	0.000003381	0.0000210	TRUE
1-1-2009	0.000004512	0.0000220	TRUE
1-1-2010	0.000004772	0.0000223	TRUE
1-1-2011	0.000004653	0.0000226	TRUE
1-1-2012	0.000004561	0.0000224	TRUE
1-1-2013	0.000004338	0.0000215	TRUE

Figure 4.

Plotting the spread $\varphi = R^k - R^d$ for all data since 1984 yields the following (Figure 5):

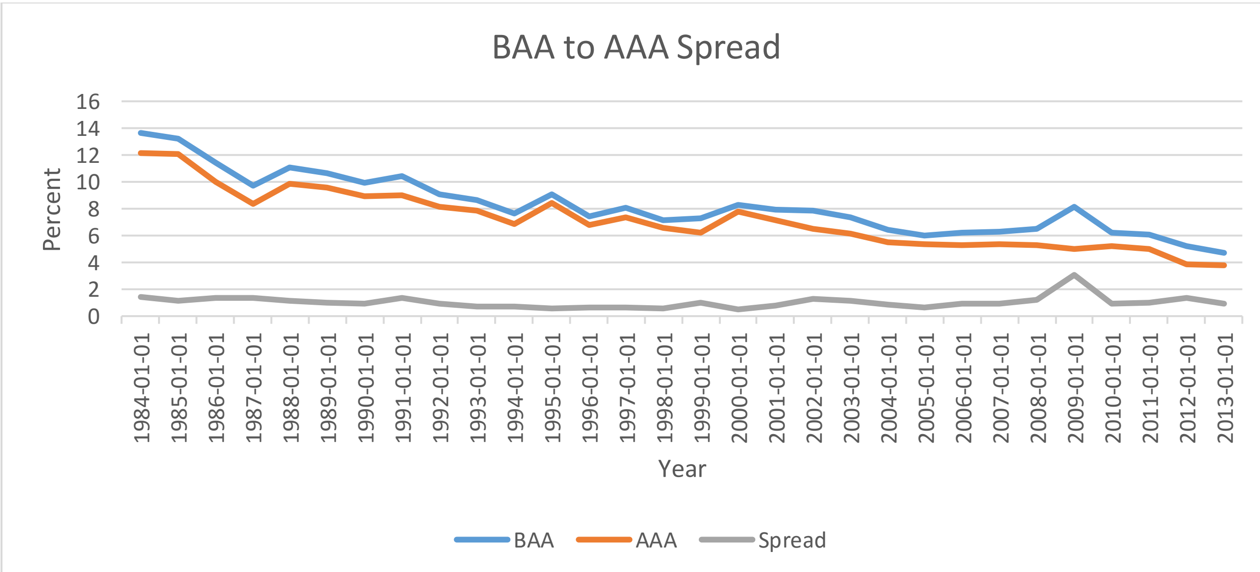

Figure 5.

The following spread (Figure 6) represents the spread data for 1998-2013, the time series used to calculate θ and θ^{max}.

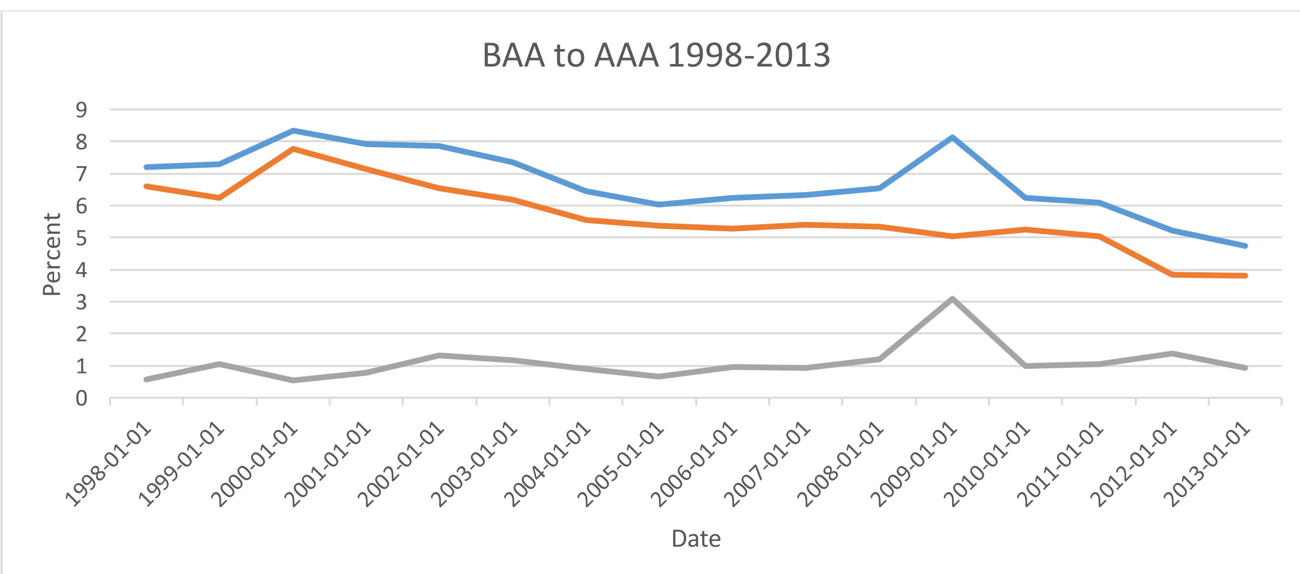

Figure 6.

The following represents the regression of the spread on θ^{max} (Figure 7).

Source	SS	df	MS			
				Number of obs	=	16
				F(1, 14)	=	3.18
Model	1.1474e-12	1	1.1474e-12	Prob > F	=	0.0962
Residual	5.0510e-12	14	3.6078e-13	R-squared	=	0.1851
				Adj R-squared	=	0.1269
Total	6.1983e-12	15	4.1322e-13	Root MSE	=	6.0e-07

thetamax	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
spread	4.74e-07	2.66e-07	1.78	0.096	-9.61e-08	1.04e-06
_cons	3.20e-06	3.28e-07	9.77	0.000	2.50e-06	3.91e-06

Figure 7.

Since the P-value is greater than 0.05, spread is not a statistically significant predictor of θ^{max}. The following (Figure 8) represents the regression of the spread on θ .

Source	SS	df	MS			
				Number of obs	=	16
				F(1, 14)	=	3.44
Model	1.7780e-12	1	1.7780e-12	Prob > F	=	0.0848
Residual	7.2363e-12	14	5.1688e-13	R-squared	=	0.1972
				Adj R-squared	=	0.1399
Total	9.0144e-12	15	6.0096e-13	Root MSE	=	7.2e-07

theta	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
spread	5.90e-07	3.18e-07	1.85	0.085	-9.23e-08	1.27e-06
_cons	.0000205	3.93e-07	52.26	0.000	.0000197	.0000214

Figure 8.

Since the P-value is greater than 0.05, spread is not a statistically significant predictor of θ either. The following regression (Figure 9) represents the relation between the spread and *N*. Spread is used as a proxy measure for profits following the equation in Figure 1.

Source	SS	df	MS			
				Number of obs	=	16
				F(1, 14)	=	3.57
Model	1.03792257	1	1.03792257	Prob > F	=	0.0797
Residual	4.07037713	14	.290741224	R-squared	=	0.2032
				Adj R-squared	=	0.1463
Total	5.1082997	15	.340553313	Root MSE	=	.5392

spread	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
capitalassetratio	17.44683	9.233948	1.89	0.080	-2.358016	37.25168
_cons	-.6974738	.9595278	-0.73	0.479	-2.755456	1.360509

Figure 9.

Since the P-value is greater than 0.05, the capital asset ratio is not a statistically significant predictor of profits. The following plot represents the visual representation of spread as a measure of profit and the capital asset ratio as a measure of *N*

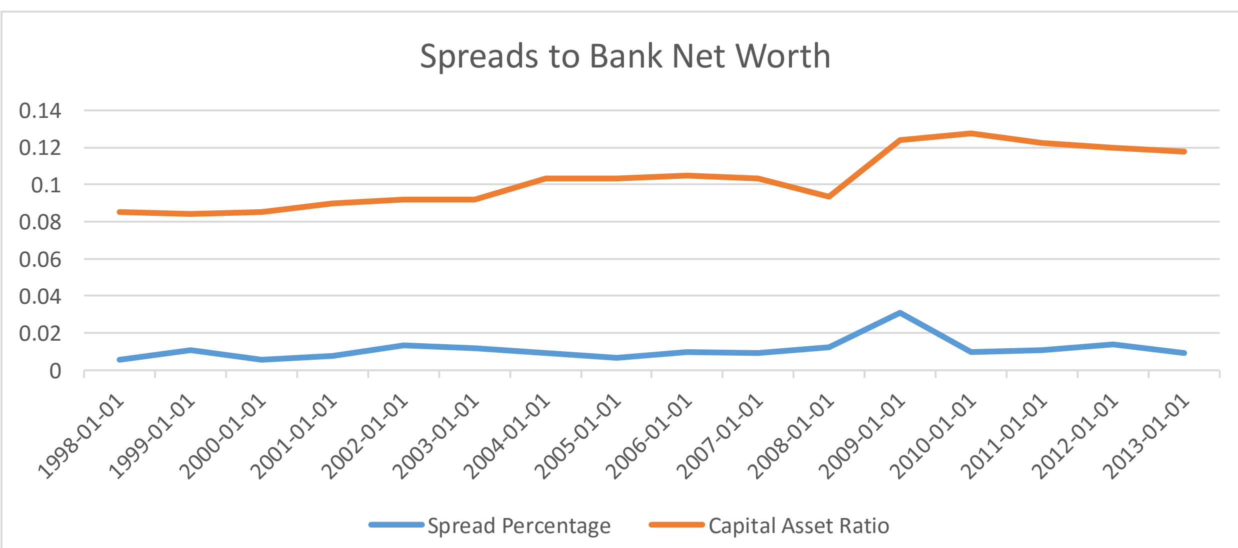

Figure 10.

Discussion

According to the yield spreads plotted in Figure 5 and Figure 6, the highest periods of yield spreads are observed during financial crises. This is most noticeable especially during the 2008 financial crisis. These plots offer a good visual explanation of when financial crises occur. These results are consistent with Hall's conclusion; increases in spread link with financial crises.

Furthermore, the regression of spreads on θ and θ^{max}suggests that spreads are not a statistically significant predictor of the θ and θ^{max}measurements. According to Christiano and Zha's model, increases in spread ought to indicate lower θ^{max} measurements. However, the results in Figures 7 and 8 suggest otherwise.

. A possible refinement that could be made is to account for the role of FDIC insurance for depositors. The model proposed does not align with the actual legal environment in the United States since it assumes that banks are able to pay off shareholders before they pay off their liabilities in the case of a default. Perhaps θ and θ^{max}should be formulaically adjusted to account for the fact that shareholders are protected by FDIC insurance.

Despite the fact that the regressions of spreads do not express any predictable relations with θ and θ^{max}, Figure 4 shows that the necessary and sufficient condition for a positive spread to occur,$\theta > \theta^{max}$ holds true for all data points. This suggests that Christiano and Zha's model is mathematically consistent, but the θ and θ^{max} still need to be modified to account for the actual circumstances of the system before more empirical studies that employ this model can take place.

Additionally, I test the effect of net worth on spreads. In contrast with the literature, such as Park's paper, which remarks that decreases in net worth increases the rate in spreads, the regression of these two variables as shown in Figure 9 show that the capital asset ratio is not a statistically significant predictor of spreads. The graphical representation on Figure 10 suggest that the 2008 crisis momentarily lowered the capital asset ratio. These findings suggest that the capital asset ratio alone may not be appropriate for accounting spread increases, and further steps should be taken to refine the model. This conclusion seems to be consistent with Nakane's study which finds that bank net worth may contribute to spread, but other macroeconomic factors play a larger role.

Conclusion

This paper seeks to apply Christiano and Zha's model to real empirical data. In particular, the regressions indicate that spreads have no significant relation to θ and θ^{max}meaning that the model is perhaps underspecified or the data too simplified in its current form. Furthermore, I test whether bank net worth N has any meaningful impact on spreads. The regression does not suggest this, and neither does the literature.

Christiano and Zha's model t lays a framework for policy interventions, but the empirical analysis to test these models shows that there is more work to be done. For future research, perhaps redefining the terms of the default to account for FDIC restrictions on banks or regulatory conditions in the US economy would offer a more robust explanation.

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