ECON3222 Group Project Report

Adjustment of Taylor Rule

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I. Introduction

This report intends to examine whether the US Federal Funds rate is set appropriately, consistent with monetary policy goals of stable inflation, maximizing GDP growth and natural rate of unemployment both currently and in the long run. First, we will compute the Federal Funds rate following basic Taylor rule for the last two quarters of 2017 and the first two quarters in 2018 to compare it with the actual Federal Funds rate. Then, we will identify three macroeconomic and financial indicators that can capture the future output growth and inflation. By incorporating these additional indicators, we hope that we can finetune the basic Taylor rule to make it more relevant to reality, and use this modified model to evaluate the appropriateness of the US monetary policies in the long run.

II. Benchmark

We first use the basic version of Taylor Rule to calculate the estimated Federal Funds rate as a benchmark. The time period chosen here is the last four quarters, namely quarter 3 and 4 of 2017, and quarter 1 and 2 of 2018. Before applying Taylor Rule, we obtained the data of some important macroeconomic factors from *FRED*, namely real GDP, potential GDP, inflation rate, effective Federal Funds rate and unemployment rate. The comparison between our estimated Federal Funds rate and effective Federal Funds rate could decompose some macroeconomic factors and then helps to evaluate the appropriate level of Federal Funds rate. Although the unemployment rate has not been used in the basic Taylor Rule, it will be used in our modified Taylor Rule which will be discussed in *Part III*. The macroeconomic data in the last four quarters is shown in *Appendix 1*.

Assumptions in Taylor Rule for the US economy include that equilibrium Federal Funds rate equals to 2%, target inflation rate equals to 2% and $\alpha = \beta = 0.5$. As equilibrium real Federal Funds rate plus inflation rate equals to the equilibrium nominal Federal Funds rate, the basic Taylor Rule implies that Federal Funds rate should respond to the deviation of the current inflation rate from the target and that of the current real GDP from the potential real GDP.

$$Federal\ Funds\ Rate(t) = equilibrium\ real\ federal\ funds\ rate(t) +$$

$$inflation\ rate(t) + \alpha[inflation\ gap(t)] + \beta[output\ gap(t)]$$

where $inflation\ gap(t) = inflation\ rate(t) - target\ inflation\ rate\ of\ Fed$

$$output\ gap(t) = \frac{GDP(t) - Potential\ GDP(t)}{Potential\ GDP(t)} \times 100\%$$

By inputting the above macroeconomic data into the basic Taylor Rule, we can get the estimated Federal Funds rates, which are 5.7444% in 2017 Q3, 5.9695% in 2017 Q4, 6.1682% in 2018 Q1 and 6.7529% in 2018 Q2. These estimations function as a benchmark for us to evaluate the effective Federal Funds rates during this period. The estimation process is shown in *Appendix 2*.

III. Additional Indicators

In this section, we would first introduce three indicators that we would like to supplement Taylor Rule and then elaborate the underlying rationale why these indicators can help. As the main targets of U.S. monetary policy are stable inflation and low unemployment rate, we would mostly explain from these two aspects.

(1) Trade-weighted Exchange rate Index (XBMTH)

The above index is a weighted average of the foreign exchange value of the U.S. dollar against the currencies of a broad group of major U.S. trading partners, of which the currency weights are based on annual trade data, varying by year.

First, exchange rate index reflects the overall health of U.S. economy, further, the systemic risk and GDP growth. It's undeniable that if U.S. economy is weakened, the investment from foreign countries in U.S. will decrease, resulting in fewer trades for USD and depreciation in USD, and vice versa. Notice that such reflection also incorporates certain forecast of the future development of the economy. For example, when relevant news that may change people's prospects on the economy, even if without current influence on economic activities, the exchange rate of USD would respond to the event immediately due to change in future expectation. When USD depreciates due to change in expectation, capital outflows will reduce the supply in loanable markets thus restraining the real economy activities. In this case, federal funds rate should increase to encourage more investment from foreign investors to keep the

Second, the determination of federal fund rate is not only bound to national economic activities, but also linked with other countries' policies and economic conditions. For example, when one major trader of U.S., like Canada, raised its BOC key interest rate, there would be more foreign capital flow into Canada, which will be reflected in the depreciation in U.S. Dollar immediately, and further, less lending and investment would occur in U.S. and correspondingly, more borrowing, which will lead to fewer suppliers of capital in real economy. In this case, companies, especially SMEs, may face changes in financing, and then spread to other economic components.

To minimize unemployment rate and stabilize the output growth, U.S. should raise federal funds rate as well to attract sufficient overseas funds for domestic operation.

(2) Yield Spread between 10-Year Treasury Bond and 3-Month Treasury Bill (IRLTLT01USM156N - TB3MS)

The yield spread is the excess yield that investors require to commit to holding a long-term bond instead of a series of shorter-term bonds. The reason why we choose 10-year and 3-month as benchmarks is that these two are most liquid Treasury debts and thus good representatives of long-term and short-term yields. As they are highly liquid and risk-free, we consider the yield spread to fully reflect part of the overall slope of the yield-curve. In this way, it actually reflects the market's view on future real interest rate, inflation rate and liquidity premium due to the expectation theory. When economy is expected to slow down, the future real interest rate is expected to be lower because firms will be less willing to borrow long term debt to invest in operation activities in down state. With inflation rate generally remains stable, this will result in lower yield in long-term securities and smaller yield spread. In this case, federal funds rate should decrease to encourage consumption and borrowing to cheer up the economy and people's expectation.

On the other hand, the economy, especially financial sector, responds sensitively to the yield spread and therefore the Central Bank has great incentives to pay close attention to this figure. As federal fund rate mostly influences the origin and short-term part of the yield curve, the Fed would be effective to prevent situations like inverted yield curve, in which situation financial institutions, who benefits from lending long-term and borrowing short-term, will suffer great

loss, and this would also alter investment decisions on other industries in real economy due to de-leveraging behavior of financial institutions.

(3) (All Sectors; Total Debt Securities; Liability + All Sectors; Total Loans; Liability)/Gross Domestic Product (ASTDSL + ASTLL/GDP)

The above total debt securities and loans include all major sectors of the U.S. economy, both financial and nonfinancial, private and public. Certain debt market offers a place for those companies, both large ones and SMEs to raise funds, through bonds, commercial papers or loans, etc, and individuals to borrow, including mortgage loans. Companies and governments borrow money from investors for the purpose of investment and expenditure and individuals borrow for consumption and investment. As this ratio would be an indicator for the investors' willingness in the future to lend, we divide the level of total credit market debt owed by real GDP, hoping to measure the financial leverage of the whole economy. Capital structure would reflect the future borrowing capacity for the economy to invest and further consume and thus would influence the GDP growth rate through the employment of corporations, wealth effect of those households, etc. For example, the special time like "credit crunch" can be reflected through previously a too high debt ratio and later a sharp drop and thus federal funds rate should probably be lowered to encourage more lending and thus SMEs can remain the production capability, in this way to stabilize the employment and output. Also, it reflects the part of debts held by foreign investors and government deficit partly, which should also be taken into consideration for the Federal funds rate.

IV. Qualitative Analysis

(1) Analysis on Federal Funds Rate based on Basic Taylor Rule

Compared with the effective Federal Funds rates in that period, the estimated Federal Funds rates are much higher mainly because of the large output gap. As the output gap is enlarging in these four quarters, the difference between the estimated Federal Funds rate and the effective Federal Funds rate is also enlarging. The estimated Federal Funds rate calculated using basic Taylor Rule indicates a benchmark rate for the Fed. In the chosen four quarters, we think the effective Federal Funds rates were too low and should have been set at a higher level referring to the estimated Federal Funds rate. Although the effective federal funds rate is increasing, it is still too slow to respond to the excess capacity. As both of the estimated and effective Federal Funds rates are increasing, the demand of borrowing is discouraged. Investment will decrease due to the decreasing borrowing and hence the output level will also be lower. In the near future the output level will decrease and approach the potential output level. Then the difference between estimated and effective Federal Funds rate will decrease.

(2) Analysis on Federal Funds Rate with Data of Additional Indicators

Data of additional indicators obtained from *FRED* for the corresponding four quarters is shown in *Appendix 3*. Intuitively, according to our analysis for each indicator, we expect the appropriate Federal Funds Rate has negative correlation with unemployment rate and debt level, and positive correlation with exchange rate and term yield spread.

Since unemployment rate is an indicator of output growth, when unemployment rate increases, there is a trend of decreasing in output, and the Federal Funds rate should decrease to encourage borrowing and investment in real economy to facilitate operation activities. When unemployment

rate decreases, there is a trend of increasing output and thus future output gap and inflation rate will increase. To maintain the target inflation level, Federal Funds rate should be increased to discourage borrowing and consumption and slow down the output growth.

From previous analysis, the depreciation in USD will accelerate overall operation activities and investment activities in the US. Then it works in the opposite way to the unemployment rate. Therefore, the exchange rate index should have positive correlation with Federal Funds rate.

Since the yield spread, which illustrates the term structure of treasury bonds, is a leading indicator of GDP, the increase in yield spread will imply the expectation of GDP growth and then work in the same way as unemployment rate. Since the signals of fluctuation in yield spread and unemployment rate show the opposite direction of economic changes, the correlation between yield spread and Federal Funds rate should have opposite sign to that of unemployment rate on Federal Fund rate, which means yield spread has positive correlation with Federal Funds rate.

(Total Debt Securities + Total Loans)/GDP works in the way to measure the debt pressure on both individuals and enterprises and how much output is driven by debt borrowing. If (Total Debt Securities + Total Loans)/GDP is high, then the pressure will push down economic operation and investment activities. Therefore, (Total Debt Securities + Total Loans)/GDP can work as an indicator of future output level. In the case of the increase in (Total Debt Securities + Total Loans)/GDP, Federal Funds rate should decrease to release the burden and avoid large scale of default events, which may further drive down economic activities and drive up the

unemployment rate. Therefore, (Total Debt Securities + Total Loans)/GDP should have negative correlation with Federal Funds rate.

We obtained data in FRED from 1992 to 2000 right after the 90's recession and before the internet bubble burst as normal period to calculate the normal level of these four indicators as benchmark. From table 1, table 2, and table 3 in Appendix, we can calculate by take an average. The result shows that normal level of unemployment rate is 5.6%, normal exchange rate index is 97.2707, normal yield spread is 1.8234% and normal (Total Debt Securities + Total Loans)/GDP is 249.70139% . Compared with our data for the recent four quarters, we can observe that the levels of unemployment rate and yield spread are both lower than normal levels, and levels of exchange rate index and (Total Debt Securities + Total Loans)/GDP are higher than normal levels. Since both yield spread and exchange rate index have positive correlation with Federal Funds rate, their impacts of deviation from normal levels are partially offset by each other. Since the unemployment rate is lower than normal level, we expect the calculated Federal Funds rate to be pushed up further to reflect the response to low unemployment rate. However, the current (Total Debt Securities + Total Loans)/GDP level is higher than that of normal period, based on which we expect a lower Federal Funds rate in response. Overall, we expect the change in calculated Federal Funds rate would be ambiguous after we include four additional indicators.

V. Extension Discussion

(1) Concrete plan of how to extend our analysis

In our analysis, we intuitively elaborate the how we decide the additional factors we choose to add to the Taylor Rule model. For deeper insights and exploration, we come up with the plan to extend our analysis.

a. Run regression to obtain modified model with new indicators we choose in previous sections. Specially, we release the settings on value of coefficients on inflation gap and output gap because new variables can have some correlation with these two old variables, which may result in a significant change in coefficients of inflation gap and output gap.

b. Revise the model. Although we analyze the indicators intuitively, in practice we may need to revise the factor due to some statistical issue, for example, the level of collinearity between two factors, etc.

c. We measure the our model using the same method as in lecture note. We use the Federal Fund Rates we calculate from the modified Taylor Rule as one variable on Housing Start, with all other variables unchanged and see whether the level of housing boom before financial crisis is lower than what is calculated using original Taylor Rule. If it is the case, than our modified Taylor Rule is more suitable to be used to determine the appropriate federal fund rate.

(2) Weaknesses of current analysis

a. Correlation may not be a good measure or even be misleading. For example, we use correlation between past term premium and GDP to inspire us about their leading and lag

relationship. In this case, however, this may be misleading. Even if there is a low correlation between two factors, they may still have strong dependency.

b. Indicators may be too few. Since we only include 3 additional factors, we omit some other factors that may relate to GDP or inflation, for example, the stock market performance, which is a leading indicator of GDP. In this case, we may have omitted variable bias in our model.

c. The Taylor Rule may be period-specific. The way we measure the suitability of Taylor Rule as Federal Fund Rate is using data of housing starts during financial crisis and other independent variables. We can conclude that Taylor Rule can lead to better economic situation if it was used as Federal Fund Rate. However, this conclusion may be period- or event-specific. Since financial crisis cannot represent as a general economic condition, the true story may be that Taylor Rule is useful where a bubble is building up but not in other cyclical periods such as recovery period. In that case, we cannot use Taylor Rule to measure the reasonability of actual Federal Fund Rate directly in any case.

(3) Suggestions on how to better evaluate in the future

Since this project is a preliminary study on this topic, we draw some ideas for further research to explore deeper issues and complete a more systematic argument.

a. Future research can include more indicators in the model or other format of variables, for example, quadratic format or exponential format, to better estimate the reasonable Federal Fund rate, and make some comparison between different versions of models.. More advanced analysis

such as advanced econometrics or time series analysis may be introduced into the research for more efficient and unbiased estimates.

b. Try to test the usefulness of Taylor Rule in more scenarios and multiple time periods to generalize the conclusion. As we mentioned in the previous section, current proof is too event-specific and cannot be used directly. Or, try to differentiate scenarios that may lead to different performance of the Taylor Rule and modify the model into several editions based on different needs in each scenario.

VI. Adjusted Rule Used by Janet Yellen (as supplementary)

In this section, we take a look on the adjusted rule used by Janet Yellen,

$$R(t) = R^* + \pi(t) + 0.5[\pi(t)-\pi^*]-2.0[U(t)-U^*]$$

where R is the Federal Funds rate; R* is the longer-run normal value of the Federal Funds rate adjusted for inflation; π is the four-quarter moving average of core PCE inflation; π^* is the FOMC's target for inflation (2%); U is the unemployment rate; and U* is the longer-run normal rate of unemployment. Based on the medians of FOMC participants' latest longer-run projections, R* is approximately 1% and U* is about 4.8%.

This rule considers the inflation gap and unemployment gap, and the latter one is not included in the standard Taylor rule. In 2009 after the Great Recession, the unemployment level is as high as 10%, which deviates far from the natural unemployment, whereas PCE inflation is about 1%, which is close to the target inflation. This rule generates a low Federal Funds rate of -9%, while the standard Taylor rule gives a Federal Funds rate of about -3%. This is because the standard

Taylor rule assigns equal weight to the inflation gap and output gap and neglects the impact of unemployment. The adjusted rule puts more weight on the effect from the unemployment gaps, reflecting the need of pushing up employment level.

Although a negative Federal Funds rate is not achievable, the result from the rule used by Janet Yellen implies that the monetary policy to be adopted is more aggressive than the basic Taylor rule does. This rule can be further adjusted to accommodate the zero lower bound of Federal fund rate. Alternatively, non-conventional monetary policies that are not restricted by such bound should be devised for the recovery of economy.

VII. Summary

In our report, we try to modify the basic Taylor rule in an effort to better evaluate U.S. monetary policies of federal fund. Since the basic Taylor rule only takes into account the current output gap and current inflation gap, the former a leading indicator of future inflation and the latter the deviation from target inflation, neglecting indicators that capture future output growth, the basic Taylor rule is not a very satisfactory forecasting model in predicting the appropriate US monetary policy. The Federal Fund rate calculated by it may not be good enough to achieve the goal of GDP growth and steady inflation.

Apart from the unemployment rate that is closely related to the output level and the goal of monetary policies, we incorporate 3 more indicators into the basic Taylor rule: Trade-weighted Exchange rate Index, Yield Spread between 10-Year Treasury Bond and 3-Month Treasury Bill, and (Total Debt Securities + Total Loans)/GDP.

Despite including more indicators, there still exist some flaws in the forecasting model. The indicators we add to the original Taylor rule need not only qualitative explanations as insights, but also further qualitative analysis to justify their relevance to the determination of Federal Fund rate, regarding different formats of variables and probably non-linear relationships, and consider different economic environments. Hopefully, we can derive a more practical and accurate version of Taylor rule to forecast the appropriate federal fund rate and therefore also evaluate the current monetary policies.

Appendix

Appendix 1. Macroeconomic Data in the Last Four Quarters

Time Period	Real GDP **(GDPC1)** *(Billions of Chained 2012 Dollars, Seasonally Adjusted Annual Rate)*	Potential GDP **(GDPPOT)** *(Billions of Chained 2009 Dollars, Not Seasonally Adjusted)*	Inflation Rate **(BPCCRO1Q156NBEA)** *(Percent Change from Quarter One Year Ago, Seasonally Adjusted)*	Federal Funds Rate **(FEDFUNDS)** *(Percent, Not Seasonally Adjusted)*	Unemployment Rate **(UNRATE)** *(Percent, Seasonally Adjusted)*
Q3, 2017	18120.843	17259.8	1.5	1.15	4.3
Q4, 2017	18223.758	17333.0	1.6	1.20	4.1
Q1, 2018	18323.963	17412.2	1.7	1.45	4.1
Q2, 2018	18511.576	17495.8	1.9	1.74	3.9

Source: FRED

Appendix 2. Estimation of appropriate Federal Funds Rate using Basic Taylor Rule

Time period: Quarter 3 and 4 of 2017; Quarter 1 and 2 of 2018
Frequency: Quarterly

Time Period	Observa-tion Date	Equil Fed Rate	Inflation Rate	α	Inflation Gap	β	Output Gap	Estimated Fed Rate	***Effective Fed Rate***
Q3, 2017	2017-07-01	2	1.5	0.5	-0.5	0.5	4.99	5.7444	***1.15***
Q4, 2017	2017-10-01	2	1.6	0.5	-0.4	0.5	5.14	5.9695	***1.20***
Q1, 2018	2018-01-01	2	1.7	0.5	-0.3	0.5	5.24	6.1682	***1.45***
Q2, 2018	2018-04-01	2	1.9	0.5	-0.1	0.5	5.81	6.7529	***1.74***

Source: FRED

Appendix 3. Data of Additional Indicators in the Last Four Quarters and Benchmark

Time period: Quarter 3 and 4 of 2017; Quarter 1 and 2 of 2018
Frequency: Quarterly

	Civilian Unemployment Rate	**Trade Weighted U.S. Dollar Index: Broad**	**Yield Spread Between 10-Year Treasury Bond and 3-Month Treasury Bill**	**All Sector Debt Securities + Loans/Nominal GDP**
Time Period	**(UNRATE)** *(Percent, Seasonal Adjusted Monthly Rate)*	**(TWEXBMTH)** *(Index Jan 1997 = 100, Monthly, Not Seasonally Adjusted)*	**(IRLTLT01USM156N - TB3MS)** *(Percent, Monthly, Not Seasonally Adjusted)*	**(ASTDSL+ASTLL/GDP)** **(Perc***ent, Quarterly, Not Seasonally Adjusted)*
Q3, 2017	4.3	119.0951	1.20667	346.88407
Q4, 2017	4.1	120.0682	1.16333	346.66051
Q1, 2018	4.1	117.6112	1.20000	347.26838
Q2, 2018	3.9	121.0006	1.08000	344.10524
Benchmark	5.6	97.2707	1.82340	249.70139

Source: FRED

** the Q2 2018 Nonfinancial Corporate Nominal Debt data hasn't been updated yet on FRED, but the resource data has already been released. We use the same source ID of FL894123005 and FL894122005 correspondingly in the file Z.1 Financial Accounts of the United States as instructed by FRED.*

Appendix 4. Graph of Additional Indicators in the Last Four Quarters and Benchmark

Table 1: Normal Period Civilian Unemployment Rate (UNRATE)

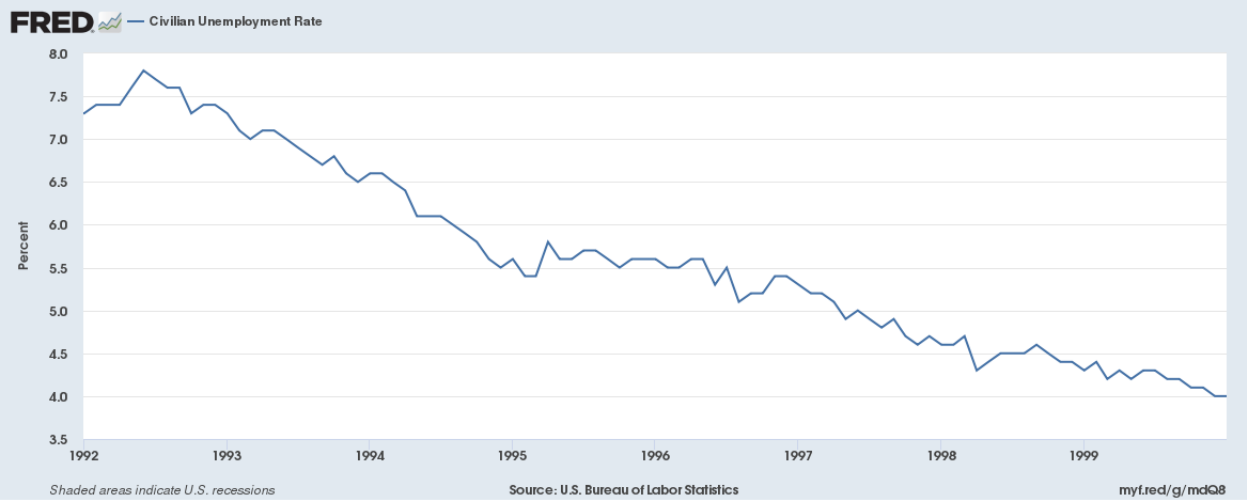

Table 2:Normal Period Trade Weighted U.S. Dollar Index: Broad (TWEXBMTH)

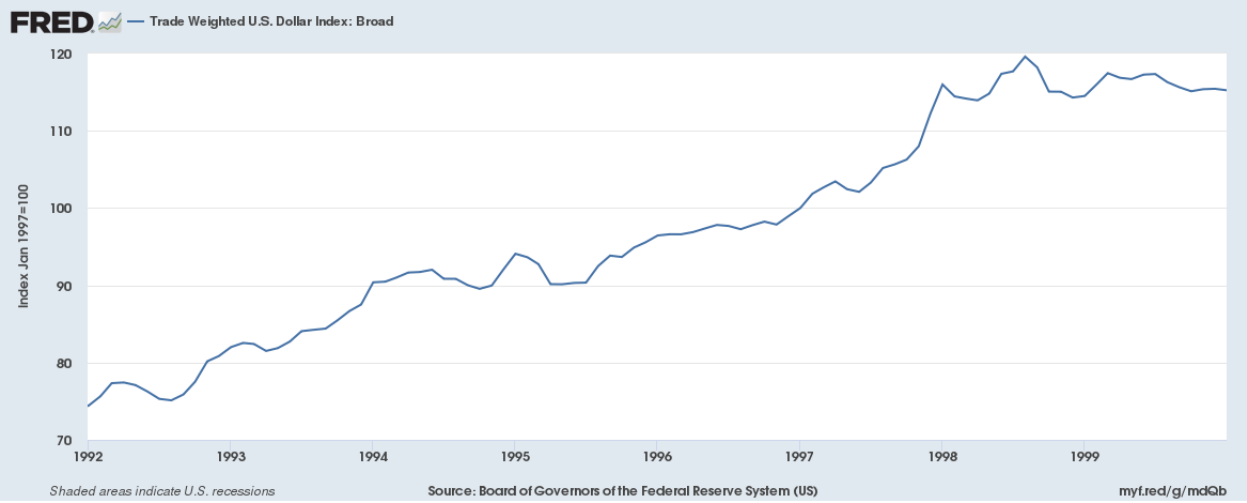

Table 3: Normal Period Yield Spread (IRLTLT01USM156N - TB3MS)

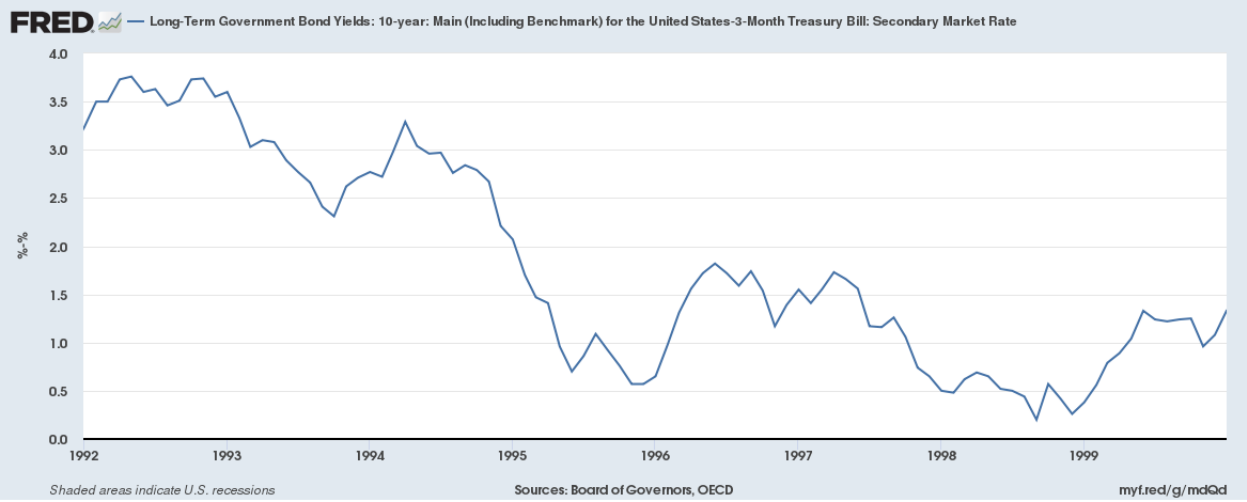

Table 4: Normal Period (Total Debt Securities + Total Loans) /GDP ((ASTDSL+ASTLL)/GDP)