The Impact of Large-Scale Asset Buybacks on Relative Valuation of U.S. Treasury Securities

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I. INTRODUCTION

The decision by the Federal Reserve to engage in Large Scale Asset Buybacks as a way of performing monetary policy has sparked much interest across the academic world. However, although there have been several analyses on the impact of those buybacks on long-term interest rates and overall macroeconomic effects, there hasn't been much research done on the impacts of those purchases on the microstructure of Treasury securities. Therefore, the purpose of this work is to fill this gap by analyzing the impact of the buybacks (also known as QE1 and QE2) on the relative pricing of US Treasury Securities across maturities and coupons.

The 2008 financial crisis caused many disruptions across asset classes and the U.S. treasuries market was no exception. The special condition of U.S treasury securities as "safe-haven" securities caused huge inflows in this asset class in the aftermath of the financial crisis and may have caused mispricing in the relative valuation of bonds across the yield curve. Moreover, as the crisis reduced overall market liquidity and increased risk premia, arbitrageurs who would normally exploit those mispricings might not have been able to do so due to impaired balance sheets.

However, there was one market participant who did not suffer from balance sheet restrictions. By engaging in its Large-Scale Asset Purchases (LSAP) programs, the Federal Reserved purchased over $900 billion of Treasury Securities from 2009 to 2011. In its operational statements, the Fed announced the maturities that it would purchase, but

let the actual securities purchased to be decided by competitive auction. Accordingly to the Federal Reserve operational statements[1]:

"Consistent with prior outright Treasury purchases, these purchases will be conducted with the Federal Reserve's primary dealers through a series of competitive auctions via the Desk's FedTrade system."

In order to correctly assess which offers to take in the competitive auction system, the Federal Reserve must have some internal methodology in order to assess whether a particular treasury security is "cheap" or "expensive" at a particular price. Although there is no official information on the methodology used, it will probably utilize some form of curve spline fit as described in (Waggoner, 1997).

Therefore, as the Federal Reserve implements its treasury purchase program, one should expect the mispricing of Treasury Securities with similar maturities to decrease. As the Fed purchases of securities it deems "cheap", it bids up their price thus reducing the mispricing. There could also be an indirect impact, as the QE program improves overall market conditions and the increased liquidity allows arbitrageurs to return to the market and exploit any opportunity they see.

This paper will try to quantify those impacts by analyzing the yield differential between On-The-Run (OTR) and Off-The-Run (OFR) securities of same maturity. The next two sections will describe how the OFR-OTR spread was measured and describe the Federal Reserve LSAP program in details. Then, sections IV and V will describe the

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[1] Federal Reserve Website, http://www.newyorkfed.org/markets/operating_policy_090318.html

methodology used to quantify the impact of the LSAP program on the OFR-OTR spread and analyze the results. Section VI will try to assess whether there was a difference between QE1 and QE2 in terms of the impact of those programs on the OFR-OTR spread and finally section VII will conclude and suggest other areas for future research.

II. MEASURING THE OFR-OTR SPREAD

In order to measure the impact of LSAP on the OFR-OTR spread, it is important to first define how to measure this spread across different maturities and coupons. U.S. Treasury Notes and Bonds are issued in fixed maturities such as 2, 3, 5, 7, 10 or 30 years. For each one of these fixed maturities, the OFR-OTR spread will be defined as follows:

$$\Delta YTM = YTM^{OFR} - YTM^{OTR}$$

Where:

YTM^{OTR} = Yield to Maturity of the mostly recently issued security for this fixed maturity (On-The-Run bond)

YTM^{OFR} = Yield to Maturity of a synthetic off-the-run bond with same maturity

The synthetic off-the-run bond will be calculated by linear interpolation of the YTM of securities with neighboring maturities as in (Amihud & Mendelson, 1991):

$$YTM^{OFR} = YTM^{PREV} \times w^1 + YTM^{NEXT} \times w^2$$

Where PREV is the bond that matures just before the OTR bond and NEXT is the bond that matures just after the OTR bond. The weights are defined accordingly to standard linear interpolation:

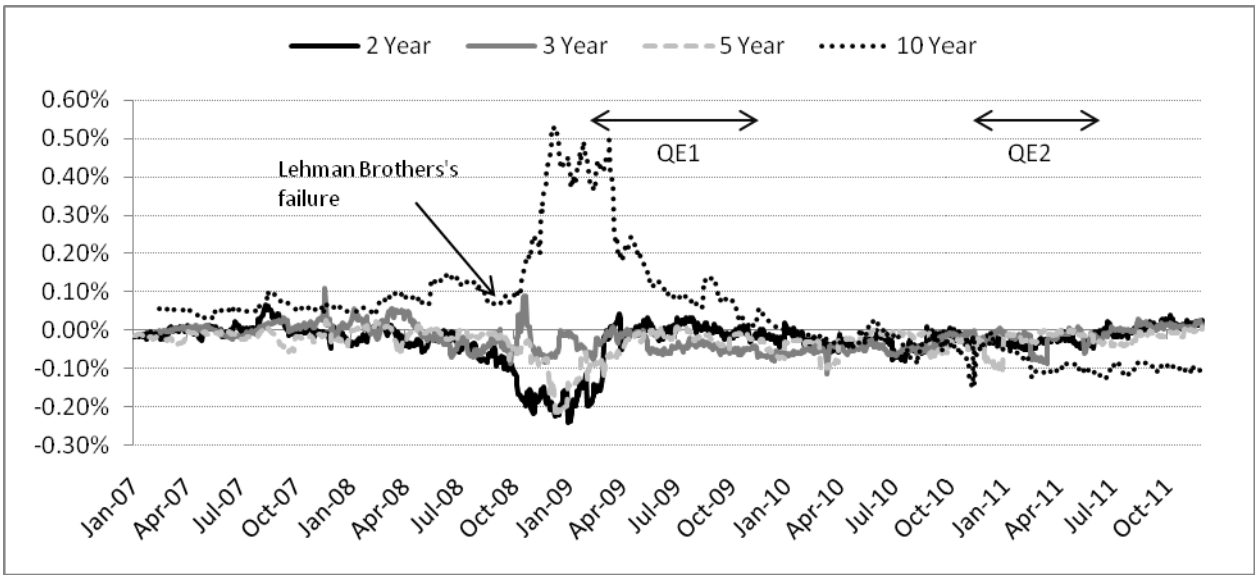
$$w^1 = (Maturity^{NEXT} - Maturity^{OTR}) / (Maturity^{NEXT} - Maturity^{PREV})$$

$$w^2 = (Maturity^{OTR} - Maturity^{PREV}) / (Maturity^{NEXT} - Maturity^{PREV})$$

In order to calculate those spreads, this work will utilize daily closing bond yields for U.S. Treasury Bonds from January/2008 to November/2011 as collected from Reuters DataStream and Bloomberg. The OFR-OTR spreads will be calculated for 2, 3, 5 and 10 year securities. 7 year securities will not be included as they started to be issued on March/2009, so there wouldn't be a time period without the Fed's purchases in order to compare the spreads. Also, 30 year securities will not be included as there is no OFR bond with the same or higher maturity than the currently issued bond.

The graph below shows the OFR-OTR spreads of different treasury securities from 2008 to late 2011:

FIGURE 1 – OFR-OTR SPREADS FOR DIFFERENT MATURITIES



By analyzing this graph is possible to see the disruptions that the financial crisis caused on the U.S. securities markets. For the 10-year bond, the OFR-OTR premium

increased markedly during the financial crisis. However, for other treasury securities the spread became negative. As the securities being compared have different coupons and slightly different durations, this spread should reflect part of those differences. Also, as noted in (Longstaff, 2002), this spread should also reflect differences in liquidity, tax treatment or repo specialness across securities.

However, even after accounting for those other factors, the negative spreads for short-term notes during the September/2008 and March/2009 period are puzzling and require further analysis. It is important to remember that markets were subject to extreme dislocations during this period, and participants that would normally take advantage of relative mispricings in the treasuries markets had their balance sheets impaired. Therefore, a large volume of trading flows could have caused the spread of short-term notes to become negative during this period without attracting countervailing flow from dealers, hedge funds or other arbitrageurs. Moreover, due to differences in market segmentation, the 10-year bond spread could have moved in the opposite direction of the short-term spread for a short period. As market conditions improved, both spreads started moving together again as expected.[2]

The difference between short and long-term spreads can also be explained by liquidity factors. One possible explanation is that dealers, who are usually the main holders of on-the-run securities, had to sell those securities hastily in order to improve their balance sheets. Therefore, the yields of short-term on-the-run bonds dropped when compared to their off-the-run equivalents. Another possible explanation is that the

[2] Special thanks for Dr. Kenneth Garbade from the New York Fed for the comments about those results

Financial Crisis caused a huge inflow into riskless securities, into a classic flight-to-quality effect. Short-term notes are the classic riskless security, and thus there might be a huge inflow of investor money into those bonds. Given that there is a limited amount of on-the-run securities available for each maturity, it is possible that this huge inflow went directly for off-the-run securities, which then became more liquid and therefore commanded a higher price than their on-the-run equivalents, causing a negative OFR-OTR spread. As long-term bonds are riskier than short-term notes, the inflow into those bonds was not as excessive, and thus their OFR-OTR spread increased instead.

In other to test this, we are going to regress the level of the OFR-OTR spread against the market volatility, as expressed in the VIX. The model will have the following form:

$$\Delta \text{ YTM} = a_0 + a_1 \text{ VIX}$$

Where:

$$\Delta \text{ YTM} = \text{YTM}^{\text{OFR}} - \text{YTM}^{\text{OTR}}$$

VIX = Daily closing value of the VIX index

The results are as follow (in bps):

	Constant	VIX	R^2	Durbin-Watson
2 year	4.10 (***)	-0.27 (***)	0.35	0.097
3 year	-1.66 (**)	-0.02	0.00	0.087
5 year	0.56	-0.13 (***)	0.18	0.075
10 year	-13.76 (***)	0.72 (***)	0.37	0.038

For notes up to 5 years of maturity, the impact of higher volatility was in the direction of lower spreads, which is consistent with the negative spreads seen during the height of the Financial Crisis. On the other hand, for the 10 year notes, the impact of higher volatility was in the opposite direction, resulting in higher spreads.

It is important to note that there is significant autocorrelation in the residuals, as can be seen in the very low Durbin-Watson numbers. Therefore, it is important to estimate robust standard errors in order to assess the statistical significance of the coefficients. The results above were estimated using Newey-West estimators[3].

Those results should be taken with some grain of salt, as trying the same model on the changes in spreads instead of the levels yields no significant results. Nevertheless, even if some other factor caused the OFR-OTR spreads to become negative, there is still some evidence of the correlation between higher volatility and lower OFR-OTR spreads for short-term securities.

[3] The model was estimated using EViews under non pre-whitened Bartlett Kernel with fixed bandwidth of 6 similar to (Stock & Watson, 2007)

III. LARGE SCALE ASSET PURCHASES

Beginning in March/2009, the Federal Reserve announced it would begin a $300 billion Treasury purchase program in order to improve conditions in the private credit markets (QE1). Later, in November/2010, the Fed announced another purchase program (QE2) that would totalize $600 billion. Moreover, the Fed would reinvest the coupon and principal payments of its existing holdings into new treasury purchases, which would bring the total value of purchases over $1.2 trillion[4]. Although almost half of the purchases were concentrated on the 5-10 year segment of the yield curve, the Fed purchased securities across the entire curve, as can be seen below:

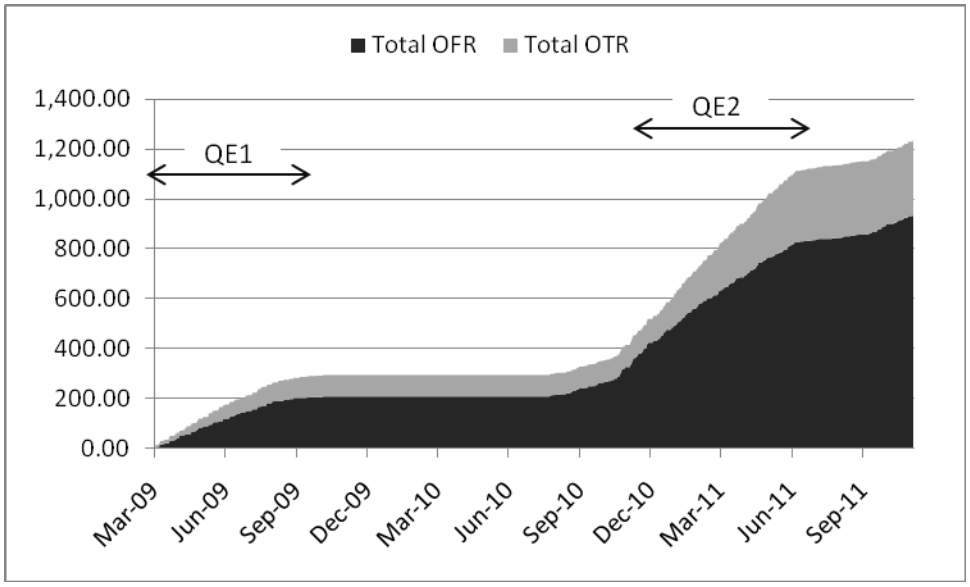
TABLE 1 – FEDERAL RESERVE TREASURY PURCHASES

	QE 1	QE 2	Reinvestment	Total
2 year	28.1	41.7	8.3	78.1
3 year	72.5	154.5	15.8	242.8
5 year	70.7	183.1	29.8	283.5
7 year	59.7	190.8	56.8	307.3
10 year	45.2	155.9	43.9	245.0
30 year	19.3	31.1	30.2	80.6
Total	295.4	757.0	184.9	1,237.3

Those purchases were distributed across On-The-Run and Off-The-Run securities. As the purchases were conducted via competitive auction, the Fed purchased the securities that appeared to be cheaper accordingly to its internal pricing model.

[4] The LSAP also purchased around $35 billion of TIPS securities which were not included in this study

FIGURE 2 – CUMULATIVE FED PURCHASES OF ON-THE-RUN AND OFF-THE-RUN SECURITIES



IV. METHODOLOGY

As shown before in Figure 1, the financial crisis had diverse impacts on the relative valuation of treasury bonds. While for some maturities On-The-Run bonds became more expensive, for others they became cheaper, which could be a result of institutional preferences for particular maturities and the effects of the financial crisis on their investment decisions and balance sheets.

However, if the Federal Reserve's actions were large enough to impact the market, it should have an effect of reducing those mispricings. In order to test this hypothesis, we will test the following model:

$$\Delta \text{ YTM} = a_0 + a_1 \Delta \text{ COUPON} + a_2 \Delta \text{ DURATION} + a_3 \text{ QE PURCHASES} + a_4 \text{ QE INTENSITY}$$

Where:

Δ YTM = YTM^{OFR} - YTM^{OTR}

Δ COUPON = $COUPON^{OFR}$ – $COUPON^{OTR}$, where $COUPON^{OFR}$ is the linear interpolation of the coupon of neighboring off-the-run securities as explained above

Δ DURATION = $DURATION^{OFR}$ – $DURATION^{OTR}$, where $DURATION^{OFR}$ is the linear interpolation of the coupon of neighboring off-the-run securities as explained above

QE PURCHASES = 30d rolling average of Federal Reserve daily treasury purchases

QE INTENSITY = Difference between the current 14d rolling average of Fed's daily treasury purchases and the previous 14d rolling average (D-14 to D-27).

V. RESULTS

The regression results can be seen below:

TABLE 2 – REGRESSION RESULTS (VALUES IN BPS)

Maturity	Constant	Δ Coupon	Δ Duration	QE Purchases	QE Intensity	R^2	Durbin-Watson
2 year	-0.232	1.306	171.321 (**)	0.513 (**)	-0.084	0.129	0.068
3 year	-0.885 (***)	0.195	32.528 (*)	0.220 (*)	0.229	0.218	0.108
5 year	-1.330 (***)	0.208	16.666 (*)	0.418 (***)	0.073	0.240	0.047
10 year	10.315 (**)	4.137	21.140	-3.184 (***)	0.807	0.167	0.011

(*) – significant at the 0.05 level, (**) significant at the 0.01 level, (***) significant at the 0.001 level

We can see that the estimated constant of the regression was negative for the 2, 3 and 5-year notes and positive for the 10-year bond. The constant can be understood as the average OFR-OTR spread after accounting for the other variables and, as show in Figure 1, the spread was negative for short-term securities during the financial crisis.

The *Δ Coupon* coefficient is not statistically significant for any maturities. The difference in coupons across securities results in different durations, and therefore its impact on the yield is already captured on the *Δ Duration* coefficient.

The *Δ Duration* coefficient is positive for all maturities. This is coherent with an upward sloping yield curve. If the OFR securities have higher durations than their OTR equivalents, they should command a higher yield and therefore increase the OFR-OTR spread.

It can also be seem that the *QE Purchases* coefficient is statistically significant than zero for all maturities. This should be evidence that the Federal Reserve purchases had some impact on the pricing of treasury securities in this period.

The *QE Purchases* coefficient is positive for the 2, 3 and 5-year notes but negative for the 10-year bond. As showed in Figure 1, in the height of the Financial Crisis the OFR-OTR spread became negative for the short-term notes, which would mean that On-The-Run bonds were cheaper to buy than their off-the-run equivalents. The positive coefficient for the *QE Purchases* variable should mean that the Federal Reserve purchases acted to increase this spread. Moreover, the spread for 10-year bonds was highly positive after the financial crisis, and thus the Federal Reserve should have preferred to purchase the cheaper off-the-run bonds instead.

The table below confirms those results and shows that the Federal Reserve practically did not purchase on-the-run 10-year notes during its LSAP programs.

TABLE 3 - TOTAL PURCHASES OF OTR AND OFR SECURITIES

	OTR	OFR	% OTR
2 year	13.25	64.86	17%
3 year	98.76	144.01	41%
5 year	67.20	216.34	24%
10 year	1.00	244.01	0%

However, the *QE Intensity* coefficient is not statistically different from zero. This could be some evidence that periods when the Federal Reserve increased its pace of purchases did not have a significant impact on the spread when compared to the periods before. Therefore, the impact of the QE program on the mispricing of securities could be

mostly caused by the improved liquidity conditions in the market, which allowed market participants to exploit any relative mispricing between treasury securities, instead of just the direct impact of the Federal Reserve bidding up the price of the "cheap" securities. In order to test this hypothesis, we will build the following model:

$$\Delta\,\Delta\,\text{YTM} = a_0 + a_1\,\Delta\,\text{TOTAL QE PURCHASES} + a_4\,\text{QE INTENSITY} + \Delta\,\text{S\&P 500}$$

Where,

$\Delta\,\Delta$ YTM = Weekly difference of the OFR-OTR spread. (Current OFR-OTR spread minus the spread in the previous week)

Δ TOTAL QE PURCHASES = Amount purchased in the current week

QE INTENSITY = Amount purchased in the current week minus the amount purchases in the previous week (first-difference of Δ TOTAL QE PURCHASES)

Δ S&P 500 = Weekly return of the S&P 500

The results are as follows:

	Δ TOTAL QE PURCHASES	**QE INTENSITY**	**Δ S&P 500**	**R^2**
2 year	0.00	0.04	-12.38 (***)	0.05
3 year	0.00	-0.05	-8.78 (**)	0.03
5 year	0.00	0.00	-6.6 (*)	0.01
10 year	-0.01	-0.06	-14.17 (**)	0.03

As can be seen in the table above, when analyzing the weekly differences in the OFR-OTR spread, the amount of securities purchased under QE has no statistically significant impact, although there appear to be some impact from the market returns. This supports the argument that the most of the impact of QE on the OFR-OTR was indirect, as the Federal Reserve actions improved market confidence and liquidity conditions. To further test this argument, the next section will compare the impact of the QE2 to QE1. As market conditions had already improved markedly during the second quantitative easing program, the impact of QE2 on the OFR-OTR spread should be reduced when compared to QE1.

VI. DIFFERENCES BETWEEN QE1 AND QE2

The second time the Federal Reserve engaged in its treasury purchases program, conditions were very different. Liquidity conditions were greatly improved and the spread between on-the-run and off-the-run securities was much reduced. Therefore, one should expect the impact of QE2 to be reduced when compared to QE1. In order to test this hypothesis, we are going to run the model in two different time periods in order to analyze the changes in the coefficients. The first period is going to be from January/2008 to December/2009 and is going to take into account the Financial Crisis and QE1. The second period is going to be from January/2010 to November/2011 and is going to take into account the reinvestment of coupon and principal payments and QE2.

TABLE 4 - QE PURCHASES ESTIMATED COEFFICIENT IN TWO PERIODS

	QE Purchases Coefficient	
	2008-2009	**2010-2011**
2 year	3.818 (***)	-0.867 (***)
3 year	0.255	0.390 (**)
5 year	2.463 (***)	-0.117
10 year	-1.548	-0.566

(*) – significant at the 0.05 level, (**) significant at the 0.01 level, (***) significant at the 0.001 level

It can be seen from the table above that, with the exception of the 3-year note, the impact of QE2 was much lower than QE1. Moreover, while during QE1 the direction of this impact was different between short-term and long-term securities, during QE2 this impact was for the most case to reduce the OFR-OTR spread.

Those results are coherent with the ones obtained for the previous regressions. First of all, during QE2, the OFR-OTR spread (after accounting for differences in coupon and duration) was positive for most maturities. Therefore, off-the-run securities were seen as cheap and the Fed's purchases worked to reduce their spread relative to on-the-run securities. Second, market conditions were markedly better during QE2, which meant that market participants were more able to exploit mispricings then during QE1. Therefore, the indirect impact of the second program of purchases would be reduced when compared to the first one.

VII. CONCLUSIONS

This paper analyzed whether the Federal Reserve LSAP program had a significant impact on the relative pricing of treasury securities. This was estimated as the difference

between the YTM of On-The-Run and Off-The-Run bonds of same maturity. After the beginning of the financial crisis, this spread moved significantly, which could be explained by liquidity differences, repo rates or other effects as in (Longstaff, 2002).

By engaging in Large-Scale Asset Purchases, also known as Quantitative Easing, the Federal Reserve purchased over $900 billion of treasury securities between March/2009 and June/2011. Those purchases were conducted under competitive bidding, which meant that the Fed purchased the securities that it considered "cheap" at a given price accordingly to its internal valuation model.

By regressing the value of the spread against the amount of treasury securities purchased in a given period, it is possible to assess whether the Fed purchases had a significant impact on the mispricing of securities in the yield curve. The results show that the purchases had positive impact on the spread for 2, 3 and 5 year notes and a negative impact for 10 year bonds. This impact can be understood as a "direct" effect, caused by the Fed purchases bidding up the prices of treasury bonds and as an "indirect" effect, caused by the improved market conditions made possible by the quantitative easing program. By testing the effect of the Federal Reserve purchases on the change of the OFR-OTR spread of securities, there is significant evidence that the "indirect" effect was relevant while the "direct" effect was negligible. Moreover, the results change markedly from the first quantitative easing program to the second, which could be further evidence that any impact was relevant mostly because dealers and other market participants suffered balance sheet constraints that prohibited them from engaging into arbitrage opportunities. During the 2008-2009 period, the average impact of the Fed purchases was on the order of 2bps for each $1 billion of average daily treasury securities purchased.

Therefore, on the height of the QE1 program, when the daily treasury purchases averaged $2.5 billion during May/2009, this could have mean that On-The-Run short-term notes were 5-6 bps more expensive than otherwise.

During the 2009-2010 period, although the amount of securities purchased increased markedly, the impact of the purchases was reduced as market conditions have improved. Therefore, although the average daily purchases reached $5 billion during February/2011, it had an estimated impact of making Off-the-Run 10-year securities just 2-3 bps more expensive than otherwise.

Although those results show that there was clearly some impact of the Federal Reserve purchases on the relative pricing of Treasury securities, the impact is not high enough to justify a trading opportunity. Although during rough market conditions the implementation of a quantitative easing program could cause the OFR-OTR spread to change by 5-6bps, the same rough market conditions would mean that market volatility and balance sheet constraints would be more pronounced. In those market conditions, a 5bps spread is probably not a high enough return to justify the increased risk.

The Federal Reserve LSAP program was an unprecedented intervention on the US Treasury Market and as such can provide the ground for different areas of research. This paper tried to analyze the impact of this program by analyzing its impact on the OFR-OTR spread, but there are different approaches for this problem that could lead to interesting areas of research. First of all, one could extend this study by looking at the individual securities purchased instead of an aggregate amount as was done in this paper. Moreover, similar to the work done in (Christensen & Gillan, 2012), one could use an

event-study approach to analyze the impact of the Fed auctions themselves and their announcements on the spread.

Also, part of the hypothesis of this paper rested on the assumption that the Federal Reserve used a spline similar to the one described in (Waggoner, 1997) to choose which securities to purchase. By fitting different splines and comparing them to the actual securities purchased in the QE program, one could try to estimate which parameters the Fed uses when assessing the price of treasury securities.

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