9-2023

Unusual Changes in the U.S. Treasury Security Market During the Fourth Round of Quantitative Easing

Kyle D. Allen
Boise State University

Scott E. Hein
Texas Tech University

sciendo

UDK: 336.761
DOI: 10.2478/jcbtp-2023-0022

Journal of Central Banking Theory and Practice, 2023, 3, pp. 5-22
Received: 09 September 2022; accepted: 15 May 2023

Kyle D. Allen [*], ***Scott E. Hein*** [**]

Unusual Changes in the U.S. Treasury Security Market During the Fourth Round of Quantitative Easing

[*] *Boise State University, Boise, Idaho, USA*

Email: kallen@boisestate.edu

[**] *Texas Tech University, Lubbock, Texas, USA*

Email: scott.hein@ttu.edu

Abstract: The Covid-19 Pandemic and policy response rattled the US Treasury markets. Conventional US Treasuries, inflation adjusted US Treasuries, and the relationship between the two developed in ways such that ignoring changes in real interest rates yielded distorted inflation expectations estimates. Since the beginning of the pandemic, monetary policy kept nominal rates low and close to zero, but positive. Real rates, on the other hand, became increasingly negative. The relationship between the two market rates became negatively correlated, and distorted because of the fourth round of quantitative easing, along with the Fed preventing nominal yields from turning negative. Federal Reserve actions during the Covid-19 pandemic drove a larger wedge between nominal interest rates and real interest rates in the inflation adjusted market.

Keywords: US Treasuries, Break Even Rate, Inflation, TIPS, Federal Reserve

JEL Code: E4, E5, G21, G23, G28.

1. Introduction

In December 2020, Jamie Dimon commented on television that he would not touch a Treasury security "with a ten-foot pole."[1] Most hearing this comment probably thought that Mr. Dimon was simply bemoaning the low level of interest rates on Treasury securities at the time. The generally low level of interest rates on conventional Treasury securities at the time suggested to many financial analysts that inflation was expected to remain low in the US for the foreseeable future. However, those analysts that follow happenings in the Treasury Inflation Protected Securities (TIPS) market probably saw Mr. Dimon's comment in a different light. At that time, interest rates on TIPS were not only low, but they were negative, across all maturities. This suggests that not only were real interest rates low, they were also negative, meaning investors now should anticipate losing purchasing power on these Treasury securities. Moreover, market analysts observed the relationship that existed between nominal yields and TIPS yields was also changing in unexpected ways.

In this paper, we analyze both the implications of negative interest rates on TIPS, and the fact that changes occurring in the TIPS market were larger and more meaningful than changes in the market for conventional Treasury securities. This means that the forces shaping market expectations for future inflation in breakeven inflation measures were also being altered in unusual ways.

Traditionally financial market analysts have focused their attention almost exclusively on the conventional Treasury security market, and generally ignored the smaller TIPS market. This behavior is motivated in part by the focus of the Federal Reserve on nominal interest rates, as seen in targeting the federal funds rate. In this setting, the only market movement that would lead them to think expected inflation was on the rise would be an increase in these nominal interest rates. Such behavior led many commentators to underestimated the changes in the Treasury securities markets occurring with the onset of the COVID-19 pandemic and the Federal Reserves' initiation of the fourth round of quantitative easing. Ignoring ongoing changes in TIPS yields in 2020 and 2021 caused many to underestimate ongoing changes in expected inflation.

TIPS make up only about 9 percent of all outstanding Treasury securities, which probably further explains some of the lack of attention for these securities. Unlike conventional Treasury securities, TIPS do not have a fixed principal, but rather

[1] See the interview here: https://www.cnbc.com/2020/12/08/jamie-dimon-says-he-wouldnt-touch-treasuries-with-a-10-foot-pole-at-these-rates.html.

have a principal tied to the (not seasonally adjusted) consumer price index (CPI). As the CPI increases, the principal increases at this same rate, offering protection of unexpected changes in purchasing power to the investor.[2]

TIPS securities are obligations of the U.S. Treasury, and investors need not worry about losses in purchasing power due to inflation, a matter that Irving Fisher called to investor's attention almost 100 years ago.[3] The inflation indexation for TIPS is not perfect, as there is a slight lag of a few weeks in the principal adjustment. This lag is due to the practical matter of the time it takes to gather the CPI data and release this information monthly.[4] Moreover, in periods of deflation, with the CPI decreasing, the Treasury still promises to pay the original principal at maturity (interim coupon payments would decline though), offering an added benefit to TIPS investors.

Ignoring the slight lag in the principal adjustment mentioned, the quoted interest rate on TIPS securities can be viewed as a good first approximation to what financial economists have called real interest rates.[5] The quoted interest rate assumes that there are no changes in the CPI, meaning no inflation or deflation. Therefore, the interest rate on these securities represents a gain in purchasing power if positive, or a loss in purchasing power if the quoted yield is negative, when there is no change in the CPI.

With the introduction of TIPS in 1996, financial economists began the practice of subtracting the interest rate on TIPS from the interest rate on a like maturity conventional Treasury security to produce a measure of financial market expectations regarding future inflation. This yield difference between the yield on a conventional Treasury security and the yield on similarly maturity TIPS, is generally referred to as the Break-Even Inflation rate (BEI). The spread represents the inflation rate that would make the expected return on the two alternative types of Treasury securities identical to one another, both in dollars and expected purchasing power.

The correlation of the nominal Treasury rate and the TIPS rate has historically been generally high. Moreover, increases in BEI have generally coincided with greater increases in conventional yields than TIPS yields of the same maturity. In

---

[2] For a detailed description of TIPS see Hein and Mercer, 2006; Sack and Elsasser, 2004.

[3] Irving Fisher, *The Money Illusion*, Simon and Schuster Digital Sales Inc. (1928).

[4] If inflation is generally stable, this lag is not expected to have significant economic consequences.

[5] See Campbell, Shiller, and Viceira (2009).

this manner, focusing attention solely on conventional Treasury yields to gauge changes in market expected inflation has worked well. However, with the onset of the Covid pandemic, these rates became negatively correlated with one another, and this distorted the traditional BEI relationship that had been observed historically with changes in nominal yields as the primary driver of changes in the BEI. This change in relationship poses a potential problem for researchers using the BEI as a measure of expected inflation. As Christensen, Lopez, and Rudebusch (2010) point out, the BEI is a widely used indicator of expected inflation. Consistent with their findings, we show that the BEI must be used with caution as outside factors are likely to affect the relationship between conventional and inflation adjusted US Treasury securities.[6]

One likely contributor to this distortion was the heavy involvement of the Federal Reserve in purchasing Treasuries during recessions. We document the particularly heavy involvement by the Federal Reserve in TIPS purchases in the fourth period of quantitative easing initiated in March 2020. As a large, committed purchaser, the Fed puts pressure on Treasury prices and yields that made the BEI much more susceptible to changes in TIPS yields, especially since the TIPS market is less liquid that the conventional Treasury security market. Christensen and Gillan (2011) show that breakeven rates can be problematic especially with liquidity constraints in the TIPS market. The added demand pressure during quantitative easing exacerbates these issues.

Another important contributor to the changing relationship between nominal and real interest rates, from early 2020 through 2021, was the fact that the Federal Reserve targeted the federal funds rate to be close to zero, but positive nonetheless. Moreover, during this time, the Federal Reserve continued to provide forward guidance that this practice of keeping the federal funds rate positive in the future. The Federal Reserve therefore established a floor on nominal interest rates, not allowing them to turn negative. These practices prevented nominal interest rates on conventional Treasury securities from turning negative, necessitating that more of financial market adjustments needed to come from the TIPS market. The Federal Reserve was in essence content to have real interest rates negative, as they targeted short-term rates to be close to zero and sought to have inflation close to two percent.

We examine changing market conditions, including the increased toxicity of US Treasuries throughout the recent Covid pandemic, by examining both con-

[6] Additionally, D'Amico, Kim, and Wei (2018) explain the widely used proxy of BEI can have inherent problems and its informational content can be distorted.

ventional Treasury securities and TIPS of both five-year and ten-year maturities. The toxicity we are referring to is the fact that all Treasury securities were anticipated to yield decreasing purchasing power over time. We highlight the market distortion created was likely attributable to Fed purchases of Treasury securities (including TIPS) and mortgage-backed securities, associated with its fourth episode of quantitative easing. We show that during much of 2020 and all of 2021, conventional Treasury bond rates increasingly lost buying power in the 5- and 10- year maturity securities. The interest rate on TIPS for both maturities has dropped into negative territory soon after the Federal Reserve established the fourth round of quantitative easing (QE4) and from there on the purchasing power in Treasury securities was expected to decrease by almost 200 basis points (bps) over the next 5 years.

2. Relevant Literature

This paper largely follows two strands of literature. First, the Break-Even Inflation (BEI) rate is a widely understood and used indicator or expected inflation. Christensen, Lopez, and Rudebusch (2010) document how it is used in research and practice. Shen (2006) states that the Federal Open Market Committee (FOMC) uses the BEI in policy deliberations related to inflation expectations. Campbell, Sunderam, and Viceira (2013) examine the components of expected inflation within the BEI. This measure is used throughout the world and understanding its value and shortcomings is important. Globally, Ejsing, Garcia, and Werner (2007) provide an analysis on how to extract accurate information about inflation expectations in the euro area. The BEI is an important measure to understand with respect to US Treasury yields and inflation expectations.

However, not all research has suggested the BEI is a perfect measure of expected inflation. Alternatively, D'Amico, Kim, and Wei (2018) show the BEI has some inherent problems within the measure. Specifically, informational content can be distorted when using only the BEI. Our paper supports both sides of the BEI analysis. Generally, the BEI is a good first approximation of expected inflation. However, it is not perfect and can be distorted with large market participants.

The second strand of literature addressed the role of the Federal Reserve in the US Treasury market. Fleming and Remolona (1999) demonstrate how the New York Federal Reserve is directly involved with the US Treasury market. This connection is important to conduct monetary policy. Campbell, Shiller, and Viceira (2009) demonstrate the need for inflation-indexed and how the Federal Reserve has a role in understanding this market. Wissing-Jorgensen (2021) shows the re-

sponse of the Federal Reserve to the 2020 Covid-19 pandemic. She provides evidence suggesting that the Federal Reserve and its security purchases were causal in reducing US Treasury yields. Furthermore, Swanson (2021) analysis the effect of the Federal Reserve's large-scale asset purchases and forward guidance on Treasury yields. He finds the Federal Reserve has a significant effect on the yields of Treasuries when attempting to manipulate the market.

3. The Role of the Federal Reserve in the Treasury Security Market

The Federal Reserve is an important player in the US Treasury market. Christensen and Rudebusch (2012) find that the Federal Reserve actions effect on yields comes largely from lower expectations for future short-term rates. Gagnon, Raskin, Remache, and Sack (2011) find a reduction in 10-year US Treasury yields following the Federal Reserve announcements of large-scale purchases. These purchases increase the Fed`s balance sheet as the Federal Reserve balance sheet has ballooned to nearly $9 trillion, much of which is held in Treasury securities.

On Sunday, March 15, 2020, the Federal Reserve announced it would begin with U.S. Treasury purchases the following day, starting with a $40 billion purchase of nominal securities and TIPS.[7] The Fed planned on purchases relative to the size of the respective markets, so as not to disrupt the market. Using data from the Federal Reserve, we see that the ratio of TIPS purchases far outran the size of the market.

Figure 1 shows the amount of both nominal Treasuries and TIPS purchases each week relative to the amount outstanding of each security type, for the period 2018 through 2021. The Fed clearly purchased a large amount of TIPS relative to the size of the market, especially around April 2020, with the initiation of QE4. These types of purchases should lead to increased prices, and lower yields, even pushing TIPS yields into negative territory. Figure 1 highlights the fact that the Fed had very few purchases of US Treasuries during 2018 and 2019. Indeed, from January 2018 through March 13th, 2020, the Fed purchased approximately $103 billion in nominal US Treasuries and $11 billion in TIPS. Over the course of the next two years (2020-2021) beginning with the March 15th, 2020 announcement, the Fed purchased over $1.8 trillion in nominal coupon notes and bonds. Over the same time period, the Fed purchased over $250 billion in TIPS.

[7] The Federal Reserve announcement: https://www.newyorkfed.org/markets/opolicy/operating_policy_200315.

The findings in Figure 1 highlight how extensively involved the Federal Reserve was in the US Treasury security market during the QE4 period. The demand from the Fed certainly had an effect of the BEI rate calculated between the nominal and TIPS yields. We use this stark increase in purchasing from the Federal Reserve to motivate our analysis for the fourth round of quantitative easing and our subsequent QE4 dummy variable in our second regression model.

4. Federal Reserve Federal Funds Rate Targeting and Forward Guidance

For all of the period 2018 through the end of 2021, the Federal Reserve targeted the federal funds rate as its main monetary policy tool. This interest rate is an overnight interest rate that banks and other financial intermediaries charge one another for overnight reserves. Since 2008, the Federal Reserve has used the interest rate it pays for bank reserves as the main vehicle to achieve its desired federal funds rate target and this vehicle has been highly successful in achieving the desired target. In addition to targeting the federal funds rate, the Federal Reserve has made use of "forward guidance" for years. This practice has been one of indicating in advance when market participants can anticipate changes in the federal funds rate target.

All of this means that while the Federal Reserve has been targeting an overnight nominal interest rate, by using forward guidance it has effectively extended to target for nominal instruments to maturities beyond overnight. As emphasized above, the Federal Reserve has never targeted a negative federal funds rate, and has since 2008 always paid a positive interest rate on overnight reserves held by banks at Federal Reserve banks. These actions have effectively put a floor on nominal interest rates on safe securities such as Treasury securities. While preventing nominal interest rates from turning negative, the Federal Reserve provided no comparable floor for real interest rates.

5. Data

We analyze changes in the market for US Treasuries in recent years by examining both conventional Treasury securities yields and TIPS yields for both five-year and ten-year maturities. We document that during the last two years conventional bond rates have increasingly lost buying power in the 5- and 10- year maturity securities. This is shown most directly by the interest rate on TIPS for both ma-

turities dropping increasingly into negative territory and largely remaining there during this COVID-19 period. As such, arbitrage across conventional and TIPS security markets suggests that all Treasury security investors should rationally expect to lose purchasing power by holding Treasury securities of either kind. In other words, *real interest rates* on all Treasury securities are negative, offering an alternative interpretation of Mr. Dimon's comment, other than the interest rates are low.

To allow an empirical investigation of 5-year and 10-year Treasury securities, as well as BEI for both maturities, we get data from the Federal Reserve. Our sample period runs from January 2018 through December 2021. This time-period gives us approximately two years of data before the start of the COVID-19 pandemic, along with the Fed's most recent quantitative easing period, and roughly two years of the pandemic/quantitative easing time-period. First, from the St Louis Federal Reserve Economic Data (FRED) database we collect daily yields on 5- and 10-year conventional bonds, 5- and 10-year TIPS, as well as the daily effective fed funds rate. Additionally, we gather Federal Reserve Treasury security purchases from its website which details all Federal Reserve purchases during our time sample.[8]

6. Empirical Findings

Figure 2 shows the yields of 5- and 10- year US bonds. We see both the 5-year and 10-year TIPS instruments generally have negative yields beginning in January 2020, which remain in negative through the end of our data sample, 2021. The only exception being during the end of March 2020 when both yields spiked briefly into positive territory. This was just before the peak of the coronavirus outbreak, at a time when the threat of extreme inflation seemed unlikely. By March 23, 2020, after the Federal Reserve QE4 announcement, these TIPS yields again went into negative territory. Note also that rates of 5-yr and 10-yr TIPS tended to move together with a very small spread prior to the introduction for QE4, but the rates diverge from one another afterwards. This same pattern is observed with conventional Treasury security rates, too.

Figure 3 provides the two respective breakeven inflation rates over our full sample period, the BEI rates for both 5- and 10-year maturities. On April 1, 2020, the 5-year conventional Treasury security had a quoted yield of only 0.37%, and

[8] Federal Reserve purchases of Treasury securities: https://www.newyorkfed.org/markets/desk-operations/treasury-securities.

the 5-year TIPS had a negative quoted yield of -0.19%. Together these two yield differences give a breakeven annual inflation rate of only 0.56%, suggesting that Treasury investors were expecting only a 0.56% annual CPI inflation average over the next five years. If markets are right and inflation turns out to be exactly 0.56%, then the investor in the conventional 5-year Treasury would experience an annual loss in purchasing power of 0.19%, a negative real return.[9] In other words, even back in April, conventional Treasuries were toxic in the sense of losing purchasing power for the investor. An investor in a 5-year Treasury security should have been expecting a loss in purchasing power, even if inflation was only 0.56% a year for the next five years.

The 10-year maturity treasuries had a similar pattern. On April 1, 2020, the conventional bond yielded 0.62%, with the TIPS yielding -0.29%. The BEI rate was 0.91% which represents a rough market estimation of expected future annual inflation over the next 10 years. If the market was exactly correct, 10-year conventional bond holders would lose purchasing power of 0.29% annually.

By December 1, 2020, the time of Mr. Dimon's statement about Treasury securities, the quoted yield on the conventional 5-year Treasury had risen, but by only 5 bps to 0.42%. In contrast, from April 1 through December 1, 2020, the quoted yield on the 5-year TIPS, however, had fallen 111 basis points to -1.30%, becoming even more negative. Thus, we see that the TIPS market showed much greater change in yields than the conventional Treasury security did, as opposed to moving mainly in sync with the conventional Treasury security as seen earlier. Moreover, arbitrage across the two Treasury securities suggests that market participants now expected an average annual CPI inflation rate of 1.72% over the next 5 years. The BEI was over three times what was expected back in April. If inflation turns out to be exactly 1.72%, then the 5-year conventional security holder can expect an annual loss of purchasing power of 1.30%. Similar relative changes can be seen in the 10-year securities too.

To shed further light on the respective movements of conventional Treasury security yields we analyze driving forces in determining breakeven inflation before and after April 1, 2020 and the introduction of QE4. We use the following equation as our basic estimation model.

---

[9] While we have now only seen about 40 percent of the full maturity time elapse since April 1, 2020, it would appear that market participants did a poor job in pricing the inflation risk we have seen since then. The 5-year TIPS bought on this date are likely to offer a superior return in comparison to the 5-year conventional Treasury securities. This example provides a good reminder that markets are not infallible in pricing risks accurately.

$$BEI_t = \alpha + \beta_1 TIPS_t + \beta_2 EFFR + \varepsilon_t \quad (1)$$

Where BEI is the breakeven inflation rate (the conventional Treasury yield less the TIPS yield), TIPS is the TIPS yield, and EFFR is the effective federal funds rate. We use the daily effective fed funds rate (EFFR) to control for monetary influences on overall daily interest rates. We run regressions on each maturity separately for two different periods, one from January 2018 through April 1, 2020 and one from April 2, 2020 through December 31, 2021.

In Table 1, we report our first regression results. In Columns 1 and 2 we show the estimation results for the 5-year BEI rate. In column 1, before our QE4 date of April 1, 2020, the relationship between the TIPS rate and the BEI rate is observed to be positive; meaning an increase in the TIPS yield corresponded to an increase in expected inflation, suggesting that the conventional yield would have to rise even more than the TIPS yield. However, after the QE4 date, the relationship seen in column 2 is negative at a greater magnitude in absolute value than unity. A 1% decrease in the TIPS rate during QE4 would result in a 1.5% increase in the BEI rate. This suggests that the conventional yield would have to fall at the same time, meaning that the conventional yield no longer is a useful inflation gauge.

In addition to the sharp change in the slope coefficients on the TIPS yield variable, columns 1 and 2 show a sharp change in the slope parameter on the effective federal funds rate. Here again, the coefficient estimates are statistically significant, but of opposite sign.

Columns 3 and 4 in Table 1 examine the BEI relationship for 10-year Treasury securities. In column 3, the pre-QE4 sample, the relationship between the TIPS rate and the BEI rate is estimated once again to be positive, again suggesting that conventional Treasury yields have to increase more than one percentage point to result in a one-percentage point increase in breakeven inflation. In contrast, in column 4, the after-QE4 sample, the relationship between the BEI rate and the TIPS rate becomes negative and highly statistically different from zero. This result shows that a 1% decrease in the 10-year TIPS rate after the QE4 date is correlated with a 2.1% increase in the BEI rate. Taken together, these results show that decreases in TIPS yields in the QE4 sample have been responsible for the BEI rates continuing to widen.

In the QE4 sample, those market participants watching the TIPS market would observe the marked increase in expected inflation as TIPS yields fell, but those focusing on conventional Treasury yields would not have sensed rising fears of expected inflation. Most of the increase in the BEI rate after April 1, 2020 have

been associated with changes in the TIPS market. Conventional Treasury yields were not moving extensively in this period.

We further analyze the relationship between the respective Treasury yields in recent years using equation (2).

$$TBOND_t = \alpha + \beta_1 TIPS_t + \beta_2 QE4 + \beta_3 TIPS_t * QE4 + \beta_4 EFFR + \varepsilon_t \quad (2)$$

In this model, the dependent variable TBOND is the daily yield for a conventional US Treasury bond. We include the daily yield for the similarly matured US Treasury-Inflation Protected Securities (TIPS) to control for market changes in real interest rates. QE4 represents a dummy variable with a value of unity in days after April 1, 2020. This variable is meant to roughly capture the period since the initiation of the fourth round of quantitative easing by the Federal Reserve in response to the heightened uncertainty created in the early stages of the COVID-19 pandemic. We also use an interaction variable interacting the daily TIPS rate and the QE4 dummy variable to estimate the change in the sensitivity of the conventional yield to changes in the respective TIPS yield, after the initiation of QE4. Estimates are reported for regressions excluding (column 1) and including this interaction variable (column 2). As a control variable, we use the daily effective fed funds rate (EFFR) to control for monetary influences on overall daily interest rates, which we constrain to be the same in our sample.

In Table 2, we report our regression results using equation 2 for the estimation results for the 5-year Treasury interest rate. In column 1 where we constrain the relationship between the conventional Treasury rate and the TIPS rate to be constant for our sample we observe a positive relationship, indicating these two interest rates are moving in the same direction. However, as seen in column 2, when we include a TIPS slope shift variable for the QE4 date, the relationship turns negative in the QE4 sample. A 1% decrease in the TIPS rate during the QE4 period would result in a 0.374% increase in the BEI rate, as the slope parameter in the QE4 period is estimated to be -0.374 (1.452 - 1.826). This means increases in the conventional yield were no longer singularly useful as an inflation gauge. In the QE4 period, decreases in TIPS yields were now responsible for much of the increases in the BEI observed. We also see that once we allow for the yield on the TIPS security to have a differential in the two periods, increases in the effective federal funds rate also signal rising BEI, but the impact is quantitatively much smaller than originally estimated, when the TIPS impact on the conventional Treasury rate was constrained to be equal in both periods.

Table 3 provides the regression estimates using equation 2 for the conventional Treasury yield using yields on 10-year securities. In column 1 where we constrain the impact of the TIPS yield to be the same across both time-periods, the relationship between the TIPS rate and the conventional interest rate is estimated to be significantly positive. In this case, the slope estimate is greater than unity, suggesting that the nominal yield would have to rise even more that the TIPS yield to result in a rising BEI. In other words, the conventional yield was the primary driver to highlight market changes in expected inflation. In column 2, we once again allow the association between the conventional yield and the TIPS yield to be different in the two respective sample periods. Here, we see once again that the estimated relationship between the conventional yield and the TIPS yield becomes negative in the QE4 sample. The TIPS slope coefficient for the QE4 period is estimated to be -0.289% (1.530% - 1.819%). This result shows that a 1% decrease in the 10-year TIPS rate after the QE4 date is correlated with a 0.289% increase in the BEI rate.

Taken together, our findings show that in the QE4 sample decreases in TIPS yields have recently been associated with slight increases in conventional Treasury yields and larger BEI rate increases. Changes in conventional yields in the QE 4 period were no longer the singular forces changing BEI rates seen earlier.

7. Conclusion and Analysis

In the last couple of years, especially during the fourth round of quantitative easing, watching only conventional Treasury yields for signs of escalating inflation fears has proven insufficient. Such focus might have made sense at one time, but the recent experience shows it does not work when the Federal Reserve is targeting the federal funds rate to be close to zero for an extended time and simultaneously engaged in large-scale purchases of Treasury and agency mortgage-backed securities. Moreover, arbitrage across the alternative Treasury security markets means that the negative yield on TIPS indicates that buyers of conventional Treasury securities should rationally expect to lose purchasing power with their investments in the era of QE4, as well.

Additionally, we suggest the use of the BEI by researchers should be used with caution during recessions. When the Federal Reserve begins large scale purchases of US Treasuries, it has the ability to distort the correlation between nominal yields and TIPS yields. The distortion of these markets, especially during recessions, should be of interest to US Treasury investors, regulators, and researchers.

References:

1. Campbell, J. Y., Shiller, R. J., & Viceira, L. M. (2009). Understanding inflation-indexed bond markets (No. w15014). *National Bureau of Economic Research*.
2. Campbell, J. Y., Sunderam, A., & Viceira, L. M. (2009). Inflation bets or deflation hedges? The changing risks of nominal bonds (No. w14701). *National Bureau of Economic Research*.
3. Christensen, J., & Gillan, J. (2011). TIPS liquidity, breakeven inflation, and inflation expectations. *FRBSF Economic Letter*, 19, 1-5.
4. Christensen, J. H., Lopez, J. A., & Rudebusch, G. D. (2010). Inflation expectations and risk premiums in an arbitrage-free model of nominal and real bond yields. *Journal of Money, Credit and Banking*, 42, 143-178.
5. Christensen, J. H., & Rudebusch, G. D. (2012). The response of interest rates to US and UK quantitative easing. *The Economic Journal*, 122(564), F385-F414.
6. D'Amico, S., Kim, D. H., & Wei, M. (2018). Tips from TIPS: the informational content of Treasury Inflation-Protected Security prices. *Journal of Financial and Quantitative Analysis*, 53(1), 395-436.
7. Ejsing, J., Garcia, J. A., & Werner, T. (2007). The term structure of euro area break-even inflation rates: The impact of seasonality. Working Paper.
8. Fleming, M. J., & Remolona, E. M. (1999). Price formation and liquidity in the US Treasury market: The response to public information. *The Journal of Finance*, 54(5), 1901-1915.
9. Gagnon, J., Raskin, M., Remache, J., & Sack, B. (2011). The financial market effects of the Federal Reserve's large-scale asset purchases. 24th issue (Mar 2011) of the *International Journal of Central Banking*.
10. Hein, S. E., & Mercer, J. M. (2006). Are Treasury inflation protected securities really tax disadvantaged? *Journal of Financial Research*, 29(4), 575-592.
11. Sack, B. P., & Elsasser, R. (2004). Treasury inflation-indexed debt: a review of the US experience. *Economic Policy Review*, 10(1).
12. Shen, P. (2006). Liquidity risk premia and breakeven inflation rates. *Economic Review-Federal Reserve Bank of Kansas City*, 91(2), 29.
13. Swanson, E. T. (2021). Measuring the effects of federal reserve forward guidance and asset purchases on financial markets. *Journal of Monetary Economics*, 118, 32-53.

Appendix

Figure 1: Federal Reserve Purchases

This figure shows the amount of outstanding US Treasuries purchased by the Federal Reserve 2018-2021. Nominal US Treasuries are shown using the gray dashed line. The black solid line represents the data for TIPS.

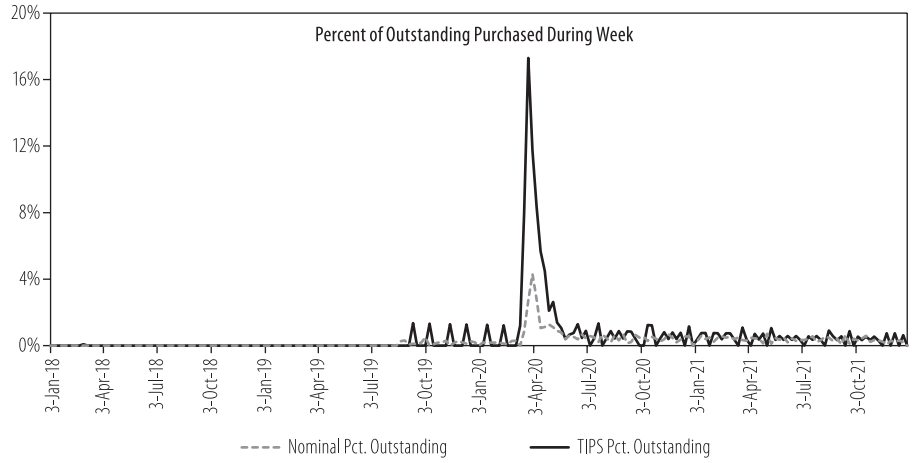

Figure 2: Treasury Yields

This figure shows daily US Treasury yields for the following securities: 5-year conventional Treasury bond, 10-year conventional Treasury bond, 5-year TIPS, 10-year TIPS. The graph goes from January 2018 through October 2021. The y-axis is shown in percentage form.

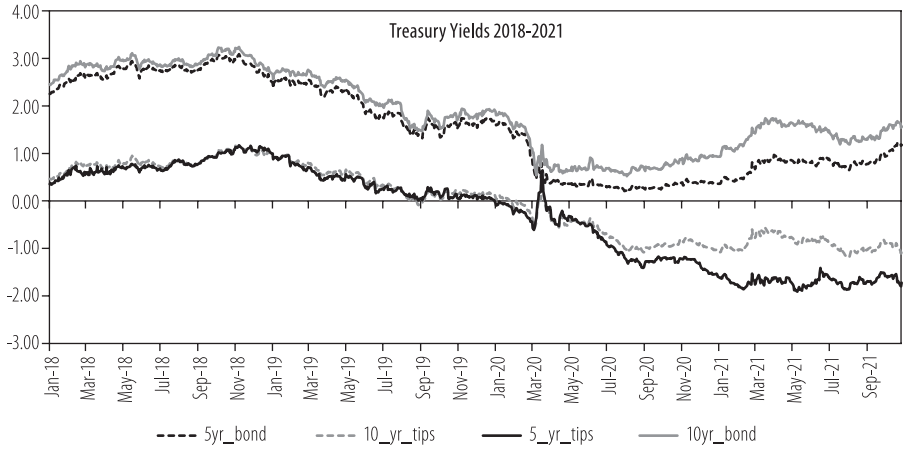

Figure 3: Breakeven Expected Inflation

This figure shows Breakeven Expected Inflation (BEI) rates for 5-year and 10-year US Treasury securities. The graph shows rates from January 2018 through October 2021. The y-axis is represented in percentage form.

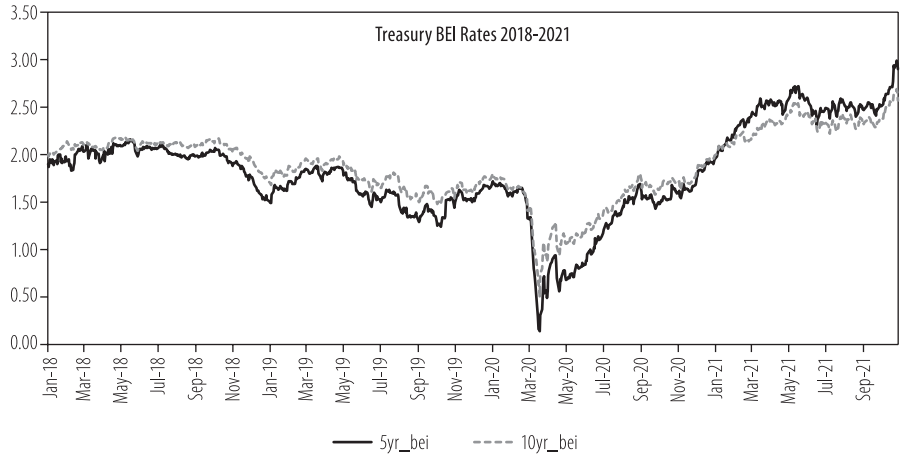

Table 1: US Treasuries

This table shows regressions using the 5-year and 10-year Break Even Inflation (BEI) rate as the dependent variable. Column 1 is 5-year treasuries before April 1, 2020. Column 2 is 5-year treasuries after April 1, 2020. Column 3 is 10-year Treasuries before April 1, 2020. Column 4 is 10-year Treasuries after April 1, 2020. The daily TIPS rate for the corresponding maturity BEI is shown as TIPS. The daily effective fed funds rate. Standard errors are listed in parentheses.

	(1)	(2)	(3)	(4)
VARIABLES	5 Year	5 Year	10 Year	10 Year
5 yr TIPS	0.449***	-1.520***		
	(0.0321)	(0.0266)		
Effective fed funds	0.0743***	-7.140***	0.0340*	-13.14***
	(0.0270)	(0.760)	(0.0187)	(1.494)
10 yr TIPS			0.527***	-2.105***
			(0.0225)	(0.115)
Constant	1.368***	0.470***	1.504***	1.236***
	(0.0490)	(0.0603)	(0.0339)	(0.0914)
Observations	562	434	562	434
R-squared	0.329	0.886	0.549	0.452

Table 2: 5-Year US Treasuries

This table shows regressions using the 5-year conventional US Treasury bond daily yield as the dependent variable. The independent variables used are: the daily yield of the 5-year TIPS, a dummy variable (COVID) representing 1 for all days from April 1, 2020, to the end of the sample and zero otherwise, an interaction variable between the 5-year TIPS daily yield and the COVID dummy variable, the daily effective fed funds rate. Standard errors are listed in parentheses.

	(1)	(2)
VARIABLES	5 Year	5 Year
5 yr. TIPS	0.492***	1.452***
	(0.0356)	(0.0293)
QE4	-0.0212	-1.324***
	(0.0909)	(0.0589)
5 yr. TIPS x QE4		-1.826***
		(0.0405)
Effective fed funds	0.388***	0.0684***
	(0.0418)	(0.0246)
Constant	1.234***	1.378***
	(0.0790)	(0.0447)
Observations	958	958
R-squared	0.797	0.935

Table 3: 10-Year US Treasuries

This table shows regressions using the 10-year conventional US Treasury bond daily yield as the dependent variable. The independent variables used are: the daily yield of the 10-year TIPS, a dummy variable (COVID) representing 1 for all days from April 1, 2020, to the end of the sample and zero otherwise, an interaction variable between the 10-year TIPS daily yield and the COVID dummy variable, the daily effective fed funds rate. Standard errors are listed in parentheses.

	(1)	(2)
VARIABLES	10 Year	10 Year
10 yr TIPS	1.192***	1.530***
	(0.0384)	(0.0344)
QE4	0.618***	-0.658***
	(0.0713)	(0.0806)
10 TIPS x QE4		-1.819***
		(0.0805)
Effective fed funds	0.145***	0.0279
	(0.0347)	(0.0285)
Constant	1.473***	1.514***
	(0.0641)	(0.0518)
Observations	958	958
R-squared	0.821	0.883