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Senior Thesis

Evaluation of the Anchoring of Inflation Expectations in Japan

I. Introduction

Since the mid-1990s, Japan has struggled against deflation. Following the end of the bubble economy, inflation declined from above 3 percent in 1991 to negative 0.1 percent by 1995. In December 2012, Shinzo Abe was elected Prime Minister. Abe introduced a series of economic policies referred to as "Abenomics," which are aimed to bolster the Japanese economy. "Abenomics" is based upon "three arrows," which are monetary easing, fiscal expansion, and structural reforms. As part of the "Abenomics" policies, the Bank of Japan introduced an inflation target of 2 percent in Japan in 2013, with the initial intention of achieving this target by 2015. This paper investigates the effectiveness of the inflation target and employs financial market-based inflation compensation measures, specifically inflation swap rates and break-even inflation rates, to evaluate how firmly inflation expectations are currently anchored in Japan.

For years, central bankers have targeted low and stable inflation as their most important mandate. Stable prices enable economic growth and effective monetary policy. Inflation targeting is a measure employed by central banks in order to achieve low and stable inflation, where the central bank commits to achieving a target inflation rate. The policy of inflation targeting began in New Zealand in 1990, and has extended to many central banks. The degree of confidence in the central bank's ability to achieve their target is usually informed by their past defense of and demonstrated commitment to the target. The credibility of the central bank's target is reflected directly in inflation expectations, which can be measured through various methods. When the inflation target is credible, inflation expectations should be firmly anchored, meaning that private actors have a high degree of consensus on the central bank's inflation objective. When inflation expectations are not firmly anchored, private actors are likely to revise their expectations of inflation in response to economic news. The reduced variability in inflation expectations when expectations are firmly anchored should also reduce the variability of actual inflation in the economy.

Central banks are mandated to target low, stable inflation as one of their key mandates. High inflation leads to the loss of purchasing power, which can create uncertainty and fear in an economy. As inflation erodes the value of cash, many individuals will be averse to holding onto the local currency, further weakening the currency, and encouraging more inflation. Deflation is also unfavorable, as when prices are falling, the risk of entering into a deflationary spiral arises. As deflation keeps real interest rates high, this encourages saving in an economy, thereby reducing aggregate demand. The decrease in demand encourages prices to continue to drop, and the economy can enter into a deflationary spiral. This was experienced in the United States during the Great Depression. Though Japan is not in the midst of a deflationary spiral, there is strong concern over falling prices.

On January 22, 2013, the Bank of Japan introduced an inflation target under Governor Masaaki Shirakawa. Shortly after, in March 2013, Shirakawa stepped down from his position as governor. His successor, Haruhiko Kuroda, specified that he would reach the 2 percent inflation target by 2015 through doubling the monetary base and the amounts outstanding of Japanese government bonds and exchange traded funds, and more than doubling the average remaining maturity of JGB purchases.[1] In September 2016, in reaction to their inability to reach the 2 percent inflation target, the Bank of Japan introduced a new framework for its quantitative and qualitative monetary easing, with the introduction of a yield curve control program. The program consists of the Bank of Japan controlling both short-term and long-term interest rates. The Bank of Japan set a negative interest rate of minus 0.1 percent to the balances in current accounts held by financial institutions at the Bank, and stated that it would purchase JGBs so that 10-year JGB yields remain at around zero percent, a policy which it has continued to uphold.[2] This paper evaluates the effectiveness of the 2 percent inflation target through the measure of how firmly market-based inflation expectations, as measured by inflation swap rates and breakeven inflation rates, are anchored in the face of CPI announcements and monetary policy announcements. We specifically investigate the behavior of inflation expectations prior to and after the introduction of the Bank of Japan's inflation target in January 2013.

II. Situation of Japan

Since the end of the bubble economy in the early 1990s, Japan has struggled with both low economic growth and deflation. From 1993 to 2012, real GDP growth averaged a mere 0.8 percent, and average annual inflation measured by CPI was barely positive at 0.02 percent.[3] From 1999 to 2005, prices, as measured by CPI, fell every year.

In 2018, the population of Japan fell by more than 430,000.[4] This was only partially offset by an inflow of 161,000 migrants. Overall population is on track to go below 100 million by 2050, a 21 percent decline from the current population. The shrinking of the population is a major headwind to the country's potential for economic growth. Since 2013, GDP has grown an average of 1.28 percent per year, while GDP per capita has averaged 1.41 percent annual growth. This rate appears more favorable due to the decline in the population. However, GDP per capita is still growing slowly.[5]

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[1] Bank of Japan. April 4, 2013. "Introduction of the "Quantitative and Qualitative Monetary Easing.'" https://www.boj.or.jp/en/announcements/release_2013/k130404a.pdf.
[2] Bank of Japan. September 21, 2016. "New Framework for Strengthening Monetary Easing." https://www.boj.or.jp/en/announcements/release_2016/k160921a.pdf.
[3] Organization for Economic Co-operation and Development, Consumer Price Index of All Items in Japan retrieved from FRED, Federal Reserve Bank of St. Louis. April 26, 2019. https://fred.stlouisfed.org/series/JPNCPIALLMINMEI
[4] Ministry of Internal Affairs and Communications. 2018. "Current Population Estimates as of October 2018." https://www.stat.go.jp/english/data/jinsui/2018np/index.html
[5] World Bank national accounts data. 2018. "GDP per capita growth (annual %)." https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG?end=2017&locations=JP&start=1961&view=chart

Many have argued that the Bank of Japan's monetary policy and government fiscal policy were not expansionary enough in their nature during the 1993 – 2012 period, and were therefore partially responsible for the persistent low growth and deflation. In 1996, Japan experienced 3 percent GDP growth. In April 1997, the government took the opportunity to raise the consumption tax rate from 3 to 5 percent and repeal an income tax cut. Subsequently, in 1997, GDP growth was a mere 1 percent, and fell to negative 1 percent in 1998. In February 1999, the Bank of Japan began a zero interest rate policy (ZIRP). However, the Bank of Japan chose to raise interest rates in August 2000, despite continued deflation in Japan. Subsequently, annual CPI inflation was -0.7 percent in 2000. The zero interest rate policy was quickly reintroduced in March 2001, and has continued since then. As of January 23, 2019, the Bank of Japan maintains this policy, and applies a nominal short-term interest rate of negative 0.1 percent to balances in current accounts held by financial institutions at the central bank. The Bank also targets 10-year Japanese Government Bond (JGB) yields of zero percent through flexible purchases of JGBs.[6]

In December 2012, Shinzo Abe took office as prime minister of Japan. Abe promptly enacted a series of economic policies referred to as "Abenomics," which were designed to stimulate the Japanese economy. These policies included expansionary monetary and fiscal policy, as well as structural reforms. In April 2013, the Bank of Japan began both quantitative and qualitative easing to reach their stated goal of 2 percent inflation by 2015. Between Q4 2012 and Q1 2015, the Bank of Japan increased the monetary base from 25 percent of GDP to 57 percent of GDP and accumulated 128 trillion yen of Japanese government bonds in efforts to achieve their price target.

Since the introduction of Abenomics, real GDP has averaged 1.2 percent annual growth and average annual CPI inflation has risen to 0.8 percent. This level of inflation is a marked improvement from the earlier period, but still significantly below the 2 percent inflation target. Therefore, inflation expectations themselves also remain below the 2 percent level. Hausman and Wieland (2014) cite slow growth, shrinking population, and large sovereign debt burden as headwinds for raising Japanese inflation expectations to the target 2 percent level.

Though the Bank of Japan has continued with their zero interest rate policy, the government's fiscal policy has not been entirely expansionary since the introduction of Abenomics. In April 2014, the consumption tax rate was raised from 5 percent to 8 percent. The tax rate was scheduled to rise again in 2015 to 10 percent, but Prime Minister Abe has postponed this rate hike to October 2019 and there is currently discussion of pushing this back further.

III. Use of Financial Markets to Measure Expectations

[6] Bank of Japan. January 23, 2019. "Statement on Monetary Policy." https://www.boj.or.jp/en/announcements/release_2019/k190123a.pdf

In order to measure how firmly anchored inflation expectations are in Japan, we employ financial market measures of inflation compensation. These measures include inflation swaps and breakeven rates, the spread between the yield on nominal and indexed Japanese government bonds.

Financial markets are an effective measure of inflation expectations, as monetary incentives motivate actors to price financial market instruments accurately and in a timely manner. Alternatives, such as household surveys, have been found to have multiple distortions in measuring inflation expectations. Kamada et al. (2015) investigated household data in Japan from an opinion survey conducted from March 2004 to September 2007, and pointed out the following distortions that arise from household data, including too many integers, zeros, and multiples of 5, but too few negative numbers. As well, the method of collection introduces distortions to the data. In the case of the opinion survey, responses were collected by mail. Kamada et al. found that only those with an incentive to respond would mail in their surveys. In this case, households that expected inflation responded to the survey, while those that expected deflation ignored the survey. Overall, Kamada et al. found there to be significant biases in the household inflation expectation survey. Moreover, survey data is available infrequently, whereas financial data can be observed daily.

However, there are limitations to relying on financial market measures. The use of financial market instruments gives us a measure of inflation compensation. Inflation compensation includes compensation not only for expected inflation, but also for taking on inflation risk and any other risk associated with the security. Therefore, these rates are not purely inflation expectation numbers, but also may incorporate both a risk premium and a liquidity premium, which could fluctuate over time.

When comparing how firmly anchored inflation expectations were in the euro area and the United States, Beechey et al. (2011) measured inflation compensation in the euro area using inflation-swaps market data. They measured U.S. inflation compensation through the spread between yields on nominal and indexed Treasury securities. Beechey et al. concluded that long-run inflation expectations were more firmly anchored in the euro area in the United States. Their study ended in 2011, at which point the euro area had an inflation target in place since 2003, while the United States did not introduce an inflation target until 2012.

This was in line with the findings of Gürkaynak et al. (2007), who found that inflation expectations in the United States were not as firmly anchored as in Canada, Sweden, and the United Kingdom, all countries that had inflation targets in place. Gürkaynak et al. employed the difference between forward rates on nominal and inflation-indexed bonds to measure forward inflation compensation levels in the United States. The forward rates enabled them to focus on the sensitivity of far-ahead inflation compensation to news.

In the case of Japan, Mandel and Barnes (2013) found that the use of inflation swaps and inflation-protected bonds as market measures of inflation expectations is not ideal, given the illiquidity of these markets. Both are traded in low volumes, especially relative to the

U.S. markets, and many issuances of 10-year inflation protected bonds have been bought back by the Ministry of Finance in Japan. Yet they found the use of inflation swaps as a measure of inflation expectations to be preferable to alternatives, as the level of inflation expectations as derived from the inflation swaps market aligned with the inflation expectations from a survey of professional economic forecasters.

An alternative approach suggested by Krugman (2013), is to use uncovered real interest rate parity and the purchasing power parity to estimate inflation expectations using U.S. inflation-linked bonds (TIPS). This measure requires taking a stand on when the real exchange rate between the United States and Japan was consistent with purchasing power parity, and then using U.S. inflation linked bonds to calculate the level of inflation expectations. However, this method comes with the difficulty of determining when purchasing power parity holds, which is often not the case. Therefore, for the purposes of this study, we employ inflation swaps and breakeven inflation rates as our measures of inflation compensation.

Table 1: Japanese Inflation Expectations

Reference Period	5-year inflation swap rate	10-year inflation swap rate	5 x 5 inflation swap rate	10-year Inflation-Indexed bonds
2018 Q2	0.7	0.6	0.4	0.6
2012 Q3	0.6	0.3	-0.1	n/a*
Change	+0.1	+0.3	+0.5	n/a*

*The 10-year Inflation-Indexed bonds were discontinued during the 2012 period
Source: Bloomberg

Inflation has turned positive, with annual CPI averaging 0.8 percent since the introduction of the target. Inflation swap rates and break-even rates have also risen above levels prior to the introduction of the inflation target, yet they too remain below the 2 percent inflation target. This could be due to risk premia and liquidity premia, but suggest that the inflation target is still not credible. De Michelis and Iacoviello (2016) found that the policies of Abenomics had been successful in moving up both underlying domestic inflation and inflation expectations by only about 1 percentage point by 2016. However, it should be noted that since then, inflation has come in even softer, so this 1 percentage point increase may not fully stand up. They argue that though raising an inflation target has a powerful effect on activity and inflation, the effect can be diminished when the policy is not fully credible. Therefore they attribute the inability of the Bank of Japan to achieve its target level of inflation to a lack of credibility among private actors.

When inflation expectations are well anchored, we would expect market-based measures of inflation compensation to exhibit little sensitivity to economic news. Inflation compensation includes risk premium and liquidity premium as well as inflation expectations. A strategy that has been used in measuring the stability of inflation expectations is to assume that this risk premium and liquidity premium are unaffected by economic news, as in the studies of Beechey et al. (2011) and Gürkaynak et al. (2007) discussed above. Therefore we focus on the sensitivity of these asset prices to economic

news surprises, rather than whether inflation expectations are anchored around the 2 percent target level. Though the level of inflation compensation is not at the target level of 2 percent, we are concerned over the degree of consensus in inflation expectations, which will indicate whether inflation expectations are stable in Japan.

By regressing the change in the prices of these financial assets on economic news surprises, we can see if there is a relationship between news announcements and the prices of these financial assets. In particular, we can examine if the relationship has changed since the introduction of the inflation target in 2013.

IV. Our Approach

In order to measure how firmly anchored market-based inflation expectations are in Japan, we employ two measures of inflation compensation: inflation swaps and breakeven inflation rates.

Inflation swaps are a contract where one party pays a fixed rate cash flow on a principle amount, while the other party pays a floating rate linked to an inflation index. These contracts are quoted on the fixed rate basis. For inflation swaps, we use three different measures from Bloomberg, the 10-year inflation swap rate (JYSWIT10), the 5-year inflation swap rate (JYSWIT5), and the 5-year, 5-year forward inflation swap rate. The 5-year, 5-year forward swap rate is calculated as (2*JYSWIT10 – JYSWIT5), and is the 5-year rate in 5-years, calculated using the current 10-year swap rate and 5-year swap rate.

Breakeven inflation rates are calculated using the difference between the yield of a nominal bond and an inflation-indexed bond with the same maturity. We use the Japanese government 10-year breakeven rate (JYGGBE10) as a measure of inflation compensation, which is calculated using 10-year Japanese government bond and 10-year inflation-indexed bonds (JGBi). 10-year inflation-indexed bonds were introduced in March 2004 in Japan, and are linked to CPI excluding fresh food. Originally, these 10-year inflation-indexed bonds had no deflation floor, meaning that when the CPI index fell below 1, the principal amount on the JGBi would decrease. In 2008, the government had to cease the sale of the inflation-indexed bonds. Break-even inflation rates collapsed as investors tried to simultaneously sell the 10-year inflation indexed bonds. The government cancelled its JGBi bond auction due to concerns over financing these rising yields.[7] They began to reissue the 10-year inflation indexed bonds in 2013, but introduced a deflation floor, so the principle amount of any JGBi issued in and after 2013 is now guaranteed at maturity.[8]

[7] Global Capital. June 17, 2013. “JGBi success is all about timing – opinion.” https://www.globalcapital.com/article/jby5chm4kdxb/jgbi-success-is-all-about-timing-opinion

[8] Ministry of Finance, Japan. 2018. “10-year Inflation-Indexed Bonds (JGBi).” https://www.mof.go.jp/english/jgbs/topics/bond/10year_inflation/index.htm

Figure 1: National CPI

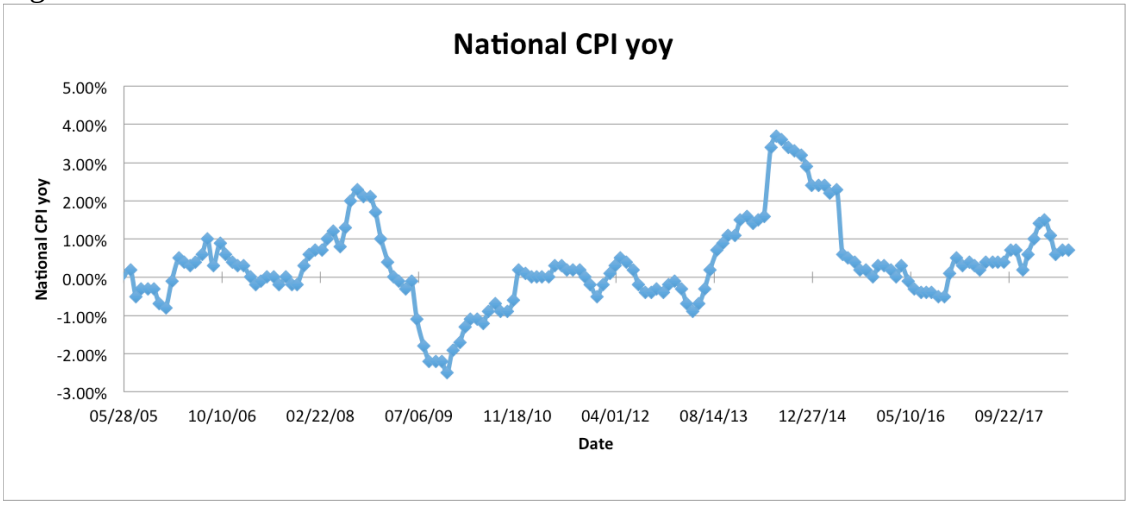


Figure 2: Inflation Swap Rates

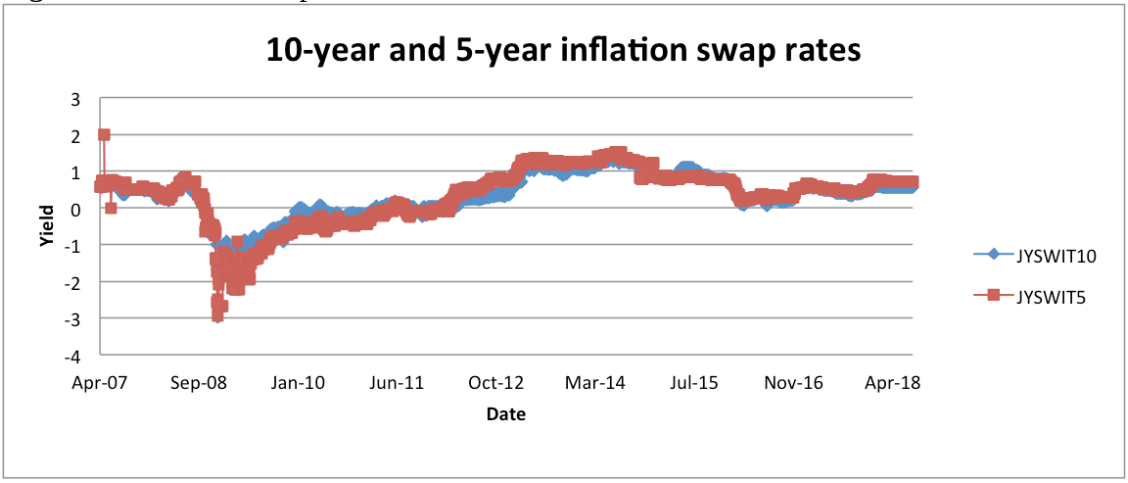
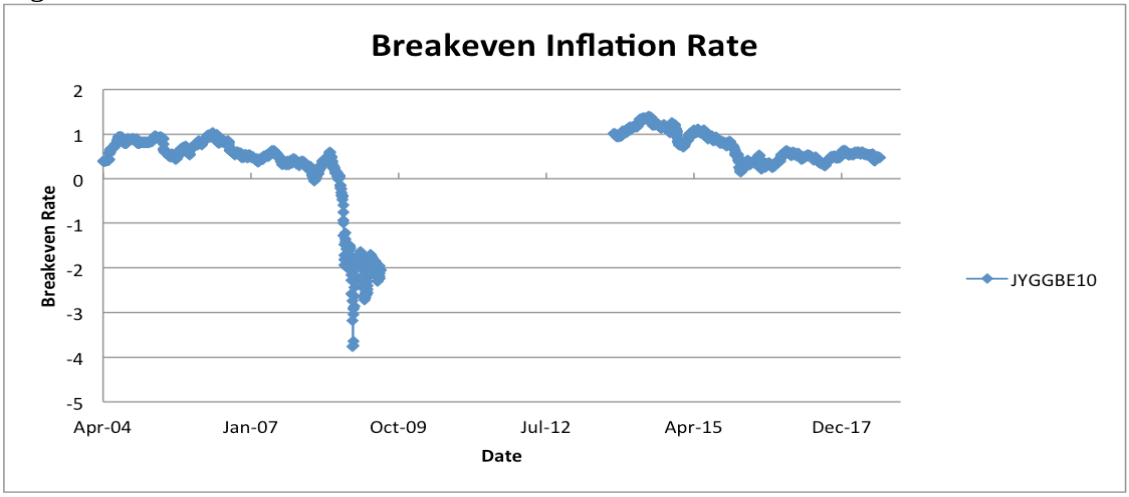


Figure 3: Breakeven Inflation Rates



*Data from Bloomberg

V. Regression methodology

For our regressions we employ two explanatory variables, the surprise in national CPI year-over-year, which measures the difference in the actual inflation rate minus the expected inflation rate. The expected inflation rate comes from the Bloomberg surveys taken shortly before the CPI announcement. The second explanatory variable we use is monetary policy surprises, which are measured by the change in the yield of 10-year JGB futures from just prior to a monetary policy announcement to just after a monetary policy announcement. This change is meant to capture the impact of the monetary policy announcement on financial asset prices, combining the effects of asset purchases and other announcements. The use of monetary policy surprise is a measure that was employed by Rogers, Scotti, and Wright (2014), and we use the monetary policy announcement dates they selected. Our model is a simple reaction function, where y_t is the inflation swap rate or breakeven inflation rate on day t, s_t is the surprise component of the CPI or monetary policy announcement, and the dummy variable d_t is equal to 1 after inflation targeting was introduced on January 22nd, 2013, and 0 before inflation targeting was introduced. The regression includes no intercept, as no surprise in the CPI or monetary policy announcement should result in no change in financial asset prices.

$$y_{t+h} - y_{t-1} = \beta s_t + \varepsilon_{t+h} \quad (1)$$

$$y_{t+h} - y_{t-1} = \beta s_t + \gamma s_t d_t + \varepsilon_{t+h} \quad (2)$$

For $y_{t+h} - y_{t-1}$, the change in the inflation swap rate or breakeven inflation rate, we measured the change over a one-day, two-day, and three-day period. The use of a one-day window reduces the impact of outside news other than the CPI or monetary policy announcement on the adjustment of inflation expectations. However, given the less liquid market for inflation derivatives, including two-day and three-day windows enables us to fully capture the market reaction to the news. Nevertheless, these larger windows will make our coefficient estimates less precise, as the price changes will exhibit a larger variance over a larger window. [9]

VI. Results

Table 2. Changes in Financial Market Measures in Response to CPI surprises

[9] *As evident in Figure 1, in December 2008, inflation began to fall rapidly, and inflation expectations for shorter-term 5-year inflation swaps dropped for a ten-day period. Because of the severity of the crisis, the cut in 10-year interest rates (monetary policy surprise) did not raise inflation expectations, which continued to fall as economic activity decreased. Given the circumstances, we omitted this change in 5-year inflation swaps during this period, as it biased our results by creating a positive relationship between the decrease in long-term interest rates and inflation expectations.*

CPI surprise	One-day change	Two-day change	Three-day change
5-year inflation swap rate	0.048	0.111**	0.076
	(0.049)	(0.046)	(0.097)
10-year inflation swap rate	0.014	0.067	0.142
	(0.044)	(0.064)	(0.096)
5-year, 5-year forward inflation swap rate	-0.025	0.058	0.263*
	(0.113)	(0.120)	(0.148)
10-year breakeven inflation rate	0.034	0.069*	0.100*
	(0.023)	(0.041)	(0.059)
	* P < 0.10	** P < 0.05	*** P < 0.01

The table shows coefficient estimates, with standard errors in parentheses, of the response of these financial market prices to a surprise in the CPI announcement. The regression corresponds to equation (1). The yields are regressed on the percentage surprise in CPI.

Table 3. Changes in Financial Market Measures in Response to Monetary Policy Surprises

Monetary policy surprise	One-day change	Two-day change	Three-day change
5-year inflation swap rate	0.019	-.498	-2.423**
	(0.512)	(0.620)	(0.983)
10-year inflation swap rate	-1.049***	-0.808*	-1.139*
	(0.390)	(0.452)	(0.594)
5-year, 5-year forward inflation swap rate	-4.496***	-4.061***	-0.306
	(0.815)	(1.021)	(0.987)
10-year breakeven inflation rate	-0.221	-0.661*	0.026
	(0.203)	(0.341)	(0.44)
	* P < 0.10	** P < 0.05	*** P < 0.01

The table shows coefficient estimates, with standard errors in parentheses, of the response of these financial market prices to the change in 10-year JGB future yields from just prior to just after a monetary policy announcement. The regression corresponds to equation (1). The yields are regressed on the change in 10-year JGB future yields.

Table 4. Changes in Financial Market Measures in Response to CPI surprises, with a dummy indicating the introduction of the inflation target

CPI surprise	One-day change		Two-day change		Three-day change	
	β	γ	β	γ	β	γ
5-year inflation swap rate	0.059	-0.026	0.130**	-0.048	0.064	0.030
	(0.063)	(0.100)	(0.059)	(0.094)	(0.126)	(0.199)
10-year inflation swap rate	0.011	0.007	0.078	-0.029	0.189	-0.120
	(0.057)	(0.091)	(0.082)	(0.131)	(0.123)	(0.196)
5-year, 5-year forward inflation swap rate	-0.036	0.029	0.012	0.119	0.323*	-0.156
	(0.147)	(0.233)	(0.153)	(0.247)	(0.189)	(0.306)
10-year breakeven inflation rate	0.029	0.013	0.084*	-0.049	0.109	-0.028
	(0.028)	(0.049)	(0.050)	(0.089)	(0.072)	(0.128)
				* P < 0.10	** P < 0.05	*** P < 0.01

The table shows coefficient estimates, with standard errors in parentheses, of the response of these financial market prices to a surprise in the CPI announcement. The yields are regressed on the percentage surprise in CPI. The regression corresponds to equation (2), with a dummy to identify if there is a significant change in the relationship following the introduction of the inflation target in 2013. Our focus here is on coefficient γ.

Table 5. Changes in Financial Market Measures in Response to monetary policy announcements, with a dummy indicating the introduction of the inflation target

Monetary policy surprise	One-day change		Two-day change		Three-day change	
	β	γ	β	γ	β	γ
5-year inflation swap rate	-0.007	0.180	-0.571	0.481	-2.904***	3.177
	(0.555)	(1.469)	(0.676)	(1.735)	(1.065)	(2.736)
10-year inflation swap rate	-1.335***	1.341	-0.905*	0.409	-1.494**	1.385
	(0.438)	(0.948)	(0.520)	(1.068)	(0.688)	(1.360)
5-year, 5-year forward inflation swap rate	-5.287***	6.061**	-4.666***	4.149	-0.461	1.027
	(0.854)	(2.363)	(1.099)	(2.877)	(1.075)	(2.770)
10-year breakeven inflation rate	-0.244	0.457	-0.724**	1.182	0.018	0.138
	(0.209)	(0.932)	(0.351)	(1.525)	(0.456)	(1.893)

* P < 0.10 ** P < 0.05 *** P < 0.01

The table shows coefficient estimates, with standard errors in parentheses, of the response of these financial market prices to the change in 10-year JGB future yields from just prior to just after a monetary policy announcement. The yields are regressed on the change in 10-year JGB future yields. The regression corresponds to equation (2), with a dummy to identify if there is a significant change in the relationship following the introduction of the inflation target in 2013. Our focus here is on coefficient γ.

CPI surprises –

We begin by examining the effect that the surprise in national CPI year-over-year, the difference in the reported annual inflation rate and the expected annual inflation rate, has on market measures of inflation compensation, estimating equation (1). Beginning with inflation swap rates, we looked at how 5-year inflation swaps, 10-year inflations swaps, and 5-year, 5-year forward swap rates are impacted by CPI surprises on a one-day, two-day, and three-day basis following the CPI announcement. We found there to be a positive relationship between a positive surprise in CPI and the 5-year inflation swap rate. The relationship was statistically significant over a two-day period. The relationship between CPI announcements and 10-year inflation swaps lacked statistical significance. We did find a statistically significant positive relationship for the CPI surprise and the 5-year, 5-year forward rate, though over a three-day window, and at a lower level of significance than the 5-year inflation swaps.

This indicates that the CPI surprise has a stronger, more immediate impact on short-term inflation expectations, and little impact on long-term inflation expectations when measured through inflation swaps. These findings are in line with our expectations. Given that the central bank cannot use monetary policy to impact inflation immediately, we would expect the information provided by the CPI announcement to impact short-term inflation expectations. Beechey et al. found that in the US, surprises in core CPI inflation resulted in markets marking up inflation compensation at short horizons, due to a higher expected path for inflation. They found that the response decayed by the five-year horizon, but was still positive and significant. This is in line with our own findings that CPI surprises impact short-term inflation expectations more significantly than long-term inflation expectations. Long-term inflation expectations should exhibit little sensitivity to CPI announcements as long-term inflation is driven primarily by monetary policy actions.

The regression of the CPI surprise on 10 year breakeven rates was also positive, and significant for two-day and three-day change. However, the statistical significance of this relationship was weaker than that with the 5-year inflation swap rate.

Monetary policy surprises –

We then looked at the impact of monetary policy surprises on these measures of inflation compensation, again using the specification in equation (1). A positive monetary policy surprise indicates an increase in rates, or a "tightening" of monetary policy. We would expect this to have a negative relationship with inflation expectations, as a rate increase is a contractionary measure that would impede growth in prices. For monetary policy surprise we found that these surprises did move inflation expectations, most significantly for the 5-year, 5-year forward inflation swaps. This relationship holds for breakeven rates, over both a one-day and two-day window.

This indicates that monetary policy changes impact long-term inflation most strongly. Low interest rates encourage inflation by encouraging increased output. Since the introduction of their inflation target, the Bank of Japan has demonstrated strong commitment to their zero interest rate policy, which has bolstered confidence in their ability to attain higher levels of inflation. Therefore it is in line with our expectations that long-term inflation expectations are strongly influenced by the Bank of Japan's monetary policy actions.

Pre-adoption of inflation target v. post-adoption of inflation target –

In equation (2), we then introduced a dummy variable, which we set equal to 1 after inflation targeting was introduced in 2013, and to 0 before the inflation target was introduced. We used this to measure any significant difference in the relationship between the impact of CPI surprise or monetary policy surprise after the introduction of the inflation target. We hypothesized that the introduction of the target should decrease the impact that CPI has on inflation compensation measures, as inflation expectations should be less sensitive to economic news if an inflation target has been introduced.

For 5-year inflation swaps, we found that the impact of CPI surprises decreases for one-day and two-day change after the introduction of an inflation target, but not at a statistically significant level. For 10-year inflation swaps, 5-year, 5-year forward inflation swaps, and the 10-year breakeven rates, we saw little to no change in the coefficients, indicating that the introduction of an inflation target had less of an impact for these longer-term inflation compensation measures. As we found in our earlier regression that CPI surprises had a more significant impact on short-term inflation expectations, it is in line with our expectations that the introduction of the inflation target should strengthen the anchoring of short-term expectations against CPI surprises, while the impact on long-term inflation expectations should remain unchanged.

For monetary policy surprises, we found that these surprises did have a diminished impact on inflation expectations across the board after the introduction of an inflation target. Most notably, the change in the 5-year, 5-year forward rate was reversed after the introduction of the target, and this was a statistically significant change. This is in line

with our expectations, as the introduction of an explicit long-term inflation target has diminished the impact of a monetary policy surprise on long-term inflation expectations.

VII. Conclusion

The Bank of Japan has been creative in solving its low inflation problem. The initiatives taken by Abenomics beginning in 2013 have employed monetary policy, fiscal policy, and other reforms to stimulate the economy and achieve a 2 percent level of annual inflation. Since the introduction of the inflation target, average annual CPI inflation has risen to 0.8 percent, a significant improvement from the prior ten-year period, where annual CPI inflation averaged 0.02 percent. Moreover, the inflation expectations are exhibiting lower volatility around that number. Short-term inflation expectations exhibit less sensitivity to CPI surprises, while long-term inflation expectations exhibit diminished sensitivity to monetary policy surprises.

Given the short time span since the introduction of the inflation target, the sample size for our data is limited, introducing uncertainty and making it difficult to draw conclusions. However, our findings are consistent with what others, such as Hausman and Wieland (2015) found. The Bank of Japan has been successful in anchoring inflation expectations at a higher level, but has not yet been succeeded in achieving their 2 percent inflation target.

Though the Bank of Japan has been committed to their monetary policy action in order to rid them of the problem of low inflation, this suggests that the country requires more aggressive policy measures to achieve target inflation. Moreover, it may be more difficult than the Bank of Japan originally realized to raise inflation in a controlled manner. Though according to modern monetary theory prices could be raised through simply increasing the supply of money in the economy, the Bank of Japan faces the challenge of raising inflation slightly, and in a controlled manner. The Bank of Japan's failure to achieve their inflation target also may have lost them further credibility, entrenching them at a below target level of inflation. Though the central bank is currently using quite radical policies to drive up prices, achieving target inflation in the future may require the introduction of a combination of still more expansionary monetary and fiscal policy.

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