Raising an Inflation Target: the Japanese Experience with Abenomics*

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Abstract

This paper draws from Japan's recent monetary experiment to examine the effects of increases in the inflation target when the economy is in a liquidity trap. We review Japanese data and examine through a VAR model how macroeconomic variables respond to identified inflation target shocks. We apply these findings to calibrate the effect of a shock to the inflation target in a new-Keynesian DSGE model of the Japanese economy. We argue that imperfect observability of the inflation target and a separate exchange rate shock are needed to successfully account for the behavior of nominal and real variables in Japan since late 2012. Our analysis indicates that Japan has made significant progress towards overcoming deflation, but further measures are needed to raise inflation to 2 percent in a stable manner.

KEYWORDS: Abenomics, Credibility, Deflation, Inflation target, Japan, Monetary policy.

JEL CLASSIFICATION: E31, E32, E47, E52, E58, F31, F41

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1 Introduction

This paper studies the effects of increases in the inflation target during a liquidity trap. To this end, we discuss Japan's recent aggressive monetary easing measures, including the adoption of a 2 percent inflation target in early 2013, and review the behavior of prices and exchange rates following this policy change. We then use a VAR to document that output and exchange rates respond more to inflation target shocks when the economy is in a liquidity trap. Finally, we use our empirical findings to calibrate two DSGE models of the Japanese economy that can account for the sluggish behavior of nominal and real variables in response to an inflation target shock. An important feature of our model is that agents update their estimates of the inflation target gradually over time rather than instantaneously. As a consequence, consistent with Japanese data since 2012, inflation and inflation expectations rise very slowly after an increase in the target. Accordingly, changes in the inflation target, while powerful in a liquidity trap, can be weakened by the slow response of inflation.

A wide economic literature has documented the Japanese malaise of low economic growth and mild deflation, alongside high public debt and a rapidly aging population (e.g. Ito and Mishkin 2006). Figure 1 shows that Japanese inflation turned negative in the late 1990s. The emergence of deflation is generally attributed to the failure of policies conducted by the Bank of Japan (BOJ). Inflation is a monetary phenomenon, the argument goes, and the BOJ was unable to stop the inflation rate from turning negative. Many observers, including Krugman (1998) and Bernanke, Reinhart, and Sack (2004), have argued that the BOJ's efforts were too little and too late, calling for more aggressive and proactive measures. The aftermath of the global financial crisis provides a case in point. The BOJ lowered its policy rate to zero and expanded the size of its balance sheet. However, as deflation intensified, the BOJ came under criticism for the limited scope of its asset purchase program and for lacking conviction that its easing would yield tangible benefits.

Against this background, Mr. Shinzo Abe was elected Prime Minister in late 2012, running on an economic platform known as "Abenomics." Abenomics calls for ending Japan's long slump with three "arrows": aggressive monetary easing; flexible fiscal policy; and structural reforms (Eichengreen 2013, Ito 2013.) Even before coming into power, Mr. Abe started calling for a radical reorientation of monetary policy in November 2012. In February 2013, the BOJ introduced a new inflation target of 2 percent, though it refrained from pursuing significantly more aggressive easing. In April 2013, under the new leadership of Governor Haruhiko Kuroda, the BOJ unveiled a new policy package entitled "Quantitative and Qualitative Monetary Easing" (QQE). The BOJ announced a sharp increase in purchases of Japanese government bonds (JGBs) and other assets, including Japanese equity ETFs. The BOJ also extended the maturity of its JGB purchases. In October 2014, the BOJ expanded its QQE program by slightly accelerating the pace of asset purchases. Figure 2 shows that the BOJ's balance sheet has more than doubled in size since the introduction of QQE. To provide a reference point, the increase in the BOJ's asset-to-GDP ratio through the second quarter of 2015 is almost twice that of the Federal Reserve over the 6-year period from 2008 to 2014.

Has the first arrow of Abenomics hit its target? In this paper, we note that there has been some progress, but that the goal has yet to be reached.. Inflation has turned positive, ending a 15-year period of persistent deflation. However, although inflation expectations have move up, they remain well below the 2 percent target, suggesting that private agents remain doubtful. Japan's experience raises the concern that expansionary monetary policies may not be effective unless they are fully credible. To better assess the risks, benefits and challenges of raising an inflation target, we first estimate the effects of an inflation target shock using a simple VAR and then analyze the monetary regime change taking place under Abenomics through the prism of two new-Keynesian models exhibiting inertial inflation behavior and imperfect credibility. Our main findings are that increasing an inflation target can have powerful effects on activity and inflation, especially when the economy is in a liquidity trap. However, we also show that these effects can be much smaller if the policy is not fully credible. Accordingly, we argue that the BOJ needs to take further steps to strengthen its credibility by better communicating the permanent nature of the monetary regime shift.

The remainder of the paper is organized as follows. Section 2 reviews how Japanese consumer prices, trade prices and exchange rates have evolved since the start of Abenomics.

Section 3 sets up a simple VAR model to examine what Japanese data over the past 40 years reveal about the real effects of changing an inflation target. Section 4 presents a theoretical analysis of an inflation target shock in a closed-economy, new-Keynesian model with inertial inflation behavior and imperfect credibility. Section 5 extends the previous analysis to an open-economy environment using the Federal Reserve staff's SIGMA model. Section 6 concludes.

2 Reflation, Prices and Exchange Rates in the aftermath of Abenomics

We see the adoption of the 2 percent inflation target as the cornerstone of Abenomics. We do not question here the optimality of this particular value. While several macroeconomic models indicate optimal inflation rates close to zero, other considerations have induced most central banks to prefer small but positive inflation rates. BOJ's Governor Kuroda gave two reasons for adopting a 2 percent target in Japan: mismeasurement of actual inflation, and risks of hitting the zero lower bound (ZLB) when inflation is low (Kuroda (2013)).

BOJ officials have appealed to a simple Phillips curve framework to justify why they need to increase their inflation target. Figure 3 shows estimates of Japan's Phillips curve, relating core inflation (excluding food and energy prices) to a constant term and the output gap, over three sample periods. Panel A is estimated over the full sample 1974Q1–2015Q2, Panel B over 1974Q1–1993Q4, and Panel C over 1994Q1–2013Q2, with B and C corresponding to the high and low inflation periods, respectively. Comparing Panel B with Panel C, the Phillips curve appears to have shifted down. The intercept term has fallen from 2.5 percent in the earlier period to 0 percent in the later period. Loosely speaking, the intercept identifies the steady-state rate of inflation that is obtained when the output gap is closed. Accordingly, merely closing the gap might not be sufficient to raise inflation to 2 percent. Indeed, the estimated Phillips curve appears so flat that raising inflation to 2 percent would take an implausibly high output gap. Rather, the actions of the BOJ under Abemomics are aimed at shifting up the Phillips curve by resetting inflation expectations to a higher value, as argued by BOJ's policy board member Shirai (2013).[1]

How much did inflation rise following the advent of Abenomics? As shown in Figure 1, total inflation has moved from −0.4 percent in the third quarter of 2012 to 0.5 percent in the second quarter of 2015 and core inflation from −0.6 percent to 0.4 percent. Both measures of inflation moved up sharply early on, raising well above 2 percent in 2014; however, a large component of this run-up reflected transitory factors. First, the yen has depreciated more than 30 percent since mid-2012, boosting import prices and, in turn, consumer prices (see Figure 4). A simple bivariate regression of total inflation on import price inflation attributes half of the 2013 increase in inflation to higher import prices.[2] Second, the consumption tax rate was raised from 5 to 8 percent in April 2014, pushing up inflation by about 2 percentage points that year. Taken together, the evidence seems to indicate that the policies of the BOJ under Abenomics have thus far moved up underlying domestic inflation by about 1 percentage point.

Inflation expectations have also moved up, but they remain well below the 2 percent target. As noted in (Mandel and Barnes 2013), there is no ideal measure of inflation expectations in Japan.[3] That said, in Table 1, we report some of the available measures of inflation expectations before and after the advent of Abenomics. Here we focus on longer-term inflation expectations because we want to assess whether the BOJ's progress towards

[1] Other studies, including Honda (2014) and Rogers and Wright (2014), have examined the effects of unconventional monetary policy in Japan. Rogers and Wright (2014) examine how asset prices are affected by unconventional monetary policy announcements. Typically, these studies have focused on the BOJ's asset purchases and have not considered economy-wide effects. A noticeable exception is the work of Hausman and Wieland (2014) who argued that Abenomics provided a substantial boost to Japanese output in 2013. In this paper, we expand this literature by investigating the transmission channels of raising an inflation target in a general equilibrium framework.

[2] We run a simple regression of total inflation on import price inflation and the output gap over the period 1992Q1-2012Q4. The regression results suggest that, over the 2012Q3–2014Q1 period, a 23 percent rise in import prices added 0.7 percentage point to total inflation. This estimate likely provides a lower bound as imports of fossil fuels jumped up after Japan shut down its nuclear reactors following the nuclear disaster in March 2011, arguably contributing to render Japan consumer prices more sensitive to exchange rate fluctuations.

[3] Measures derived from financial markets suffer from the lack of sufficient liquidity. In particular, breakeven inflation measures are not reliable because the market for inflation-linked Japanese government bonds is very thin and a majority of the issuance has been bought back by the Ministry of Finance in recent years. Short-term measures of inflation expectations from surveys of households, investors, and professional forecasters appear to be more responsive to actual inflation than predictive of the future. Longer-term measures, such as the $6-10$ year ahead inflation forecasts by Consensus, performed poorly over the past two decades, remaining close to 1 percent despite the emergence of persistent deflation.

its goal of raising inflation to 2 percent "in a stable manner." As is also shown in Figure 5, the $5x5$ swap rate (a measure of inflation compensation $6-10$ year ahead) has increased from 0 percent in mid-2012 to 1.2 percent in mid-2015 whereas $6-10$ year ahead inflation forecasts by Consensus have move up by 0.8 percentage point. In addition, $10-$year JGB yields have remained very low, trading near 50 basis points in 2015, and $10-$year forward rates are barely above 1 percent even at the end of 2018 suggesting that inflation risk premia have remained very low (Figure 6). In sum, we read the available evidence as indicating that Japanese longer-term inflation expectations have risen by only 1 percentage point since the start of Abenomics and remain well below the new 2 percent inflation target of the Bank of Japan.

Table 1: Japanese Longer-Term Inflation Expectations (pct)

	5x5 inflation swap rate	10-year inflation swap rate	6-10 year ahead inflation by Consensus	2-6 year ahead inflation by EPS
2012 Q3	0.0	0.3	0.8	0.4
2015 Q2	1.2	1.0	1.6	1.3
change (ppt)	1.2	0.7	0.8	0.9

Sources: Bloomberg, Consensus Economics, and Japanese Center for Economic Research.

3 VAR Evidence on Shocks to the Inflation Target

Do changes in the inflation target produce real effects? Ideally, one would like to identify in the data exogenous movements in the inflation objective of the central bank that are uncorrelated with other developments in the economy. In practice, such movements almost never occur. We then proceed by adopting an operational definition of what a change in inflation target should do, adapting the methodology developed by King, Plosser, Stock, and Watson (1991) and Warne (1993).

We formulate a 5-variable vector error correction model with core inflation, long-term lending interest rate, real exchange rate, GDP, and real oil price inflation.[4] We control for

[4] Core inflation is the four-quarter change in the consumer price level, excluding food and energy

oil prices in the VAR to better account for cost–push factors that can drive core inflation dynamics.

To identify shocks to the inflation target, we impose the restrictions that (1) a change in the inflation target affects inflation and the interest rate by the same amount (percentage-wise) in the long-run, but (2) has no long-run effect on GDP, the real exchange rate, and real oil price inflation. These restrictions might appear draconian, but are implied by nearly all modern monetary business cycle models. We also assume that Japanese domestic variables (inflation, output, and interest rate) have no contemporaneous effect on real oil price inflation, reflecting that the price of oil is determined by global rather than Japanese-specific developments.

Figure 7 plots the impulse responses of inflation, interest rate, exchange rate and GDP[5] to the identified inflation target shock for the VAR estimated over two subperiods, 1974Q1-1993Q4 and 1994Q1-2015Q2. We choose these two samples to account for the different effects of inflation target shocks depending on whether the economy is in a liquidity trap or not. As noted earlier, 1994 is when the low inflation period starts, with core inflation falling persistently below 1 percent. To facilitate the comparison between the two periods, we scale the plots so that the inflation target shock equals 2 percentage points. Such a shock corresponds to a 3 standard deviation shock in the early sample, when inflation in Japan was high and volatile, and, perhaps unsurprisingly, to a larger 6 standard deviation shock in the late sample, when inflation was low and relatively stable.

In both periods, the identified inflation target shock leads to a gradual and permanent increase in inflation and the nominal interest rate, and to a temporary boost in output. By construction, GDP as well as the real exchange rate return to their initial baseline in the long run.

prices (Haver series mnemonic: S158PCXG@G10) and net of the effects of the consumption tax hikes of 1989Q2, 1997Q2, and 2014Q2. GDP is the the Cabinet's Office output gap (Haver series mnemonic: JPGDPG@JAPAN), a measure of the cyclical component of GDP akin to the CBO's output gap for the United States. The real exchange rate is the de-meaned Trade Weighted Real Effective Foreign Exchange Rate (EERBR@JAPAN). The interest rate is the Average Lending Rate by City Banks (AICG@JAPAN) on loans and discounts with maturity of less than one year at the time of origination. Oil inflation is the 4-quarter growth rate of WTI (PZTEXP@USECON) deflated by U.S. CPI 4-quarter inflation.

[5] The response of the oil price (not shown in the figure) to the inflation target shock is modest and not significantly different from zero at all horizons.

The comparison between the two periods reveals important differences. In the early period, the identified inflation target shock leads to a temporary rise in real interest rates, as the nominal interest rate rises faster than inflation. In turn, higher real rates lead to a real appreciation, and thus GDP rises only slightly above its baseline. In the late sample, perhaps because short-term interest rates are effectively at zero, the response of the lending rate is more subdued in spite of the more front-loaded increase in the inflation rate. Accordingly, the real rate declines. In contrast with the early period, the real exchange rate depreciates substantially and persistently. In line with these findings, the boost to GDP is substantially larger in the late sample. To give some quantitative flavor, a 2 percentage point increase in the target leads to a rise in GDP of only 0.3 percent in the early sample and almost 4 percent in the late sample.

The results from the VAR analysis indicate that reflating the economy can bring substantial short-run benefits in terms of output when the economy is in a liquidity trap. However, taken at face value, this analysis also suggests the Bank of Japan needs to produce an inflation shock that is 6 standard deviations above its mean over the last 20 years. This is a formidable challenge, especially in an environment where private agents might take only limited signal from movements in interest rates, which at shorter maturities remain constrained by the zero lower bound.

The estimated VAR can be used to quantify the extent to which the recent BOJ policies have effectively moved the inflation target. To address this question, we carry out a historical decomposition of inflation into the shocks identified by our model. Figure 8 plots the contribution over time of the inflation target shock to the behavior of core inflation since 2010. The figure shows that the inflation target shock identified by the model has added at most 1 percentage point to core inflation since the start of Abenomics. Moreover, even prior to Abenomics, the contribution of the inflation target shock is positive; perhaps reflecting earlier attempts by the BOJ to escape deflation. This finding also suggests that the BOJ under Abenomics has not engineered a clear discontinuity with the past. All told, the historical decomposition indicates that the BOJ has raised trend inflation only partially toward its new 2 percent target, confirming the findings of Section 2.

In Appendix A, we confirm the plausibility of our identification scheme by showing results from an analogous VAR for U.S. data. This exercise also shows that an inflation target shock can lead to a short-run increase in output.

4 The Effect of Inflation Target Shocks in a New-Keynesian Model

Section 3 showed how Japanese macroeconomic variables respond to identified inflation target shocks. We now continue our investigation by examining the effect of inflation target shocks in a standard closed economy new-Keynesian model. The model, a variant of a small-scale DSGE model in the tradition of Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2007), features Calvo-style nominal price and wage rigidities, habit formation in consumption, investment adjustment costs, a fiscal authority, and a central bank that follows an interest rate rule subject to the zero lower bound. In most respects, the calibration of the model closely follows the estimated parameters in Smets and Wouters (2007). The main difference is that we choose a somewhat higher degree of price and wage rigidity to better characterize the slow and muted response of inflation to movements in the output gap that we documented in Figure 3. Additionally, we assume that the steady-state inflation rate is zero, and that the steady state nominal and real interest rates are both equal to 1 percent, assumptions that are in line with Japan's experience over the last two decades.

Households maximize a lifetime utility function given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\mathsf{a}_{ct} \log \left(c_t - \varepsilon_c c_{t-1} \right) - \frac{1}{1+\eta} n_t^{1+\eta} \right) \tag{1}$$

where c_t is consumption in period t, and n_t are hours worked. The term a_{ct} is a consumption preference shock. Their budget constraint is given by:

$$c_t + k_t + \phi_t = w_t n_t + \left(R_{kt} z_t + 1 - \delta \right) k_{t-1} + \text{div}_t - \tau_t - b_t + \frac{R_{t-1}}{\Pi_t} b_{t-1} \tag{2}$$

where k_t is capital, ϕ_t denotes convex investment adjustment costs,[6] $w_t n_t$ is wage income, $\left(R_{kt} z_t + 1 - \delta \right) k_{t-1}$ is capital income (and z_t is the variable capital utilization rate), div_t are

[6] Investment adjustment costs take the form $\phi_t = \phi \left(i_t - i_{t-1} \right)^2 / \bar{i}$, where $\bar{i}$ is steady-state investment and investment and capital are linked by $k_t = i_t + (1-\delta) k_{t-1} - \phi_t$.

dividends from ownership of sticky price and wage firms, τ_t are lump-sum taxes levied by the government, b_{t-1} is one-period government debt, which pays a gross nominal interest R_{t-1}, and Π_t is the one-period gross inflation rate.

The economy–wide production function takes the form:

$$Y_t = n_t^{1-\mu} \left(z_t k_{t-1} \right)^{\mu}. \tag{3}$$

where μ is the capital share. Additionally, the presence of monopolistic competition in the goods and labor markets, coupled with staggered nominal adjustment *à la* Calvo, results in two standard price and wage Phillips curves. We assume that firms that do not adjust their prices and wages index them to the previous period inflation rate with a elasticities given by ι_π and ι_w, respectively. The price and wage Phillips curves are thus:

$$\ln \pi_t - \iota_\pi \ln \pi_{t-1} = \beta \left(E_t \ln \pi_{t+1} - \iota_\pi \ln \pi_t \right) - \varepsilon_\pi \ln \left(X_{pt}/X_p \right), \tag{4}$$

$$\omega_t - \iota_w \ln \pi_{t-1} = \beta \left(E_t \omega_{c,t+1} - \iota_w \ln \pi_t \right) - \varepsilon_w \ln \left(X_{wt}/X_{wc} \right) \tag{5}$$

where $\omega_t \equiv \frac{w_t \pi_t}{w_{t-1}}$ denotes wage inflation, and $\varepsilon_\pi = \frac{(1-\theta_\pi)(1-\beta\theta_\pi)}{\theta_\pi}$ and $\varepsilon_w = \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w}$ denote the elasticity of price and wage inflation to price and wage markups, respectively.

The government levies lump-sum taxes which respond to beginning of period debt, and buys g_t as a constant fraction of the final output each period. The economy-wide market clearing condition is:

$$Y_t = c_t + i_t + g_t. \tag{6}$$

The behavior of the central bank is characterized by a Taylor rule subject to the ZLB constraint:

$$r_t = \max \left(0, \phi_r r_{t-1} + (1-\phi_r) \left(rr + \pi_t + \phi_\pi \left(\pi_t - \pi_t^* \right) + \frac{\phi_y}{4} \widetilde{y}_t \right) + e_t \right) \tag{7}$$

where $r_t = R_t - 1$ is the net nominal interest rate, $\pi_t = \Pi_t - 1$ is the net inflation rate, $\phi_r = 0.75$ is the inertial coefficient in the rule, rr is the steady state real interest rate, equal to 1 percent on an annual basis, $\phi_\pi = 0.5$ is long-run response coefficient of the real rate to inflation, and $\phi_y = 0.5$ is the response to the output gap $\widetilde{y}_t$ (here defined as output relative to its steady state). Finally, π_t^* is a very persistent monetary shock, whereas e_t is a transient monetary policy shock which captures short-run deviations of the interest rate from its historical rule. Formally:

$$\begin{bmatrix} \pi_t^* \\ e_t \end{bmatrix} = \begin{bmatrix} 0.999 & 0 \\ 0 & 0.001 \end{bmatrix} \begin{bmatrix} \pi_{t-1}^* \\ e_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{pt} \\ \varepsilon_{qt} \end{bmatrix} \tag{8}$$

where ε_{pt} and ε_{qt} are normal iid innovations with variances σ_p^2 and σ_q^2 respectively. As in Erceg and Levin (2003), the linear combination of these two shocks, given by $Z_t = e_t - (1 - \phi_r)\,\phi_\pi \pi_t^*$, identifies the central bank's time-varying inflation target.

The properties of this model in response to e_t and π_t^* shocks are, of course, well known, especially outside of the ZLB, as studied for instance in Erceg and Levin (2003) and Ireland (2007).[7] A temporary *reduction* in e_t lowers nominal interest rates. With sticky prices, however, the real rate falls. Thus, aggregate demand and output rise, and inflation increases temporarily above the baseline. An *increase* in π_t^* leads to a persistent increase in inflation. As the nominal interest rate only slowly increases, the real rate falls, again stimulating output and aggregate demand. Eventually, if the change in π_t^* is assumed to be permanent, the change in the target will have (almost) no effects on the real variables, and the nominal interest rate will rise one-for-one with inflation and with the target itself.[8] All else equal, for a given change in the nominal interest rate relative to what the Taylor rule would prescribe, a change in π_t^* has a more powerful effect on the economy than a change in e_t, since it signals the intention of the central bank to keep its policy interest rate lower for longer.

These effects are also present at the ZLB. Changes in e_t may have either little (if they are large enough) or no effects on the policy rate, since they affect only the notional interest rate,[9] but are unable to affect r_t when $r_t = 0$ and the economy is in a liquidity trap. By

[7] The Calvo parameters for prices and wages are respectively $\theta_\pi = 0.95$ and $\theta_w = 0.925$. The indexation parameters are equal to $\iota_\pi = \iota_w = 0.8$. The consumption habit parameter ε is equal to 0.5. The capital share is $\mu = 0.3$, and the depreciation rate is $\delta = 0.03$. The labor supply elasticity parameter is $\eta = 1$. Government spending is a constant fraction of GDP equal to 0.2. The investment adjustment cost parameter is set at $\phi = 10$.

[8] This is true insofar as the long-run Phillips curve is vertical, which is almost true in the standard new-Keynesian model.

[9] The notional interest is the rate that would prevail were the zero lower bound on the interest rate not present.

contrast, increases in π_t^* can have powerful expansionary effects on the economy as the central bank keeps, on average, lower interest rates for longer because of the ZLB. Figure 9 illustrates these results for a very persistent change in the target (autocorrelation of 0.999).[10] To match Japan's context, we assume a baseline where a sequence of negative demand shocks (triggered by a sequence of negative realizations of $\mathtt{a}_{ct}$) lowers output and is expected to keep the policy rate at zero until year 2017, and report all the variables in deviation from such baseline. We then assume that a sequence of shocks to π_t^* over the 2012Q4-2013Q2 brings the inflation target from 0 to 2 percent: this sequence mimics events the monetary policy regime change set in motion by Abenomics, as discussed in Section 2. A 2 percentage point increase in the target boosts GDP by about 1.5 percent after two years, before GDP slowly returns to the baseline. The driver for the rise in GDP is the decline in real rates which is further boosted by the fact that interest rates are kept at zero for a long period. By contrast, under a baseline where interest rates are not constrained by the ZLB, although the response of inflation is similar, output rises less since nominal rates respond sooner to the higher inflation rate. In both experiments, even if prices are assumed to be very sticky, inflation rises above 1.5 percent in less than two years and reaches its target after three years, while long-run inflation expectations immediately jump and remain anchored to the new 2 percent target.

The fast response of inflation and inflation expectations following a change in the target in Figure 9 appears at odds with our reading of the recent experience of Japan. As discussed in Sections 2 and 3, we think that Abenomics pushed up underlying domestic inflation and long-term inflation expectations by about 1 percentage point. Other studies, Hausman and Wieland (2014) have also pointed out that the BOJ's 2 percent target is not yet fully credible. In light of this, we therefore proceed by modifying the model to allow for imperfect observability of the inflation target itself, following Erceg and Levin (2003). In particular, we assume that agents have perfect knowledge of all the aspects of the model, including the reaction function of the central bank in absence of the ZLB. However, agents can only observe the sum of the persistent and transitory monetary shocks Z_t, and infer their individual

[10] We solve for the various scenarios of the models described in Sections 4 and 5 using the OccBin toolkit described in Guerrieri and Iacoviello (2015).

components solving a signal extraction problem. Figure 10 compares the perfect credibility case with the case in which agents revise their expectations about the persistent component of the monetary shock only slowly over time. We set the signal-to-noise ratio so that the half-life of the perceived inflation target is about three years. This assumption better lines up with the actual experience of Japan since Abenomics, as discussed above. Under imperfect credibility, inflation rises much more slowly, the decline in the real rate is less pronounced, and the increase in GDP is accordingly more muted.

One way to break out from the slow increase in inflation would be to make a much bolder statement about the inflation target itself. For instance, one possibility would be to temporarily adopt an inflation target higher than 2 percent. In Appendix B, we examine the benefits and also the possible costs of such bolder actions, by assuming that higher inflation prompts a decline in real rates (benefits) alongside an increase in risk premia (costs). We show that in such a scenario an increase in the inflation target may lead to a decline in GDP and, through higher borrowing costs, to a higher public debt-to-GDP ratio.

In our baseline specification, we assume that firms that do not re-optimize their prices every period index prices to previous period inflation with an elasticity given by $\iota_\pi = 0.8$ (see equation 4). Alternatively, we could assume, as in Ireland (2007), that firms that do not re-optimize adjust their prices in line with the perceived inflation target. Under this alternative specification, we find that, absent the ZLB, an increase in the inflation target yields a faster rise in inflation and, accordingly, a smaller boost to GDP. This finding is not surprising, since the price-setters' decision to adjusting price to the inflation target effectively mimics optimal behavior. In other words, price setting becomes more forward looking thus reducing the real effects of an inflation target shock. By contrast, we find that the differences between the two types of indexation are more muted at the ZLB. Under a liquidity trap, higher price flexibility boosts the output response since monetary policy cannot offset the rise in inflation. Thus, indexing to the perceived inflation target dampens the response to output to an inflation target shock as price setters become more forward looking but also boosts the response of output as monetary policy is constrained by the ZLB, and these two effects roughly offest each other. All told, the type of indexation does not seem very consequential for an economy in a liquidity trap, as is the case for Japan. Moreover, we think that our baseline specification better captures the backward-looking behaviour of Japanese households and firms and their ”entrenched deflationary mindset” BOJ's officials regularly to (e.g. Kuroda (2013)).

5 Inflation Target Shocks in the SIGMA Model

One obvious limitation of the model in the previous section is that it lacks open economy considerations. However, as the exchange rate behavior in the VAR in Section 3 suggests, open economy considerations may be an important channel of transmission of inflation target shocks in the Japanese economy. Accordingly, in this section we assess the transmission mechanism of shocks to the inflation target using a version of the Federal Reserve staff's forward-looking, multicountry, dynamic general equilibrium model, SIGMA. We conduct our simulations in a three-country version of SIGMA that includes the United States, Japan, and an aggregate "rest of the world" (ROW) block comprised of all other foreign countries. The properties of the model are described in Erceg, Guerrieri, and Gust (2006). As in the model of the previous section, we assume a baseline where Japan is expected to be in a liquidity trap until 2017.

Studying inflation dynamics using SIGMA allows us to quantify the role of both domestic and foreign sources of inflation. An important feature of SIGMA is the assumption that producers in each country are assumed to set prices in the local buyers' currency, but are subject to Calvo-style price rigidities in doing so. We choose a calibration of SIGMA that assumes that Japanese exporters (to the United States and ROW) change their prices very infrequently, whereas U.S. and ROW exporters (who export to Japan) adjust their prices relatively more frequently. This assumption captures the behavior of Japanese import and export prices in the aftermath of the large depreciation of the yen since the beginning of Abenomics. As shown in Figure 4, Japanese import prices (in yen) have risen almost one-for-one with the weaker yen, thus indicating a large pass-through.[11] Japanese export prices (measured in yen) have also risen nearly one-for-one, but this result suggests limited pass-through on the export side. To the extent that changes in the inflation target affect exchange

[11] The drop in import prices since mid-2014 is fully attributable to the drop in oil and other energy prices.

rates, the degree of pass–through from exchange rates to trade prices should in turn affect the response of net exports and GDP.

A fully credible inflation target shock in SIGMA produces substantially larger effects on GDP and on inflation when the economy is a deep liquidity trap. Figure 11 shows that, at the ZLB, GDP rises about 3 percent above the baseline when the inflation target is raised to 2 percent, whereas the corresponding increase without the ZLB would be less than 1 percent. The large rise in GDP at the ZLB is made possible by the fact that interest rates are unchanged for several years after the shock. In turn, lower interest rates throughout the duration of the liquidity trap lead, through the UIP condition, to a large depreciation of the yen on impact. In addition, the dynamics of total (domestic and imported) inflation are affected in important ways by the behavior of the exchange rate. On impact, the large depreciation causes a surge in import prices and, in turn, in total inflation. As the short-run boost to import prices dies out, both import price inflation and total inflation decline in the medium run before slowly converging to their 2 percent target. The large responses of output and the real exchange rate when the economy is in a liquidity trap mirror the evidence in the VAR that inflation target shocks produce larger real effects in the late sample compared to the early one.

One drawback of the model with perfect observability of the target is that inflation expectations jump too quickly following a change in the inflation target. Accordingly, we proceed by introducing in SIGMA imperfect observability of the inflation target, following the same approach as in Section 4. Figure 12 shows the model dynamics when the signal-to-noise ratio is calibrated so that long-term expected inflation gradually rises to 1 percent in about two years relative to the baseline, thus mirroring the actual behavior of expected inflation in the data documented in Section 2. All told, the gradual rise in inflation curbs the decline in real interest rate and thus the output response.

Regardless of what one assumes about the credibility of changes in the inflation target, it is of independent interest to offer a more complete account of the probable real effects of Abenomics when we calibrate the model in order to simultaneously match both the change in inflation expectations and the substantial depreciation of the yen which took place since late 2012. In Figure 13, we combine the inflation target shock with an exogenous increase in the risk premium on home-currency-denominated assets so to generate a 15 percent depreciation of the real yen index. In the imperfect credibility case, the two shocks combined yield a rise in GDP relative to the baseline of about 4 percent. On impact, inflation jumps to 2 percent as soon as the higher inflation target is announced. However, as the one-off effect of the yen's depreciation dissipates, total inflation recedes to about 1 percent before slowly rising to its higher target.

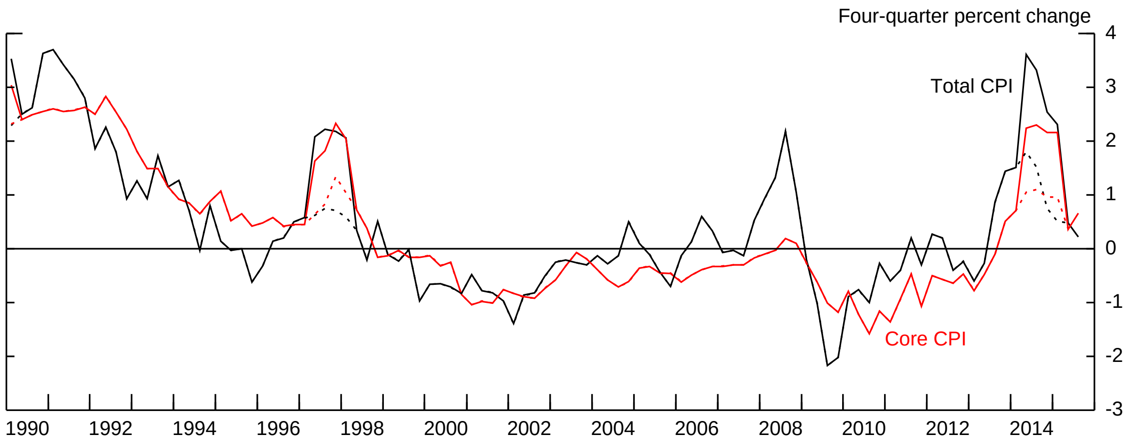
6 Conclusions

Policymakers are confronted with a credibility issue with every big change in policy. In this paper, we argued that the Bank of Japan is facing such a problem now, and further bold actions are needed to raise inflation to 2 percent in a stable manner.

The arguments presented in this paper formalize, using the framework proposed by Erceg and Levin (2003), the "timidity trap" recently illustrated by Krugman (2014): "But what does it take to credibly promise inflation? Well, it has to involve a strong element of self-fulfilling prophecy: people have to believe in higher inflation, which produces an economic boom, which yields the promised inflation. But a necessary (not sufficient) condition for this to work is that the promised inflation be high enough that it will indeed produce an economic boom if people believe the promise will be kept."

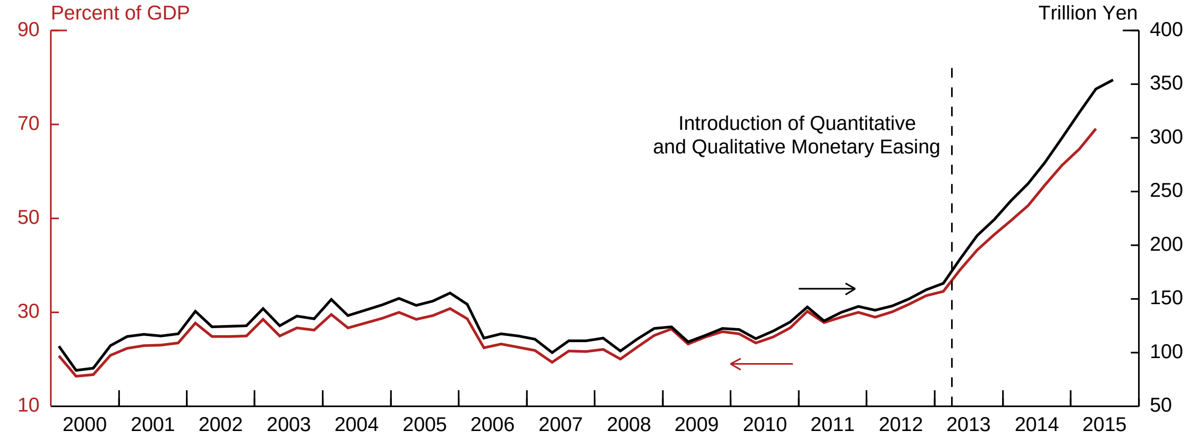
We conclude by highlighting two directions for future work. First, our analysis assumes that the degree of credibility of a central bank is given and exogenous. A natural extension of our analysis would be to examine what steps a central bank can take to improve the credibility/observability of a new inflation target, following insights from the monetary policy commitment literature (Schaumburg and Tambalotti 2007). Second, structural reforms – one of the stated goals of Abenomics – could exert deflationary pressures (Eggertsson, Ferrero, and Raffo 2014) which may undermine the effects of increasing the inflation target; jointly studying the credibility of both reforms and changes in the target would be an interesting avenue for future research.

Figure 1: Total and Core Inflation in Japan



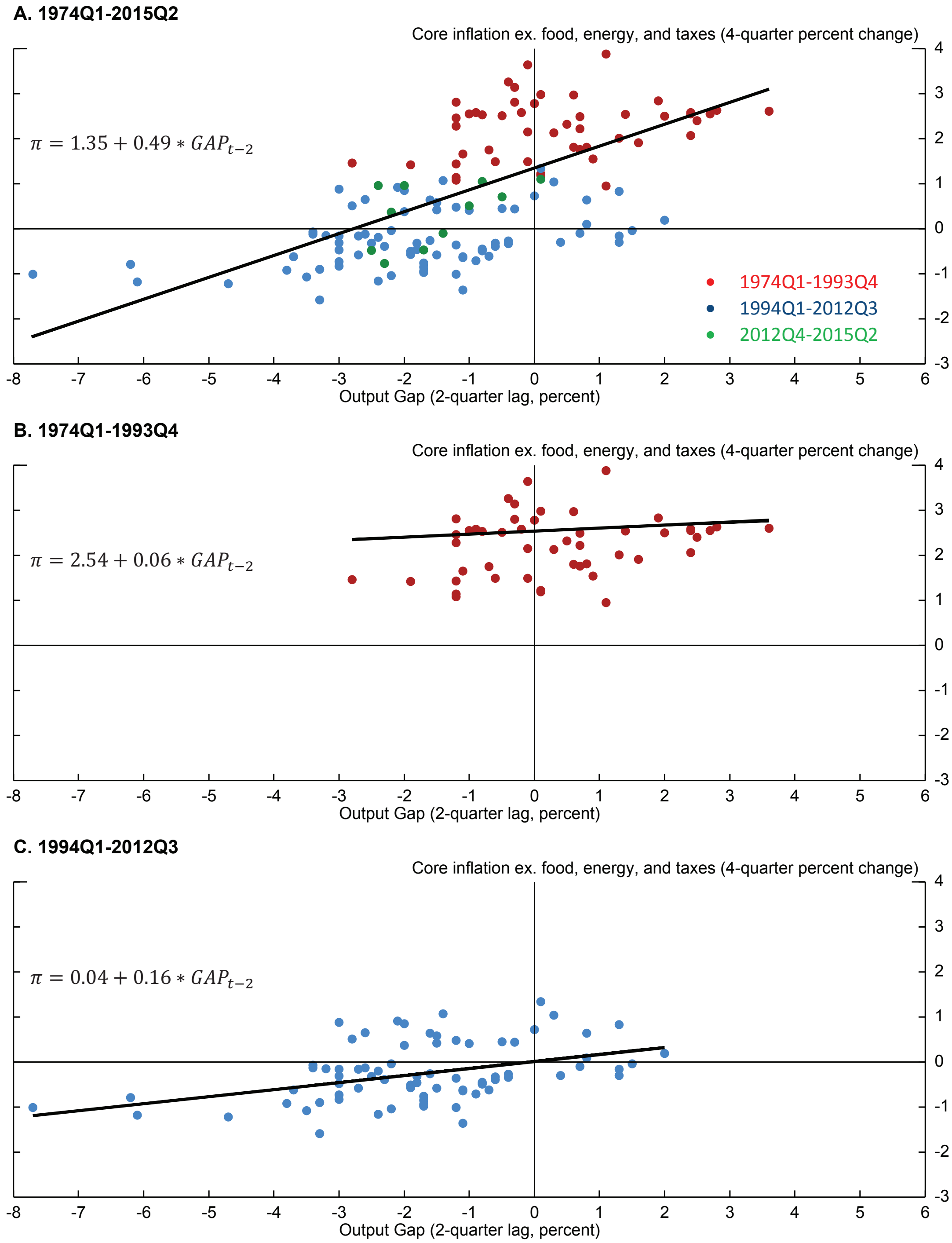
Note: The source of the data is Haver Analytics. The Haver mnemonic for the total CPI series is CIJ102@JAPAN. The core CPI (excluding food and energy prices) is based on the Haver series S158PCXG@G10. The dottel lines show total and core inflation net of the effects of the 3 consumption tax Japan introduced in April 1989 and then raised to 5 percent in April 1997 and 8 percent in April 2014.

Figure 2: Total Assets Held by the Bank of Japan



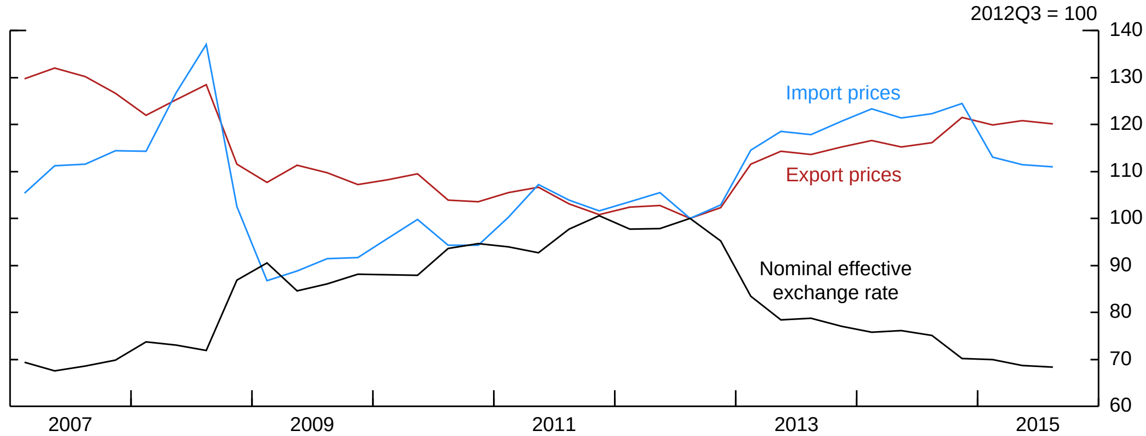
Note: The source of the data is Haver Analytics. The Haver mnemonic for the total assets held by the Bank of Japan series is ACTT@JAPAN and the nominal GDP series is N9DP2@JAPAN.

Figure 3: Phillips Curves



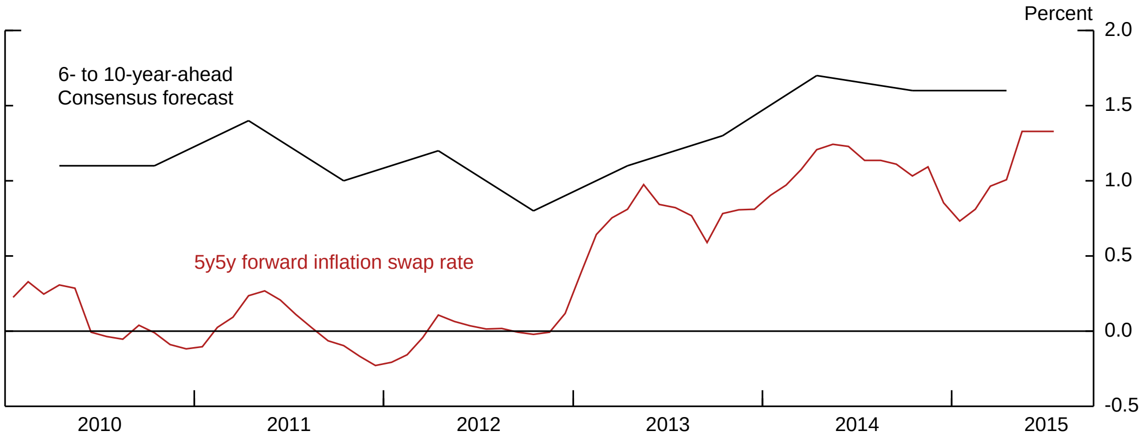
Note: The source of the data are Haver Analytics. Core inflation is four-quarter change in the consumer price level, net of consumption tax changes and food and energy prices and the output gap is from Japan's Cabinet Office (JPGDPG@JAPAN). The equations on the left side of each panel report the results of a simple regression of the core inflation over a constant term and the 2 -quarter lagged output gap for the relevant sample period.

Figure 4: Yen, Export Prices, and Import Prices



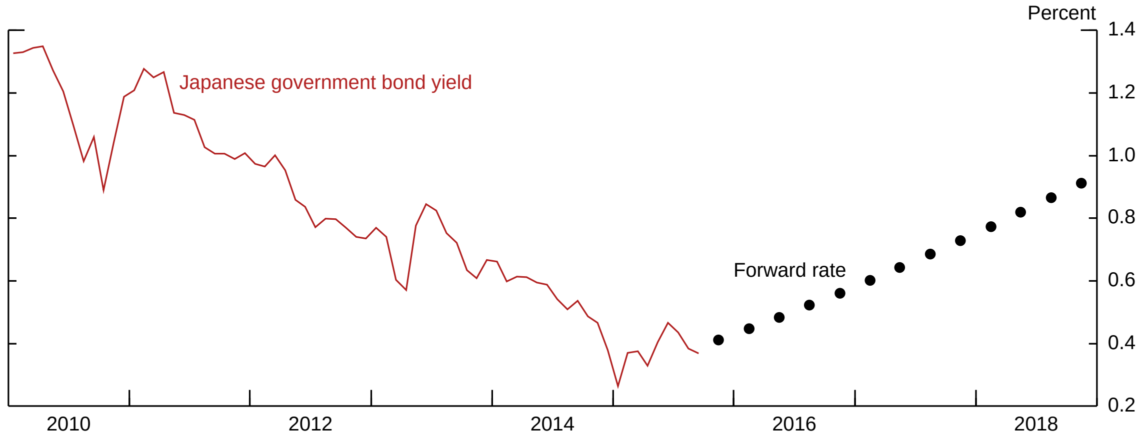
Note: The source of the data is Haver Analytics. The nominal effective exchange rate is the Bank of International Settlement's Trade Weighted Nominal Effective Foreign Exchange Rate (EERBN@JAPAN). The yen export price series is EPYA10@JAPAN and the yen import price series is IPYA10@JAPAN.

Figure 5: Japanese Inflation Expectations



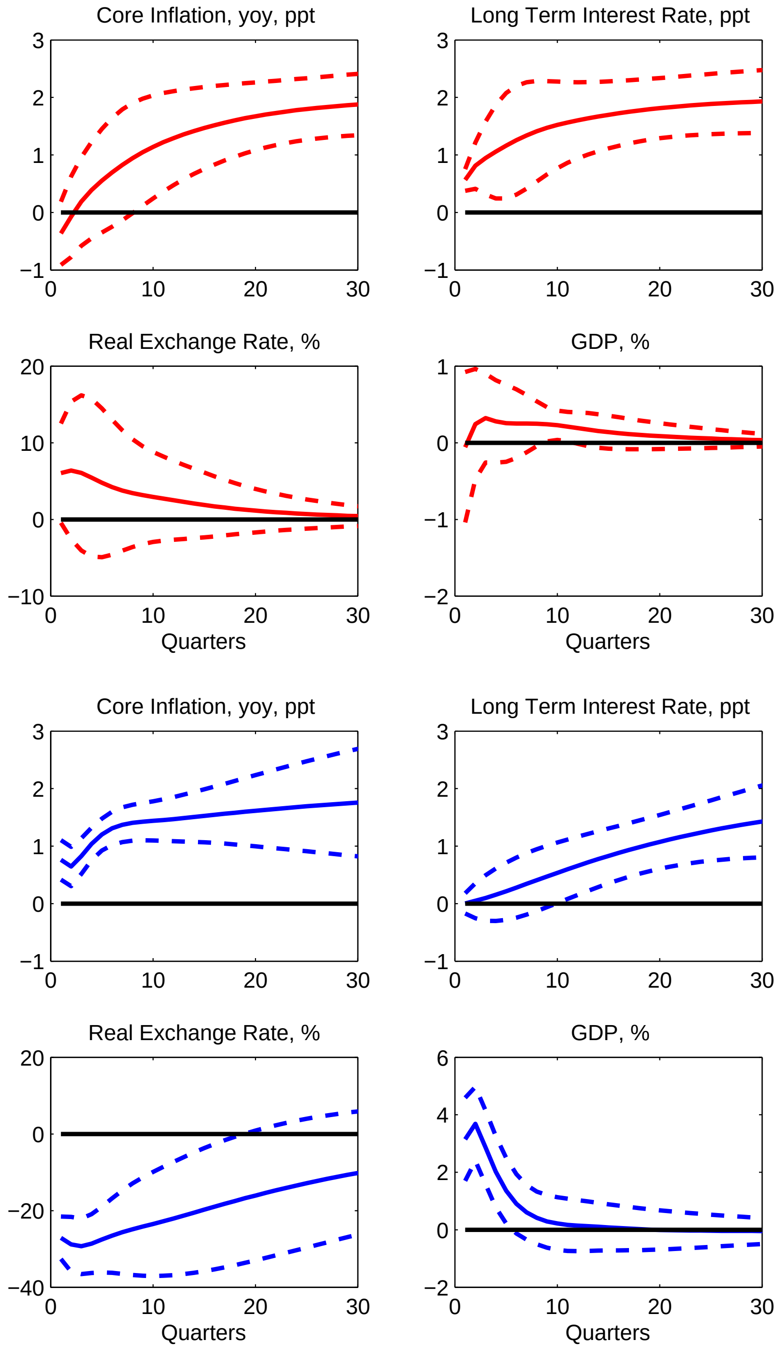
Note: The sources of the data are Bloomberg and Consensus Economics. The Bloomberg's ticker for the inflation swap rate is FWISJY55 Curncy.

Figure 6: Ten-Year Rate



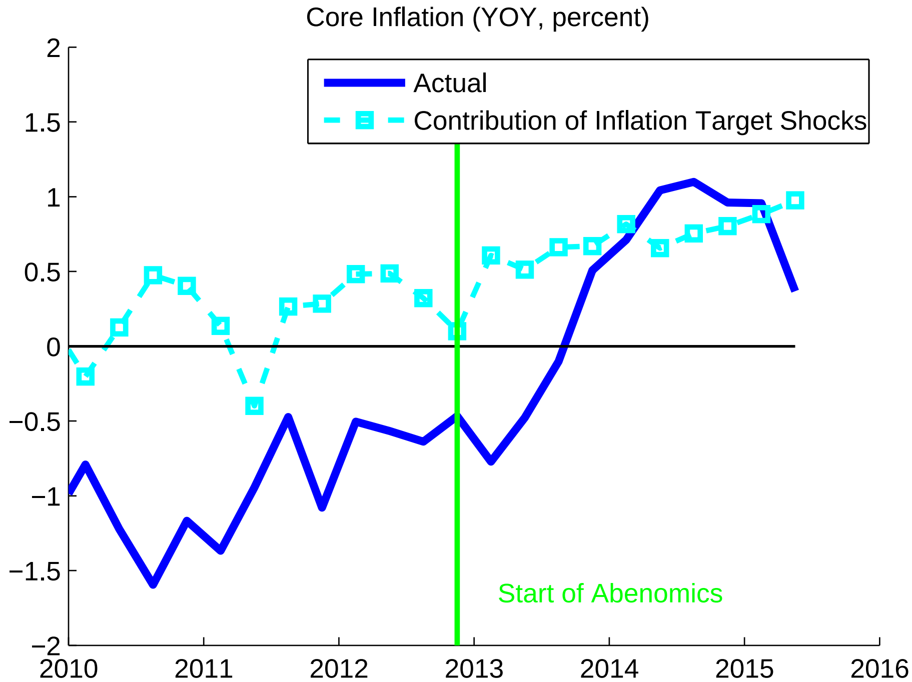
Note: The source of the data is Bloomberg. The Bloomberg ticker for the 10-year benchmark Japanese government bond yield is GJGBBNCH Index. The Japanese 10-year forward rate is estimated by the Federal Reserve Board staff based on based on a zero-coupon yield curve model.

Figure 7: Inflation Target Shocks: VAR Evidence for Japan in Two Sample Periods



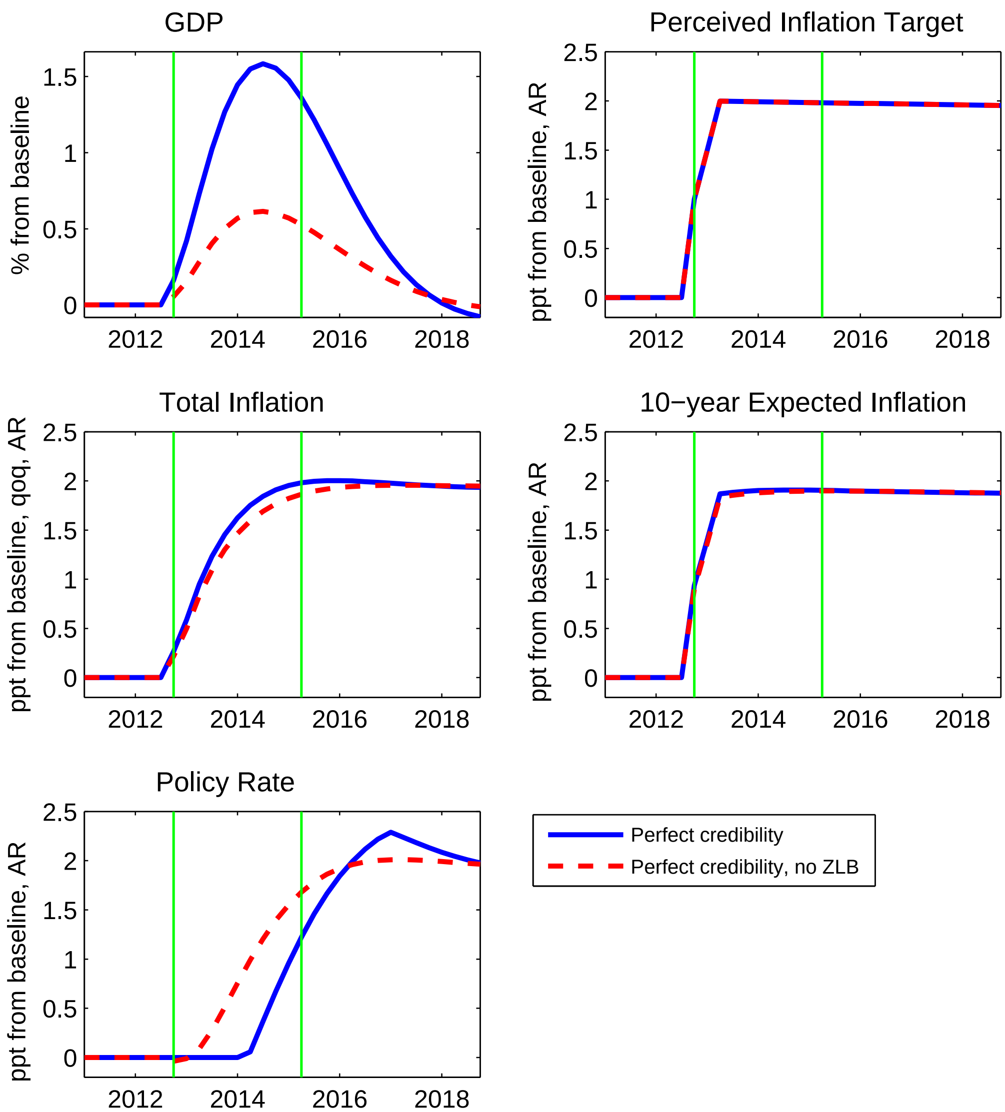
Note: The top four panels plot the impulse responses (together with one s.e. bands) to a 2 percentage point inflation target shock (3 standard deviations) in the early sample (1974Q1-1993Q4). The bottom four panels plot the impulse responses to a 2 percentage point inflation target shock (6 standard deviations) in the late sample (1994Q1-2015Q2).

Figure 8: The Contribution of the Identified Inflation Target Shock to Core Inflation



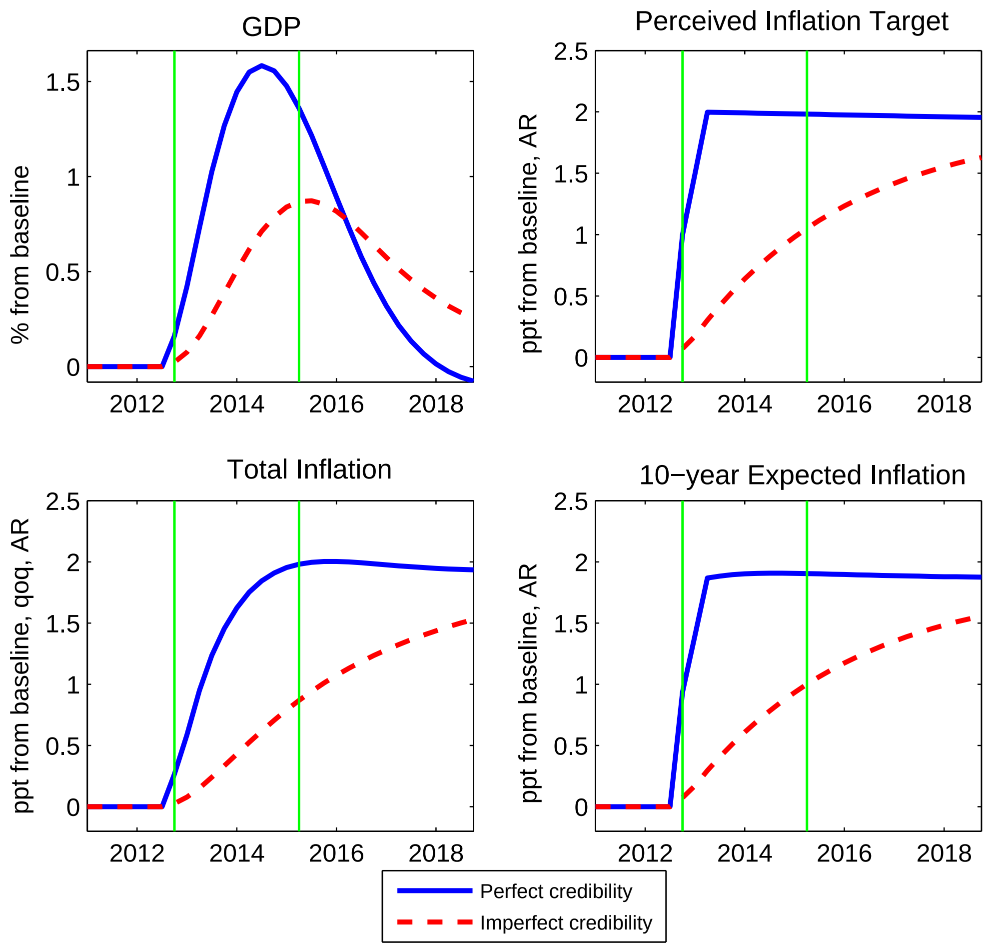
Note: The panel is based on a historical decomposition of core inflation into the shocks identified by the VAR over 1994Q1-2015Q2.

Figure 9: NK Model. Change in Inflation Target: ZLB vs No ZLB



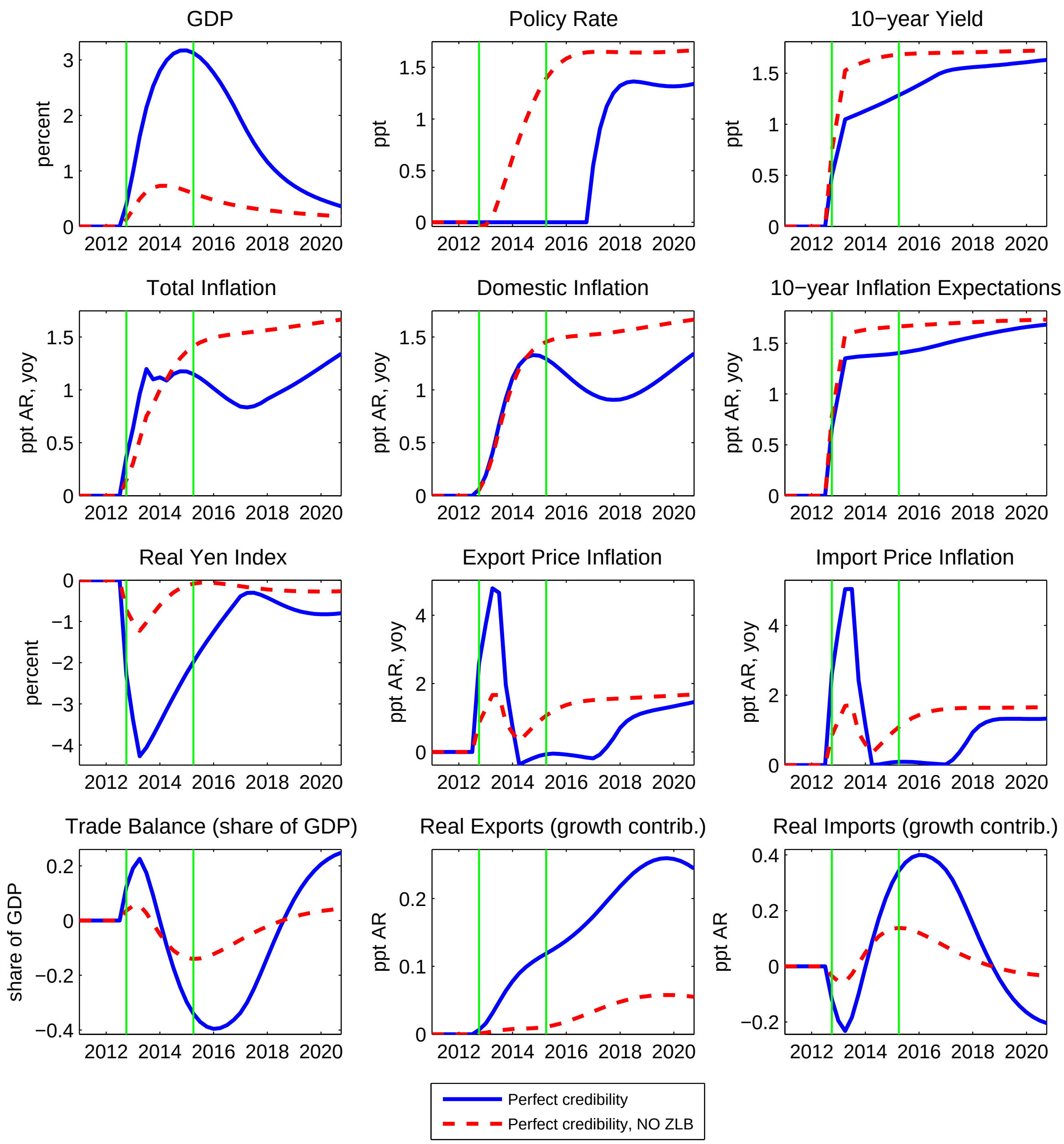
Note: The lines plot the impulse response to a 2 percentage point inflation target shock. The shock takes place over three periods (2012Q4-2013Q2). The solid lines plot the benchmark responses against a baseline where the policy rate is expected to be at zero until 2016Q4. The dashed lines plot the responses when the policy rate is not constrained by the zero lower bound (ZLB). The first vertical green line identifies the start of Abenomics (2012Q4) and the second one corresponds to 2015Q2.

Figure 10: NK Model. Change in Inflation Target: Perfect vs Imperfect Credibility



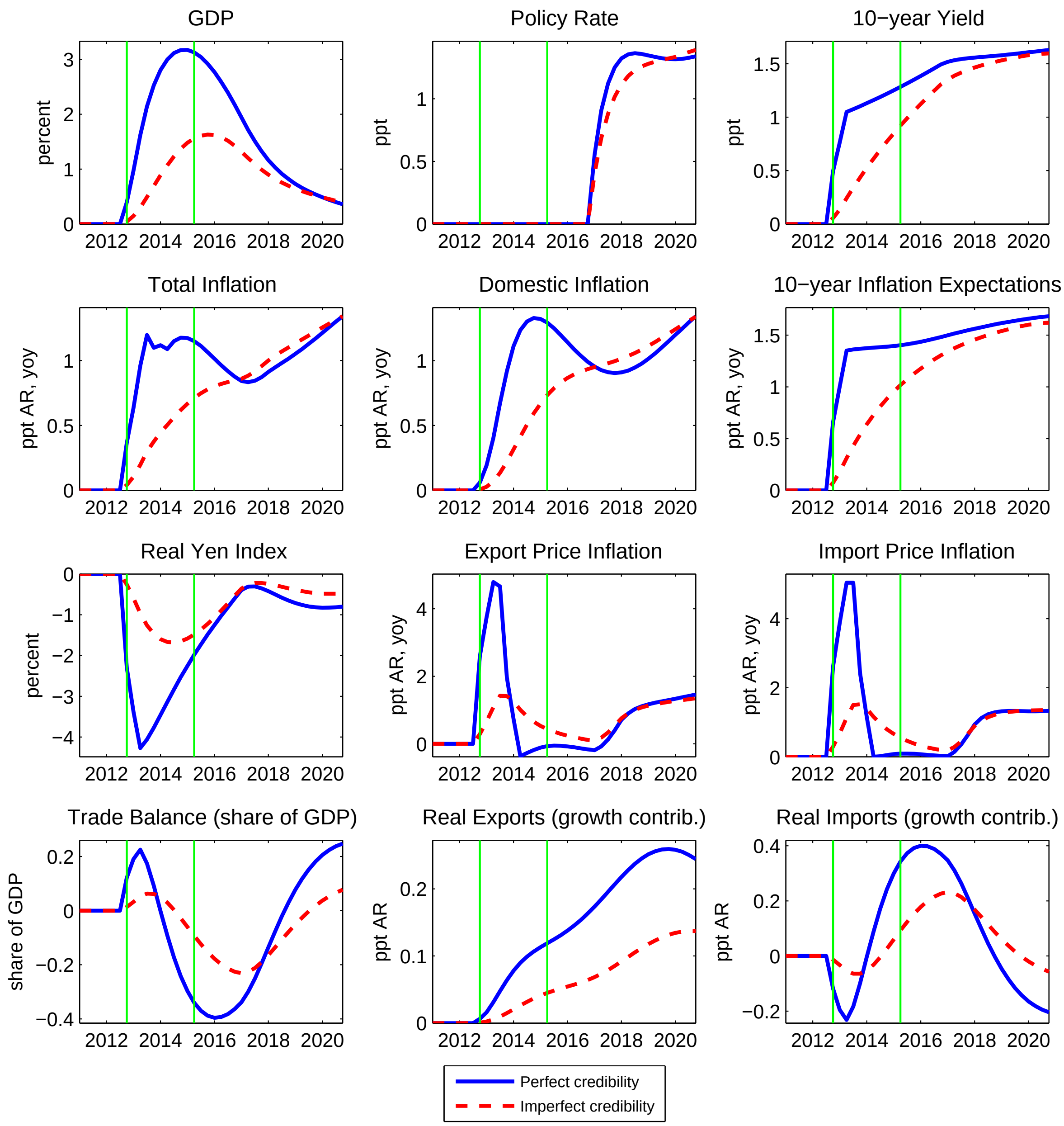
Note: The lines plot the impulse response to a 2 percentage point inflation target shock. The shock takes place over three periods (2012Q4-2013Q2) against a baseline where the policy rate is expected to be at zero until 2016Q4. The solid lines plot the benchmark case when agents have full information about the change in the inflation target. The dashed lines plot the responses when the inflation target is imperfectly observed. The first vertical green line identifies the start of Abenomics (2012Q4) and the second one corresponds to 2015Q2.

Figure 11: SIGMA Model. Change in Inflation Target: ZLB vs No ZLB



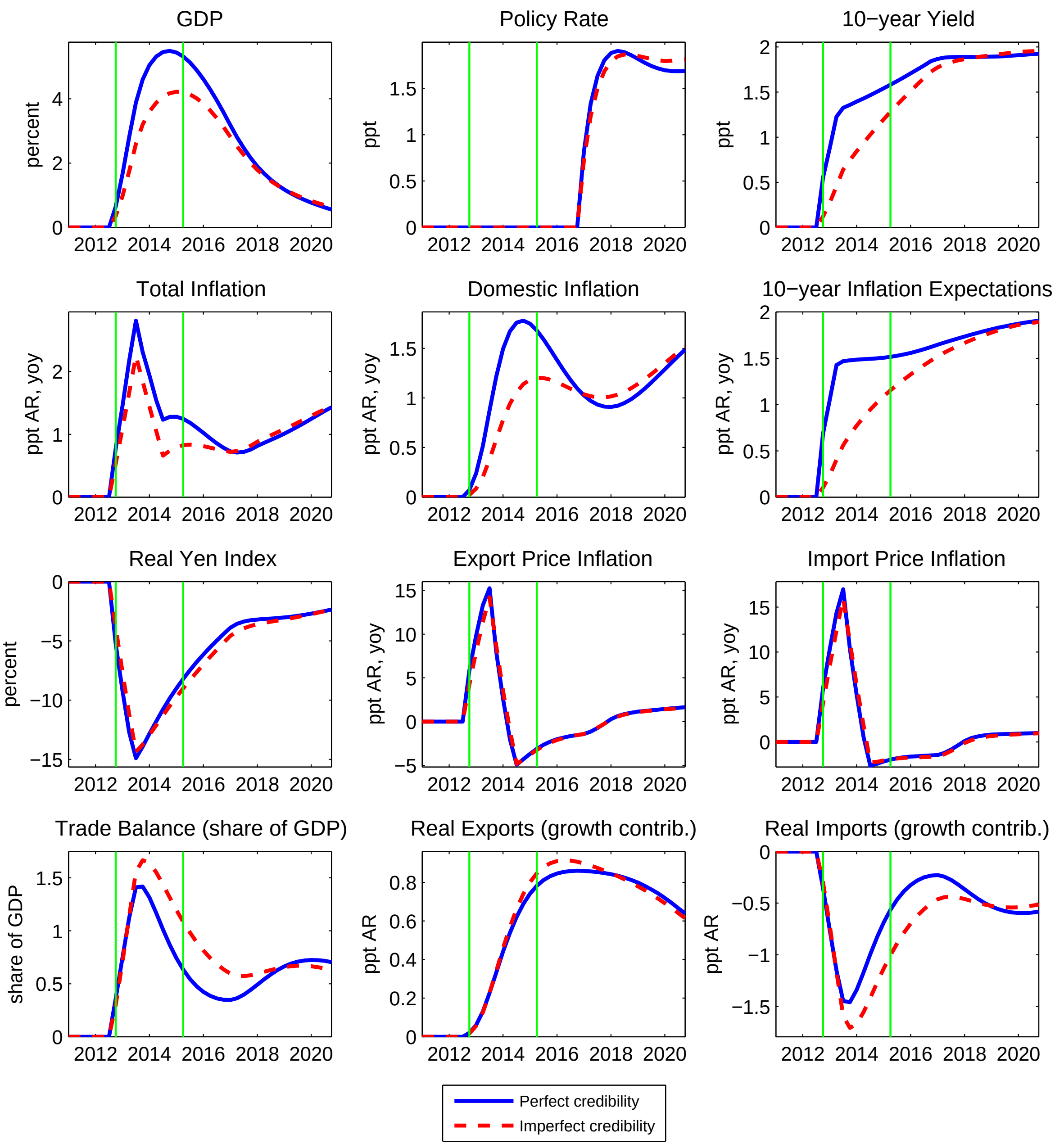
Note: The lines plot the impulse response to a 2 percentage point inflation target shock. The shock takes place over three periods (2012Q4-2013Q2). The solid lines plot the benchmark responses against a baseline where the policy rate is expected to be at zero until 2016Q4. The dashed lines plot the responses when the policy rate is not constrained by the zero lower bound (ZLB).

Figure 12: SIGMA Model. Change in Inflation Target: Perfect vs Imperfect Credibility



Note: The lines plot the impulse response to a 2 percentage point inflation target shock. The shock takes place over three periods (2012Q4-2013Q2) against a baseline where the policy rate is expected to be at zero until 2016Q4. The solid lines plot the benchmark case when agents have full information about the change in the inflation target. The dashed lines plot the responses when the inflation target is imperfectly observed.

Figure 13: SIGMA Model. Change in the Inflation Target and Exchange Rate Shock



Note: The lines plot the impulse response to a 2 percentage point inflation target shock coupled with a risk premium shock that leads to a 15 percent depreciation of the real yen index. The shock takes place over three periods (2012Q4-2013Q2) against a baseline where the policy rate is expected to be at zero until 2016Q4. The solid lines plot the benchmark case when agents have full information about the change in the inflation target. The dashed lines plot the responses when the inflation target is imperfectly observed.

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Appendix

Appendix A Robustness Analysis on the VAR

In Section 3 we show how Japanese macroeconomic variables respond to an inflation target shock using a structural VAR. The identified shock leads to a permanent increase in inflation and nominal interest rates and causes a short-lived expansion in economic activity alongside a temporary depreciation of the currency. In this Section we validate the robustness of our VAR results by applying the same identification restrictions to a VAR on U.S. data for the period 1970Q1-2013Q4. We formulate a 4-variable vector error correction model with inflation, detrended GDP, the long-term interest rate, and the real exchange rate.[12] We do not include real oil price inflation in this VAR because U.S. domestic variables arguably affect the behavior of oil prices.

Figure A.1 plots the impulse response to the identified inflation target shock for the United States. When the shock is normalized so that it leads to a 2 percentage point long-run increase in inflation (corresponding approximately to a 3 standard deviations shock), it leads to a temporary decrease in real interest rates, to a depreciation of the exchange rate (about 4 percent after one year), and to a short-run boost in economic activity. In the first year after the shock, GDP is almost 1.5 percent above the baseline, somewhere in between the response of GDP in Japan for the two sub-samples.

Appendix B Risk Premia

Section 4 and 5 showed that the dynamics under imperfect credibility seem to capture reasonably well the recent Japanese experience. However, they also imply that inflation will rise to 2 percent very slowly, rasing the question of what the BOJ could do to achieve sooner its goal. One way to break out from this slow adjustment would be to make a much bolder statement about the inflation target itself. For instance, one possibility would be to temporarily adopt an inflation target higher than 2 percent, a scenario we explore using the closed-economy model developed in Section 4. In Figure A.2, we show the responses to an additional boost in the inflation target from 2 to 3 percent between 2015Q2 and 2016Q4.

[12] The real exchange rate is the JP Morgan Broad Real Effective Exchange Rate Index for the United States, log transformed (Haver mnemonic: N111XJRB@G10). The long-term interest rate is the 10-Year Treasury Note Yield at Constant Maturity (FCM10@USECON). Inflation is the four-quarter change in the consumer price level net of food and energy (S111PCXG@G10). Finally, we extract the business cycle component of real GDP (GDPH@USECON) using a band-pass filter that selects frequencies between 2 and 32 quarters.

Following the announcement, the inflation target perceived by the agents rise much faster. Accordingly, inflation immediately accelerates and approaches 2 percent in 2016, much earlier than in the previous case. The resulting lower real rates also provide an additional lift to GDP.

There may be risks associated with such bolder policies, including the possibility that inflation might get out of control. Given Japan's precarious public finances –net debt is near 150 percent of GDP– some observers (e.g Eichengreen 2013) have discussed the possibility that a misstep in the direction of substantially higher inflation might induce investors to think that fiscal objectives have come to dominate monetary policy, triggering a self-fulling vicious cycle of destabilizing inflation and debt dynamics. In other words, fears of fiscal dominance or debt monetization might materialize in case of large enough inflation surprises, prompting a jump in risk premia. To explore such a scenario, we modify our benchmark new-Keynesian model and allow for risk premia on government debt which are triggered by increases in the inflation rate above a certain threshold. More specifically, we re-write the budget constraint, equation (1), as:

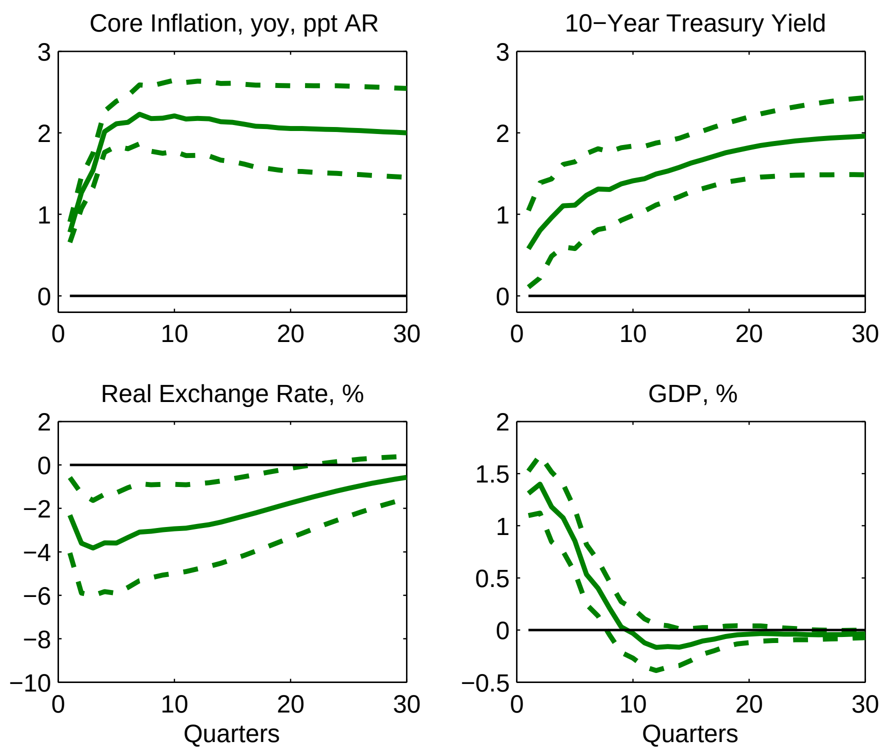
$$c_t + k_t + \phi_t = w_t n_t + \left(R_{kt} z_t + 1 - \delta\right) k_{t-1} + \text{div}_t - \tau_t - b_t + \frac{\widetilde{R}_{t-1}}{\pi_t} b_{t-1} \tag{9}$$

where the gross interest on government debt $\widetilde{R}_{t-1} = R_{t-1} + \varepsilon_t$ and the risk premium ε_t follows:

$$\varepsilon_t = \begin{cases} \alpha\left(\pi_t - \pi_{t-1}\right) & \text{if } \pi_t - \pi_{t-1} > \lambda \\ 0 & \text{if } \pi_t - \pi_{t-1} \leqslant \lambda \end{cases} \tag{10}$$

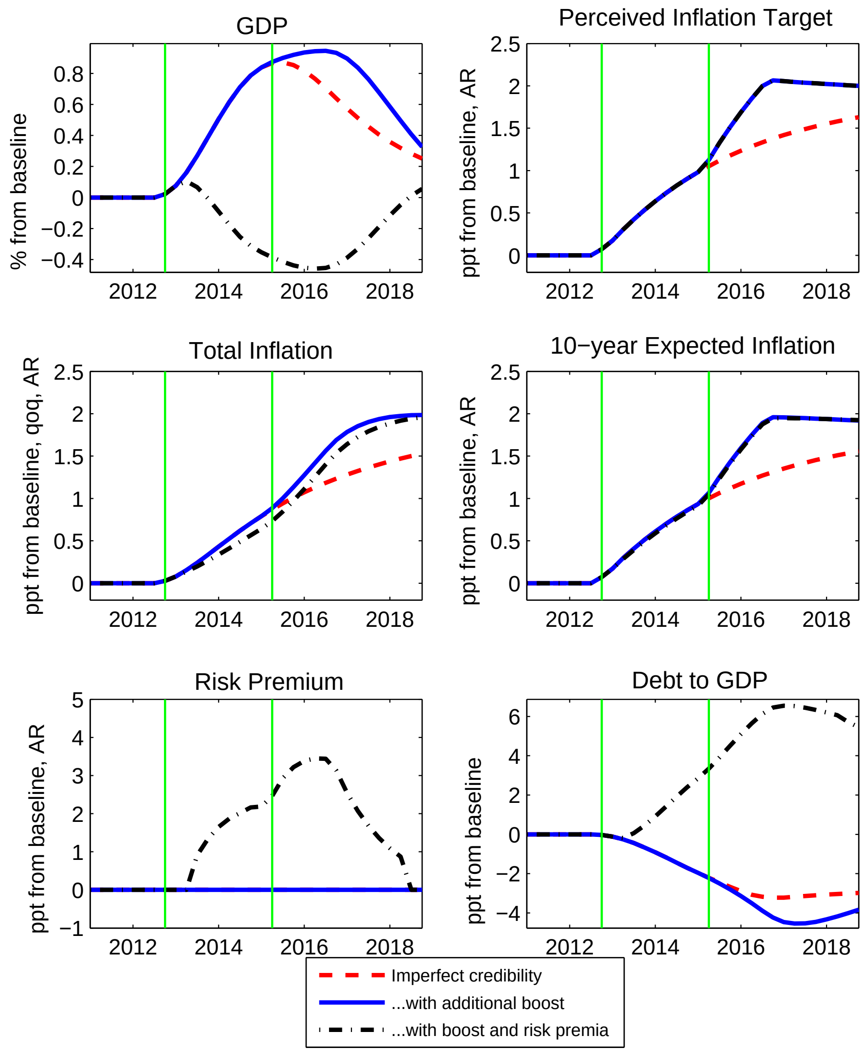
where $\alpha > 0$ is a scaling factor. To the extent that inflation does not accelerate too quickly between one period and the next, $\varepsilon_t = 0$, and the model is unchanged. By contrast, when inflation accelerates quickly, ε_t is positive and the risk premium shock enters the households's first order condition for government debt. Figure A.2 shows the model dynamics when the additional boost to the inflation target leads to a faster pickup in inflation and, in turn, to a rise in risk premia. We set $\lambda = 0.01$ and $\alpha = 20$, so that when quarterly inflation rises at at an annual pace faster than 0.05 percentage point, risk premia increase roughly 400 basis points after eight quarters, a calibration that mimics the rise in sovereign risk spreads of the vulnerable euro-area countries during the European debt crisis. In this scenario, inflation expectations still meet the 2 percent target in 2016, but the rise in risk premia causes output to fall and the debt-to-GDP ratio to rise 6 percentage points above baseline. As a result of the dip in output, inflation rises a bit more slowly.

Figure A.1: Inflation Target Shocks: VAR Evidence for the United States



Note: The panels plot the impulse responses (together with one s.e. bands) to a 2 percentage point inflation target shock (about 3 standard deviations) in the United States for the period 1970Q1-2013Q4.

Figure A.2: NK Model. Change in Inflation Target: Imperfect Credibility and Risk Premia



Note: The lines plot the impulse response to a 2 percentage point inflation target shock. The shock takes place over three periods (2012Q4-2013Q2) against a baseline where the policy rate is expected to be at zero until 2016Q4. The dashed lines plot the responses when the inflation target is imperfectly observed. The solid lines plot the responses when the target is imperfectly observed, and the central bank announces a temporary increase in the inflation target from 2 to 3 percent between 2015Q2 and 2016Q4. The dash-dotted lines plot the responses when the target is imperfectly observed, the central bank announces a temporary increase in the inflation target from 2 to 3 percent between 2015Q2 and 2016Q4, and risk premia reacts endogenously when inflation increases more than 0.05 percentage point between one quarter and the next.