

# ECB spillovers and domestic monetary policy effectiveness in small open economies

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## Abstract

In this paper, we examine whether financial spillovers from the European Central Bank's monetary policy have consequences for the effectiveness of domestic monetary policy in small open economies. Recent work suggests that the trilemma in international economics as we used to know it, is actually a dilemma: even with floating exchange rate regimes, small open economies can only have effective monetary policies when the capital account is managed. We find that although domestic monetary policy seems to be effective for the shorter end of the yield curve, ECB spillover effects reduce domestic control over the longer end of the curve. In the dilemma/trilemma debate, this result leans towards a dilemma: the transmission channel of domestic monetary policy decisions operates through the whole yield curve and hence is weakened considerably if the medium to long term lending and bond rates are little affected.

**Keywords:** monetary policy effectiveness, global financial cycle, international spillovers, asset prices, small open economies

**JEL classification codes:** E43; E44; E52; E58; G12

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# 1 Introduction

Over the recent years, it has become clear that monetary policy conducted by large central banks may have substantial spillover effects on other countries, and that global financial integration can make monetary policy less effective in general. Rey (2015) argues that lending conditions of global financial institutions, as well as credit growth and capital flows, are largely driven by the global financial cycle, which in turn is mostly determined by monetary policy of the major central banks. This leads her to argue that rather than the classical *trilemma* (“with free capital mobility, effective monetary policies are feasible if and only if exchange rates are floating”), we are dealing with a *dilemma*: effective national monetary policy is only possible with some capital controls, regardless of exchange rate regime.

Against this background, policy decisions and statements by major central banks, like the Federal Reserve (Fed) and the European Central Bank (ECB), are likely to cause spillovers to other countries and may even impair the ability of central banks in small open economies (SOEs) to have an effective monetary policy.<sup>1</sup> In this paper, we argue that although central banks of SOEs that are highly integrated with the euro area are able to affect the shorter end of their domestic yield curve, ECB spillover effects reduce the domestic control over the longer end of the curve.

The empirical literature on how economic and financial variables in a country are affected by foreign monetary policy is dominated by studies looking at spillovers from the Fed to emerging market economies<sup>2</sup> and between advanced economies.<sup>3</sup> There are also several studies that evaluate spillovers from the US to a large number of countries, often focusing on equity markets.<sup>4</sup> The literature on spillovers from the ECB includes Fratzscher et al. (2016) and Georgiadis and Gräß (2016), who find positive spillovers of ECB’s unconventional policies on equity markets and confidence in advanced economies. Furthermore, Burriel and Galesi (2018), Georgiadis (2015) and Leombroni et al. (2017) find that ECB’s monetary policies, both conventional and unconventional, have hetero-

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<sup>1</sup>By comparison, Georgiadis and Mehl (2016) find that increased financial globalisation has amplified, rather than muted, monetary policy effectiveness.

<sup>2</sup>See e.g. Takats and Vela (2014), Chen et al. (2014), Tillmann (2016) and Gilchrist et al. (2018).

<sup>3</sup>See e.g. Ehrmann et al. (2011), Rogers et al. (2016), Bauer and Neely (2014) and Neely (2015).

<sup>4</sup>See e.g. Ehrmann and Fratzscher (2009), Hausman and Wongswan (2011) and Dedola et al. (2017).

geneous effects on countries within the euro area.

The literature on the effect of ECB's monetary policy on non-euro area SOEs, however, is scarce. Falagiarda et al. (2015) use high frequency identification (HFI) to show that spillovers occur from the ECB's unconventional monetary policy to yields in non-euro area countries from Central and Eastern Europe. Also, by means of a factor-augmented VAR, Potjagailo (2017) finds large monetary policy spillovers to 14 European non-euro area countries, with the strongest effects for countries with fixed exchange rates.

In this paper, we examine the spillover effects of unexpected changes in ECB monetary policy on asset prices and yields in three SOEs that are comparable to each other and highly integrated with the European (Monetary) Union: Denmark, Norway, and Sweden. These are interesting cases because of their varying degree of integration and monetary policy independence: Denmark and Sweden are both members of the European Union (EU), but have not adopted the euro. Norway is not an EU member, but a member of the European Economic Agreement (EEA), which provides for the inclusion of EU legislation covering among other things the "four freedoms" (i.e. free movement of capital, goods, services and persons). Furthermore, Denmark has an exchange rate peg to the euro, whereas Sweden and Norway have floating exchange rates and independent monetary policies practising inflation targeting.

We focus on financial variables, i.e. interest rates, equity prices and exchange rates. These variables respond instantly to unexpected changes in monetary policy and are typically considered starting points of the transmission mechanisms initiated by a monetary policy decision. Several studies (e.g. Canova (2005), Kim (2001), Feldkircher and Huber (2016)) have found that for US monetary policy, the transmission channel through interest rates is the most important.

Moreover, we look at both spillovers from unexpected changes in the key policy rate and unexpected changes in measures affecting the expected path of monetary policy<sup>5</sup>, like communication about future policy (forward guidance) or asset purchase programmes. We distinguish between the two policy surprises using high frequency identification (HFI)

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<sup>5</sup>Brand et al. (2010) find that market expectations for the path of monetary policy change considerably during the press conference following a key policy rate decision by the ECB.

techniques.<sup>6</sup> We adopt the methodology of Gürkaynak et al. (2005) and apply factor analysis on several European money market instruments to identify an ECB *target* factor and *path* factor.

We study the impact of the ECB target and path surprises in two steps. First, we analyse the spillover effects of such policies in two countries that are economically and financially integrated with the euro area, but have independent monetary policies with floating exchange rates: Norway and Sweden. Second, we compare these spillover effects to a comparable country that has an exchange rate peg to the euro: Denmark. We also propose a sample split when the ECB's deposit rate hit zero to examine whether the monetary policy transmission has altered after key policy rates entered effective lower bound (ELB) territory.

Our findings suggest that both factors have strong and significant effects on all three countries. Whereas the spillover effects of target surprises die out quickly, the path surprises are very persistent and may therefore also affect real economic variables in these countries. Moreover, for interest rates with maturities of two years or more, we find that both surprises have stronger spillover effects in the ELB period, in many cases twice as strong as during normal times.

Finally, by the same methodology, we investigate the impact and persistence of domestic monetary policy surprises on financial variables in Norway and Sweden. We find that both target surprises and path surprises are effective in moving market rates, and that the effects are more persistent than their European counterparts for the shorter end of the yield curve. The domestic surprises also have a significant effect on the longer end of the yield curve, but these effects are less strong than the spillover effects from the ECB surprises. Control over the domestic yield curve therefore seems to diminish for the longer end of the curve. In the dilemma/trilemma debate, this result leans towards a dilemma: the transmission channel of domestic monetary policy decisions to vital economic variables like output and inflation operates through the whole yield curve and hence is weakened considerably if the medium to long term lending and bond rates are

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<sup>6</sup>Several papers have assessed responses to monetary policy shocks in a HFI framework, see e.g. Andrade and Ferroni (2018), Campbell et al. (2012), Brubakk et al. (2017), Gürkaynak et al. (2005), Hamilton (2008), Hanson and Stein (2015), Kuttner (2001), Nakamura and Steinsson (2018) and Swanson (2018).

little affected.

The remainder of the paper is organised as follows: section 2 presents the data. Section 3 provides an overview of the applied identification methods. The empirical analysis and results are presented in section 4. Section 5 concludes.

## 2 Data

We analyse intraday data on a variety of European, Norwegian, Swedish, and Danish financial variables for all days with an ECB monetary policy announcement and associated press conference from January 2002 to June 2018.<sup>7</sup> Over the sample period, the ECB had 185 meetings with key policy rate decisions.

As part of our analysis, we divide the data sample into two subsamples to examine whether the high frequency monetary policy transmission has altered after key policy rates entered effective lower bound (ELB) territory. We refer to the subsamples as the pre-ELB and ELB periods and make the sample split at the time when the ECB's deposit rate hit zero in July 2012. The meeting on 5 July 2012, in which the deposit rate was lowered to zero, is the last meeting included in the pre-ELB period. We consider this an intuitive split of the sample because further expansionary measures would require an unconventional response (e.g. lowering rates into negative territory or introducing asset purchase programmes), which may affect the markets differently due to the lack of historical references.

In the factor analysis in section 3.2, we use European OIS rates for one, three, six, nine, 12, 18, and 24 months.<sup>8</sup> We also use the five- and ten-year German Treasury bonds, the STOXX50, and the EURUSD exchange rate (dollars per euro) to get an idea of the size of the impact of monetary policy for euro area rates.

In the evaluation of spillover effects, we make use of a wide variety of financial deriva-

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<sup>7</sup>We choose not to start earlier as Rosa and Verga (2008) show that it took market participants until 2001 to learn how to interpret and trust signals from the ECB. Moreover, the ECB only held press conferences for every second rate decision in 2001.

<sup>8</sup>European OIS contracts are fixed-for-floating interest rate swaps where the Euro Overnight Index Average (EONIA) is the floating leg interbank rate, i.e. the weighted average of the interest rates on overnight unsecured transactions for the panel banks (<http://www.emmi-benchmarks.eu/euribor-eonia-org/about-eonia.html>).

tives contracts that reflect short, medium, and long term interest rates, including money market rates up to one year (FRAs), and interest rate swaps with maturities of two, five, and ten years. We use swap rates rather than government bond yields due to the low volume and poor liquidity of the Norwegian bond market in particular. The FRA market is regarded the most liquid part of the Norwegian, Swedish and Danish money markets. The FRA contracts reflect the short to medium end of the yield curve, while the swap contracts reflect the expected average short term interest rates over the two-, five-, and ten-year horizons.<sup>9</sup> We include the first to fourth quarter FRA contracts. These contracts capture the three-month interest rate in one to four quarters out. For equity prices, we use data for the OSEBX (Norwegian) and OMX (C-Danish and S-Swedish) equity indices.

Variables are obtained from one-minute frequency observations from the Thomson Reuters Tick History database. The data are aggregated from tick-by-tick data by Thomson Reuters. The observation at the time of the ECB policy decision press release, at 1:45 p.m., is the latest mid-price before that exact time (e.g. the average of the best prevailing bid and ask quotes at 1:44:59 p.m.).<sup>10</sup>

To construct the domestic monetary policy surprises in Norway and Sweden, we make use of a one-month rate<sup>11</sup>, the first to fourth quarter FRA contracts and the two-year swap rate. The sample period is the same as for the ECB sample, and the event windows are of the same length as the one used for the ECB announcements (section 3.2). Over the sample period, Norway had 127 meetings and Sweden had 110 meetings with key policy rate decisions.

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<sup>9</sup>*Forward rate agreements* (FRAs) are over-the-counter (OTC) cash-settled agreements to exchange fixed interest rate and reference rate (NIBOR) payments on a notional amount of NOK 1 million. *Interest rate swaps* are agreements between two parties to swap interest rate payments where the buyer pays a fixed rate (swap rate) and the seller pays the floating rate for a pre-determined period.

<sup>10</sup>If an observation is missing, we assume that there is no change from the previous non-NaN observation. The underlying quotes are only based on the top of the (order) book, that is, only the best quotes prevailing at the time are used to calculate a mid-price from a bid and an ask quote.

<sup>11</sup>This rate is a synthetic one-month interest rate instrument constructed by the use of forward exchange rates (USDNOK and USDSEK) in combination with covered interest parity. The rate is constructed because Norway does not have an OIS or interest rate futures market, and the Swedish series is too short. For more details on this one-month rate, see Brubakk et al. (2017).

## 3 Identification

### 3.1 High frequency identification

In line with Kuttner (2001) and Gürkaynak et al. (2005), among others, we identify the unexpected changes in monetary policy by using an interest rate instrument that covers expectations about the short term monetary policy stance. Potential instruments consist of overnight index swaps (OIS) and futures rates with maturities shorter than the time between two ECB monetary policy meetings. As there is no futures market for the ECB key policy rate, we use OIS rates. At the day of the ECB monetary policy meeting, if  $t$  is some time after the policy rate announcement, and  $t - j$  is right before the announcement, then  $\Delta i_t^{OIS} = i_t^{OIS} - i_{t-j}^{OIS}$  is assumed to be the unexpected part of the ECB policy rate decision.

Since the beginning of the sample, the ECB key policy rate decision has been announced in the press release at 1:45 p.m., followed by a press conference 45 minutes later, at 2:30 p.m.<sup>12</sup> We define the *full announcement window* as the time window from 1:30 p.m. to 3:45 p.m., containing both the press release and the press conference.

### 3.2 Factor analysis using principal components

Through its monetary policy announcements, the ECB provides information about its current rate decision and future monetary policy. Therefore, changes in market rates around the time of these announcements may not only contain a key policy rate surprise, but also a surprise related to the future path of the key policy rate. Since we are interested in all dimensions of the monetary policy surprises, we need to employ methods to separate the two components. Following Gürkaynak et al. (2005), we apply principal component analysis on changes in various interest rates around the time of the ECB's monetary policy announcements to extract a *target* factor (i.e. the key policy rate surprise) and a *path* factor that together explain most of the variation in these rates around the chosen time window. In order to extract the factors, we use data on interest rate changes of

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<sup>12</sup>All times are in CET. The press conference lasts approximately 45 minutes and consists of an introductory statement with a subsequent session of Q&As.

maturities up to two years. This can be represented by:

$$X = F\Lambda + \eta \tag{1}$$

where  $X$  is a  $T \times n$  matrix of  $T = 185$  ECB key policy rate announcements and  $n = 7$  European financial variables: the one-, three-, six-, nine-, 12-, 18-, and 24-month European OIS rates.<sup>13</sup>  $F$  denotes a  $T \times k$  matrix of the unobserved factors with  $k < n$ , and  $\Lambda$  is a  $k \times n$  matrix of factor loadings.  $\eta$  represents white noise error terms. Each element of  $X$  is the change in one of the  $n$  variables for the full announcement window. Using principal component analysis on  $X$ , we extract the unobserved factors  $F$ .<sup>14</sup>

The Cragg-Donald test rejects the hypothesis of more than two factors at the 5 percent level. Hence, the test implies that in addition to the target factor, one factor is enough to explain variation in European interest rates within the full announcement window.

Furthermore, to provide a more structural interpretation of the factors, we again follow Gürkaynak et al. (2005) and rotate the two extracted factors  $F_1$  and  $F_2$  into a new set of factors denoted  $Z_1$  and  $Z_2$ .<sup>15</sup> The most important identifying restriction is that a path surprise should move interest rates with maturities beyond the current policy meeting, but should not at all be related to the surprise in the current key policy rate. In other words, only the first rotated factor,  $Z_1$ , should load onto the interest rate with the shortest maturity, which is the one-month European OIS rate (i.e. the first column of matrix  $X$ ). Consequently,  $Z_1$  may be interpreted as the policy rate surprise, and  $Z_2$  may be interpreted as all other information in the event window that changes financial

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<sup>13</sup>The one-month OIS rate provides a good estimate of the market expectation of the ECB's key policy rates for the closest upcoming Governing Council meeting. For robustness tests, we have investigated several specifications: we expanded  $X$  with five-year and ten-year German Treasury yields, and we have extracted the factors separately for the two subsamples. Correlations were very high (between 0.899 and 0.999). The only specification that does not give similar factors, is when we use an announcement window that excludes the press conference. In that case, the target factors are very similar, but the path factors are not. For more details on the latter, see section A.2 in the Appendix.

<sup>14</sup>Jarociński and Karadi (2018) propose an alternative way of separating different components of monetary policy surprises. By assuming that the co-movement of interest rates and stock prices in the narrow window around the ECB announcement is informative in itself, they define the conventional policy surprises as the negative high-frequency co-movements (because unexpected higher interest rates should lower asset price valuation through conventional transmission channels) and the positive high-frequency co-movements as the presence of some other information, defined as an information surprise. Note that their method focuses on one particular interest rate surprise (three months).

<sup>15</sup>The computational details of this factor rotation can be found in the appendix of Gürkaynak et al. (2005).



market expectations about the future path of key policy rates (Swanson (2018)). Prior to the ECB's introduction of asset purchases, the extracted path factor is likely to mainly capture surprises in the communication about future policy intentions (forward guidance). After the ECB started its asset purchase programmes, however, we expect the path factor to also capture unexpected information related to asset purchases.

Finally, to facilitate the interpretation of the rotated factors,  $Z_1$  is rescaled such that it moves one-for-one with the surprise component of the key policy rate setting (measured as the change in one-month OIS). Hence,  $Z_1$  can be interpreted as basis points surprise changes in the one-month OIS. Moreover,  $Z_2$  is rescaled so that it can be interpreted as basis points surprise change in the one-year OIS, in line with Leombroni et al. (2017). For the domestic monetary policy surprises in Norway and Sweden, the rescaling of the factors occurs in the same fashion as for the European factors: the target factor is rescaled to be interpreted as basis points surprise change in the domestic one-month rate, and the path factor is rescaled to be interpreted as basis points surprise change in the domestic one-year rate.

Table 1 shows the results of regressing the input variables ( $X$ ), as well as longer term rates, the equity index, and the EURUSD, on the two rotated and rescaled factors ( $Z_1$  and  $Z_2$ ). The coefficient estimates on the input variables ( $X$ ) can be interpreted as the loadings of  $Z_1$  and  $Z_2$ . The results imply that the overall effects of a target surprise are strongest for the shortest maturities and die out for longer maturities, consistent with theory (key policy rates affect the shorter end of the yield curve). Furthermore, the path factor,  $Z_2$ , has the characteristic hump-shape with strongest effects on European interest rates with maturities of about 18 to 24 months. These findings are in line with what Gürkaynak et al. (2005) and Swanson (2018), among others, find for the US, and what Brubakk et al. (2017) find for Norway and Sweden.

For equity prices, there is a slight decline in the European stock market following a positive target surprise and no significant response from a path surprise. When it comes to the stock market response, there can be two competing forces. On the one hand, an interest rate hike increases the discount factor and decreases future expected cash flows, which would have a negative impact on stock prices. On the other hand, an interest rate

hike could signal that economic conditions are better than expected, which would have a positive impact on stock prices. The negative sign for the target surprise indicates that the first effect dominates. Furthermore, the response of the EURUSD is as expected: a contractionary monetary policy surprise induces an appreciation of the euro.

Table 1: Factor diagnostics: ECB’s target and path factors and European rates

	Target ( $Z_1$ )	Path ( $Z_2$ )	Adj. $R^2$	Obs
1M OIS	1.0000*** (0.0224)	0.0000 (0.0249)	0.95	185
3M OIS	0.9953*** (0.0241)	0.3565*** (0.0257)	0.94	185
6M OIS	1.0323*** (0.0356)	0.6293*** (0.0296)	0.97	185
9M OIS	1.0071*** (0.0294)	0.8528*** (0.0217)	0.97	185
12M OIS	0.9493*** (0.0167)	1.0000*** (0.0149)	0.98	185
18M OIS	0.9342*** (0.0282)	1.1612*** (0.0245)	0.97	185
24M OIS	0.8859*** (0.0486)	1.2000*** (0.0412)	0.96	185
5Y GTY	0.5813*** (0.0792)	1.0966*** (0.0694)	0.76	185
10Y GTY	0.2011*** (0.0689)	0.6458*** (0.0942)	0.46	185
STOXX	-0.0435* (0.0259)	-0.0235 (0.0178)	0.03	140
EURUSD	0.0537*** (0.0166)	0.0596*** (0.0102)	0.24	185

*Note:* This table shows the factor loadings and financial market effects for the rotated factor matrix  $Z$ . OIS rates from one month to two years are used as input variables to obtain the target and path factors. Results are obtained using ordinary least squares with HAC standard errors (in parentheses). By construction,  $Z_2$  has no effect on the one-month OIS. Constant terms are excluded for presentation convenience. \*\*\*=1% \*\*=5% \*=10% significance level. Sample: from January 2002 to June 2018. Data for the equity index starts in October 2005. Announcement window: from 1:30 p.m. to 3:45 p.m.

Figure A.1 in the appendix plots  $Z_1$  and  $Z_2$  over the sample period. Note that the factors do not necessarily move in the same direction, i.e. that different surprise components of the ECB announcements may influence interest rates in opposite directions. To better illustrate the content of the path surprises, we pick some of the larger realisations in Figure A.1 and study what was communicated in the corresponding press releases and/or at the corresponding press conferences. The results of this narrative study, which is presented in more detail in section A.1 in the appendix, show that these realisations

are often surprises about communication of future policy actions, or expected actions that did not materialise. In its communication throughout the years, the ECB has been careful as to slowly prepare the market for changes in its policy, whether that would be changing its key policy rates (including opening up for the possibility to go into negative territory) or introducing unconventional measures like its asset purchase programmes. This communication policy is also the likely reason why the size of the path surprises does not seem to be related to the introduction of asset purchase programmes: by the time these programmes were introduced, they were already somewhat expected by the market, and therefore do not visibly show up in the path factor.

## 4 Empirical analysis and results

### 4.1 ECB monetary policy spillovers to SOEs

To determine whether the identified ECB monetary policy surprises have spillovers to the SOEs of interest, we run the following regression:

$$\Delta R_{t,i} = \alpha + \beta_1 Z_{1,t} + \beta_2 Z_{2,t} + \epsilon_t \quad (2)$$

where  $\Delta R_{t,i}$  is the observed change in the interest rate or (log) asset price  $i$  for time window  $t$ , and  $Z_{1,t}$  and  $Z_{2,t}$  are the rotated and rescaled target factor and path factor, respectively.

The results are presented in Table 2. The spillovers are sizeable over the yield curve for Norwegian and Swedish rates, and for both factors. As expected, the shorter end of the yield curve respond more strongly to the target surprise than the longer term interest rate instruments, whereas the response to the path surprise is strongest for the longer term rates. By comparison, the interest rate responses are in general stronger for Denmark for both factors. The comparison illustrates the size of the spillovers in the two countries with floating exchange rates: Denmark's exchange rate peg against the euro requires strong interest rate responses, but the differences between the three countries are relatively small, especially for the longer end of the curve.

Table 2: Effects of ECB's target and path surprises on Norwegian, Swedish, and Danish financial variables

	Norway			Sweden			Denmark			
	Target	Path	Adj. $R^2$	Target	Path	Adj. $R^2$	Target	Path	Adj. $R^2$	Obs
FRA 1	0.4178*** (0.1013)	0.2833*** (0.0575)	0.36	0.3903*** (0.0685)	0.1739*** (0.0468)	0.42	1.0054*** (0.1633)	0.4837*** (0.0561)	0.60	185
FRA 2	0.5092*** (0.0829)	0.3769*** (0.0774)	0.47	0.5148*** (0.0858)	0.2881*** (0.0674)	0.53	0.9159*** (0.0827)	1.0705*** (0.0352)	0.74	185
FRA 3	0.5168*** (0.0882)	0.5616*** (0.0721)	0.48	0.6322*** (0.0822)	0.4389*** (0.0908)	0.61	0.8919*** (0.1110)	1.2729*** (0.0421)	0.87	185
FRA 4	0.5310*** (0.0864)	0.6699*** (0.0713)	0.52	0.6517*** (0.1064)	0.5382*** (0.1063)	0.55	0.8332*** (0.1307)	1.4211*** (0.0608)	0.88	185
2Y SWAP	0.3632*** (0.0562)	0.5251*** (0.0438)	0.52	0.7839*** (0.1391)	0.5828*** (0.1333)	0.15	0.6742*** (0.0588)	1.0017*** (0.0601)	0.83	185
5Y SWAP	0.2857*** (0.0757)	0.5431*** (0.0497)	0.43	0.4400*** (0.0948)	0.6172*** (0.1110)	0.52	0.4752*** (0.0682)	0.9505*** (0.0692)	0.74	185
10Y SWAP	0.1860*** (0.0514)	0.5176*** (0.0484)	0.45	0.2367*** (0.0808)	0.5057*** (0.0899)	0.37	0.1342** (0.0678)	0.5821*** (0.0929)	0.41	185
Equity	-0.0348** (0.0157)	0.0105 (0.0127)	0.02	-0.0200 (0.0201)	-0.0143 (0.0106)	0.01	-0.0220 (0.0300)	0.0056 (0.0202)	0.00	140
FX	0.0112 (0.0120)	0.0179** (0.0082)	0.05	0.0197* (0.0116)	0.0200*** (0.0055)	0.12	0.0005*** (0.0002)	0.0000 (0.0002)	0.00	185

*Note:* This table displays the effects of ECB's target and path factors on Norwegian, Swedish and Danish financial variables, obtained by estimating Equation 2. Ordinary least squares with HAC standard errors (in parentheses). Constant terms excluded for presentation convenience. \*\*\*=1% \*\*=5% \*=10% significance level. Sample: from January 2002 to June 2018. Data for the equity indices start in October 2005. Event window: from 1:30 p.m. to 3:45 p.m. The estimated coefficients can be interpreted as the percentage point change in the interest rates and the percent change in the equity indices and exchange rates following a one percentage point surprise increase.

Also for exchange rates, the signs are as expected: a contractionary ECB monetary policy surprise in the euro area appreciates the euro and hence depreciates both the EURNOK exchange rate (Norwegian kroner per euro) and the EURSEK exchange rate (Swedish kroner per euro). The hardly visible effect on exchange rates may be attributed to the spillover effects on interest rates, keeping the interest rate differentials moderate.

The target surprise only significantly affects Norwegian equity prices. The sign is as expected: interest rates are used to discount future cash flows. Higher interest rates imply higher discount rates and lower expected future dividends, leading to lower equity prices.<sup>16</sup> This is also the effect that dominates for the European stock market, as could be seen in Table 1.

## 4.2 Stronger spillover effects in the ELB period

Next, we examine whether the spillovers of ECB's policy surprises altered after key policy rates entered effective lower bound (ELB) territory, here defined as the period after the ECB's deposit rate hit zero in July 2012. We refer to the subsamples as the pre-ELB and ELB periods and make the sample split after the meeting on July 5 2012, in which the deposit rate was lowered to zero. In our analysis, we first evaluate how transmission to European rates varies between the two samples. Next, we examine whether the spillovers to the SOEs are affected.

The results for the transmission to European rates are presented in Table 3. Columns 2 and 3 show the estimates for the pre-ELB period, whereas columns 4 and 5 show how much these estimates change in the ELB period. For short to medium term interest rates, the transmission of target and path surprises have not changed much from entering ELB territory. However, interest rates with maturities of more than one year respond stronger in the ELB period, especially for the path factor, and the difference is quite sizeable. The results may not be too surprising given the ECB's explicit focus on reliable forward guidance and asset purchase programmes in the ELB period in an attempt to affect long term interest rates. The effect on the exchange rate is also much stronger. This increased

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<sup>16</sup>One could argue that the large share of oil-related companies in the Norwegian equity index makes this index more sensitive to global economic conditions than the Swedish or Danish equity indices as global demand affects oil prices.

sensitivity of exchange rates to monetary policy in times of low rates is in line with the findings in Ferrari et al. (2017). Moreover, while the European stock market does not respond much to policy surprises in normal times, it is negatively affected by both the target and the path surprises in the ELB period.

Table 3: Effects of ECB target and path surprises on European financial variables

	Target	Path	Target*ELB	Path*ELB	Adjusted $R^2$	Obs
1M OIS	0.9952*** (0.0259)	-0.0031 (0.0274)	0.0521 (0.0362)	0.0364 (0.0387)	0.95	185
3M OIS	0.9965*** (0.0271)	0.3579*** (0.0283)	-0.0130 (0.0361)	-0.0165 (0.0386)	0.93	185
6M OIS	1.0439*** (0.0410)	0.6321*** (0.0328)	-0.1208* (0.0634)	-0.0364 (0.0495)	0.97	185
9M OIS	1.008*** (0.0327)	0.8587*** (0.0234)	-0.0143 (0.0431)	-0.0654* (0.0371)	0.97	185
12M OIS	0.9573*** (0.0159)	1.0062*** (0.0162)	-0.087 (0.0743)	-0.0727*** (0.0287)	0.98	185
18M OIS	0.9234*** (0.0338)	1.1585*** (0.0266)	0.1134*** (0.0426)	0.0349 (0.0409)	0.97	185
24M OIS	0.8745*** (0.0554)	1.1859*** (0.0452)	0.1289* (0.0754)	0.1631** (0.0740)	0.96	185
5Y GTY	0.5135*** (0.0760)	1.0331*** (0.0554)	0.7509*** (0.1682)	0.7405*** (0.1746)	0.80	185
10Y GTY	0.1588*** (0.0556)	0.5603*** (0.0657)	0.5105** (0.2578)	0.9748*** (0.2112)	0.55	185
STOXX	-0.0166 (0.0259)	-0.0061 (0.0166)	-0.2543*** (0.0918)	-0.1817*** (0.0672)	0.18	140
EURUSD	0.0391*** (0.0120)	0.0436*** (0.0071)	0.1638*** (0.0362)	0.1863*** (0.0284)	0.42	185

*Note:* This table displays the effects of ECB target and path surprises on European financial variables, respectively. The results are obtained by estimating Equation 2, including a dummy to account for the ELB period. Ordinary least squares with HAC standard errors (in parentheses). \*\*\*=1% \*\*=5% \*=10% significance level. Constant term excluded for presentation convenience. Sample: from January 2002 to June 2018. The ELB period starts after the monetary policy meeting on 5 July 2012. Data for the equity indices start in October 2005. Event window: from 1:30 p.m. to 3:45 p.m. The estimated coefficients can be interpreted as the percentage point change in the interest rates and the percent change in the equity indices and exchange rates following a one percentage point surprise increase.

Tables 4 to 6 provide the results for the SOEs. The pattern is the same as for the European transmission, indicating that the spillovers to the SOE interest rates increase in line with the additional effects on European rates in the ELB period. Moreover, the negative effect on European stock markets seems to transfer to the SOE stock markets as well.<sup>17</sup>

<sup>17</sup>A possible explanation for the negative effects on the SOE stock markets is that asset purchases may have caused portfolio rebalancing towards Norwegian, Swedish, and Danish assets since the ECB started asset purchase programmes.

Table 4: Effects of ECB target and path surprises on Norwegian financial variables

	Target	Path	Target*ELB	Path*ELB	Adjusted $R^2$	Obs
FRA 1	0.4467*** (0.1033)	0.2789*** (0.0642)	-0.2918*** (0.1139)	0.0352 (0.0958)	0.37	185
FRA 2	0.5238*** (0.0882)	0.3582*** (0.0900)	-0.1321 (0.1160)	0.2022 (0.1263)	0.48	185
FRA 3	0.5226*** (0.0951)	0.5502*** (0.0809)	-0.0490 (0.1583)	0.1250 (0.1532)	0.47	185
FRA 4	0.5353*** (0.0925)	0.6430*** (0.0840)	-0.0199 (0.2044)	0.2980 (0.2151)	0.52	185
2Y SWAP	0.3693*** (0.0599)	0.5039*** (0.0472)	-0.0434 (0.1538)	0.2332 (0.1601)	0.52	185
5Y SWAP	0.2711*** (0.0849)	0.4998*** (0.0494)	0.1879 (0.2056)	0.4901** (0.2107)	0.45	185
10Y SWAP	0.1551*** (0.0542)	0.4725*** (0.0415)	0.3563** (0.1640)	0.5180*** (0.1410)	0.49	185
OBX	-0.0283 (0.0186)	0.0185 (0.0124)	-0.0659 (0.0442)	-0.0803*** (0.0340)	0.04	140
EURNOK	0.0018 (0.0120)	0.0079 (0.0060)	0.1059*** (0.0204)	0.1162*** (0.0165)	0.28	185

Table 5: Effects of ECB target and path surprises on Swedish financial variables

	Target	Path	Target*ELB	Path*ELB	Adjusted $R^2$	Obs
FRA 1	0.3868*** (0.0752)	0.1694*** (0.0491)	0.0398 (0.1802)	0.0521 (0.1322)	0.41	185
FRA 2	0.5268*** (0.0906)	0.2802*** (0.0724)	-0.1160 (0.1308)	0.0829 (0.1263)	0.53	185
FRA 3	0.6498*** (0.0846)	0.4249*** (0.0974)	-0.1678 (0.1215)	0.1485 (0.1547)	0.62	185
FRA 4	0.6566*** (0.1159)	0.5177*** (0.1132)	-0.0317 (0.1470)	0.2264 (0.1949)	0.55	185
2Y SWAP	0.8062*** (0.1549)	0.5664*** (0.1447)	-0.2136 (0.2248)	0.1726 (0.2087)	0.14	185
5Y SWAP	0.4011*** (0.1063)	0.5725*** (0.1100)	0.4386** (0.1983)	0.5182*** (0.2091)	0.55	185
10Y SWAP	0.2086*** (0.0839)	0.4540*** (0.0830)	0.3345 (0.2549)	0.5908*** (0.2301)	0.41	185
OMX-S	-0.0127 (0.0237)	-0.0075 (0.0112)	-0.0713 (0.0459)	-0.0694* (0.0356)	0.03	140
EURSEK	0.0149 (0.0120)	0.0139*** (0.0053)	0.0551*** (0.0220)	0.0703*** (0.0138)	0.22	185

Table 6: Effects of ECB target and path surprises on Danish financial variables

	Target	Path	Target*ELB	Path*ELB	Adjusted $R^2$	Obs
FRA 1	1.0491*** (0.1770)	0.4932*** (0.0623)	-0.4562* (0.2397)	-0.1266 (0.0908)	0.60	185
FRA 2	0.9123*** (0.0928)	1.0794*** (0.0373)	0.0296 (0.1103)	-0.0981 (0.0717)	0.74	185
FRA 3	0.8746*** (0.1247)	1.2658*** (0.0461)	0.1832 (0.1288)	0.0868 (0.0755)	0.87	185
FRA 4	0.8184*** (0.1473)	1.4158*** (0.0661)	0.1564 (0.1757)	0.0667 (0.1331)	0.87	185
2Y SWAP	0.6569*** (0.0666)	0.9748*** (0.0666)	0.2013 (0.1287)	0.3085*** (0.1319)	0.84	185
5Y SWAP	0.4328*** (0.0653)	0.8834*** (0.0560)	0.4936** (0.2485)	0.7686*** (0.2344)	0.78	185
10Y SWAP	0.1039* (0.0607)	0.5113*** (0.0727)	0.3745 (0.2460)	0.8057*** (0.2063)	0.48	185
OMX-C	-0.0185 (0.0332)	0.0182 (0.0237)	-0.0444 (0.0590)	-0.1227*** (0.0475)	0.05	140
EURDKK	0.0004** (0.0002)	-0.0002 (0.0002)	0.0011 (0.0009)	0.0019*** (0.0007)	0.02	185

*Note:* Tables 4-6 display the effects of ECB target and path surprises on Norwegian, Swedish, and Danish financial variables, respectively. The results are obtained by estimating Equation 2, including a dummy to account for the ELB period. Ordinary least squares with HAC standard errors (in parentheses). \*\*\*=1% \*\*=5% \*=10% significance level. Constant term excluded for presentation convenience. Sample: from January 2002 to June 2018. The ELB period starts after the monetary policy meeting on 5 July 2012. Data for the equity indices start in October 2005. Event window: from 1:30 p.m. to 3:45 p.m. The estimated coefficients can be interpreted as the percentage point change in the interest rates and the percent change in the equity indices and exchange rates following a one percentage point surprise increase.

### 4.3 Spillover persistence on SOE interest rates

The relevance of spillovers depends on their persistence. If the spillover effects identified in this paper die out quickly, they will most likely not have real economic effects. To examine the spillover persistence on interest rates in the small open economies of interest, we follow the methodology proposed by Swanson (2018) by using a simplified version of the method of local projections first presented by Jordà (2005). In particular, this implies running regressions of the form:

$$\Delta R_{t+h,i} = \alpha + \beta_{1,h}Z_{1,t} + \beta_{2,h}Z_{2,t} + \varepsilon_{t+h} \quad (3)$$

where  $\Delta R_{t,i}$  denotes the difference in the closing price of interest rate  $i$  on announcement day  $t$  and  $t - 1$ , and  $Z_{1,t}$  and  $Z_{2,t}$  denote the target and path factor, respectively. Effec-



tively, by running this regression for  $h = 0$  to  $h = 29$ , we obtain the effect that monetary policy surprises have on asset prices the first 30 days after the announcement.

Figures 1 - 3 plot the results with 95 percent confidence bands for Norwegian, Swedish, and Danish interest rates for both factors (blue lines), alongside the persistence of the effect on European rates (red lines).<sup>18</sup> The results indicate that the ECB path surprises generate persistent spillover effects on Norwegian and Swedish interest rates. The effects are somewhat stronger for Sweden than for Norway. By comparison, the ECB target surprises do not generate persistent spillover effects. There seems to be some persistence on Norwegian long term rates, but the effect is short-lived. For Danish rates, the effects of the path surprise follow a similar pattern as for Swedish rates, albeit slightly stronger. One may argue that the target surprise has stronger and more persistent effects on Danish rates, although this result does not survive the somewhat strict test for significance.

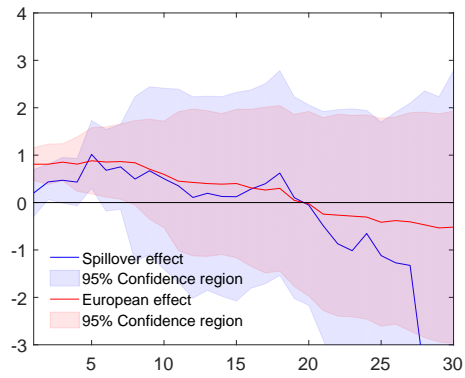
Comparing the spillover effects to the impact of ECB monetary policy surprises on European rates, we see that the differences are almost indistinguishable for Danish rates. This is as expected given the Danish peg to the euro. However, also for Sweden, which has a floating exchange rate regime, the impact of ECB policy surprises on Swedish rates is almost as strong as on European rates. For the ten-year swap rate, this is also the case for Norway.<sup>19</sup>

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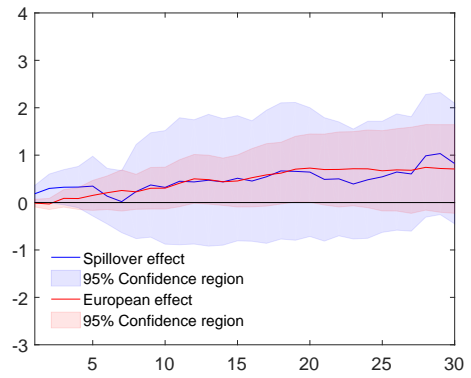
<sup>18</sup>Note that the comparison is not perfect because we use different interest rate instruments for European rate persistence than for the SOEs. The effects on the FRA 1 are plotted alongside the effect on the three-month European OIS, the effects on the FRA 4 are plotted alongside a synthetic three-month rate four quarters ahead (obtained by combining nine-month and 12-month OIS contracts). The effects on the five- and ten-year swap rates are plotted alongside the effects on five- and ten-year German Treasury yields.

<sup>19</sup>Compared to the HFI results in Jarociński and Karadi (2018), we find a smaller and less persistent impact of European target surprises on the one-year European rate. However, our methodology differs in several aspects, so the results are not perfectly comparable. While we use local projections and split up our surprises into a target factor and a path factor, where the target is based on the change in the one-month OIS rate, Jarociński and Karadi (2018) specify a full VAR (which will affect the confidence bands) and base their surprises on a three-month rate.

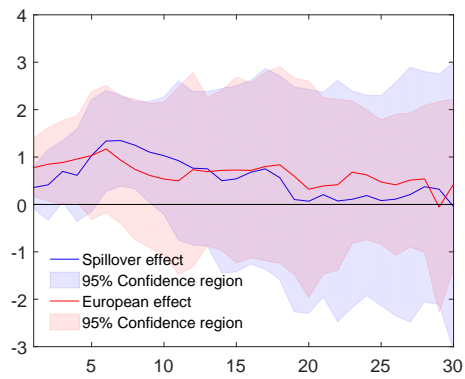
Figure 1: Persistence of ECB target and path surprises for Norwegian interest rates



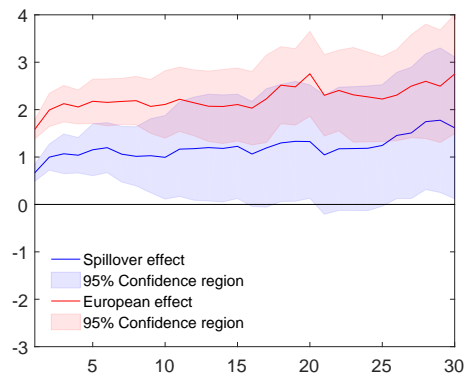
(a) Persistence of target on FRA 1



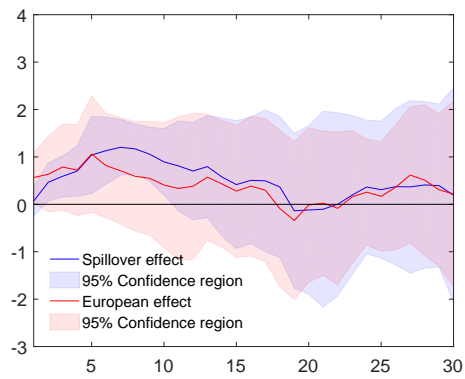
(b) Persistence of path on FRA 1



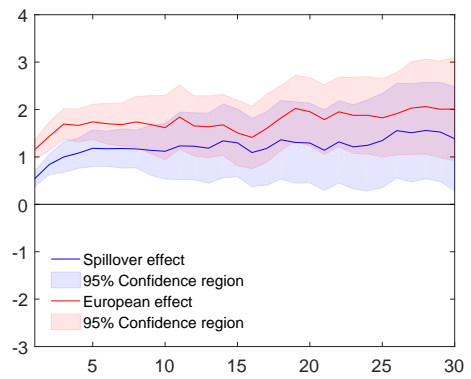
(c) Persistence of target on FRA 4



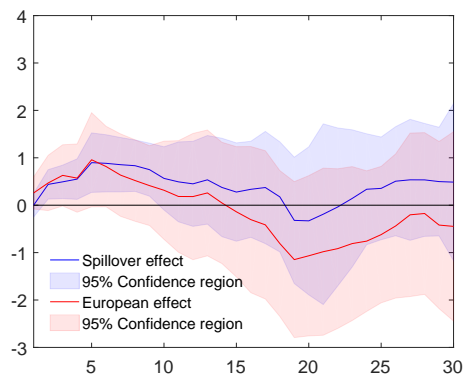
(d) Persistence of path on FRA 4



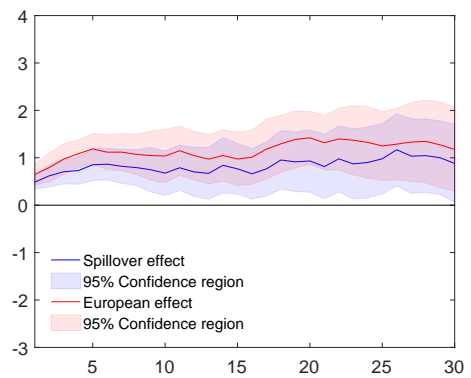
(e) Persistence of target on 5Y Swap



(f) Persistence of path on 5Y Swap



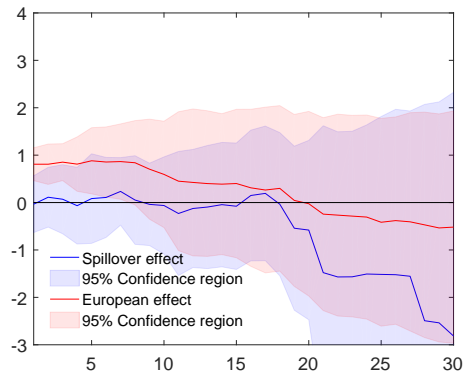
(g) Persistence of target on 10Y Swap



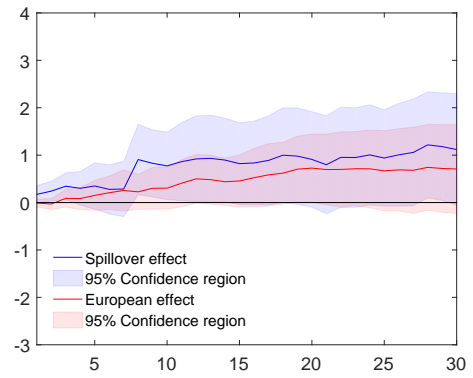
(h) Persistence of path on 10Y Swap

*Note:* Persistence of the spillovers to Norwegian interest rates from ECB target and path surprises for up to 30 days (blue lines) alongside the effect on European rates of the same ECB surprises (red lines). Obtained by estimating Equation 3 for  $h = 0$  to  $h = 29$  with HAC standard errors. 95% confidence bands.

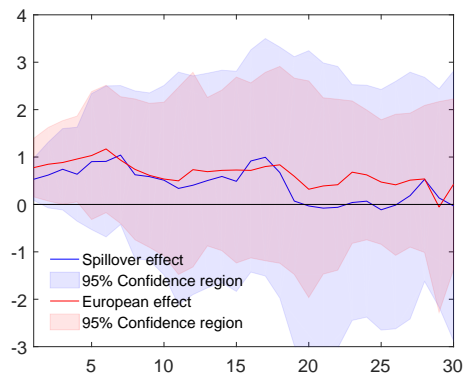
Figure 2: Persistence of ECB target and path surprises for Swedish interest rates



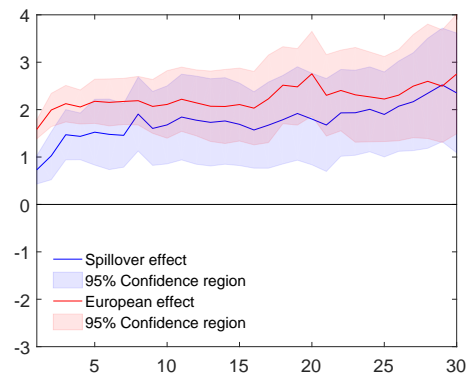
(a) Persistence of target on FRA 1



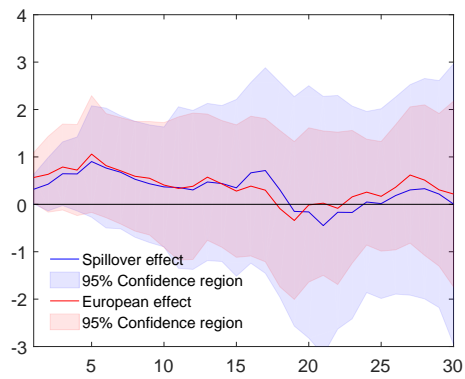
(b) Persistence of path on FRA 1



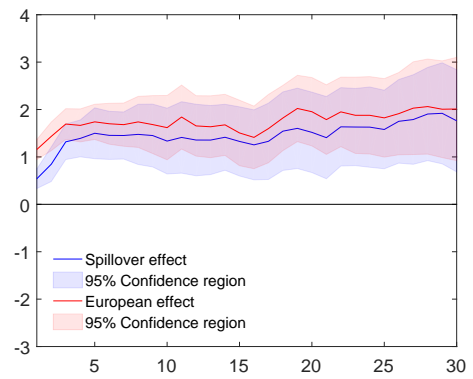
(c) Persistence of target on FRA 4



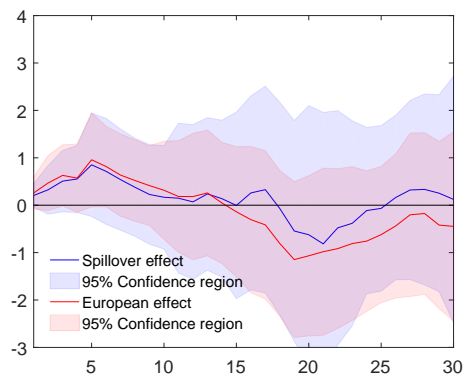
(d) Persistence of path on FRA 4



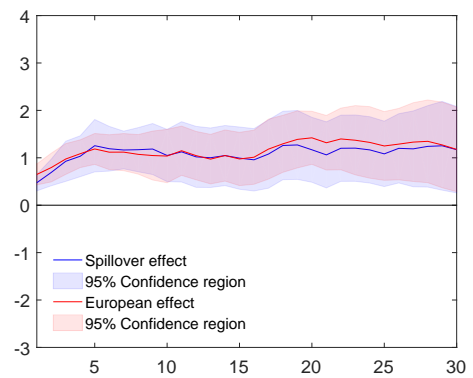
(e) Persistence of target on 5Y Swap



(f) Persistence of path on 5Y Swap



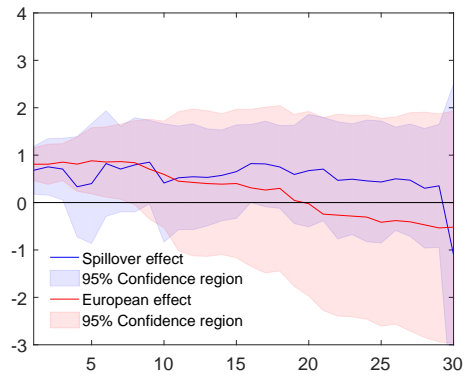
(g) Persistence of target on 10Y Swap



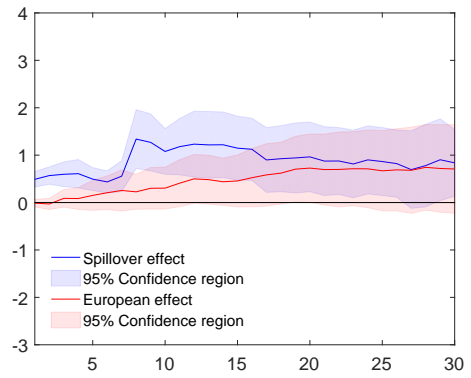
(h) Persistence of path on 10Y Swap

*Note:* Persistence of the spillovers to Swedish interest rates from ECB target and path surprises for up to 30 days (blue lines) alongside the effect on European rates of the same ECB surprises (red lines). Obtained by estimating Equation 3 for  $h = 0$  to  $h = 29$  with HAC standard errors. 95% confidence bands.

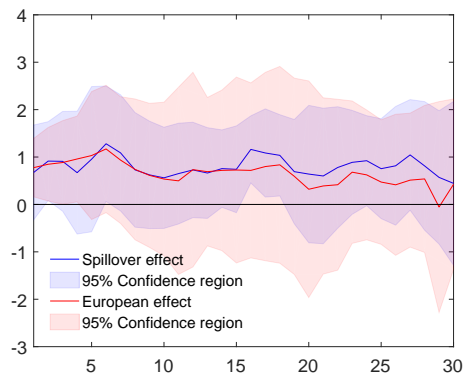
Figure 3: Persistence of ECB target and path surprises for Danish interest rates



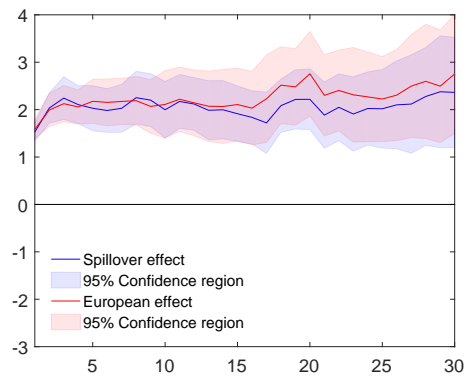
(a) Persistence of target on FRA 1



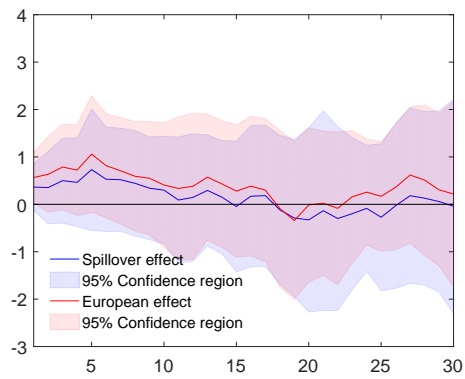
(b) Persistence of path on FRA 1



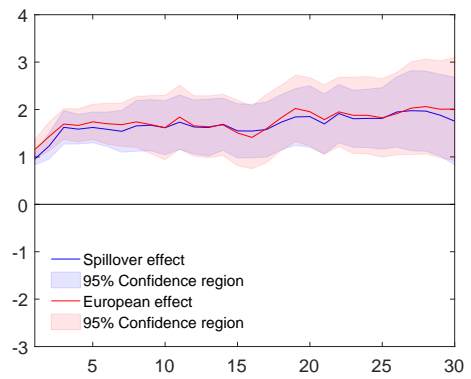
(c) Persistence of target on FRA 4



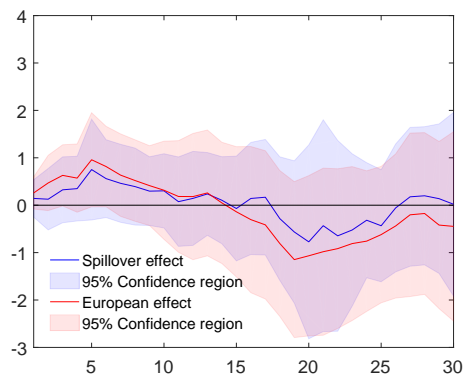
(d) Persistence of path on FRA 4



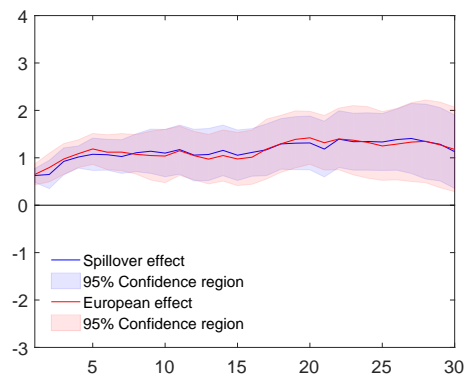
(e) Persistence of target on 5Y Swap



(f) Persistence of path on 5Y Swap



(g) Persistence of target on 10Y Swap

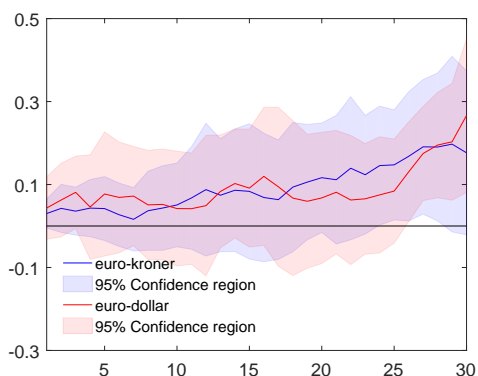


(h) Persistence of path on 10Y Swap

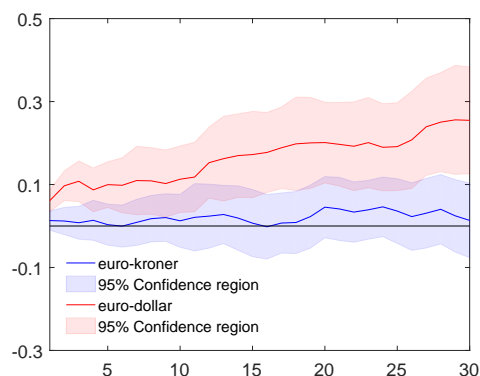
*Note:* Persistence of the spillovers to Danish interest rates from ECB target and path surprises for up to 30 days (blue lines) alongside the effect on European rates of the same ECB surprises (red lines). Obtained by estimating Equation 3 for  $h = 0$  to  $h = 29$  with HAC standard errors. 95% confidence bands.

Figure 4 shows the persistence of the effects of ECB target and path surprises on the EURNOK and the EURSEK. The results are plotted alongside the persistence of the impact on the EURUSD. The results suggest there is no significantly persistent effect of the target factor on exchange rates. The path factor only has a significant and persistent effect on the EURUSD. This is as expected: when interest rates of SOEs converge to foreign rates (in this case European rates), the interest rate differential closes, and as such one would not expect a lasting effect on the exchange rate. By comparison, a large and important economy like the US is not expected to have converging rates. A persistent interest rate differential can therefore have a long-lasting effect on the EURUSD.

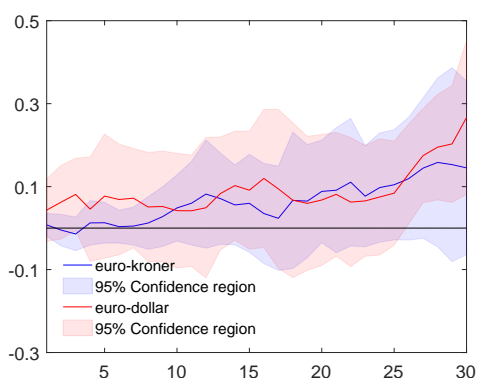
Figure 4: Persistence of ECB target and path surprises for exchange rates



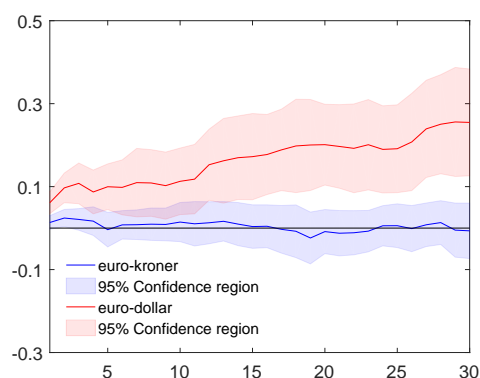
(a) Persistence of target factor on EURNOK



(b) Persistence of path factor on EURNOK



(c) Persistence of target factor on EURSEK



(d) Persistence of path factor on EURSEK

*Note:* Persistence of the spillovers to the Norwegian krone and the Swedish Krone from ECB target and path surprises for up to 30 days (blue lines) alongside the effect on the USD (red lines). Obtained by estimating Equation 3 for  $h = 0$  to  $h = 29$  with HAC standard errors. 95% confidence bands.

## 4.4 Effectiveness of domestic monetary policy in Norway and Sweden

Finally, in order to further link ECB spillovers to the effectiveness of domestic monetary policy in Norway and Sweden, we examine the effects of domestic policy surprises and compare them to the spillover effects presented in Table 2. The results for the domestic surprises are shown in Table 7. For Norway, the effects of domestic target and path surprises are much stronger than the corresponding spillover effects for the short to medium term interest rates (maturity up to two years). For the longer term interest rates, however, the spillover effects are somewhat stronger than the domestic surprise effects. For Sweden, the effects of the domestic path surprise are much stronger than the spillover effects for maturities up to two years, and stronger than the domestic effects on Norwegian rates. The effects of the domestic target surprise, however, are considerably smaller than the spillover effects for all maturities but the shortest rates. For both Norway and Sweden, the currencies appreciate somewhat when faced with a contractionary monetary policy surprise, as expected. Finally, whereas Norwegian equity prices move in response to ECB target surprises, they do not move in response to domestic monetary policy surprises.

Overall, these high frequency results indicate that monetary policy in Norway is effective in moving market rates for the shorter end of the domestic yield curve (up to two years). For the longer end of the curve, however, control seems to diminish. For Sweden, the results are more ambiguous with dominant spillover effects from target surprises for the major part of the yield curve, and from path surprises for the medium to long end of the curve.

Figures 5 and 6 compare the persistence of the spillover effects and the domestic surprise effects on different interest rates for Norway and Sweden, respectively. The results clearly illustrate how spillover effects from the ECB's path surprises dominate the effects of domestic path surprises for the longer end of the yield curves. For Sweden, in particular, the spillover effects are not only stronger than the domestic effects, but they are also more persistent. One possible interpretation of this result is that the domestic effects are persistent only in the time window between the Riksbank policy meeting and the next ECB policy meeting. Once the ECB makes its announcement, and possibly

creates a surprise, the effect on Swedish interest rates from a Riksbank surprise that took place some weeks earlier may be offset.<sup>20</sup>

For both countries, the responses of domestic interest rates to the ECB's target surprises are not significantly persistent. By comparison, the responses to the domestic target surprises are both strong and persistent, especially for the shorter end of the yield curve. The domestic path factor also has a persistent and significant effect on domestic rates, especially for Norway, but the effects weaken for the longer end of the curve.

In sum, we conclude that both domestic target surprises and domestic path surprises are effective in moving market rates in SOEs, and that the effects are more persistent than their European counterparts for the shorter end of the yield curve (up to two years). Control over the domestic yield curve, however, seems to diminish for the longer end of the curve. As expectations about future rates is an important channel for monetary policy transmission, our results suggest that monetary policy effectiveness in a small open economy is limited by monetary policy from a major central bank. It also seems to be the case that the inefficiency of monetary policy is stronger the more integrated the small open economy is with the country/area of the larger central bank. Denmark, being the most integrated with the euro area, has the strongest spillover effects from the ECB policy surprises. Sweden is more integrated than Norway and has indeed more dominant spillover effects.<sup>21</sup>

In the dilemma/trilemma debate, the results in this section lean towards a dilemma: the transmission channel of domestic monetary policy decisions to vital economic variables like output and inflation operates through the whole yield curve and hence is weakened considerably if the medium to long term lending and bond rates are little affected.

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<sup>20</sup>The dates of the monetary policy meetings in the Riksbank and ECB do not overlap throughout the sample. For most of the sample period, the ECB has had monthly meetings in general, taking place in the beginning of each month. Since January 2015, the ECB has had meetings every six weeks, reducing the amount of yearly meetings to eight per year. The Riksbank has six meetings per year in general.

<sup>21</sup>By comparison, small open economies not integrated with the euro area, like Australia and New Zealand, have very little spillover effects from ECB policy surprises, see Figures A.3 and A.4 in the appendix.

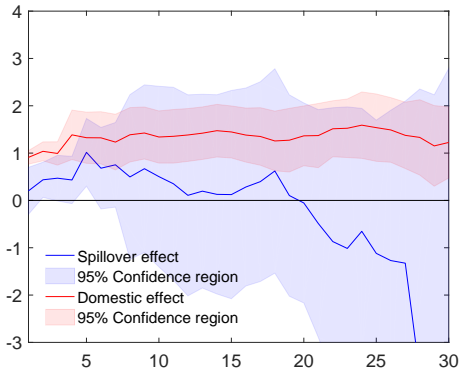
Table 7: Effects of domestic monetary policy surprises on financial variables in Norway and Sweden

	Norway				Sweden			
	Target	Path	Adj. $R^2$	Obs	Target	Path	Adj. $R^2$	Obs
FRA 1	0.9354*** (0.0679)	0.5422*** (0.0336)	0.93	127	0.6370*** (0.0711)	0.8855*** (0.1569)	0.68	110
FRA 2	0.8445*** (0.0333)	0.7621*** (0.0300)	0.96	127	0.5156*** (0.0165)	1.0215*** (0.0329)	0.98	110
FRA 3	0.7078*** (0.0225)	0.9701*** (0.0229)	0.98	127	0.4487*** (0.0202)	1.0109*** (0.0480)	0.95	110
FRA 4	0.6272*** (0.0251)	1.0000*** (0.0250)	0.98	127	0.4033*** (0.0251)	1.0000*** (0.0733)	0.92	110
2Y SWAP	0.5160*** (0.0274)	0.8019*** (0.0170)	0.96	127	0.4668*** (0.0181)	0.9685*** (0.0199)	0.98	110
5Y SWAP	0.3529*** (0.0313)	0.5902*** (0.0288)	0.87	127	0.2800*** (0.0304)	0.6094*** (0.0891)	0.78	110
10Y SWAP	0.2026*** (0.0307)	0.3962*** (0.0313)	0.72	127	0.1622*** (0.0305)	0.3721*** (0.0825)	0.50	110
Equity	0.01130 (0.0123)	-0.0072 (0.0149)	0.00	94	-0.0005 (0.0106)	-0.0246 (0.0153)	0.04	80
FX	-0.0359*** (0.0091)	-0.0440*** (0.0091)	0.40	127	-0.0247*** (0.0058)	-0.0510*** (0.0067)	0.48	110

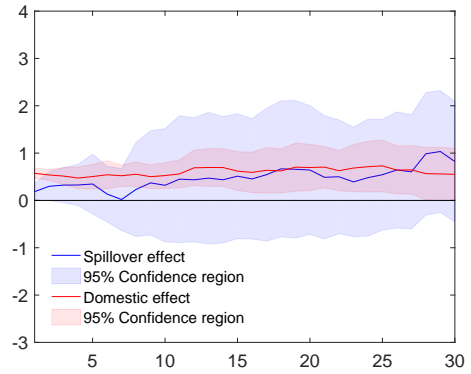
*Note:* This table displays the effects of domestic policy surprises on domestic interest rates for Norway and Sweden. The results are obtained by estimating Equation 2. Ordinary least squares with HAC standard errors. Constant terms are excluded for presentation convenience. \*\*\*=1% \*\*=5% \*=10% significance level. Sample: from January 2002 to June 2018. Data for the equity indices start in October 2005. Event window: from 15 minutes before announcement to 120 minutes after. The estimated coefficients can be interpreted as the percentage point change in the interest rates and the percent change in the equity indices and exchange rates following a one percentage point surprise increase.



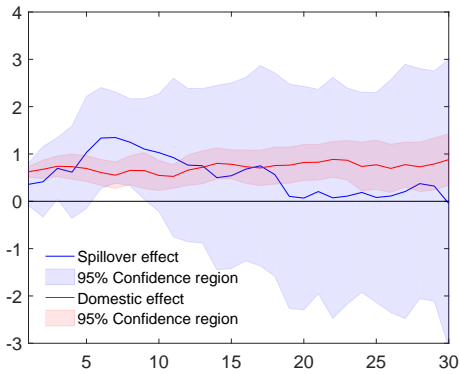
Figure 5: Persistence of domestic target and path surprises for Norwegian interest rates



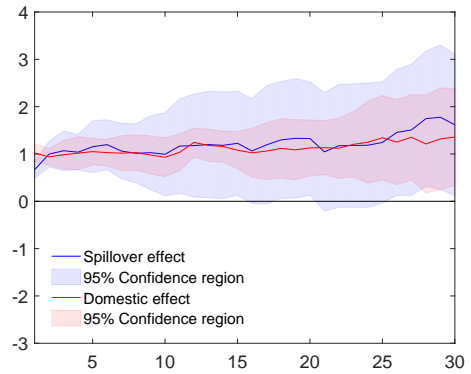
(a) Persistence of domestic target on FRA 1



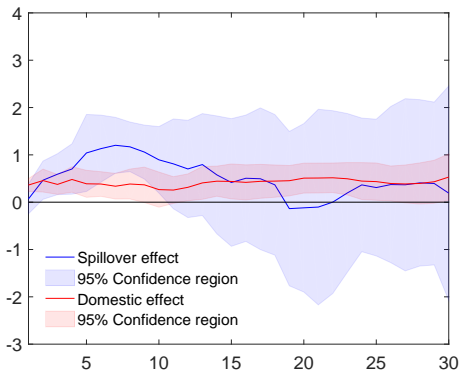
(b) Persistence of domestic path on FRA 1



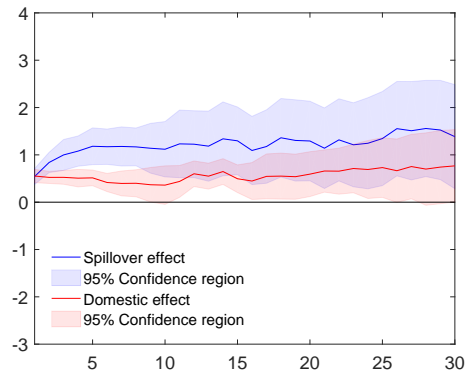
(c) Persistence of domestic target on FRA 4



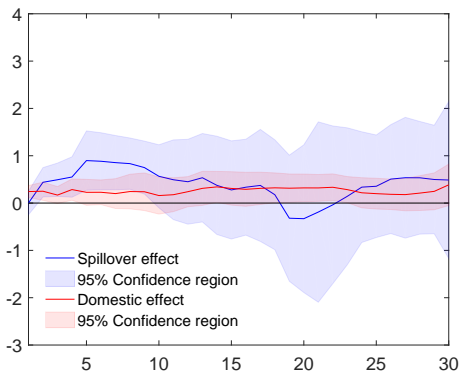
(d) Persistence of domestic path on FRA 4



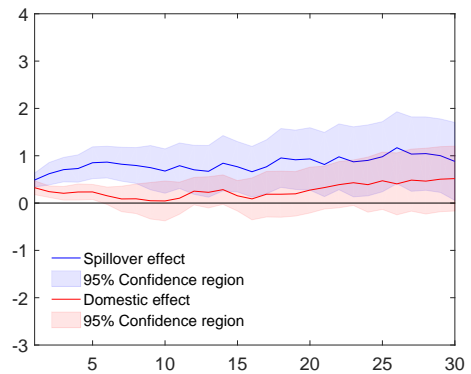
(e) Persistence of domestic target on 5Y Swap



(f) Persistence of domestic path on 5Y Swap



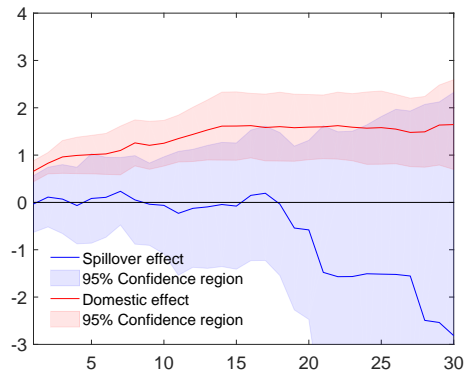
(g) Persistence of domestic target on 10Y Swap



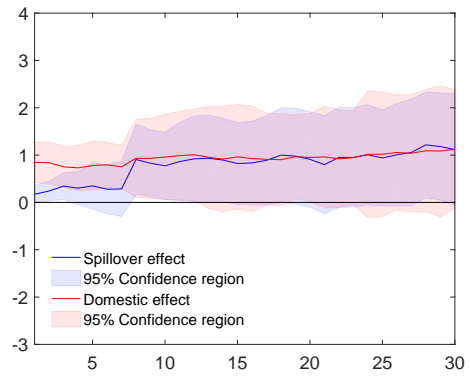
(h) Persistence of domestic path on 10Y Swap

*Note:* Persistence of the effects on Norwegian interest rates of domestic target and path surprises for up to 30 days (blue line), alongside the effect on European rates of the ECB surprises (red line). Obtained by estimating Equation 3 for  $h = 0$  to  $h = 29$  with HAC standard errors. 95% confidence bands.

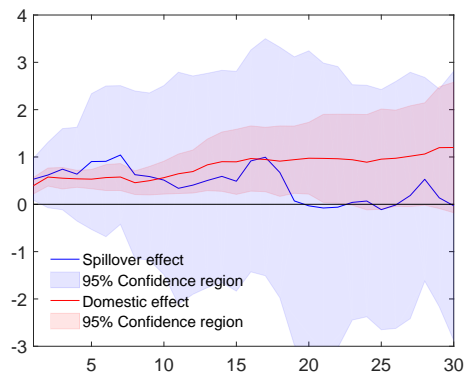
Figure 6: Persistence of domestic target and path surprises for Swedish interest rates



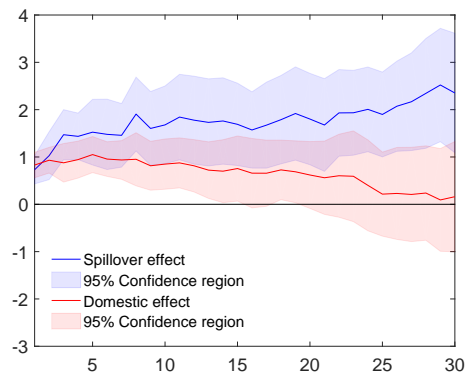
(a) Persistence of domestic target on FRA 1



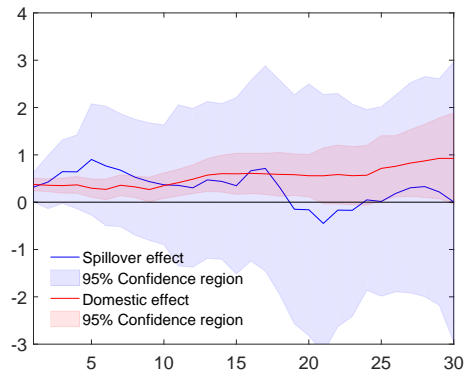
(b) Persistence of domestic path on FRA 1



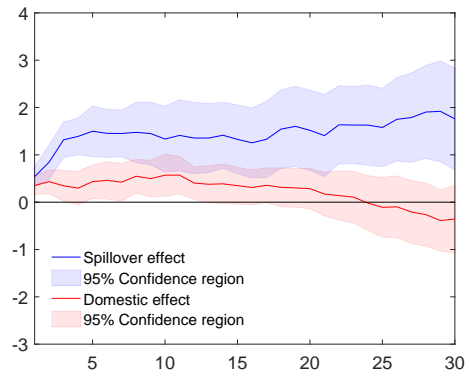
(c) Persistence of domestic target on FRA 4



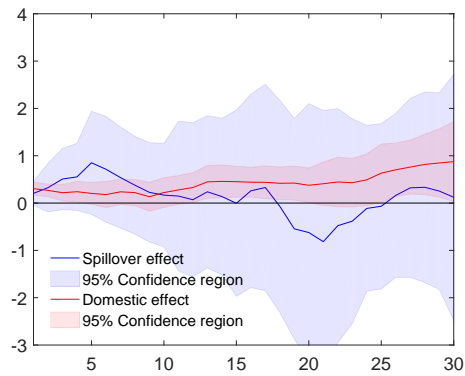
(d) Persistence of domestic path on FRA 4



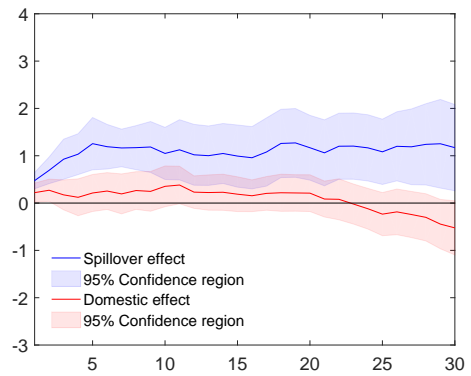
(e) Persistence of domestic target on 5Y Swap



(f) Persistence of domestic path on 5Y Swap



(g) Persistence of domestic target on 5Y Swap



(h) Persistence of domestic path on 5Y Swap

*Note:* Persistence of the effects on Swedish interest rates of domestic target and path surprises for up to 30 days (blue line), alongside the effect on European rates of the ECB surprises (red line). Obtained by estimating Equation 3 for  $h = 0$  to  $h = 29$  with HAC standard errors. 95% confidence bands.

## 5 Conclusion

In this paper, we examine whether financial spillovers from the European Central Bank's monetary policy have consequences for the effectiveness of domestic monetary policy in small open economies. We employ a high frequency identification approach and extract two factors from the ECB's policy announcements: a target rate surprise and a path surprise, where the latter contains information provided by the ECB beyond the policy rate decision. We find significant spillovers to small open economies with close ties to the euro area. The spillover effects from the ECB path surprises are particularly strong and persistent. For the longer end of the yield curve, we find that the spillover effects have become more dominant since the ECB entered effective lower bound territory in July 2012. Although domestic monetary policy seems to be effective for the shorter end of the yield curve, ECB spillover effects reduce domestic control over the longer end of the curve for the small open economies with floating exchange rates that we study (i.e. Norway and Sweden).

Recent work suggests that the trilemma in international economics as we used to know it, is actually a dilemma: even with floating exchange rate regimes, small open economies can only have effective monetary policies when the capital account is managed. In this debate, our results point in the direction of a dilemma: the transmission channel of domestic monetary policy decisions operates through the whole yield curve and hence is weakened considerably if the medium to long term lending and bond rates are little affected.

## Acknowledgments

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search assistance. We further thank Stine Louise Daetz, Meredith Beechey Österholm, Valentina Corradi, Elena Stepanova, and an anonymous reviewer for helpful comments and discussions, and participants of Normac 2017, the workshop on Interest Rates After the Financial Crisis, CEF 2018, IAAE 2018, and seminars at Norges Bank and Danmarks Nationalbank for their comments.

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## A Appendix

### A.1 Narratives behind the ECB's target and path factors

Figure A.1 shows that many of the large target and path surprises occur between 2008 and 2011, when there was a lot of uncertainty, and financial markets were very volatile. Since rates moved into ELB territory in 2012, the surprises have been much smaller, but the market still reacts to surprises. To better illustrate the content of the path surprises, we take a narrative approach and study how the realisations of the path factor relate to what was communicated by the ECB in the corresponding press releases and/or at the press conferences. The path surprises of particular interest (because of their size) are highlighted in Figure A.1, see surprises A-D. The figure also highlights three surprises related to information about the ECB's asset purchase programmes (surprises 1-3), which will be discussed in detail below.

In its communication throughout the years, the ECB has been careful as to slowly prepare the market for changes in its policy, whether that would be changing its key policy rates (including opening up for the possibility to go into negative territory) or introducing unconventional measures like its asset purchase programmes. Our narrative study suggests that the path surprises are mostly due to unexpected communication of future policy actions (e.g. June 2008, March 2011 and October 2015), or expected actions that did not materialise (e.g. July 2008):

- **A:** 5 June 2008: Figure A.1 shows a large positive surprise. During the press conference, president Trichet reveals that there is potential for a rate hike at the next meeting. Subsequently, markets price in a series of rate hikes.
- **B:** 3 July 2008: Figure A.1 shows a large negative surprise. During the press conference, president Trichet confirms that the Governing Council feels this action (i.e. a cut in key policy rates) is sufficient to reach price stability. Subsequently, the series of hikes that was priced in after the previous meeting, are reversed.
- **C:** 3 March 2011: Figure A.1 shows a large positive surprise. During the press conference, president Trichet hints at an interest rate hike at next meeting, focusing



on upside inflation risk: “We mentioned that we are being very vigilant and my understanding of the position of the Governing Council - fully in line with assessments made in the past - is that an increase in interest rates at the next meeting is possible.” Markets perceive this as surprisingly hawkish.

- **D:** 22 October 2015: Figure A.1 shows a large (for the ELB period) negative surprise. During the press conference, president Draghi opens up the possibility of future rate cuts: “Further lowering of the deposit facility rate was indeed discussed, and its one of the instruments of monetary policy that I referred to when I said all instruments have been discussed”. As a consequence, the whole European yield curve is considerably lowered.

In addition, our narrative study also suggests that there are few sizeable path surprises related to the introduction of the ECB’s asset purchasing programmes (APP).<sup>22</sup> The above forward-looking communication policy is probably the reason: the programmes were already priced in by the market. For example, at the meeting where the expanded APP was launched, on 22 January 2015, the market was hardly surprised, see Figure A.1, surprise 1.<sup>23</sup> Already at the press conference on 2 October 2014, president Draghi explicitly stated that the ECB planned to expand their unconventional measures: “I can only reiterate that the Governing Council is unanimous in its commitment to using other unconventional instruments if it were to judge that the risk of too low inflation for too prolonged a time were to deteriorate.” Moreover, part of the ECB’s introductory statement of 4 December 2014, reads: “Should it become necessary to further address risks of too prolonged a period of low inflation, the Governing Council remains unanimous in its commitment to using additional unconventional instruments within its mandate. This would imply altering early next year the size, pace and composition of our measures. In response to the request of the Governing Council, ECB staff and the relevant Eurosystem committees have stepped up the technical preparations for further measures, which could,

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<sup>22</sup>The ECB announces its planned APPs in its written statement and/or during the press conference. Hence, since the start of the APP, the path factor likely contains an APP-related component.

<sup>23</sup>The argument is supported by a question raised at the press conference: “You mentioned that [inflation expectations] have decreased further in recent days and weeks, and this is despite the fact that markets were increasingly pricing in QE and seeing it as a done deal. What makes you confident that this trend will now be reversed now that you have decided and you are going for QE?”

if needed, be implemented in a timely manner.”

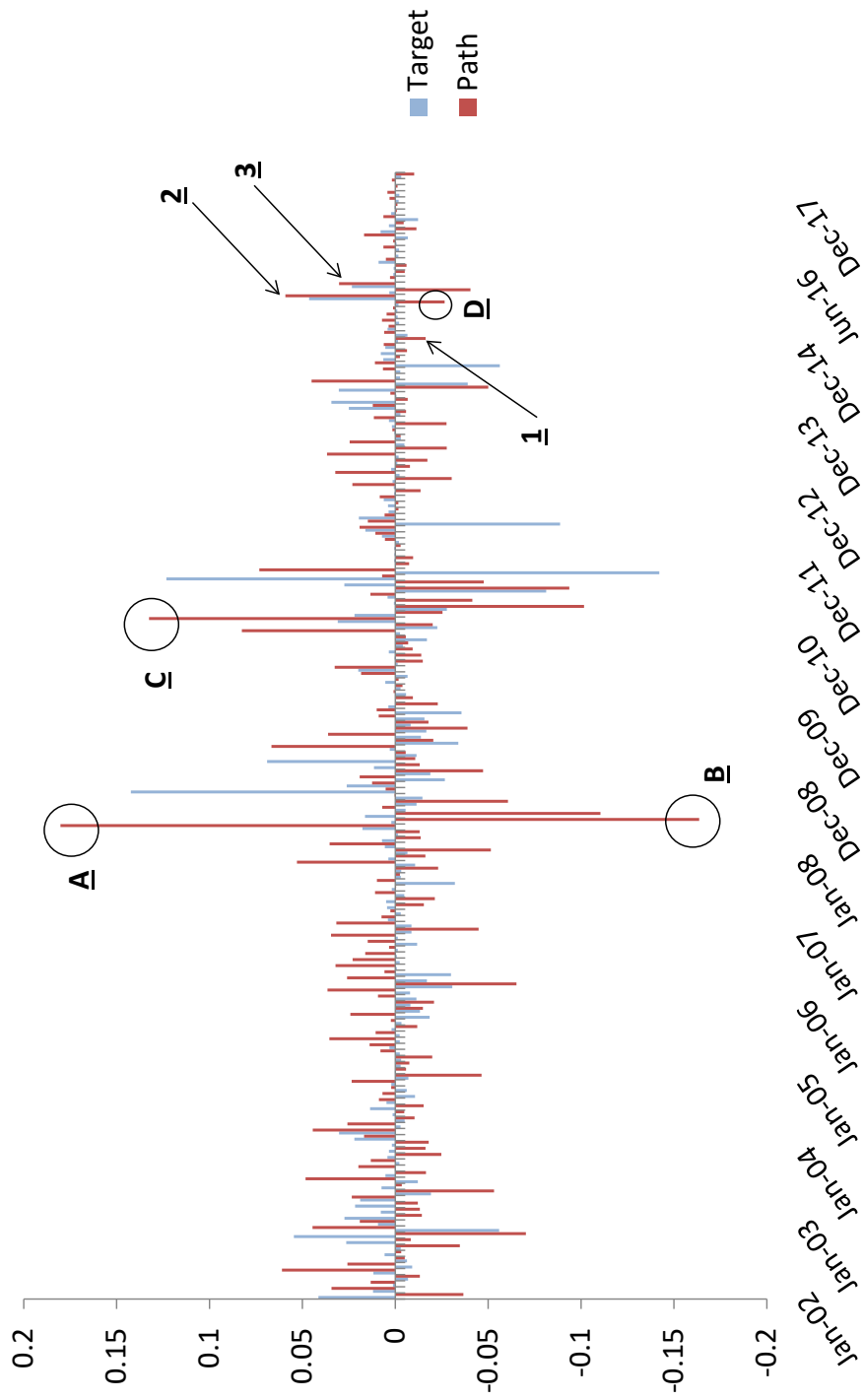
The ECB has extended the expanded APP on several occasions.<sup>24</sup> After the meeting on 3 December 2015, markets showed a positive surprise in response to a 10 bp cut in the deposit rate and an extension of the APP, see Figure A.1, surprise **2**. As it turned out, measures were not as aggressive as what was expected.<sup>25</sup> Moreover, the market responses after the meeting on 10 March 2016 illustrate how powerful communication during the press conference can be. At the meeting, the ECB decided to further expand the APP (from EUR 60 bn to EUR 80 bn) and also to cut all three key policy rates. The APP expansion was larger than expected by most market participants, and as a result market rates dropped immediately after the statement was made public at 1:45 p.m. However, despite this market reaction, the path surprise is positive, see Figure A.1, surprise **3**. This result is attributed to the following statement by president Draghi at the press conference: “we do not anticipate that it will be necessary to reduce interest rates any further”. The markets went into reverse on the news of a possible end to expansionary measures.

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<sup>24</sup>Note that none of the announcements not discussed in this paper about extensions or build down of the expanded APP caused substantial market surprises.

<sup>25</sup>The argument is supported by a question raised at the press conference: “[...]it seems like what you’ve done is a little bit on the low end of the range of what the financial markets had expected, in terms of your stimulus package today. It seems like the initial reaction in the financial markets bears this point. Why didn’t you do more, given how much you’ve warned about the risks of low inflation? Why didn’t you raise the monthly purchase amount? Why didn’t you cut the deposit rate more?”

Figure A.1: The ECB target and path surprises over the sample period



Note: This figure shows the realisations of the ECB target factor  $Z_1$  and the path factor  $Z_2$  over the sample period (January 2002 - June 2018). A few events are highlighted: (A) 5 June 2008; (B) 3 July 2008; (C) 3 March 2011; (D) 22 October 2015; (1) 22 January 2015; (2) 3 December 2015; and (3) 10 March 2016.

## A.2 Narrow announcement window

To illustrate the importance of the ECB's press conference for realisations of the path factor, we have extracted the target and path factors for an event window that excludes it altogether. The new time window runs for 45 minutes, from 15 minutes before the announcement (1:30 p.m) to 30 minutes after (2:15 p.m.). The only information market participants gain during this window is the content of the press release at 1:45 p.m.

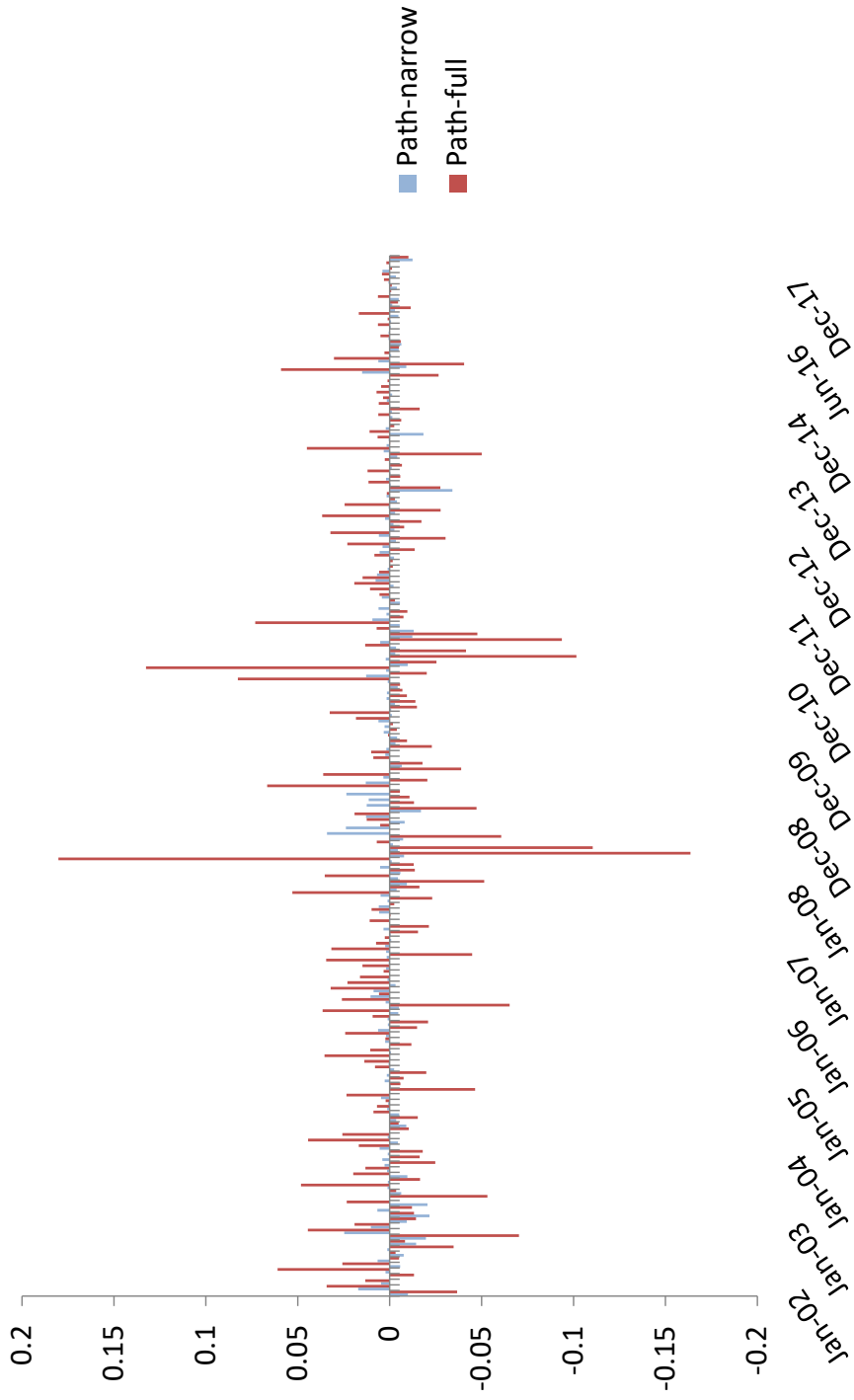
For the major part of our sample period, from January 2002 to December 2014, the press release only contained the decision on the current interest rate accompanied with a sentence stating that the ECB President will comment on the considerations underlying the decisions at the press conference. Hence, there was no information in the press release about the future path of monetary policy, and it is therefore unlikely that sizeable path surprises would occur based merely on information in the press release. Since 2015, however, the press releases have become increasingly informative. In January 2015, the last sentence of its statement (referring to what the ECB president would do at the press conference) was changed to "Further monetary policy measures will be communicated", indicating that the press conference would bring information beyond the decisions already made public. In the subsequent meetings, the sentence was included only when there was new information on "further policy measures". This change alone probably does not add much to the narrow window path surprises. Even though the market participants were told in advance that new information would be communicated at the press conference, they did not know the content of the news.

In the context of whether the press release contains information that affects the path factor, the most important change was made at the meeting on 10 March 2016. Then, the ECB suddenly stated changes in its asset purchase programmes directly into the press release. In the subsequent meetings, the press release statement has had a separate paragraph on non-standard monetary policy measures. Since September 2016, the paragraph also contains explicit forward guidance.

Compared to the path factor extracted from the event window including the press conference, the narrow window path factor misses most of the relevant communication about likely future policy paths. The correlation of these two path factors is only 0.21,

while the correlation of the corresponding target factors is 0.84. Moreover, the path surprises extracted from the narrow window are clearly much smaller over the sample period, see Figure A.2. Interestingly, Tables A.1 and A.2 show that the path factor still seems to maintain most of its properties, while there are some odd features to it as well, such as its negative impact on the European three-month OIS rate and its strongly reduced spillovers to Norwegian rates. The target factors are roughly the same in both event windows, as expected. One possible reason why the path factor still has strong explanatory power in the narrow window is that the dependent variables are also measured using that same window.

Figure A.2: Two variations of the ECB's path surprises over the sample period



Note This figure shows the realisations of the ECB path factor,  $Z_2$  extracted from either a narrow event window that excludes the press conference (from 15 minutes before until 30 minutes after the announcement) or from the full event window that includes the press conference (from 15 minutes before until 120 minutes after the announcement).

Table A.1: Factor diagnostics: ECB's target and path factors and European rates.

	full announcement window			narrow announcement window			Obs
	Target	Path	Adj. $R^2$	Target	Path	Adj. $R^2$	
1M OIS	1.0000*** (0.0224)	0.0000 (0.0249)	0.95	1.0000*** (0.0508)	0.0000 (0.1276)	0.91	185
3M OIS	0.9953*** (0.0241)	0.3565*** (0.0257)	0.94	0.8571*** (0.0356)	-0.2493*** (0.0958)	0.94	185
6M OIS	1.0323*** (0.0356)	0.6293*** (0.0296)	0.97	0.7851*** (0.0361)	0.2027*** (0.0649)	0.93	185
9M OIS	1.0071*** (0.0294)	0.8528*** (0.0217)	0.97	0.7840*** (0.0443)	0.6136*** (0.0641)	0.78	185
12M OIS	0.9493*** (0.0167)	1.0000*** (0.0149)	0.98	0.7207*** (0.0209)	1.0000*** (0.0702)	0.93	185
18M OIS	0.9342*** (0.0282)	1.1612*** (0.0245)	0.97	0.5794*** (0.0155)	1.3326*** (0.0529)	0.95	185
24M OIS	0.8859*** (0.0486)	1.2000*** (0.0412)	0.96	0.5453*** (0.0365)	1.5071*** (0.0661)	0.93	185
5Y GTY	0.5813*** (0.0792)	1.0966*** (0.0694)	0.76	0.3072*** (0.0915)	1.3893*** (0.1757)	0.47	185
10Y GTY	0.2011*** (0.0689)	0.6458*** (0.0942)	0.46	0.0483 (0.0713)	0.9241*** (0.1435)	0.27	185
STOXX	-0.0435* (0.0259)	-0.0235 (0.0178)	0.03	-0.067*** (0.0275)	0.0053 (0.1021)	0.12	140
EURUSD	0.0537*** (0.0166)	0.0596*** (0.0102)	0.24	0.0102 (0.0220)	0.0535 (0.0473)	0.03	185

*Note:* This table shows the factor loadings and financial market effects for the rotated factor matrix  $Z$ . OIS rates from one month to two years are used as input variables to obtain the target and path factors. Results are obtained using ordinary least squares with HAC standard errors (in parentheses). Constant terms are excluded for presentation convenience. \*\*\*=1% \*\*=5% \*=10% significance level. Sample: from January 2002 to June 2018. Data for the equity indices start in October 2005. Full announcement window: from 1:30 p.m. to 3:45 p.m. Narrow announcement window: from 1:30 p.m. to 2:15 p.m.

Table A.2: Narrow window: Effects of ECB's target and path factors on Norwegian, Swedish, and Danish financial variables.

	Norway			Sweden			Denmark			Obs
	Target	Path	Adj. $R^2$	Target	Path	Adj. $R^2$	Target	Path	Adj. $R^2$	
FRA 1	0.3796*** (0.0917)	-0.0265 (0.4121)	0.25	0.1962*** (0.0590)	0.5078*** (0.1594)	0.28	0.0039*** (0.0013)	0.8643*** (0.1387)	0.61	185
FRA 2	0.4919*** (0.0959)	0.4175 (0.3497)	0.44	0.2882*** (0.0799)	0.7247*** (0.1455)	0.45	0.0022** (0.0010)	0.5477*** (0.0497)	0.6	185
FRA 3	0.4105*** (0.0591)	0.6751 (0.4280)	0.33	0.4138*** (0.0963)	0.9968*** (0.1660)	0.59	0.0007 (0.0010)	0.5572*** (0.0519)	0.64	185
FRA 4	0.3645*** (0.0566)	0.6026 (0.5292)	0.21	0.4115*** (0.0554)	1.2586*** (0.2176)	0.64	0.0013 (0.0009)	0.3556*** (0.0969)	0.61	185
2Y SWAP	0.2147*** (0.0563)	0.6726*** (0.2223)	0.29	0.3594*** (0.0634)	1.3325*** (0.2184)	0.23	0.0001 (0.0007)	0.3058*** (0.0411)	0.57	185
5Y SWAP	0.1965*** (0.0419)	0.9918*** (0.2167)	0.25	0.2459*** (0.0677)	1.0129*** (0.2101)	0.28	-0.0001 (0.0008)	0.3287*** (0.0527)	0.14	185
10Y SWAP	0.1146** (0.0575)	0.9818*** (0.2423)	0.17	0.0730 (0.0613)	0.9226*** (0.1348)	0.1	0.0003 (0.0009)	0.0562 (0.0783)	0.15	185
Equity	-0.0520** (0.0260)	0.1580 (0.1100)	0.13	-0.0357 (0.0247)	0.0888 (0.0732)	0.23	-0.0002 (0.0004)	-0.0548*** (0.0203)	0.06	140
FX	0.0220*** (0.0057)	0.0207 (0.0262)	0.00	0.0264*** (0.0082)	0.0121 (0.0159)	0.00	0.0000 (0.0000)	0.0003 (0.0003)	0.00	185

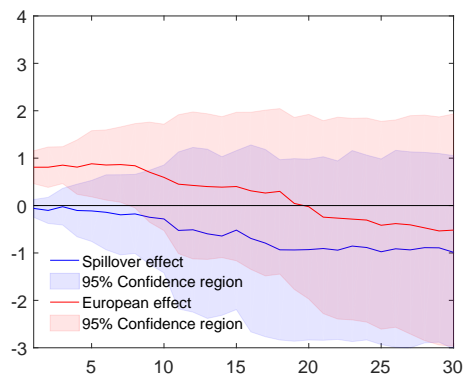
*Note:* This table displays the results from estimating Equation 2: analysing the effects of ECB's target and path factors on Norwegian, Swedish and Danish financial variables. Results are obtained using ordinary least squares with HAC standard errors (in parentheses). Constant terms are excluded for presentation convenience. \*\*\*=1% \*\*=5% \*=10% significance level. Sample: from January 2002 to June 2018. Data for the equity indices start in October 2005. Event window: from 1:30 p.m. to 2:15 p.m.



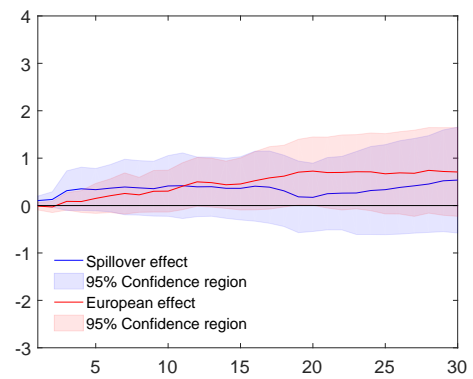
### A.3 ECB spillovers - Australia and New Zealand

In order to examine to what extent the identified ECB spillover effects on the SOEs of interest are driven by the countries' strong integration with the euro area, we conduct a "placebo" test on two comparable, but less integrated, countries: Australia and New Zealand. Due to time-zone differences, it is not possible to reproduce the high frequency results, but it is still informative to redo the local projections exercise. When running equation 2,  $t$  refers to the day after the announcement, i.e. the first day the Australian and New Zealand markets are open after the ECB's press conference. We can observe some spillovers to these countries, but only for the very long end of the yield curve in response to the path factor, and the effects die out much faster than for Norway and Sweden, see Figures A.3 and A.4. Hence, it seems that the ECB policy affects term premiums, which for a few days also has an effect on the term premiums of Australian and New Zealand rates.

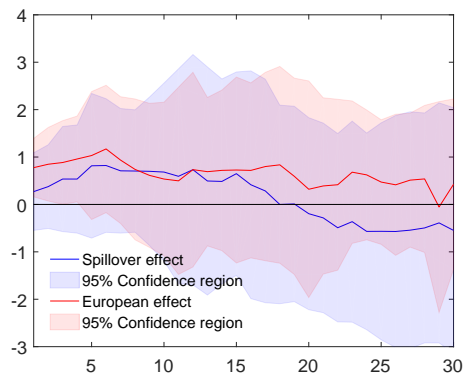
Figure A.3: Persistence of ECB target and path factor for Australian variables



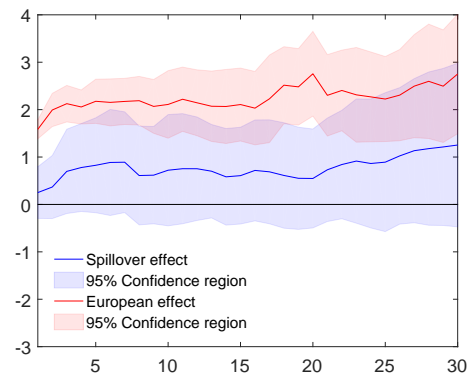
(a) Persistence of target on 1 month rate



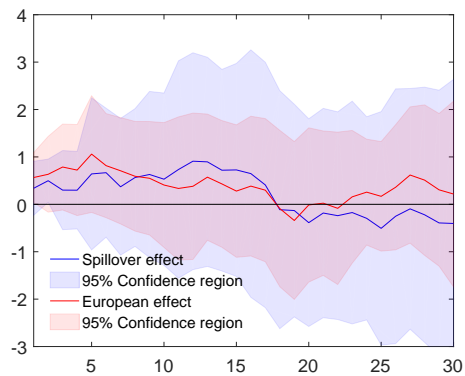
(b) Persistence of path on 1 month rate



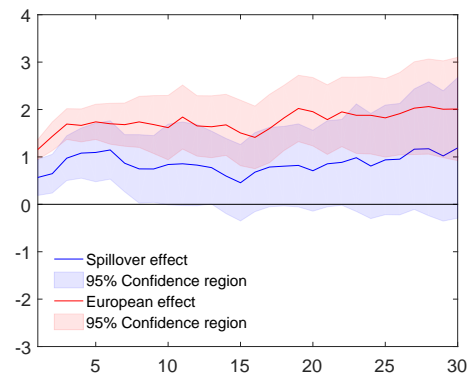
(c) Persistence of target on 9 month rate



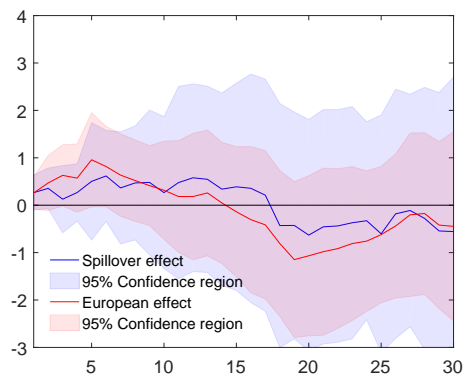
(d) Persistence of path on 9 month rate



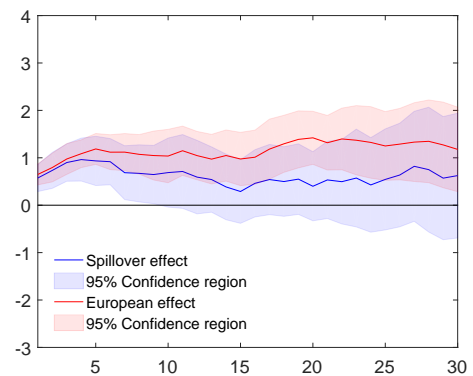
(e) Persistence of target on 5Y Bond yield



(f) Persistence of path on 5Y Bond yield



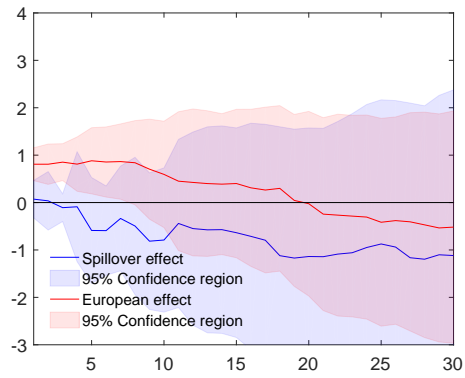
(g) Persistence of target on 10Y Bond yield



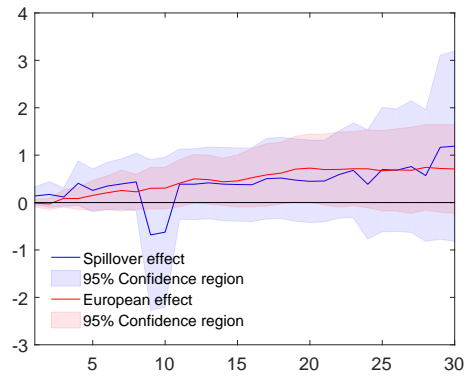
(h) Persistence of path on 10Y Bond yield

*Note:* Persistence of the spillovers to Australian interest rates from ECB target and path surprises for up to 30 days (blue lines), alongside the effects on European rates of the same ECB surprises (red lines). Obtained by estimating Equation 3 for  $h = 0$  to  $h = 29$  with HAC adjusted standard errors. 95% confidence bands. Rather than looking at FRA 1 and FRA 4 for Australia, we look at the three-month and nine-month OIS rates due to data availability. We use Treasury bond yields rather than swap yields for the medium to long end of the yield curve.

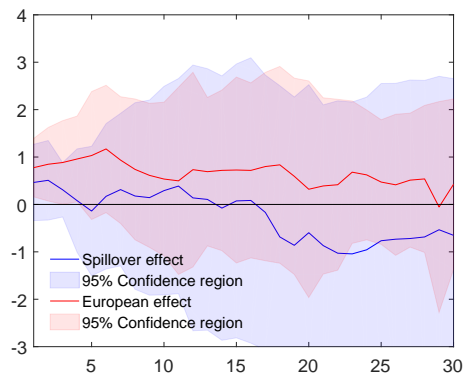
Figure A.4: Persistence of ECB target and path factor for New Zealand variables



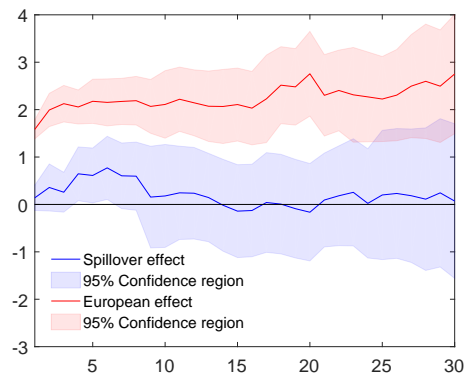
(a) Persistence of target on FRA 1



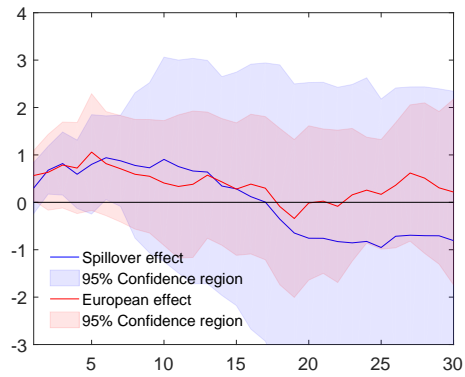
(b) Persistence of path on FRA 1



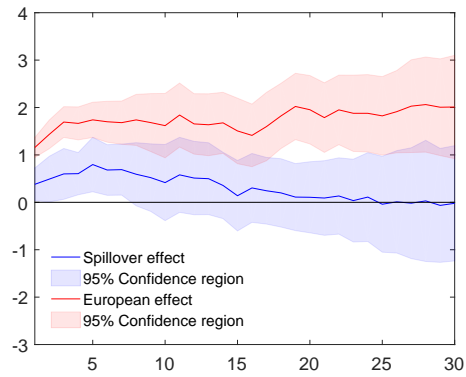
(c) Persistence of target on FRA 4



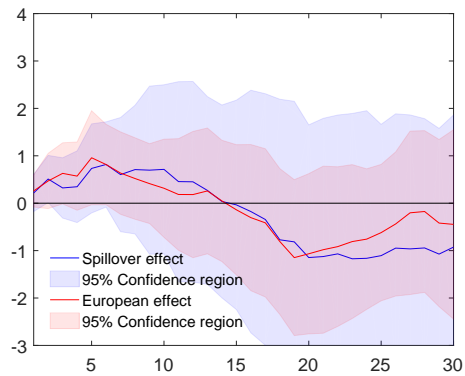
(d) Persistence of path on FRA 4



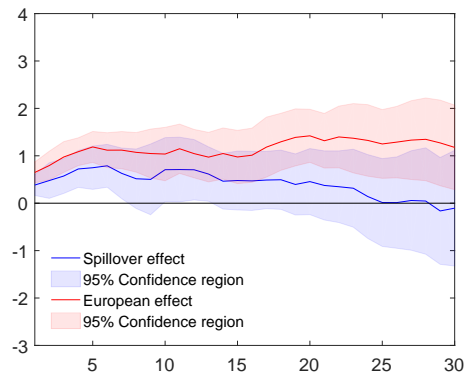
(e) Persistence of target on 5Y Swap



(f) Persistence of path on 5Y Swap



(g) Persistence of target on 10Y Swap



(h) Persistence of path factor on 10Y Swap

*Note:* Persistence of the spillovers to New Zealand interest rates from ECB target and path surprises for up to 30 days (blue lines), alongside the effects on European rates of the same ECB surprises (red lines). Obtained by estimating Equation 3 for  $h = 0$  to  $h = 29$  with HAC adjusted standard errors. 95% confidence bands.