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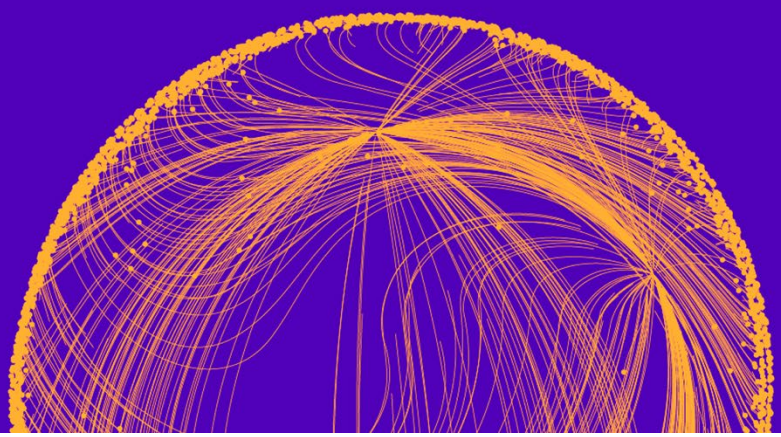
ECB's Monetary Policy Spillovers to Financial Markets: Evidence from Small Open Economies

Joose Vanhanen



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1 Introduction

This paper examines the impact of the European Central Bank's (ECB) monetary policy on non-euro area financial market by evaluating changes in Swedish and Danish government bond yields, stock market indices, and exchange rates. Financial variables are critical channels through which monetary policy influences the real economy (Feldkircher and Huber, 2016). Using an event study regression, this research assesses how these variables react to ECB policy surprises.

While extensive studies have explored the spillover effects of US monetary policy (e.g., Takáts and Vela, 2014; Tillmann, 2016; Rogers, Scotti and Wright, 2018; Gilchrist, Yue and Zakrajšek, 2019), there is limited evidence on the ECB's influence, especially on Nordic small open economies (SOEs) (e.g., Fratzscher, Lo Duca and Straub, 2016; Georgiadis and Gräb, 2016; Burriel and Galesi, 2018; Leombroni et al., 2021). Ter Ellen et al. (2020) provide one of the few notable studies in this area.

Sweden and Denmark, both EU members with close ties to the euro area, offer unique contexts for studying such spillovers. They represent different currency regimes: Swedish krona (SEK) floats, while Danish krone (DKK) is pegged to the euro. This distinction allows an exploration of the evolving "trilemma" in international economics, where the classic notion that effective monetary policy is possible only with floating exchange rates and free capital mobility is reconsidered (Rey, 2015). Evidence of strong spillovers would support the "dilemma" hypothesis, indicating domestic monetary policy's diminishing effectiveness irrespective of the exchange rate regime.

The study covers the period from 2006 to 2022, including 168 scheduled ECB meetings. Additionally, a sub-period during which the ECB's policy rate lowered at or below zero between July 2012 and July 2022, known as the effective lower bound (ELB), is examined. This period was unique as it marked the first-time euro area rates reaching zero levels, and partially prompted the ECB's shift to unconventional measures.

Methodologically, this paper utilizes a high-frequency intra-day interest rate dataset (EA-MPD) from Altavilla et al. (2019) to proxy ECB policy surprises. The changes in the 1-month and 12-month OIS rates serve as "target" and "path" surprises, respectively. A target surprise captures unexpected decisions related to the current policy rate level, while a path surprise indicates decisions that affect beyond the current meeting, such as forward guidance or unconventional measures. (Ter Ellen et al., 2020)

The results reveal significant spillover effects. Path surprises correlate with positive effects on government bond yields, especially in Denmark, and associates with the euro depreciating against SEK, suggesting at a portfolio rebalance effect. Conversely, target surprises have limited impact on short-term money market rates, indicating domestic central banks' higher control over these rates. During the ELB period, policy surprises negatively impact Swedish and Danish equity markets, particularly in the industrial sector.

This paper contributes to the debate on the "trilemma," suggesting a partial shift towards a "dilemma" for SOEs, where incumbent central banks

maintain control over short-term rates while larger central banks influence longer yields. It offers additional evidence to the study of ECB's policy actions on the Nordic SOEs, likely being the first to cover the entire ELB period. The findings suggest that the currency exchange rate is consequential for the transmission of a monetary policy surprise: fixed regimes respond more robustly to ECB policies, both in target and path surprises, whereas the floating regime predominantly responds to path surprises. The ELB period amplifies spillover effects across both regimes. Additionally, this paper introduces a novel indicator for quantifying the potency of the monetary policy surprises, classifying them into "weak," "medium," or "strong" categories.

2 Monetary policy surprise

Similarly, as Altavilla et al. (2019), Ter Ellen et al. (2020), and Nitschka and Hager (2022), this paper measures monetary policy surprise using an instrument which reflects anticipation of monetary policy decisions. In the euro area, this type of instrument is the euro Overnight Index Swap (OIS) rate. An OIS refers to a financial derivative contract which involve "the exchange of fixed interest rate payments for floating interest rate payments", where the floating leg is linked to a benchmark index representing daily interbank rates, namely the €STR rate (Remolona and Wooldridge, 2003). The unexpected part of the monetary policy decision can be presented as in Equation 1, where t is some time before the monetary policy decision is published and t + j is time after the press conference.

$$\Delta i_t^{OIS} = i_{t+j}^{OIS} - i_t^{OIS} \quad (1)$$

This paper utilizes Euro Area Monetary Policy Event Study Database (EA-MPD) provided by Altavilla et al. (2019). EA-MPD includes an exhaustive set of high frequency intra-day changes of European rates around the ECB monetary policy decisions. Their dataset has all ECB policy meeting dates starting from 7th of January 1999 updated constantly with the latest policy meeting dates. For the policy meeting dates, the authors have calculated the change in the median quote for the different rate types in four different monetary policy meeting windows. This paper utilizes the "Monetary Event Window," which considers change in the median rate quote from the window 13:25-13:35 (before the press release) to the median quote in the window 15:40-15:50 (after the press conference). Therefore, the changes in the quotes account for both parts of the monetary policy meeting–the press release and conference. A graphical illustration of the monetary policy event windows is presented in Figure 1.

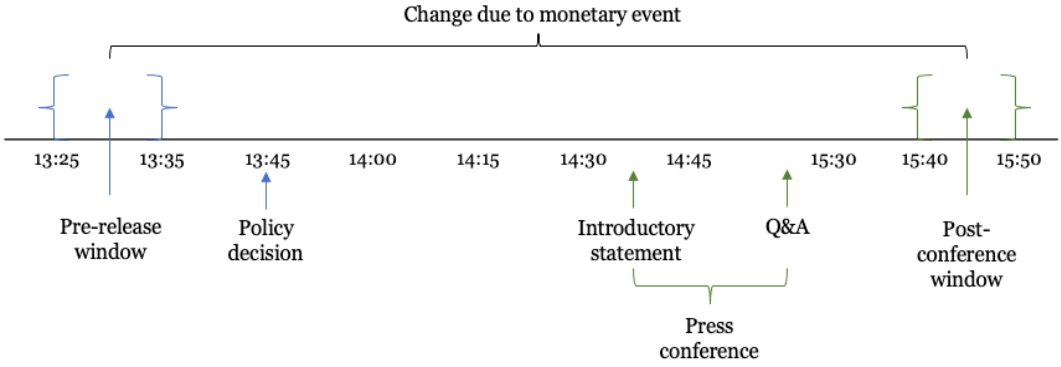

Figure 1: ECB monetary policy communication timeline. The graph is a modified version of Figure 1 presented in Altavilla et al. (2019).

As demonstrated by Ter Ellen et al. (2020), the change in the 1-month OIS rate, Δi_t^{OIS}, represents a "target" surprise. The identifying assumption is if the monetary policy meeting held new information regarding the current policy rates, the market participants immediately price the information into the forward rates. As the data is high frequency and the event window is narrow, it is assumed that there are no other factors behind these shocks in the financial instruments, other than the monetary policy surprises. Altavilla et al. (2019) illustrate in their appendix Figure 2 intraday OIS-rate pricing development around four historical monetary policy meeting windows, indicating that OIS rates react quickly to new information. As ECB has had monetary policy meetings approximately every six weeks, it is assumed that the change in 1-month OIS rate only reflects the surprise component of the meeting in time t. The pricing of longer maturity OIS rates (e.g., 3-month, 6-month) could already anticipate the outcomes of upcoming meetings.

Continuing with the same analogy as Ter Ellen et al. (2020), the change in the 12-month OIS rate, Δi_t^{OIS}, captures a "path" surprise. A path surprise may relate to central bank forward policy communication or new information on quantitative easing, i.e., information past the current meeting in time t.

To validate that these rate changes capture the surprise elements of the monetary policy decision, a simple OLS regression is run on different European financial variables. The financial variables include different maturity euro OIS rates (from 3-month to 10-years), euro to US dollar exchange rate (EURUSD), and a European equity index[1] (ESTOXX50). Equation 2 demonstrates the form of the simple OLS regression.

$$\Delta Z_t = \alpha + \beta \text{Target}_t + \gamma \text{Path}_t + \epsilon_t \quad (2)$$

In Equation 2, ΔZ_t denotes the t-1 to t basis points difference of OIS rates, stock index, and exchange rate. Coefficients β and γ reveal the effect of the surprise proxies on the financial variables. Target_t and Path_t denotes the

[1] The European equity index used is the Euro Stoxx 50, which tracks Eurozone's largest, highly traded companies (STOXX, 2024).

target and path surprises estimated in time t with Equation 1 using 1-month and 12-month euro OIS rates, respectively. The time index t encompasses all dates on which scheduled ECB policy decisions were made. Terms α and ϵ_t represent constant and error terms, respectively. Results of running this regression equation with robust standard errors is presented in Table 1.

Table 1: Target and path surprise proxies on European financial variables.

	Target	Path	Adj. R^2	Obs
3M OIS	0.5762***	0.3882***	0.85	168
	(0.0658)	(0.0565)		
6M OIS	0.3171***	0.6557***	0.94	168
	(0.0655)	(0.0434)		
24M OIS	-0.1628***	1.1164***	0.93	168
	(0.0433)	(0.0555)		
5Y OIS	-0.3348***	1.0104***	0.65	104
	(0.2400)	(0.2125)		
10Y OIS	-0,3402***	0.6212***	0.33	105
	(0.2842)	(0.2514)		
ESTOXX50	-0.0679***	-0.0148	0.10	168
	(0.0289)	(0.0162)		
EURUSD	-0.0171	0.0586***	0.23	168
	(0.0335)	(0.0261)		

Note: A simple OLS regression with sample from May 2006 to October 2022. Robust standard errors in parenthesis. ***=1% **=5% *=10% significance level.

As Table 1 demonstrates, a target surprise positively influences the shorter end of the yield curve, and the effect turns negative in longer maturities. The path surprise, inversely, affects most distinctly the longer maturities. The effect of target surprise on the European equity index is negative. This could be due to the higher discount rate in valuation models, resulting in a decrease in equity value. The target surprise on euro US dollar rate does not demonstrate statistical significance, but there seems to be a statistically significant positive response on path surprise.

For additional evidence on the use of these changes in rates as surprise proxies, refer to Figure 2, which plots the surprises on a timeline from 2006 to 2022. In Figure 2, four distinct ECB monetary policy meeting dates are marked with alphabets: A: 5 June 2008, B: 3 July 2008, C: 3 March 2011, and D: 27 October 2022.

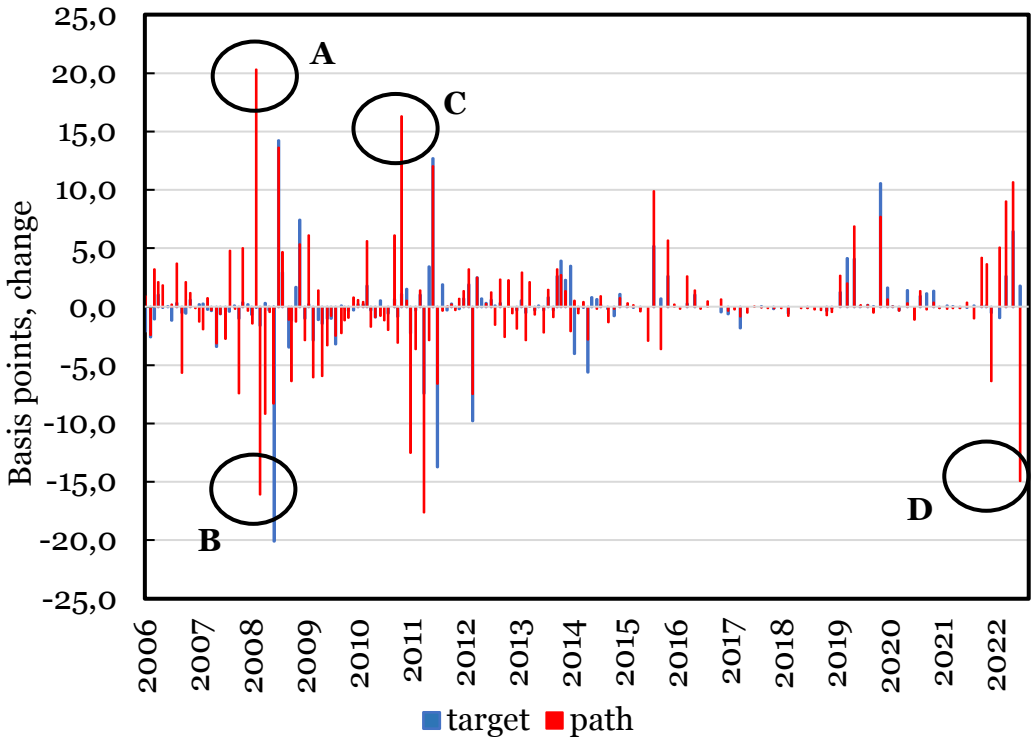

Figure 2: Target and path surprises between 2006 and 2022. A: 5 June 2008, B: 3 July 2008, C: 3 March 2011, and D: 27 October 2022. Table 2 has detailed commentary on the dates A-D.

Figure 2 demonstrates there have been constant policy surprises between 2006 and 2022. The minimum change in the target surprise was negative 20 bp and maximum change was 14 bp, with a mean change of 0.09 bp. For the path surprise, the minimum change was negative 18 bp and the maximum change was 20 bp, with mean change of 0.07 bp. The most distinct surprises occurred during and after the financial crisis. Surprise changes in the rates were less pronounced during the ELB period. Table 2 demonstrates four events from the timeline (marked by alphabets) and presents qualitative information on the ECB monetary policy meetings held on those days.

Table 2: Qualitative examples of ECB's surprises.

A	5 June 2008	A positive path surprise. President Trichet mentioned in the press conferences following the monetary policy decision that "...we could decide to move our rates by a small amount in our next meeting in order." This statement prompted an uptick in markets prices for short-term rates.
B	3 July 2008	A negative path surprise. President Trichet asserted in the press conference that "...we had to increase the rates of our monetary policy stance by 25 basis points, and we trust that this will contribute to delivering price stability in the medium term." Consequently, the market promptly scaled back its expectations for future hikes.
C	3 March 2011	A positive path surprise. President Trichet expressed in the press conference that a rate hike in the upcoming meeting is possible, leading the market interpret this statement as a signal that rates were kept on a higher lever for a longer.
D	27 October 2022	A negative path surprise. The monetary policy decision, following a second consecutive 75 bp hike, announced the next decision would be approached on a "meeting-by-meeting" basis. Additionally, the decision provided indications of an economic slowdown.

2.1 Indicator for monetary policy surprise strength

2.1.1 Measuring monetary policy surprise strength

To evaluate the potency of the monetary policy surprise, this paper proposes a novel indicator based on percentile scores. The target and path surprises, as estimated in the previous chapter, are further segregated into positive and negative surprises within the dataset. Subsequently, the percentile ranges are calculated for the resulting positive and negative target and path responses.

The strength of the response is categorized into three levels: "weak," "medium," and "strong." A response labeled as "weak" indicates that it falls below the 25^{th} percentile, while responses falling between the 25^{th} and 75^{th} percentiles are designed as "medium." Responses surpassing the 75^{th} percentile are categorized as "strong." For negative surprises, the labels are reversed for clarity in interpretation. In the context of a negative response, the more negative it is, the stronger it is perceived.

It is important to acknowledge that the classification into percentile ranges is arbitrary. The aim of this exercise is to establish a relatively simple measurement. The decision to divide into three ranges is inspired by the efficient market hypothesis introduced by Fama (1970), which posits that market efficiency can be categorized as either "weak," "semi-strong," or "strong."

The descriptive statistics for the surprise strength variables are presented in Table 3. The positive target variable reveals a mean of 1.68, indicating considerable variability with a standard deviation of 2.70 and a range of values from 0.01 to 14.2. In contrast, the negative target variable exhibits a mean of -1.55, accompanied by a higher standard deviation (3.17) and a broader range from -20.1 to -0.01.

The positive path variable, with a mean of 3.12, displays a higher standard deviation (3.95) and a range from 0.01 to 20.3, suggesting greater variability. Conversely, the negative path variable, with a mean of -2.43, demonstrates comparable variability (standard deviation of 3.53) and a range from -17.6 to -0.02.

Table 3: Descriptive statistics for positive and negative target and path surprises.

Variable	Obs	Mean	Std. Dev.	Min	Max
Positive target	75	1.680	2.698	.01	14.2
Negative target	71	-1.549	3.173	-20.1	-.01
Positive path	73	3.122	3.952	.01	20.3
Negative path	89	-2.426	3.531	-17.6	-0.02

Table 4 presents the indicator for monetary policy surprise strength, denoted in basis points. Figure 3, depicted below, offers a visual representation to the values outlined in Table 4. For target surprises, a weak positive response is defined between zero and 0.2 bp, a medium response between 0.2 and 1.9 bp, and a strong response above 1.9 bp. Conversely, for negative target surprises, a weak response lies between zero and -0.3 bp, medium response spans -0.3 to -1.5 bp, and a strong response is below -1.5 bp.

Concerning path surprise, a weak positive response is situated between zero and 0.5 bp, a medium response spans 0.5 to 4.2 bp, and a strong response is above 4.2 bp. For a negative path surprise, a weak response is between zero and -0.3 bp, a medium response spans -0.3 to -2.9 bp, and a strong response falls below -2.9 basis points.

Table 4: Monetary policy surprise strength classified into three categories based on percentile ranges.

	Target surprise		Path surprise	
	Positive	Negative	Positive	Negative
Weak	0..0.2	0..-0.3	0..0.5	0..-0.3
Medium	0.2..1.9	-0.3..-1.5	0.5..4.2	-0.3..-2.9
Strong	> 1.9	< -1.5	> 4.2	< -2.9

Note: "Weak" corresponds to responses below the 25th percentile, "medium" encompasses responses falling between the 50th to 75th percentiles, and "strong" pertains to responses exceeding the 75th percentile. Numerical values are in basis points. These percentile ranges are derived from OIS rate reactions observed between 2006 and 2022.

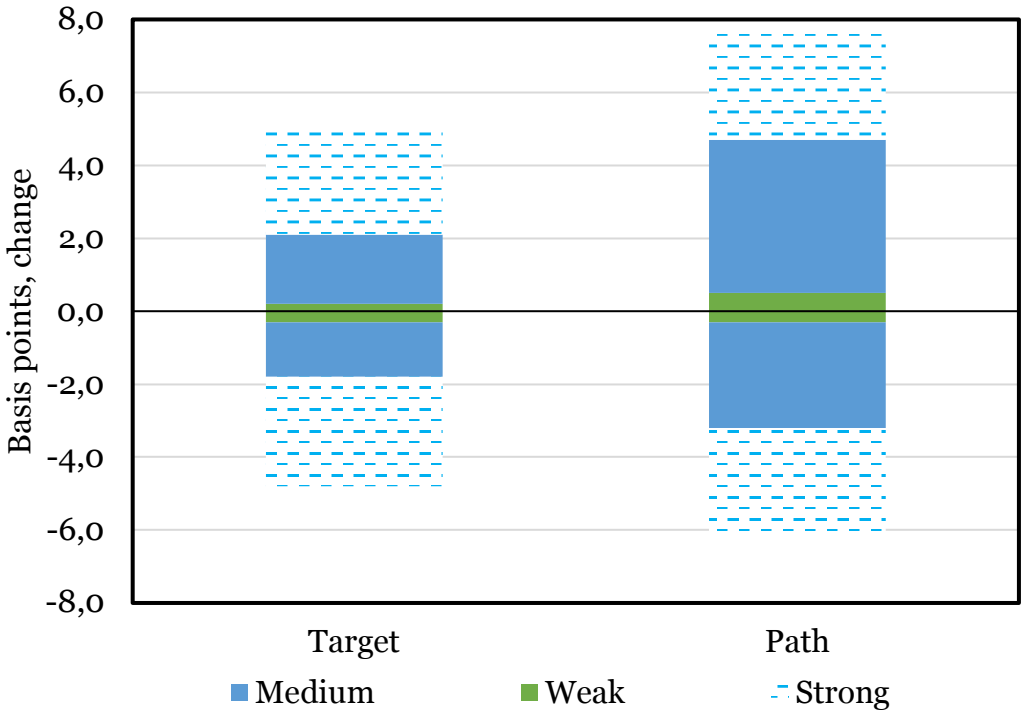

Figure 3: Graphical illustration of Table 4. Given that strong surprises are theoretically infinite, the figure represents this with an area of dotted horizontal lines. Table 3 presents the realized bounds of target and path surprises between 2006 and 2022.

2.1.2 Implications of the surprise strength indicator

Defining surprise strength should extend beyond historical data points, incorporating additional measures. This proposal suggests the inclusion of both quantitative and qualitative metrics for a more nuanced assessment. For

instance, analyzing comments from financial market speculators or analysts immediately after the ECB's monetary policy decision can offer valuable insights. Utilizing web scraping[2], specific words employed by these market participants in their reactions can gauge the perceived "amount of surprise" by the markets.

While the proposed indicator may seem simplistic, its practical implications in financial economics are noteworthy. Analysts can leverage this indicator to assess market reactions promptly after the ECB meeting. In practical terms, analysts should utilize intra-day data for the OIS instruments, aligning with the monetary event window. Calculating the delta by estimating median quote in the pre-release window (13:25-13:35) and in the post-conference window (15:40-15:50) provides the surprise measurement. The obtained delta can then be cross-referenced with the framework presented in Table 4, offering an additional, relatively straightforward measurement to evaluate the surprise effect of the ECB monetary policy event.

3 Empirical event study analysis

This paper applies OLS regression to measure the impact of the announcement of a surprising monetary policy news on financial variables. This approach is rooted in the efficient market hypothesis, positing that market pricing adheres to a random walk in the absence of new information (Kampl, 2021). In more detail, the model used in this paper builds on recent works by Altavilla et al. (2019), Ter Ellen et al. (2020), and Nitschka and Hager (2022). Equations 3 and 4 demonstrates the forms of the empirical event study regressions.

$$\Delta X_t = \alpha + \beta \text{Target}_t + \gamma \text{Path}_t + \epsilon_t \quad (3)$$

$$\Delta X_t = \alpha + \beta \text{Target}_t + \gamma \text{Path}_t + \delta D_{ELB} + \epsilon_t \quad (4)$$

In Equation 3 and 4, ΔX_t denotes the t-1 to t percentage point return of stock indices or exchange rate or t-1 to t percentage point first differences of government bond yields or OIS rate. Coefficients β and γ reveal the effect of the surprise proxies on the financial variables. Target_t and Path_t denotes the target and path surprises estimated in time t with Equation 1 using 1-month and 12-month OIS euro rates, respectively. The time index t encompasses all dates on which scheduled ECB policy decisions were made. Terms α and ϵ_t represent constant and error terms, respectively. Equation 4 incorporates a dummy variable D_{ELB} indicating the ELB period.

[2] Web scraping is the practice for collecting data from the internet in an automated way, involving variety of programming techniques (Mitchell, 2018).

3.1 Data

This study examines the spillover effects of policy surprises on the fixed income, equity, and foreign exchange markets in both Sweden and Denmark (countries marked in the tables by "SWE" and "DEN", respectively). To depict the movements in the shorter end of the yield curve, various maturity Swedish krona (SEK) and Danish krone (DKK) OIS rates (1-, 3-, and 6-months) are included. Additionally, the examination extends to government bond yields (marked by "GOV"), representing medium- and long-term yields, encompassing maturities of 1-, 2-, 5-, and 10-years for both countries. Stock market spillover effects in Sweden and Denmark are assessed using Nasdaq OMX stock indices, namely OMX Stockholm 30 (OMXS30) for Sweden and OMX Copenhagen 20 (OMXC20) for Denmark. Sectoral breakdowns, including banking ("BANK"), industrials ("INDU"), and technology ("TECH"), are considered for both countries. Euro currency exchange rate against the Swedish krona and Danish krone ("EURSEK" and "EURDKK", respectively) are also incorporated into the analysis. Summary statistics for these data points is presented in Table 5.

Table 5 illustrates that the financial data comprises 160-165 observations from scheduled ECB policy meetings between 2006 and 2022. The mean first difference ranges from negative 0.47-0.52 percentage points for 1-, 3-, and 6-month SEK OIS rates. The rate changes exhibit a maximum value between 10.3 and 14.8, with a more pronounced minimum value ranging from negative 32.0-58.0 percentage points. In the case of 1-, 3-, and 6-month DKK rates, the minimum responses are less pronounced (negative 21.1-24.2), while the maximum values are higher compared to Sweden (positive 20.2-32.2). A similar pattern emerges when comparing the first difference response of government bond yields between Sweden and Denmark; Danish yields show higher maximum reactions compared to Sweden, while the minimum values are in proximity. The mean reactions of Swedish and Danish stocks are generally similar in the sample, except for Danish banking stocks, which seem to exhibit a positive average reaction compared to a negative reaction in Swedish banking stocks. On average, the euro depreciates against both SEK and DKK in the sample.

Table 5: Summary statistics for Swedish and Danish financial variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
SEK 1M OIS	163	-.467	5.919	-58	10.3
SEK 3M OIS	163	-.528	5.176	-45.5	10.6
SEK 6M OIS	163	-.482	4.837	-32	14.8
SWE GOV 1Y	163	-.782	4.05	-23.15	9.34
SWE GOV 2Y	163	-.335	4.48	-19.96	11.11
SWE GOV 5Y	163	.038	4.996	-17.11	14.56
SWE GOV 10Y	163	.269	4.804	-14.11	19.02
OMXS30	164	-.159	1.675	-10.571	5.047
OMXS BANK	164	-.078	2.093	-13.183	8.775
OMXS INDU	164	-.116	1.972	-9.925	6.753
OMXS TECH	164	-.363	2.299	-12.771	5.487
EURSEK	160	.027	.541	-1.645	2.283
DKK 1M OIS	160	.375	5.534	-21.1	30.8
DKK 3M OIS	160	-.126	4.73	-21.1	32.2
DKK 6M OIS	160	.043	4.707	-24.2	20.2
DEN GOV 1Y	165	-.204	5.985	-18.92	41.26
DEN GOV 2Y	165	-.05	6.289	-21.879	34.31
DEN GOV 5Y	165	.096	6.257	-21.968	30.2
DEN GOV 10Y	165	.39	5.442	-14.78	22.37
OMXC20	165	-.116	1.48	-7.523	3.323
OMXC BANK	165	.018	1.968	-9.4	6.299
OMXC INDU	165	-.153	1.854	-9.05	4.813
OMXC TECH	165	-.131	1.798	-10.116	5.52
EURDKK	160	.001	.023	-.166	.116

4 Results

4.1 Spillovers to Sweden and Denmark

Derived from the sample between 2006 to 2022, no statistically significant association exists between the target surprise and Swedish variables. This contradicts findings of Ter Ellen et al. (2020), as their study revealed an association between short- and long-term rates and the target surprise. Apart from methodological differences, disparate results may stem from variations in variables and time periods. Ter Ellen et al. (2020) employed forward rate agreements (FRAs) to represent Swedish short money market rates, whereas this paper utilized OIS rates. According to BIS (2024) derivatives statistics, notional amount of swap contracts have been distinctly higher compared to FRAs during the recent years; therefore it can be assumed that pricing is more efficient in swaps, supporting the study setup. For longer yields, Ter

Ellen et al. (2020) used swap rates, while this paper employed government bond yields. Government bond yields are more effective for studying longer maturities, as OIS rates are not as regularly traded for maturities exceeding one year (Finlay and Olivan, 2012). Additionally, Ter Ellen et al. (2020) study covered the period between 2002 and 2018, whereas this study spans from 2006 and 2022, resulting in a divergence of approximately eight years.

A one percentage point (pp) path surprise increase is associated with a 0.3-0.5 pp increase in Swedish government bond yields (1-,2-,5-, and 10-year maturities), at a statistically significant level. This finding supports Ter Ellen et al. (2020), as their results demonstrated that a path surprise influences longer Swedish swap rates (2-, 5-, and 10-year). Additionally, aligning with Nitschka and Hager (2022), who observed that a "QE" surprise triggers a significant response in 5- and 7-year maturity Swiss government bond yields. This study does not find statistically significant responses for equity market or exchange rate in Sweden in the full sample.

In Danish financial markets, a target surprise elicits statistically significant responses. A one pp target surprise is associated with a 0.6-1.0 pp decrease in Danish government bond yields (1-, 2-, 5-, and 10-year maturities). This contradicts Ter Ellen et al. (2020), as their analysis demonstrated longer-term Danish swap rates reacting with a positive response to a target surprise. This paper found that a one pp path surprise increases Danish government bond yields (1-, 2-, 5-, and 10-year maturities) 0.8-1.4 pp. The effect is more pronounced compared to Swedish government bond yield responses. A path surprise is associated with an increase in Danish money market rates, as 3- and 6-month OIS rates reacted to a one pp path surprise with a 0.5 and 0.8 pp increase, respectively. There are no statistically significant spillovers in the Danish stock or exchange rate market during the sample period. The results for Sweden and Denmark are presented in Table 6 and Table 7, respectively.

Table 6: Target and path surprise elements on Swedish financial variables.

	Target	Path	Adj. R^2	Obs
SEK 1M OIS	0.274	-0.128	0.017	163
	(0.172)	(0.101)		
SEK 3M OIS	0.376	-0.184	0.043	163
	(0.238)	(0.119)		
SEK 6M OIS	0.583	-0.144	0.112	163
	(0.367)	(0.163)		
SWE GOV 1Y	0.0960	0.300***	0.147	163
	(0.101)	(0.0686)		
SWE GOV 2Y	0.0408	0.500***	0.278	163
	(0.123)	(0.0715)		
SWE GOV 5Y	0.152	0.425***	0.199	163
	(0.194)	(0.104)		
SWE GOV 10Y	-0.150	0.360***	0.095	163
	(0.135)	(0.0904)		
OMXS30	0.0260	-0.0223	0.003	164
	(0.129)	(0.0409)		
OMXS BANK	0.0856	-0.0393	0.013	164
	(0.147)	(0.0455)		
OMXS INDU	0.0209	-0.0121	0.001	164
	(0.139)	(0.0478)		
OMXS TECH	0.0360	-0.00509	0.002	164
	(0.190)	(0.0625)		
EURSEK	0.0152	0.00902	0.021	160
	(0.0120)	(0.0131)		

Note: Results obtained from estimating Equation 3. OLS regression with sample from May 2006 to October 2022. Robust standard errors in parenthesis. ***=1% **=5% *=10% significance level. Estimated coefficients represent percentage point changes following a one percentage point surprise increase in ECB policy.

Table 7: Target and path surprise elements on Danish financial variables.

	Target	Path	Adj. R^2	Obs
DKK 1M OIS	0.249	0.220	0.081	160
	(0.500)	(0.194)		
DKK 3M OIS	-0.305	0.500***	0.183	160
	(0.474)	(0.173)		
DKK 6M OIS	-0.314	0.797***	0.497	160
	(0.285)	(0.110)		
DEN GOV 1Y	-0.919*	1.133***	0.477	165
	(0.472)	(0.202)		
DEN GOV 2Y	-0.960***	1.386***	0.643	165
	(0.323)	(0.129)		
DEN GOV 5Y	-0.880***	1.240***	0.519	165
	(0.272)	(0.117)		
DEN GOV 10Y	-0.614***	0.776***	0.270	165
	(0.220)	(0.0978)		
OMXC20	-0.0383	0.00842	0.005	165
	(0.120)	(0.0472)		
OMXC BANK	0.0908	-0.0645	0.019	165
	(0.147)	(0.0627)		
OMXC INDU	-0.0626	0.0288	0.008	165
	(0.137)	(0.0538)		
OMXC TECH	0.0436	-0.0520	0.011	165
	(0.174)	(0.0706)		
EURDKK	0.00302	-0.000709	0.133	160
	(0.00194)	(0.000650)		

Note: Results obtained from estimating Equation 3. OLS regression with sample from May 2006 to October 2022. Robust standard errors in parenthesis. ***=1% **=5% *=10% significance level. Estimated coefficients represent percentage point changes following a one percentage point surprise increase in ECB policy.

4.2 Spillovers during effective lower bound period

During the effective lower bound (ELB) period (July 2012 – July 2022), spillover effects are more distinctive in both countries' financial markets. During ELB, a target surprise affects the Swedish money market rates, with a one pp target surprise being associated with a 0.2 pp increase in the 6-month OIS rate. A one pp path surprise is associated with a 0.7-1.0 pp increase in the Swedish government bond yields (2-, 5-, 10-year maturities); the effect is stronger compared to the full sample period.

ELB period reveals statistically significant spillovers to the equity market, which were not present in the full sample. A one pp path surprise is associated with a negative return of 0.2 pp in the OMX Stockholm index. From the sector indices of the Swedish equity market, there is a distinct effect on the industrial sector; a one pp path surprise is associated with a negative return of 0.1 pp in industrial sector. The negative effect on the industrial sector remains puzzling. One hypothetical explanation could be that QE is associated with higher inflation, which in turn could be more harmful for investment-heavy and capital-intensive industries. High inflation could require more investments into assets and working capital, negatively impacting free cash flows, and therefore, stock valuation models. During the ELB, a one pp path surprise is associated with a 0.06 pp increase in EURSEK rate.

During the ELB period, a one pp target increase is associated with a 0.3-0.6 pp increase in Danish OIS rates (1-, 3-, and 6-month maturities). The negative effect on Danish government bonds is more pronounced compared to the full sample: the bond yields responded with a 0.2-0.6 pp decrease to a one pp target surprise. Similarly, to a one pp path surprise, the 1- and 6-month Danish OIS rates reacted with 0.3 and 0.5 pp increases, respectively. The effect of one pp path surprise on Danish government bond yields is economically high, 1.0-1.8 pp (1-, 2-, 5-, 10-year maturities). The Danish stock market is more affected by the path surprises in the ELB period compared to the full sample. The OMX Copenhagen is associated with a 0.2 pp return decrease to a one pp path surprise. Similarly, to Sweden, from the sectoral indices, only the industrial sector is statistically significantly affected by the path surprise: a one pp path surprise is associated with a 0.2 pp decrease in returns. Table 8 and Table 9 present results from the ELB period for Sweden, and Denmark, respectively.

Table 8: Target and path surprise elements on Swedish financial variables.

	Target*ELB	Path*ELB	Adj. R^2	Obs
SEK 1M OIS	0.168	0.0365	0.012	89
	(0.121)	(0.156)		
SEK 3M OIS	0.0710	-0.0185	0.001	89
	(0.150)	(0.216)		
SEK 6M OIS	0.249*	-0.0145	0.027	89
	(0.146)	(0.187)		
SWE GOV 1Y	0.322	0.250	0.116	88
	(0.211)	(0.214)		
SWE GOV 2Y	0.0874	0.699***	0.266	88
	(0.290)	(0.240)		
SWE GOV 5Y	-0.170	1.001***	0.244	88
	(0.281)	(0.312)		
SWE GOV 10Y	-0.154	0.749***	0.116	88
	(0.231)	(0.266)		
OMXS30	-0.163	-0.166**	0.208	88
	(0.245)	(0.0709)		
OMXS BANK	-0.300	-0.0892	0.189	88
	(0.306)	(0.0891)		
OMXS INDU	-0.117	-0.224***	0.197	88
	(0.232)	(0.0770)		
OMXS TECH	-0.169	-0.129	0.090	88
	(0.277)	(0.0908)		
EURSEK	0.0212	0.0571**	0.134	90
	(0.0293)	(0.0244)		

Note: Results obtained from estimating Equation 4 with a dummy variable indicating the ELB period. OLS regression with sample from May 2006 to October 2022. Robust standard errors in parenthesis. ***=1% **=5% *=10% significance level. Estimated coefficients represent percentage point changes following a one percentage point surprise increase in ECB policy.

Table 9: Target and path surprise elements on Danish financial variables.

	Target*ELB	Path*ELB	Adj. R^2	Obs
DKK 1M OIS	0.466***	0.313**	0.207	90
	(0.144)	(0.142)		
DKK 3M OIS	0.598***	0.122	0.494	90
	(0.123)	(0.126)		
DKK 6M OIS	0.295***	0.479***	0.700	90
	(0.0900)	(0.0835)		
DEN GOV 1Y	-0.167	0.993***	0.618	88
	(0.137)	(0.131)		
DEN GOV 2Y	-0.644**	1.615***	0.637	88
	(0.246)	(0.209)		
DEN GOV 5Y	-0.649***	1.828***	0.504	88
	(0.205)	(0.187)		
DEN GOV 10Y	-0.556***	1.306***	0.224	88
	(0.203)	(0.204)		
OMXC20	-0.0822	-0.238***	0.277	88
	(0.183)	(0.0751)		
OMXC BANK	-0.243	-0.0627	0.110	88
	(0.247)	(0.114)		
OMXC INDU	-0.0973	-0.218***	0.231	88
	(0.223)	(0.0632)		
OMXC TECH	-0.255	-0.181	0.233	88
	(0.235)	(0.114)		
EURDKK	-0.000387	0.000919	0.006	90
	(0.00224)	(0.00114)		

Note: Results obtained from estimating Equation 4 with a dummy variable indicating the ELB period. OLS regression with sample from May 2006 to October 2022. Robust standard errors in parenthesis. ***=1% **=5% *=10% significance level. Estimated coefficients represent percentage point changes following a one percentage point surprise increase in ECB policy.

4.3 Spillovers under different exchange rate regimes

In this paper, the primary focus is on Sweden and Denmark, each characterized by a different exchange rate regime–the Swedish krona operates as a floating currency, while the Danish krone is fixed with a euro-peg. The magnitude of the spillover effects from monetary policy surprises, particularly in small and open economies, is intertwined with the currency regime, manifesting through the exchange rate channel (Borrallo and Hierro, 2019).

The fully floating exchange rate regime, exemplified by Sweden, exhibits a greater resilience towards major central banks decisions. This paper found no statistically significant relationship between the target surprise and Swedish financial variables over the full period. This contrasts with the fixed exchange regime in the Danish market, where the target surprise resulted in an increase in government bond yields. However, the timeframe seems to be a significant factor, as during the ELB, Sweden demonstrated returns in the 6-month OIS rate in response to a target surprise.

The relevance of the currency regime appears somewhat diminished when considering a path surprise. The path surprise seems to influence government bond yields in both countries, with a more pronounced response observed in the fixed exchange regime. As discussed by Nitschka and Hager (2022), the path surprise may encompass elements related to new information on future quantitative easing programs. Given the free flow of capital in both Sweden and Denmark, quantitative program announcements could have substantial effects on both countries' markets, potentially through the portfolio rebalance channel. This effect has been captured by, e.g., Koijen et al. (2017), as their study found ECB's targeted asset purchase programs leading to foreign investors rebalancing their portfolios to seek higher yields.

For both currency exchange regimes, the ELB period reveals stronger spillovers in yields, consistent with the findings of Ter Ellen et al. (2020). This result remains perplexing as conventional monetary policy at the ELB becomes less potent due to the ECB's limited control over the interbank money market. The effects observed could be attributed to the impact on the banking sector, where a prolonged period of low interest rates may impact the profitability of banks. Any unexpected policy change by the ECB might affect the net interest margin for Danish and Swedish banks, influencing their lending and investment activities. Furthermore, consideration must be given to investor behavior affecting outcomes. In extended low-rate periods, stagflation concerns may lead to an overreaction to unexpected ECB news.

In summary, it appears that the currency exchange rate is consequential for the transmission of a monetary policy surprise. The fixed exchange rate regime responds more robustly to ECB policies, both in target and path surprises, whereas the floating exchange regime predominantly responds to path surprises. The ELB period intensifies spillovers for both currency regimes.

5 Conclusions

This paper examined the impact of the ECB's monetary policy surprise spillovers to the financial markets of two non-euro-area small open economies, Sweden, and Denmark. Despite their significant economic and political ties to the euro area, these Nordic countries have received limited attention in terms of spillover effects. This paper employed high-frequency intra-day interest rate data to proxy two types of surprises: target and path surprises. The target surprise is measured as the change in the 1-month euro OIS rate around the monetary policy announcement, while the path surprise reflects the change in the 12-month euro OIS rate during the same window. The financial variables of interest included OIS rates, government bond yields, equity market indices, and exchange rates. The primary study period spanned from May 2006 to October 2022, which covered 168 expected ECB policy meetings. This paper also overviewed a subperiod, effective lower bound (ELB), which was in effect from July 2012 to July 2022.

The primary finding of this paper is the existence of significant spillovers from the ECB's policy to non-euro area markets, with these effects becoming more pronounced during the ELB period. A path surprise is associated with a statistically and economically significant positive spillover effect on government bond yields for both Sweden and Denmark, with Danish bond yields displaying a more pronounced response. Conversely, no evidence was found for a target surprise affecting the SEK or DKK money market rates. These results suggest that domestic central banks may exert greater control over the shorter end of the yield curve, while ECB policy influences the longer yields in foreign economies.

During the ELB period, equity market spillovers become evident, with a path surprise correlating with a negative return in Swedish and Danish equity markets. A novel finding is the negative impact of a path surprise on the industrial sector's equity prices during the ELB period. High inflation could require more investments into assets and working capital, negatively impacting free cash flows and stock valuation models. This paper did not uncover evidence of the monetary policy surprise proxies affecting the banking or technology sectors. The influence on the overall stock market indices could be attributed to the dominance of industrial companies in the Swedish and Danish markets.

Additionally, during the ELB period, this paper observes that a path surprise is associated with the euro depreciating against SEK, implying that expansionary measures by the central bank may lead to domestic currency depreciation. This effect is potentially linked to the portfolio rebalance channel, where foreign investors adjust their portfolios outside the euro area.

The results are consistent with prior literature on spillovers from ECB's operations. Similar to the findings of Nitschka and Hager (2022) and Ter Ellen et al. (2020), a path surprise exhibits a positive association with responses in longer yields. Comparable effects on yields were also discovered by Falagiarda et al. (2015) when examining different set of non-euro area countries in Eastern and Central Europe. The ELB period emerges as a

significant factor in spillover effects, with the effects being more pronounced in alignment with Ter Ellen et al. (2020) findings. The paper also identifies spillovers to path surprises in equity markets. This aligns with Fratzscher et al. (2016) and Georgiadis and Gräb (2016), who determined that asset purchase programs reinforced international equity markets, albeit in a broader array of countries.

The paper contributes to the ongoing discourse on the "trilemma" of international economics, suggesting a partial "dilemma" wherein effective monetary policy for small open economies requires some capital account management, in the presence of floating exchange rates. The findings imply that the ECB's policy may impact longer yields, thereby weakening the transmission channels of domestic central banks.

For future research, exploring stock market spillovers in SOEs and utilizing a more extensive selection of stock market and sectoral indices could offer valuable insights. This could involve breaking down stock returns into overall market movements, "beta," or excess returns, and creating a "placebo" index for a more nuanced analysis. Investigating possible transmission channels explaining the impact on the industrial sector in SOEs and extending the study to include Iceland, an uncovered Nordic SOE, would further enrich the evidence of spillovers. Furthermore, this paper initiated a discourse on quantifying the potency of monetary policy surprises and introduced a novel indicator. Future researchers should delve deeper into exploring this indicator to achieve a more comprehensive measure of the strength of monetary policy surprises.

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