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Financial Flows and Exchange Rate Dynamics: Evidence from Sweden*

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Abstract

We examine how central bank foreign exchange (FX) operations affect nominal exchange rates by exploiting two large operations by Sveriges Riksbank: foreign currency purchases during 2021–2022 and domestic Swedish krona (SEK) purchases—that is, FX forward sales— during 2023–2024. Using daily data and local projections, we identify unanticipated operation shocks to the SEK against the euro (EUR) and the U.S. dollar (USD). On average, we observe sign consistency—depreciation during FX purchases and appreciation during SEK purchases. Three main results emerge: (i) effects unfold gradually but fade quickly, becoming statistically insignificant after about ten trading days; (ii) they are regime-dependent, with FX purchases inducing larger depreciations and domestic currency purchase yielding smaller, delayed appreciations; and (iii) FX purchases generate long-run (11-60 days) currency-specific effects, with a stronger SEK depreciation against the EUR relative to the USD. However, results are more uniform across currencies in the short run (1–10 days) and throughout the domestic currency purchase period.

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1 Introduction

What drives nominal exchange rate fluctuations remains one of the foundational yet unresolved questions in international macroeconomics. Since the collapse of the Bretton Woods system, the debate has centered on whether exchange rates are anchored by macroeconomic fundamentals or shaped by other forces, such as financial frictions and capital market imperfections. Traditional models based on equilibrium conditions—such as Purchasing Power Parity and Uncovered Interest Parity—have long failed to explain short- and medium-run exchange rate dynamics. Recent theoretical advances, including Itskhoki and Mukhin (2021), attribute persistent exchange rate movements to non-fundamental financial shocks, particularly in environments with segmented markets and limited risk-bearing capacity. These insights echo earlier portfolio balance models (Kouri, 1976; Branson and Henderson, 1985), now reframed through the lens of balance sheet constraints and incomplete markets. In parallel, Wallace (1979) showed that fiat currencies lack a natural anchor in the absence of policy rules or frictions. The most common monetary policy rule nowadays, inflation targeting, does not imply a stationary price level or nominal exchange rate.[1] Theoretical arguments thus suggest that cross-border financial flows—especially those originating from balance-sheet-sensitive agents—can have lasting effects on exchange rates.

With this background in mind, the present study examines two episodes of foreign exchange operations conducted by Sveriges Riksbank, the central bank of Sweden, during the period 2021–2024, with the aim of understanding how these operations affected the nominal exchange rate of the Swedish krona against its main trading partners' currencies — the U.S. dollar and the euro.

The first episode, occurred between January 2021 and December 2022, involved net purchases of foreign exchange to refinance FX reserves, amounting to approximately 3.5% of GDP. The second episode, from September 2023 to January 2024, consisted of FX sales on the forward market aimed at partially hedging existing FX reserve positions, totaling about 1.7% of GDP. We will refer to these two episodes as RF and HDG, respectively.[2]

These operations were not undertaken for active exchange rate management purposes. This institutional setting thus provides a *potential* quasi-experimental environment in which these FX flows can be treated as plausibly exogenous. However, estimating the causal link of central bank foreign exchange (FX) operations on the nominal exchange rate requires isolating variation in such flows that is plausibly exogenous to macroeconomic fundamentals and market expectations, something we cannot easily assume. Recent studies have sought to address this by exploiting higher-frequency information and more transparent identification schemes. For instance, short-horizon analyses using

[1] For a discussion of the non-stationarity of nominal exchange rates, see Benigno and Benigno (2008) and Engel and Wu (2023), among others.

[2] Note that the size of the FX reserves was not changed by the operations. The RF-period was simply a change of financing form, from loans from the Swedish National Debt Office to central bank reserves.

daily or intraday data Fatum and Hutchison (2003); Dominguez (2003); Fratzscher et al. (2019); Caspi, Friedman and Ribon (2022) have reduced simultaneity concerns, while longer-horizon approaches based on lower-frequency data Blanchard, Adler and de Carvalho Filho (2015) often rely on instruments or proxies that are difficult to validate. More recently, researchers have combined daily data with external-instrument approaches to evaluate the persistence of operation effects across multiple countries Menkhoff, Rieth and Stöhr (2021).

While our work is related to this literature, its objective and empirical design differ in important ways. Rather than assuming that operations are exogenous or relying on external instruments, we focus on the *unanticipated* component of the Riksbank's FX transactions. Specifically, our empirical strategy extracts shocks from residuals of predictive models of operation timing and volume, estimated through both standard OLS and machine-learning (LASSO) techniques. We then trace the impact of these unanticipated shocks on the nominal exchange rate using *local projections*, controlling for conventional factors such as interest rate differentials, financial volatility, and seasonal patterns. This framework allows us to examine how the exchange rate response evolves over time and to test for heterogeneity across currencies (USD and EUR) and across policy regimes, without requiring strict exogeneity assumptions.[3]

Our preferred specification—OLS with a full set of controls—suggests that the average effect over 60 trading days of a 1% of GDP FX purchase during the RF period caused a 1.8% depreciation of the SEK against the euro (EUR) and a 0.1% depreciation against the U.S. dollar (USD). In the HDG period, the reverse operation led to a 0.2% appreciation against both currencies.

The average effects and dynamic responses reported in Figure 5 reveal three key characteristics of the Riksbank's FX operations: (i) they unfold gradually over time for both currencies, though not always with statistically significant magnitudes; (ii) they differ across regimes; and (iii) they are currency-specific. Regarding the first characteristic, following a 1% of GDP purchase, the SEK initially depreciates by about 0.5% against the EUR within 1–5 trading days and by around 0.6% against the USD over the same horizon. The magnitude of the response increases over time, reaching roughly 1.6% and 1.3% depreciations over the 6–20 day window and cumulating to slightly above 2% after 60 days.

Turning to the second characteristic, the effects differ across regimes. During the hedging (HDG) period, the reverse operations—FX sales—generated much milder and more delayed appreciations of the SEK, amounting to around 0.15–0.16% against both the EUR and the USD after 60 days. In the short run, the impact is close to zero, and even as the effects accumulate, they remain small compared with the depreciation

[3] We use the term "regime" somewhat loosely for intuitive reasons, as it conveniently captures distinctions between different types of FX operations. However, we acknowledge that the term may not strictly apply but retain it here for ease of exposition.

episodes observed during the RF period. These patterns confirm the asymmetric nature of purchase versus sale operations and the structural difficulty for a small open economy like Sweden to achieve appreciations, given market depth, liquidity, and the global dominance of the euro and dollar.

Finally, regarding the third characteristic, currency-specific differences materialize mainly over longer horizons (11–60 trading days) and only during the RF period. In the short run (1–10 days) and throughout the HDG period, the SEK's response is largely uniform across currencies. Beyond the first two weeks of the RF episode, however, the depreciation against the USD weakens relative to that against the EUR, consistent with greater dollar-related volatility. In fact, we observe that between January 2021 and December 2022, the standard deviation of daily log-returns for EUR/SEK was approximately 0.34%, compared with 0.74% for USD/SEK and 0.36% for EUR/USD, indicating that the krona's fluctuations were more pronounced vis-à-vis the dollar.

The direction and shape of the responses remain broadly consistent across alternative shock definitions (LASSO) and model specifications (IV). Although these alternative approaches occasionally produce smaller or more delayed effects—and in some cases partial reversals—the estimates remain within a fairly tight range. This narrow, directionally consistent band of outcomes enhances the credibility of our core results and reinforces the importance of shock construction in empirical FX research.[4]

Reassuringly, the magnitude of our results is broadly in line with previous empirical studies of central bank operations. For example, Caspi, Friedman and Ribon (2022) estimate that a 1% of GDP operation by the Bank of Israel leads to a 3% depreciation of the ILS/USD rate, while Adler, Lisack and Mano (2019) report an average elasticity of around 2% across 52 countries. Other recent studies using high-frequency or granular data, such as Sizova, Syrstad and Hansen Savareid (2024) for Norway and Bippus, Lloyd and Ostry (2023) for the UK, document larger elasticities for private sector flows. Our findings are also consistent with modern portfolio balance and financial friction models of exchange rate determination, including Itskhoki and Mukhin (2021), Gabaix and Maggiori (2015), and Maggiori (2020), which emphasize the role of imperfect asset substitutability and limited risk-absorbing capacity. They also speak to the historical literature on FX operations in Sweden, see Aguilar (Ragnartz); Humpage and Ragnartz (2006).

The findings of this paper reinforce the growing view that nominal exchange rates are strongly influenced by financial flows—including central bank operations—even when there is no explicit exchange rate target. Our main contribution lies in demonstrating that the effects of foreign exchange (FX) operations unfold gradually over time and exhibit both currency-specific and regime-specific patterns in their impact on exchange rates. Our evidence has implications for the design of reserve management strategies, the

[4]Some attenuation or partial reversals emerge at longer horizons—particularly in the hedging period—where the sample size is significantly smaller due to the shorter horizon of the operations and likely generating differences in identification strength, signal-to-noise ratios, or sensitivity to the timing and persistence of flows.

transparency of central bank operations, and the modeling of exchange rate dynamics.

The paper is organized as follows. Section 2 describes the Riksbank's FX operations, the data, and the main exchange rate descriptives. Section 3 outlines our empirical strategy, including the identification and validation of operation shocks. Section 4 presents the main empirical evidence, while Section 5 concludes. Additional materials, robustness checks, and supplementary analyses are provided in the online appendix.

2 Riksbank FX Operations

Since adopting an inflation-targeting regime in 1993, the Riksbank has generally allowed the exchange rate to float freely, with only sporadic foreign exchange (FX) operations. After a period of fixed exchange rate regimes—marked by repeated devaluations—the central bank abandoned its peg in 1992. Notable operations occurred in 1993 and 2001, but FX activity remained limited until recently.[5] In 2021–2022, the Riksbank undertook substantial FX purchases—totaling 3.5% of GDP—to repay foreign currency loans from the Swedish National Debt Office previously used to finance the FX reserves.The pace of FX purchases was accelerated about half way through the program, which we also take into consideration in our empirical analysis. In 2023–2024, the Riksbank sold foreign currency (amounting to about 1.7% of GDP) as part of a hedging program to reduce balance sheet risks. These transactions, though not intended as exchange rate policy, shifted the net FX position of the central bank considerably, potentially affecting exchange rate dynamics via supply-demand and portfolio balance channels. Our analysis focuses on these two recent operations.

Table 1 provides a summary of the Riksbank's foreign exchange operations between 2021 and 2024. The table reports cumulative net purchases (or sales) of foreign currency, distinguishing between the RF period (2021–2022) and the HDG period (2023–2024). While the purchases were executed in the spot market, the hedging operations were implemented primarily through swap contracts, with the purpose of altering the Riksbank's net exposure to FX risk.

[5] See Berg and Gröttheim (1997) and Heikensten and Borg (2002) for discussions of these two episodes, respectively.

Table 1: The Riksbank's FX operations

	Reserve Refinancing (RF)	Hedging (HDG)
Period	1 Feb 2021 – 31 Dec 2022	25 Sep 2023 - 31 Jan 2024
Type	FX Purchases	SEK Purchases
FX instruments	Spot	Swaps, Spot
USD (in SEK Billions)	140	85
EUR (in SEK Billions)	58	23
Total (in SEK Billions)	198	108
Total (% of Swedish GDP)	3.5	1.7

Note: The fourth and fifth rows show the amount of USD and EUR, expressed in Swedish krona, sold or purchased in each of the two major FX operations. For the total amount as a share of GDP, we use the annual GDP for 2023 for the hedging period and the average of 2021 and 2022 for the reserve financing period. ***Source:*** Sveriges Riksbank.

2.1 Data and FX Descriptives

Our dataset contains daily proprietary data on the Riksbank's foreign exchange transactions from 1 February 2021 to 31 January 2024. Figure 1 reports the cumulative FX transactions (in SEK billion) against the nominal exchange rate of the krona versus the USD and EUR. The visual correlation suggests three key dynamics: (i) the SEK depreciated steadily as FX purchases accumulated during 2021–2022; (ii) the rate of depreciation accelerated as purchases intensified in early 2022; and (iii) the trend reversed in late 2023 as FX sales began, with a corresponding appreciation of the SEK. Although these patterns are only suggestive, they align with predictions from portfolio balance models, where relative currency supplies and market segmentation drive exchange rate movements.

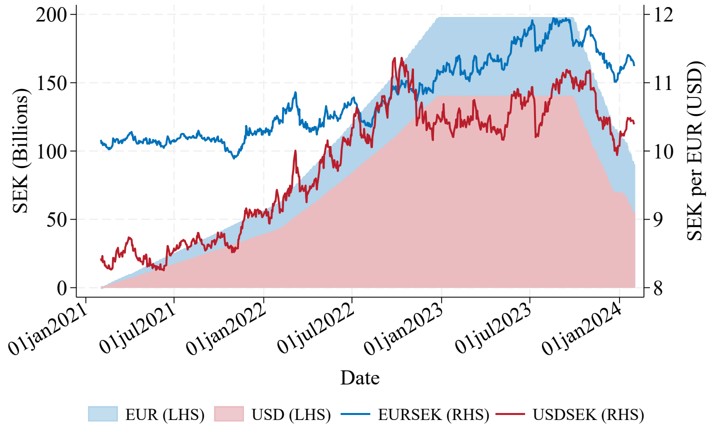


Figure 1: The Riksbank's FX operations and the krona exchange rate

Note: The left axis shows the Riksbank's cumulative purchase/sale position of FX expressed in billions of SEK. Increasing amounts reflect purchases while decreasing amounts reflect sales. The right axis shows bilateral exchange rates. ***Sources:*** Sveriges Riksbank and Bloomberg.

Before turning to empirical details, the visual analysis above can be complemented in two ways. First, we present a simple regression where the nominal exchange rate is regressed on cumulative FX transactions (i.e., the variables shown in Figure 1). Second, we leverage the similarity with the Norwegian krone to provide a comparative perspective (Figures 2 and 3).[6]

Table 2 summarizes the results of the first exercise. A 1% of GDP increase in the cumulative transaction amount, jointly on both EUR and USD is associated with a 4.7% change in the SEK exchange rate, with slightly larger effects observed during FX purchases. These estimates, however, should be interpreted with caution, as they reflect correlations rather than causal effects. In the next section, we turn to a more rigorous identification strategy to isolate the causal impact of FX operations on the SEK.

Table 2: Exploratory Stock Effect Estimates

	Full	RF	HDG
FXres	4.672***	5.711***	-3.153***
	(0.216)	(0.300)	(0.484)
N	1564	1000	184
R^2	0.155	0.162	0.096

Note: The table presents the point estimates from a panel regression in which the log of the EURSEK and USDSEK exchange rates is the dependent variable and the Rikbank's cumulative purchase/sale position is the independent variable. Robust standard errors are shown in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Next, we leverage the comparative behavior of the Norwegian krone (NOK) as a natural benchmark.

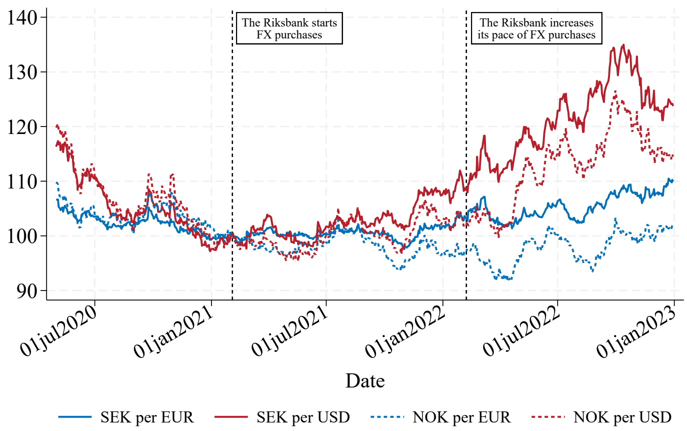


Figure 2: Nominal exchange rates. SEK and NOK vs. USD and EUR, Reserve Refinancing Period (2021-2022)

Note: A higher (lower) value indicates appreciation (depreciation) of the NOK and SEK against the USD and EUR, respectively. The exchange rates are indexed at 100 on February 1, 2021. This is when the Riksbank started transitioning to a self-funded FX reserve by purchasing EUR and USD.
Source: Macrobond.

Figure 2 compares the evolution of the SEK and NOK vis-à-vis the USD and EUR during the RF period. Prior to early 2022, both currencies followed broadly similar paths against the USD and the EUR. However, from February 2022—when the Riksbank increased the pace of FX purchases—the SEK began to depreciate more sharply against

[6]We are grateful to Mambuna Njie who produced the original versions of Figures 1-3.

these two currencies than the NOK. Given the absence of similar operations by Norges Bank, the divergence lends circumstantial support to the hypothesis that the Riksbank's actions may have influenced the exchange rate.

Figure 3 performs a similar comparison during the HDG period. Again, SEK and NOK trends were parallel prior to September 2023. Following the announcement and initiation of FX sales by the Riksbank, the SEK appreciated more strongly, ending the period about 4.4% stronger against the EUR and 4.1% against the USD compared to the NOK. These developments reinforce the notion that the Riksbank's FX transactions may have had measurable effects, even absent a formal exchange rate objective.

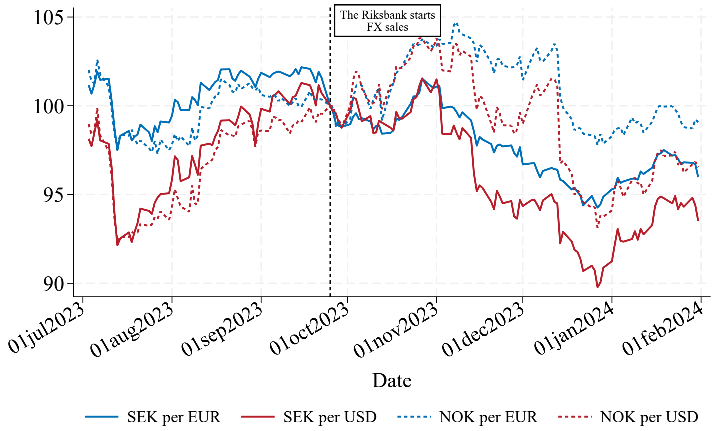


Figure 3: Nominal exchange rates. SEK and NOK vs. USD and EUR, Hedging Period (2023-2024)

Note: A higher (lower) value indicates appreciation (depreciation) of the NOK and SEK against the USD and EUR, respectively. The exchange rates are indexed at 100 on September 25, 2023. This is when the Riksbank started to hedge its FX reserves by selling EUR and USD.

Source: Macrobond.

3 Empirical Evidence

With the descriptive trends above in mind, we now turn to formally estimating the causal impact of the Riksbank's FX operations during 2021–2024 on the SEK exchange rate.

3.1 Empirical Strategy

The Riksbank's FX operations during the 2021–2024 period were publicly communicated but not as active monetary policy measures. Instead, they were motivated by balance sheet considerations—specifically, to self-finance the FX reserves and to hedge foreign exchange exposures, respectively. This institutional setting provides a useful identification environment: actual net transaction volumes can be considered plausibly exogenous to contemporaneous exchange rate movements and unobserved determinants of policy intent. However, a central empirical challenge remains. Even in the absence of explicit signaling, observed FX flows may correlate with exchange rate dynamics through anticipatory market behavior or joint responses to broader macro-financial shocks. Therefore, estimating the causal effect of operations requires isolating the unexpected component of FX operations from potentially endogenous responses, ruling out simple correlation-based approaches.

To address this, we construct a set of high-frequency operation shocks designed to isolate the unanticipated component of the FX operations. Our baseline identification strategy employs a residual-based approach: we regress daily operation volumes on a rich set of contemporaneous and lagged covariates—including macroeconomic indicators, financial conditions, calendar effects, and lagged exchange rates—and define the shock as the residual from this prediction. We implement this in both an ordinary least squares (OLS) and a LASSO (Least Absolute Shrinkage and Selection Operator) framework. The latter helps mitigate overfitting and selects a parsimonious subset of predictors from a potentially high-dimensional set of controls, ensuring that the residual shock reflects unexpected, rather than systematic, operation activity.

Interestingly, while our empirical strategy focuses on the effects of daily FX flows, the cumulative nature of exchange rate responses implies that persistent shocks can translate into meaningful shifts in exchange rate levels over time. By tracing the dynamic response of the exchange rate to individual flow shocks using local projections, we effectively capture how cumulative operation volumes impact exchange rate trajectories. This approach allows us to infer the level implications of the Riksbank's FX operations, even though our estimation is conducted at the flow level.

We then estimate the dynamic effect of these shocks on the SEK exchange rate vis-à-vis the EUR and USD using local projection methods (Jordà, 2005). This allows for flexible impulse response estimation without imposing parametric structure on the adjustment path. Across all approaches, standard errors are computed using Newey-West heteroskedasticity and autocorrelation-consistent estimators.

Our constructed shock series is intended to isolate the unanticipated component of FX operations and satisfies standard placebo tests consistent with exogeneity. Nevertheless, residual-based approaches may still capture endogenous variation if relevant determinants are omitted or if the projection model is misspecified, warranting further validation.

To assess the robustness of this identifying assumption, we implement an alternative estimation strategy using two-stage least squares (2SLS), treating the constructed residual shock as an instrument for actual operation volumes. This approach effectively inverts the baseline setup, testing whether the shock satisfies the relevance and exclusion restrictions required for valid identification. The directional consistency between the 2SLS estimates and our baseline results reinforces the interpretation of the residual-based shock as a valid proxy for unexpected and exogenous operation activity. While the point estimates differ in magnitude, the alignment in sign and timing of the responses supports the robustness of our identification strategy.[7]

[7] Quantitative differences between our local projection and 2SLS estimates are not unexpected and

This combination of identification strategies strengthens our ability to interpret the estimated exchange rate responses as reflecting the causal effect of unexpected FX operations, rather than mechanical co-movements or endogenous policy reactions. While full identification of the precise transmission mechanism remains challenging, the alignment across specifications suggests that we are plausibly isolating the exogenous component of the Riksbank's operations with meaningful implications for nominal exchange rate dynamics.

3.2 Shock identification

In this section, we present the results of our identification strategy for isolating unexpected FX operation shocks. We construct shocks as residuals from a high-frequency OLS regression of operation amounts on observable controls, capturing the unanticipated component of the Riksbank's operations. To assess the validity of this approach, we examine the predictive content of the residuals and explore alternative shock constructions.

3.2.1 Shock Construction via Linear OLS

We begin by constructing structural FX operation shocks using a linear regression model estimated via ordinary least squares (OLS). Specifically, we regress total daily FX transactions on a set of observable controls:

$$FXI_t = \alpha + \beta \boldsymbol{X}_t + \varepsilon_t \ , \tag{1}$$

where FXI_t denotes the daily FX transaction amount as a share of GDP, $\boldsymbol{X}_t$ is a vector of control variables, and the residual ε_t represents the unanticipated component of the operation—our proxy for the structural FX shock.

On days with zero nominal FX transactions, we set $\varepsilon_t = 0$ by construction. The model is estimated separately for each operation episode—the RF period (February 1, 2021 to December 31, 2022) and HDG period (September 25, 2023 to January 31, 2024)—and for operations in EUR and USD.

To capture the discrete change in operation intensity during the RF period, we include a shift dummy equal to one from February to December 2022, corresponding to the Riksbank's decision to accelerate the transactions in anticipation of program termination.

The objective in this stage is prediction rather than inference. As such, we estimate the model using the full set of controls described in Table 3, without imposing a priori

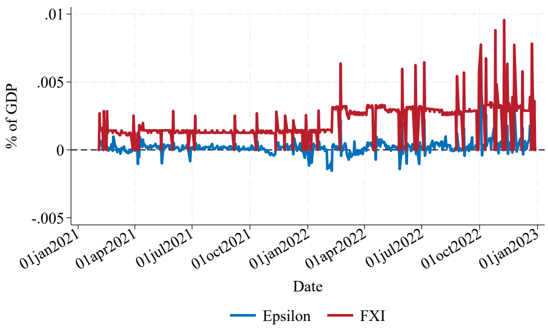
can arise from several sources. First, the two approaches target different estimands: local projections flexibly trace the dynamic response to shocks at each horizon, while the IV approach captures an average causal effect over time. Second, the residual-based shock may contain measurement error, potentially attenuating the LP estimates, whereas the IV setup can mitigate this at the cost of increased sampling variability. Finally, both methods weigh variation in different ways, especially in finite samples and in the presence of non-linear dynamics. The fact that the two methods yield directionally consistent but quantitatively distinct results is therefore consistent with econometric expectations and reinforces our interpretation of the core findings.

restrictions on individual coefficients. To assess the robustness of our shock construction to model selection, we also compute an alternative shock series using a LASSO regression, which selects a more parsimonious set of predictors. For brevity, these results are reported in the Online Empirical Appendix A.1.

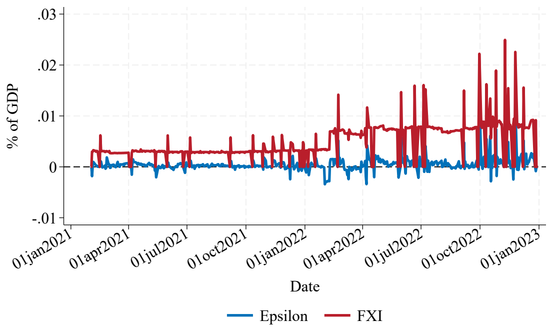
Table 3: Control variables.

Control	Transformation	Period
FXamount	% GDP	t-1, ..., t-5
FXamount^2	% GDP	t-1
FXamount^3	% GDP	t-1
FXrate	log	t-1
FXrate^2	log	t-1
FXrate^3	log	t-1
ΔEURUSD spot rate	log-difference	t-1
VSTOXX index	log	t-1
Bid-ask spread	Percentage	t-1
1-month interest rate differential		t-1
3-month risk reversal		t-1
2-year interest rate differential		t-1
1-quarter-ahead labor productivity forecast		t
SE inflation surprise		t
SE GDP surprise		t
SE Unemployment surprise		t
US/EA inflation surprise		t
US/EA GDP surprise		t
US/EA Unemployment surprise		t
RFShift Dummy		t

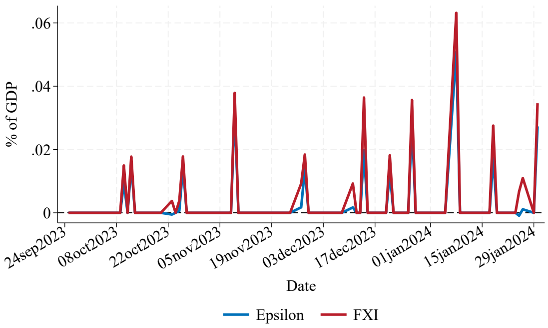
Note: The table presents the full set of control variables and the temporal relationship to estimates at time t. The shift dummy = 1 from 1 February 2022 and = 0 otherwise, and is only included in the shock specifications for the reserve refinancing period to account for the upward shift in daily transaction amount from February 2022 onward.
Sources: See Appendix B.



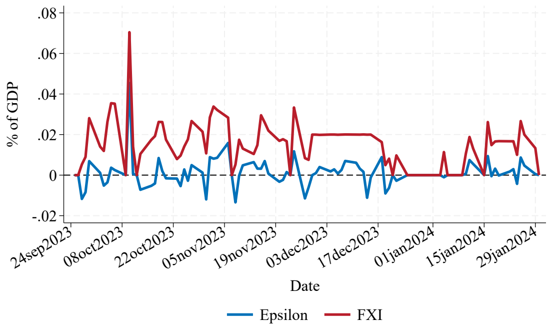
(a) Refinancing (EUR)



(b) Refinancing (USD)



(c) Hedge (EUR)



(d) Hedge (USD)

Figure 4: OLS Shock series ε and net transaction amounts

Note: The figure plots the estimated shock series (Epsilon) against the original net transaction amount series (FXI). The shock series are the residuals from estimating Equation 1.

Figure 4 plots the identified shock series against actual net FX transaction amounts. Panel (a) reports the series for the EUR over the RF period, and Panel (b) report the USD series over the same period. The HDG period for both is reported in Panel (c) (EUR) and Panel (d) (USD). Table 4 provides summary statistics to assess the properties of the shock series.

The figures help visualize the relationship between shocks and raw operation data. To interpret this, consider the explanatory power of the first-stage regressions reported in Table 4. When the R^2 is high, a large portion of FXI_t is explained by observed controls $\boldsymbol{X}_t$, and the resulting residual shock ε_t is relatively small. In such cases, the residual is more likely to represent a "clean" shock—one that plausibly excludes the predictable, potentially endogenous component of operation behavior. Visually, this means that the shock and the raw FXI_t series should diverge substantially, as seen in Figure 4, Panel (a).

In contrast, a low R^2—such as for EUR transactions during the HDG period—indicates that FXI_t is largely unexplained by observables. This leads to a residual shock that is large in magnitude and more difficult to interpret. While it may suggest an absence of systematic policy responses, it also raises concerns about omitted variables, such as unobserved expectations or internal forecasts. In such cases, the residual may reflect unexplained structure rather than true exogeneity. This is illustrated in Figure 4, Panel (c), where the shock closely tracks the level of FXI_t, indicating limited informational separation between the two series.

Table 4: Summary Statistics of Estimated Shock Series

OLS	EUR RF	USD RF	EUR HDG	USD HDG
R^2	0.46	0.49	0.15	0.48
RMSE	0.00	0.00	0.01	0.01
DW	2.02	1.99	2.03	2.16
ADF p-value	0.00	0.00	0.00	0.00

Note: R^2 measures the proportion of the in-sample variation in the log nominal exchange rate explained by the regressors. RMSE is the root mean squared error of the prediction. DW is the Durbin-Watson test statistic, where values near 2 suggest no first-order autocorrelation. ADF p-value reports the p-value from the Augmented Dickey-Fuller test of the residuals (with five lags), where low values suggest stationarity.

3.2.2 Shock Validation

To assess the exogeneity of the identified shock series, we conduct placebo regressions using lagged exchange rate changes as the dependent variable. If the shocks are truly exogenous, they should not systematically predict exchange rate movements that occurred prior to their realization. We therefore regress the exchange rate at time $t-1$ on each shock at time t, including actual FX flows, OLS-constructed shocks, and LASSO-based shocks, controlling for the full set of covariates used in the main specification. Table 5 presents the results. Across all specifications, we find no evidence of statistically significant relationships, supporting the interpretation that the shock series captures the unanticipated component of operation activity.

To further address this concern, we later implement a formal instrumental variable (IV) strategy, using the residual-based shock as an instrument for total operation volume. This provides a complementary test of instrument validity. The consistency in direction and robustness of the estimates lends additional credibility to our identification strategy.

Table 5: Placebo Regression

	EUR RF	USD RF	EUR HDG	USD HDG
FXI OLS_{t+1}	-0.373	-0.104	0.026	0.005
	(0.301)	(0.217)	(0.033)	(0.064)
N	499	499	91	91

Note: The dependent variable is the log of the nominal exchange rate, EURSEK or USDSEK. The regressions include the full set of controls specified in Table 3. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. If the shocks are truly exogenous, they should not systematically predict exchange rate movements prior to their realization. Consistent with this, we find no evidence of predictive power in pre-treatment periods. Coefficients are not statistically significant.

4 Estimating the Impact of the Riksbank's 2021–2024 FX Operations

Having constructed two alternative shock series, we proceed to estimate the dynamic effects of the Riksbank's FX operations on the exchange rate using the local projections (LP) method of Jordà (2005). To avoid contamination across operation regimes, we estimate each episode separately. The sample used for estimations covering the RF period therefore spans from 1 February 2021 to 24 September 2023, while the sample for estimations covering the HDG period covers 25 September 2023 to 11 April 2025, which is the end of our available data.

The LP specification takes the form:

$$y_{t-1+h} - y_{t-1} = \alpha_{(h)} + \beta_{(h)}\varepsilon_t + \gamma_{(h)}\boldsymbol{X}_t + u_{(h),t-1+h} \ , \tag{2}$$

where:

- y_t denotes the log exchange rate (SEK per EUR or USD),
- ε_t is the FX operation shock identified in the first stage (either via OLS or LASSO),
- $\boldsymbol{X}_t$ is a vector of control variables, including lags of the exchange rate and operation measure, financial market variables and macroeconomic release surprises.

The left-hand side measures the cumulative change in the exchange rate from $t-1$ to $t-1+h$, and $\beta_{(h)}$ traces out the cumulative impulse response of the nominal exchange rate h trading days after the operation shock.

We estimate this specification separately for each currency pair (EURSEK and USDSEK), operation regime (RF and HDG), and shock construction method (OLS or LASSO). To assess robustness, we consider three nested specifications: (1) A naive version without controls; (2) A more detailed version which adds one lag of the FX operation variable, one lag of the logged VSTOXX index and one lag of the 1-month interest rate differential; (3) A fully saturated specification including the full set of variables listed in Table 3. We report the latter specification below and relegate to the Online Appendix the first two cases. For completeness, in the online appendix we also report a specification where instead of using the shock series we fed the actual daily net transaction amounts.

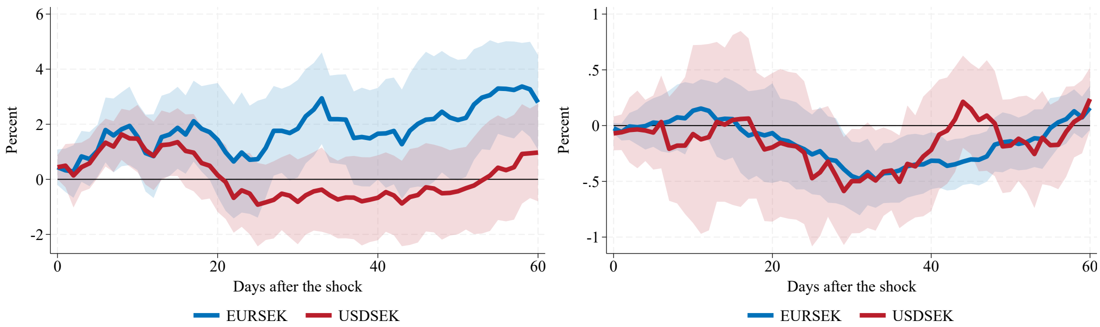
Our main results regarding the dynamic effects of the Riksbank's FX operations on the SEK versus the EUR and USD are presented in Figure 5 and Table 6. The dynamic response functions in Figure 5 trace the average effect of an FX operation shock equivalent to 1% of GDP, expressed in cumulative percentage changes in the SEK exchange rate relative to the EUR and USD, respectively. Table 6 provides some averages at various horizons. The effects of the FX operations evolve over time and differ across currencies and operation periods. During the RF period the average effect of a 1% of GDP FX purchase implies a 1.81% and 0.09% depreciation against the EUR and USD, respectively. These large divergence across currencies is the average effect. However, Figure 5 suggests that the effects are similar over the first 1–10 days of trading, during which the SEK depreciated by about 1.08% against the EUR and 0.87% against the USD. Most importantly, this is also the period in which the effects are clearly most statistically significant. A plausible candidate for this divergence is the currency-specific volatility. We observe that between January 2021 and December 2022, SEK exhibited notably different behaviour vis-à-vis the euro and the US dollar. The standard deviation of daily log-returns given by $log(P_t/P_{t-1})$ for EUR/SEK was approximately 0.34%, whereas for USD/SEK it was 0.74%, and for the EUR/USD cross-rate 0.36%. Even after controlling for U.S. factors, the higher volatility of the SEK–USD pair indicates that the krona's movements were more sensitive to dollar-specific shocks than to euro-area dynamics.

During the HDG period, the average effect of a 1% of GDP FX sale led to a 0.15% and 0.16% appreciation of the SEK against the EUR and USD, respectively. Figure 5, panel b, reports the corresponding dynamic impulse response. In this case, the results appear more uniform across currencies, although volatility remains higher against the USD, reflecting heterogeneous fluctuations across currency pairs. The standard deviation of daily log-returns for EUR/SEK was approximately 0.39%, while for USD/SEK it was 0.64%, and for the EUR/USD cross-rate 0.43%. Even after controlling for EUR and U.S. macroeconomic factors, EUR-USD rate, the SEK continued to display greater sensitivity to dollar movements, suggesting that the SEK dynamics are more influenced by USD-specific shocks than by euro-area factors. Overall, however, the more uniform repsonse in this case can be partly explained by the fact that, as a small open economy, SEK appreciations are inherently harder to achieve against the main currencies, and the average effects remain broadly similar across both them. At the same time, the shorter duration of the second operation and the limited sample period constrain our ability to draw strong statistical inferences.

Table 6: Average Estimated effects: Local Projections

Days	EUR RF	USD RF	EUR HDG	USD HDG
Average	1.812	0.085	-0.149	-0.156
1-5	0.524	0.419	-0.022	-0.050
6-20	1.589	1.130	0.036	-0.066
21-60	2.032	-0.370	-0.242	-0.213
N	630	630	344	344

Note: The table displays the different average effects of FX operations on the EURSEK and USDSEK exchange rates across different time horizons, separately for the Reserve Refinancing (RF) and Hedging (HDG) periods. The dependent variable is the h-period ahead cumulative change in the log of the nominal EURSEK (USDSEK) exchange rate. The estimation sample covers 1 February 2021 - 24 September 2023 for the FX period, and 25 September 2023 - 11 April 2024 for the Hedge period. The maximum number of days is set to 60. Regardless of the period considered, an increase in the EURSEK (USDSEK) exchange rate indicates a depreciation of the SEK against the EUR (USD). The estimation relies on Newey-West HAC robust standard errors, reported respectively in Tables A.1.1 and A.1.2 of the Online Appendix A.1.



(a) Refinancing (b) Hedge

Figure 5: Impulse response functions. Extended controls

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The results are generated from estimating Equation 2 with the full set of controls presented in Table 3, less the RF shift dummy. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

4.1 Robustness: IV regressions

While local projections offer a flexible way to trace the dynamic effects of FX operations, we complement this analysis with a more formal instrumental variable (IV) approach. Specifically, we use the two residual shock series as instruments for the actual amount of FX operations. This allows us to estimate average causal effects and test the strength and validity of the identification strategy. As discussed in the introduction, this approach helps assess the robustness of our baseline findings, with directionally consistent results reinforcing the interpretation of the shocks as valid proxies for unanticipated operation activity. Table 7 presents the corresponding estimates.

Table 7: Estimated effects: IV regressions

Days	EUR RF	USD RF	EUR HDG	USD HDG
FXamount	0.272	0.257	-0.017	-0.056
	(0.214)	(0.181)	(0.0103)	(0.081)
First-stage F-stat	115.5	218.2	1755.7	115.5
Wu-Hausman p-value	0.64	0.54	0.16	0.56
Anderson-Rubin p-value	0.20	0.16	0.10	0.51
R^2	0.994	0.995	0.962	0.962
N	690	690	404	404

Note: The dependent variable is the log of the nominal exchange rate, EURSEK (USDSEK). The specification includes all of the controls specified in Table 3, less the polynomial terms of FX rate and the FX transaction amount, and the RF shift dummy. The sample periods are identical to those in the local projections specifications. Newey-West HAC robust standard errors are shown in parentheses. *p $<$ 0.05, ** p $<$ 0.01, *** p $<$ 0.001.

The first-stage F-stat indicates the strength of the instrument, with an F-stat $>$ 10 generally indicating a strong instrument. Across specifications and periods, the shock series F-stat well surpasses the relevant threshold. The Wu-Hausman test of endogeneity has the null hypothesis that the instrumented variable is exogenous. Across specifications and periods, we fail to reject the null hypothesis that the instrumented variable is indeed exogenous, at any conventional significance level. The Anderson-Rubin test provides robust inference on the significance of the instrumented variable even in the presence of a weak instrument. The null hypothesis for the test is that the coefficient of the endogenous regressor is zero. Across specifications and periods, we fail to reject the null hypothesis that the coefficient on FXamount is statistically different from zero at the 5% significance level.

4.2 Additional Robustness

To assess the robustness of our findings, we explore a range of alternative specifications. Online Appendices A present results using shocks identified via LASSO regressions, and examines specifications incorporating alternative control sets. Specifically, we verify that our estimates are robust to replacing the 2-year interest rate swap differentials with 2-year government bond yield differentials, and to using policy rate differentials in lieu of 1-month overnight index swap rates in the local projections. We further test the sensitivity of the shock identification regressions to: (i) including these alternative interest rate measures directly in the shock construction, (ii) augmenting the model with a dummy for trading activity on the previous day or the EURUSD exchange rate, and (iii) first-differencing the interest rate differentials. The results from these additional checks, available upon request, confirm that our main conclusions are not sensitive to these modifications.

5 Conclusions

Portfolio balance models suggest that changes in the relative supplies and demands for assets denominated in different currencies should affect nominal exchange rates. The absence of an explicit nominal exchange rate target in most modern monetary policy frameworks further supports the hypothesis that exchange rates are influenced by financial flows, including those generated by central bank operations. A growing body of empirical research has indeed found evidence consistent with such effects.

Identifying the quantitative impact of central bank operations and other financial flows on exchange rates, however, remains challenging. Our study of the Riksbank's FX operations over 2021–2024 reinforces the view that nominal exchange rates are affected by financial flows—even when operations are not motivated by exchange rate objectives. The main contribution of this paper lies in showing that the effects of foreign exchange (FX) operations unfold gradually over time and display both currency-specific and regime-specific patterns in their impact on the Swedish krona (SEK).

Taken together, our results reveal that the exchange rate impact of Riksbank FX operations is short-lived, heterogeneous, and shaped by the structural characteristics of a small open economy. The dynamic impulse responses show that operations move the SEK in the expected direction—depreciations following FX purchases and appreciations following SEK purchases—but that their magnitude, persistence, and cross-currency asymmetry depend on the operation regime and market context. Currency-specific effects emerge only over the longer horizon of the refinancing (RF) period, reflecting the krona's higher volatility and sensitivity to dollar-driven shocks, while short-run and hedging (HDG) responses remain remarkably uniform across currencies. This asymmetry—whereby FX purchases induce larger and faster depreciations, while domestic currency purchases yield smaller and more delayed appreciations—underscores the structural constraints facing small open economies. Market depth, liquidity conditions, and the global dominance of the euro and the U.S. dollar critically shape the transmission and effectiveness of central bank FX operations, offering new insights into the anatomy of exchange rate policy in financially integrated environments.

Future research should expand the analysis to private sector capital flows—such as those from pension funds, insurance companies, or collective investment schemes—and to FX-related operations by local National Debt Office, as was recently the case for Sweden. Comparative cross-country studies using harmonized high-frequency data would further clarify the mechanisms at work. Finally, more work is needed to understand the asymmetric response of exchange rates to purchases versus sales and how these dynamics interact with broader macro-financial conditions.

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Online Appendices for "Financial Flows and the Swedish Krona: A Case Study of the Riksbank's Foreign Exchange"

Artta et al., (2025)
June 2025

Contents

A Empirical Appendix

A.1 Baseline OLS: Alternative Control Set

In this section, the complete results using the OLS residuals as shocks are presented.

Table A.1.1: Cumulative response, Reserve Financing period. OLS shocks.

	EURSEK			USDSEK		
Horizon	(1)	(2)	(3)	(4)	(5)	(6)
Average	1.310	1.676	1.812	-1.388	-1.324	0.085
1-5	0.400	0.533	0.524	0.283	0.347	0.419
6-20	0.448	1.010	1.589	0.153	0.292	1.130
21-60	1.710	2.042	2.032	-2.182	-2.141	-0.370
1	0.398	0.486	0.439	0.372	0.400*	0.439**
	(0.342)	(0.331)	(0.330)	(0.241)	(0.240)	(0.223)
5	0.523	0.699	0.735	0.339	0.417	0.581
	(0.668)	(0.608)	(0.503)	(0.567)	(0.549)	(0.470)
10	0.905	1.353	1.941***	0.757	0.857	1.485***
	(1.178)	(1.055)	(0.727)	(0.849)	(0.808)	(0.519)
15	0.373	1.005	1.627**	0.175	0.322	1.269**
	(1.500)	(1.239)	(0.768)	(1.010)	(0.961)	(0.585)
30	1.051	1.665	1.680*	-2.356*	-2.152*	-0.593
	(2.153)	(1.539)	(0.880)	(1.372)	(1.286)	(0.773)
60	3.183**	3.073***	3.269***	-1.095	-1.258	0.945
	(1.558)	(1.027)	(0.880)	(1.839)	(1.657)	(0.831)
N	630	630	630	630	630	630
Controls	No	Limited	Extended	No	Limited	Extended

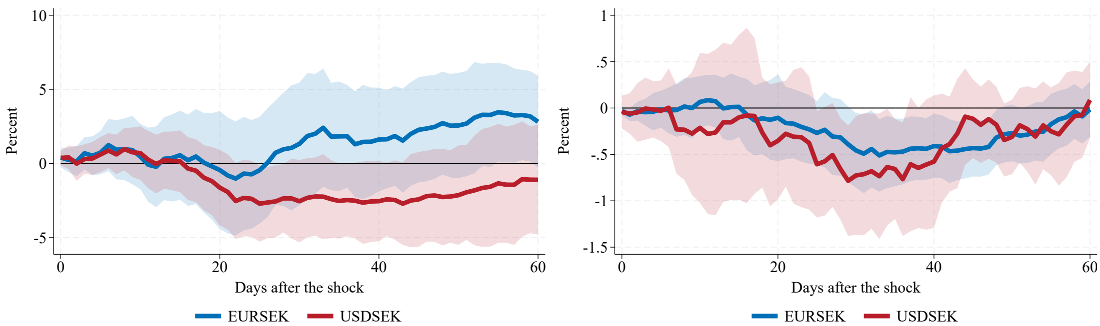
Note: The dependent variable is the h-period ahead cumulative change in the log of the nominal EURSEK (USDSEK) exchange rate. The estimation sample covers 1 February 2021 - 24 September 2023. An increase in the EURSEK (USDSEK) exchange rate indicates a depreciation of the SEK against the EUR (USD). Newey-West HAC robust standard errors are shown in parentheses. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table A.1.2: Cumulative response, Hedge period. OLS shocks.

	EURSEK			USDSEK		
Horizon	(1)	(2)	(3)	(4)	(5)	(6)
Average	-0.221	-0.365	-0.149	-0.315	-0.275	-0.156
1-5	-0.044	-0.066	-0.022	-0.034	-0.061	-0.050
6-20	-0.016	-0.127	0.036	-0.184	-0.253	-0.066
21-60	-0.325	-0.496	-0.242	-0.409	-0.322	-0.213
1	-0.030	-0.037*	-0.024	-0.044	-0.050	-0.070
	(0.022)	(0.022)	(0.024)	(0.090)	(0.089)	(0.077)
5	-0.040	-0.078	-0.004	-0.014	-0.058	-0.044
	(0.103)	(0.109)	(0.107)	(0.155)	(0.154)	(0.140)
10	0.000	-0.085	0.066	-0.276	-0.335	-0.179
	(0.167)	(0.177)	(0.166)	(0.339)	(0.305)	(0.313)
15	0.010	-0.122	0.061	-0.154	-0.237	0.008
	(0.185)	(0.189)	(0.190)	(0.427)	(0.380)	(0.353)
30	-0.391*	-0.593***	-0.391**	-0.785**	-0.762***	-0.587**
	(0.207)	(0.213)	(0.167)	(0.303)	(0.260)	(0.247)
60	-0.090	-0.230*	0.073	-0.074	0.029	0.079
	(0.150)	(0.138)	(0.095)	(0.236)	(0.233)	(0.167)
N	344	344	344	344	344	344
Controls	No	Limited	Extended	No	Limited	Extended

Note: The dependent variable is the h-period ahead cumulative change in the log of the nominal EURSEK (USDSEK) exchange rate. The estimation sample covers 25 September 2023 - 11 April 2025. An increase in the EURSEK (USDSEK) exchange rate indicates a depreciation of the SEK against the EUR (USD). Newey-West HAC robust standard errors are shown in parentheses. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

A.1.1 No controls

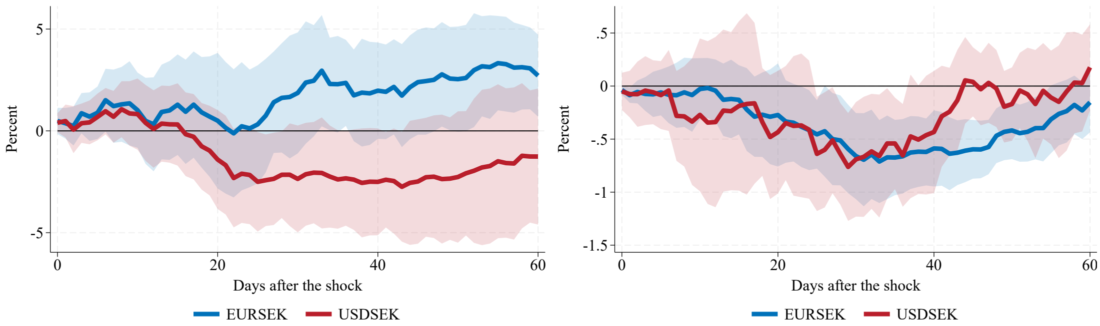


(a) Refinancing (b) Hedge

Figure A.1.1: Impulse response functions. No controls

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The results are generated from estimating Equation 2 with no controls. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

A.1.2 Limited controls



(a) Refinancing (b) Hedge

Figure A.1.2: Impulse response functions. Limited controls

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The results are generated from estimating Equation 2 with controls for one lag of the FX operation variable, one lag of the logged VSTOXX index and one lag of the 1-month interest rate differential. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

A.2 Alternative Shock identification: LASSO

We construct a second series of FX operation shocks using machine learning techniques, specifically penalized regression. The key benefit of this approach lies in its ability to perform automatic, data-driven variable selection, thereby mitigating the risk of omitted variable bias and reducing reliance on subjective, theory-driven model specification. Among penalized regression techniques, the LASSO (Least Absolute Shrinkage and Selection Operator) is well suited for high-dimensional settings, as it simultaneously conducts variable selection and regularization by shrinking some coefficients exactly to zero.

However, standard LASSO is known to perform poorly in the presence of multicollinearity, which is a common feature in macro-financial time series. To address this issue while preserving a wide array of candidate controls, we adopt the Adaptive LASSO estimator proposed by Zou (2006). This method applies variable-specific penalization weights derived from an initial ridge regression, allowing for more stable and consistent selection in collinear environments.

The structural FX operation shocks are identified as the residuals from the following Adaptive LASSO regression:

$$FXI_t = \alpha + \beta^{\lambda} \boldsymbol{X}_t + \varepsilon_t^{\text{LASSO}}, \tag{3}$$

where FXI_t denotes the daily FX operation amount (as a share of GDP), $\boldsymbol{X}_t$ is the vector of control variables, and β^{λ} are the penalized coefficients selected by the Adaptive LASSO. The resulting residual $\varepsilon_t^{\text{LASSO}}$ captures the estimated unanticipated component of the FX operation.

A comprehensive list of candidate predictors used in the Adaptive LASSO estimation is reported in Table A.2.1. We estimate this model separately by operation period and by currency. As in the baseline specification, we assign $\varepsilon_t^{\text{LASSO}} = 0$ on days when no FX operation occurred.

$$FXI_t = f(\boldsymbol{X}_{t-1}) + \varepsilon_t \ , \tag{4}$$

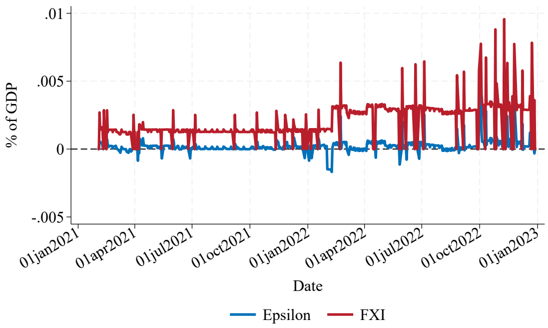
where X_{t-1} includes a broad set of potential predictors. The residual ε_t is again interpreted as the unexpected component of the FX operation — our structural shock. Contrary to regular OLS, the LASSO regressions objective is not only to minimize the residual sum of squares (RSS), but adds to this a regularization parameter. As such, the LASSO selects only the most predictive variables, shrinking irrelevant coefficients to zero. This reduces overfitting and captures the expected (systematic) component of FXI_t more robustly.

Table A.2.1: Non-zero LASSO coefficients

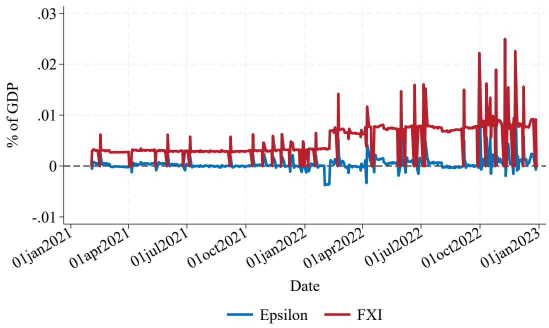
	EUR RF	USD RF	EUR HDG	USD HDG
FXamount^2_{t-1}	x			
FXamount_{t-1}	x	x		
FXamount^3_{t-1}	x	x		
Shift dummy	x	x		
FXamount_{t-3}		x		x
FXrate^3_{t-1}		x		
Bidask_{t-1}				x
FXrate_{t-1}				x
$\Delta\text{EURUSD}_{t-1}$				x

Note: Each column indicates, for each currency-pair and period, which variables were selected by the LASSO as the most predictive. For each specification, the penalized coefficients of these variables are used to calculate the residuals.

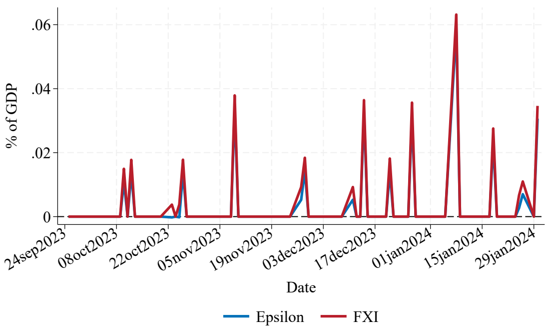
A.2.1 Shock Series



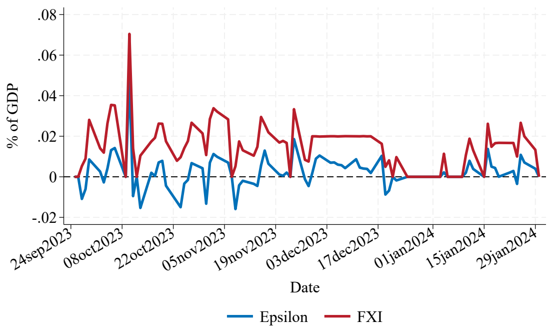
(a) Refinancing (EUR)



(b) Refinancing (USD)



(c) Hedge (EUR)



(d) Hedge (USD)

Figure A.2.1: LASSO shock series and net transaction amounts

Note: The figure plots the estimated shock series (Epsilon) against the original net transaction amount series (FXI). The shock series are the residuals from estimating Equation 4.

Table A.2.2: Summary Statistics of Estimated LASSO Shock Series

	EUR RF	USD RF	EUR HDG	USD HDG
R^2	0.42	0.47	0.00	0.24
RMSE	0.00	0.00	0.01	0.01
ADF p-value	0.00	0.00	0.00	0.01
Non-zero Coef.	4	5	0	4

Note: R^2 measures the proportion of the in-sample variation in the log nominal exchange rate explained by the regressors. RMSE is the root mean squared error of the prediction. DW is the Durbin-Watson test statistic, where values near 2 suggest no first-order autocorrelation. ADF p-value reports the p-value from the Augmented Dickey-Fuller test of the residuals (with five lags), where low values suggest stationarity. "Non-zero Coef." denotes the number of predictors selected by the LASSO model.

A.2.2 Validation

Table A.2.3: Placebo Regression

	EUR RF	USD RF	EUR HDG	USD HDG
FXI LASSO$_{t+1}$	-0.482	-0.378	0.019	0.048
	(0.292)	(0.198)	(0.029)	(0.063)
N	499	499	91	91

Note: The dependent variable is the log of the nominal exchange rate, EURSEK or USDSEK. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. If the shocks are truly exogenous, they should not systematically predict exchange rate movements prior to their realization. Consistent with this, we find no evidence of predictive power in pre-treatment periods. Coefficients are not statistically significant.

A.3 Local projections with LASSO shocks

In this section, results using the LASSO residuals as shocks are presented.

Table A.3.1: Cumulative response, Reserve Financing period. LASSO shocks.

	EURSEK			USDSEK		
Horizon	(1)	(2)	(3)	(4)	(5)	(6)
Average	0.464	1.275	2.264	-1.277	-1.166	0.463
1-5	0.278	0.572	0.858	0.141	0.246	0.387
6-20	-0.439	0.577	2.023	-0.366	-0.138	1.050
21-60	0.766	1.582	2.494	-1.812	-1.737	0.225
1	0.454	0.621*	0.619*	0.362	0.403*	0.384*
	(0.331)	(0.327)	(0.351)	(0.234)	(0.244)	(0.221)
5	0.118	0.516	1.113**	0.009	0.134	0.540
	(0.645)	(0.609)	(0.504)	(0.470)	(0.461)	(0.464)
10	0.192	1.003	2.399***	0.277	0.435	1.407***
	(1.145)	(1.075)	(0.759)	(0.763)	(0.698)	(0.522)
15	-0.485	0.656	2.179***	-0.338	-0.101	1.237**
	(1.358)	(1.137)	(0.750)	(0.919)	(0.836)	(0.583)
30	-0.372	0.912	2.033**	-2.124	-1.792	0.021
	(2.267)	(1.650)	(0.989)	(1.376)	(1.217)	(0.743)
60	3.280**	3.349***	4.194***	-0.564	-0.793	1.547**
	(1.362)	(1.219)	(0.808)	(1.936)	(1.523)	(0.715)
N	630	630	630	630	630	630
Controls	No	Limited	Extended	No	Limited	Extended

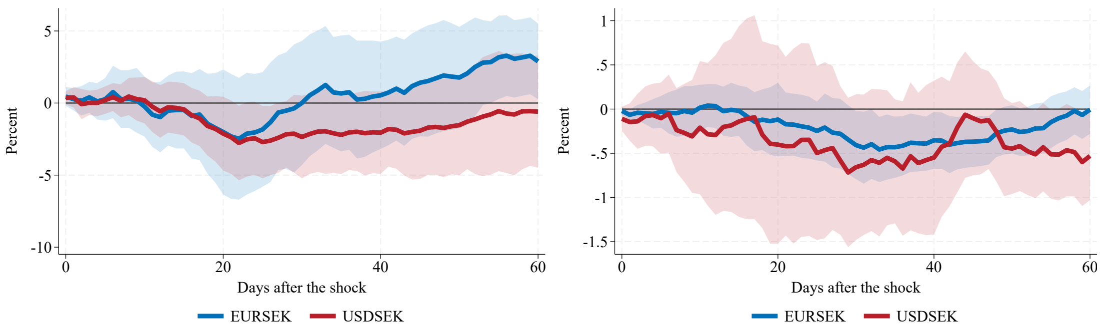
Note: The dependent variable is the h-period ahead cumulative change in the log of the nominal EURSEK (USDSEK) exchange rate. The estimation sample covers 1 February 2021 - 24 September 2023. An increase in the EURSEK (USDSEK) exchange rate indicates a depreciation of the SEK against the EUR (USD). Newey-West HAC robust standard errors are shown in parentheses. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table A.3.2: Cumulative response, Hedge period. LASSO shocks.

	EURSEK			USDSEK		
Horizon	(1)	(2)	(3)	(4)	(5)	(6)
Average	-0.201	-0.325	-0.131	-0.368	-0.288	0.045
1-5	-0.046	-0.065	-0.032	-0.108	-0.140	-0.038
6-20	-0.042	-0.138	-0.008	-0.211	-0.286	0.166
21-60	-0.285	-0.433	-0.197	-0.455	-0.307	0.015
1	-0.021	-0.027	-0.019	-0.110	-0.118*	-0.086
	(0.021)	(0.022)	(0.022)	(0.069)	(0.066)	(0.061)
5	-0.054	-0.086	-0.031	-0.067	-0.115	0.017
	(0.085)	(0.091)	(0.087)	(0.181)	(0.176)	(0.162)
10	-0.040	-0.115	-0.004	-0.309	-0.384	0.027
	(0.154)	(0.162)	(0.155)	(0.326)	(0.288)	(0.238)
15	-0.009	-0.123	0.026	-0.185	-0.282	0.250
	(0.156)	(0.160)	(0.161)	(0.499)	(0.440)	(0.280)
30	-0.345*	-0.517**	-0.321**	-0.717*	-0.638*	-0.144
	(0.198)	(0.200)	(0.159)	(0.431)	(0.353)	(0.177)
60	-0.067	-0.183	0.091	-0.599**	-0.352**	-0.257**
	(0.138)	(0.126)	(0.088)	(0.254)	(0.171)	(0.107)
N	344	344	344	344	344	344
Controls	No	Limited	Extended	No	Limited	Extended

Note: The dependent variable is the h-period ahead cumulative change in the log of the nominal EURSEK (USDSEK) exchange rate. The estimation sample covers 25 September 2023 - 11 April 2025. An increase in the EURSEK (USDSEK) exchange rate indicates a depreciation of the SEK against the EUR (USD). Newey-West HAC robust standard errors are shown in parentheses. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

A.3.1 No controls

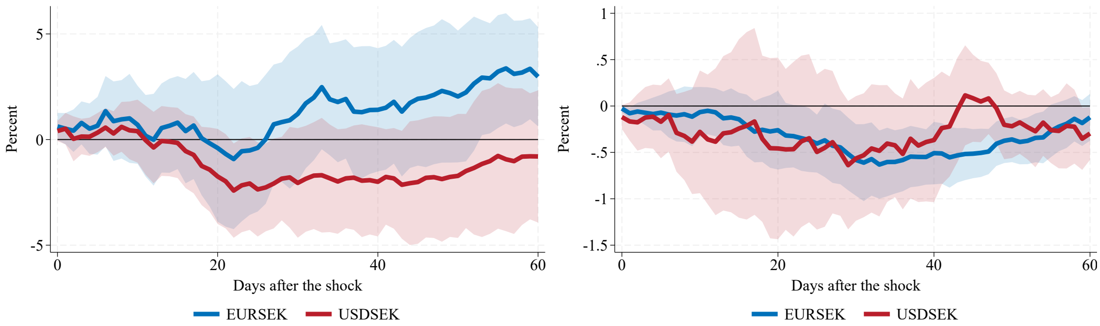


(a) Refinancing (b) Hedge

Figure A.3.1: Impulse response functions. No controls

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The shock variable is the residual estimated from 4. The results are generated from estimating Equation 2 with no controls. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

A.3.2 Limited controls

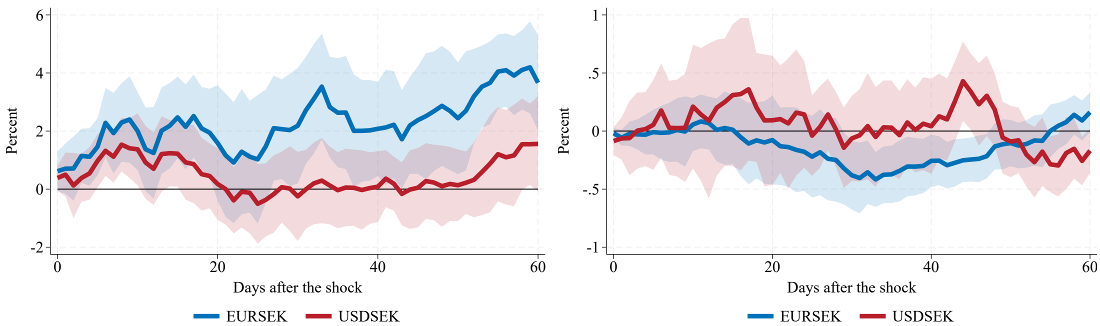


(a) Refinancing (b) Hedge

Figure A.3.2: Impulse response functions. Limited controls

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The shock variable is the residual estimated from 4. The results are generated from estimating Equation 2 with controls for one lag of the FX operation variable, one lag of the logged VSTOXX index and one lag of the 1-month interest rate differential. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

A.3.3 Extended controls



(a) Refinancing (b) Hedge

Figure A.3.3: Impulse response functions. Extended controls

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The shock variable is the residual estimated from 4. The results are generated from estimating Equation 2 with the full set of controls presented in Table 3, less the RF shift dummy. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

A.4 LASSO IV regressions

Table A.4.1: Estimated effects: IV regressions

Days	EUR RF	EUR HDG	USD RF	USD HDG
Instrument: LASSO shocks				
FXamount	0.331	0.275	-0.013	-0.093
	(0.212)	(0.194)	(0.012)	(0.065)
First-stage F-stat	104.7	159.5	3082.6	628.6
Wu-Hausman p-value	0.27	0.46	0.23	0.91
Anderson-Rubin p-value	0.12	0.16	0.29	0.16
R^2	0.994	0.995	0.962	0.962
N	690	690	404	404

Note: The dependent variable is the log of the nominal exchange rate, EURSEK (USDSEK). The specification includes all of the controls specified in Table 3, less the polynomial terms of FX rate and the FX transaction amount, and the RF shift dummy. The sample periods are identical to those in the local projections specifications. Newey-West HAC robust standard errors are shown in parentheses. *p $<$ 0.05, ** p $<$ 0.01, *** p $<$ 0.001.

A.5 Alternative Specifications: Actual FX amounts

Here we present the results of the local projections using the actual daily net transaction amounts below.

Table A.5.1: Cumulative response, Reserve Financing period. Daily net amounts.

	EURSEK			USDSEK		
Horizon	(1)	(2)	(3)	(4)	(5)	(6)
Average	-0.066	1.372	0.430	0.169	0.264	0.895
1-5	0.093	0.579	0.431	0.139	0.326	0.426
6-20	-0.218	1.258	0.720	0.122	0.543	1.024
21-60	-0.046	1.514	0.325	0.180	0.158	0.908
1	0.084	0.332**	0.149	0.097	0.206*	0.236*
	(0.130)	(0.156)	(0.183)	(0.086)	(0.107)	(0.121)
5	0.119	0.828***	0.730***	0.196	0.410*	0.719***
	(0.368)	(0.288)	(0.261)	(0.289)	(0.249)	(0.265)
10	-0.107	1.080**	0.570	0.157	0.506	0.786***
	(0.701)	(0.508)	(0.375)	(0.526)	(0.387)	(0.251)
15	-0.185	1.572***	0.988**	0.166	0.645	1.267***
	(1.014)	(0.572)	(0.411)	(0.725)	(0.530)	(0.319)
30	-0.478	1.622	0.199	-0.093	0.391	1.010**
	(1.702)	(1.046)	(0.811)	(1.208)	(0.904)	(0.411)
60	0.746	1.607**	0.498	0.668	0.077	0.886***
	(1.510)	(0.660)	(1.071)	(1.762)	(0.976)	(0.309)
N	630	630	630	630	630	630
Controls	No	Limited	Extended	No	Limited	Extended

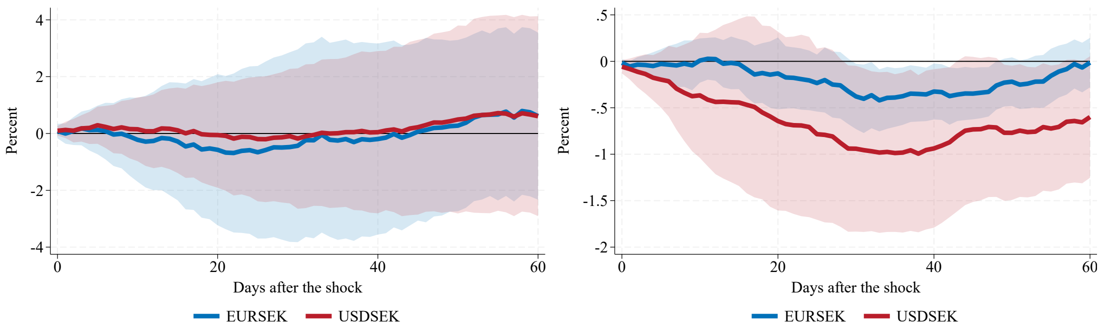
Note: The dependent variable is the h-period ahead cumulative change in the log of the nominal EURSEK (USDSEK) exchange rate. The estimation sample covers 1 February 2021 - 24 September 2023. An increase in the EURSEK (USDSEK) exchange rate indicates a depreciation of the SEK against the EUR (USD). Newey-West HAC robust standard errors are shown in parentheses. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table A.5.2: Cumulative response, Hedge period. Daily net amounts.

	EURSEK			USDSEK		
Horizon	(1)	(2)	(3)	(4)	(5)	(6)
Average	-0.191	-0.310	-0.114	-0.649	-0.513	0.106
1-5	-0.040	-0.058	-0.025	-0.113	-0.176	-0.043
6-20	-0.046	-0.140	-0.011	-0.404	-0.497	0.147
21-60	-0.269	-0.409	-0.171	-0.808	-0.565	0.115
1	-0.016	-0.022	-0.014	-0.058	-0.097**	-0.089*
	(0.020)	(0.020)	(0.021)	(0.037)	(0.039)	(0.045)
5	-0.051	-0.083	-0.028	-0.177	-0.268***	-0.006
	(0.076)	(0.079)	(0.076)	(0.124)	(0.097)	(0.108)
10	-0.043	-0.117	-0.013	-0.376	-0.505***	0.022
	(0.137)	(0.142)	(0.137)	(0.302)	(0.189)	(0.148)
15	-0.017	-0.129	0.022	-0.440	-0.569**	0.167
	(0.145)	(0.145)	(0.143)	(0.439)	(0.284)	(0.215)
30	-0.323*	-0.486***	-0.279**	-0.939**	-0.844***	0.104
	(0.180)	(0.177)	(0.139)	(0.457)	(0.251)	(0.200)
60	-0.067	-0.182	0.080	-0.656*	-0.420**	-0.208
	(0.136)	(0.122)	(0.079)	(0.335)	(0.167)	(0.168)
N	344	344	344	344	344	344
Controls	No	Limited	Extended	No	Limited	Extended

Note: The dependent variable is the h-period ahead cumulative change in the log of the nominal EURSEK (USDSEK) exchange rate. The estimation sample covers 25 September 2023 - 11 April 2025. An increase in the EURSEK (USDSEK) exchange rate indicates a depreciation of the SEK against the EUR (USD). Newey-West HAC robust standard errors are shown in parentheses. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

A.5.1 No controls

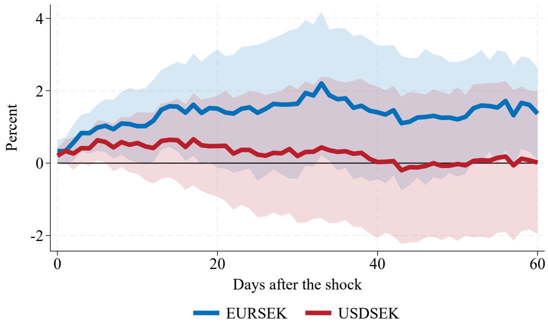


(a) Refinancing (b) Hedge

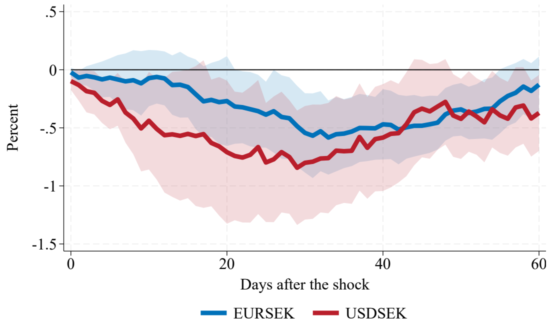
Figure A.5.1: Impulse response functions. No controls

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The shock variable is the actual net transaction amount. The results are generated from estimating Equation 2 with no controls. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

A.5.2 Limited controls



(a) Refinancing

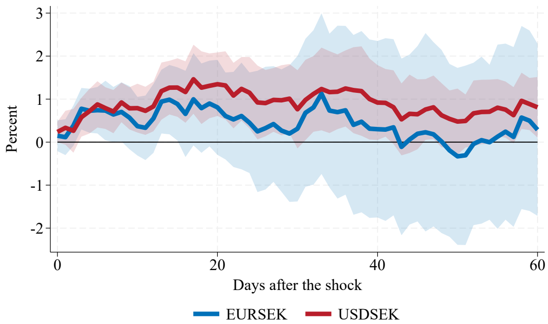


(b) Hedge

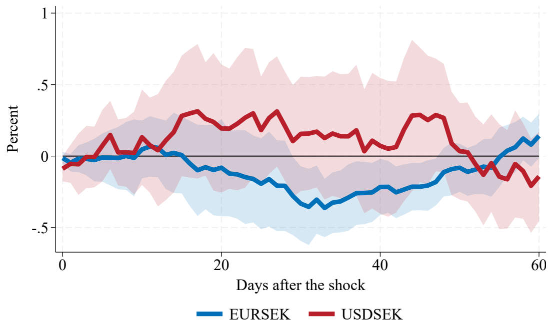
Figure A.5.2: Impulse response functions. Limited controls

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The shock variable is the actual net transaction amount. The results are generated from estimating Equation 2 with controls for one lag of the FX operation variable, one lag of the logged VSTOXX index and one lag of the 1-month interest rate differential. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

A.5.3 Extended controls



(a) Refinancing



(b) Hedge

Figure A.5.3: Impulse response functions. Extended controls

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The shock variable is the actual net transaction amount. The results are generated from estimating Equation 2 with the full set of controls presented in Table 3, less the RF shift dummy. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

A.6 Panel regressions

In this section, we briefly present the results from estimating both the shock series and the corresponding local projections in a panel setting. Since the sample is restricted to the number of days on which the Riksbank operated in the FX market, the number of observations is naturally limited–in particular for the HDG period. To increase statistical power, we pool the data across currency pairs under the assumption that the central bank's reaction function responds similarly to financial market variables and macroeconomic conditions in both currency markets. This allows us to estimate a unified panel specification, effectively doubling the sample size for each operation period. We again estimate the shocks linearly for each of the two operation periods using the following specification:

$$FXI_{i,t} = \alpha + \theta_i + \beta \boldsymbol{X}_{i,t} + \varepsilon_{i,t} \ , \tag{5}$$

where FXI_i, t denotes the daily FX transaction amount for each currency pair as a share of GDP, $\boldsymbol{X}_t$ is a vector of control variables, presented in Table 3. θ_i are currency-pair fixed effects and the residual ε_t represents the unanticipated component of the operation. We include currency-pair fixed effects to account for persistent pair-specific differences in levels, for example transaction intensity and volume. Conversely, the coefficients on the explanatory variables are constrained to be common across pairs, so the estimated coefficients represent the average response to changes in the covariates across pairs.

Because the residuals display some remaining autocorrelation we fit a simple AR(1) model to purge the serial correlation from the residuals,

$$\varepsilon_{i,t} = \rho \varepsilon_{i,t-1} + \epsilon i, t \ , \tag{6}$$

where $\varepsilon_{i,t}$ is the residual from Equation 5 and $\epsilon_{i,t}$ is the residual purged of first-order autocorrelation.[8] Table A.6.1 presents summary statistics for tests of stationarity and serial correlation of the shock series.

Table A.6.1: Summary statistics for residual series

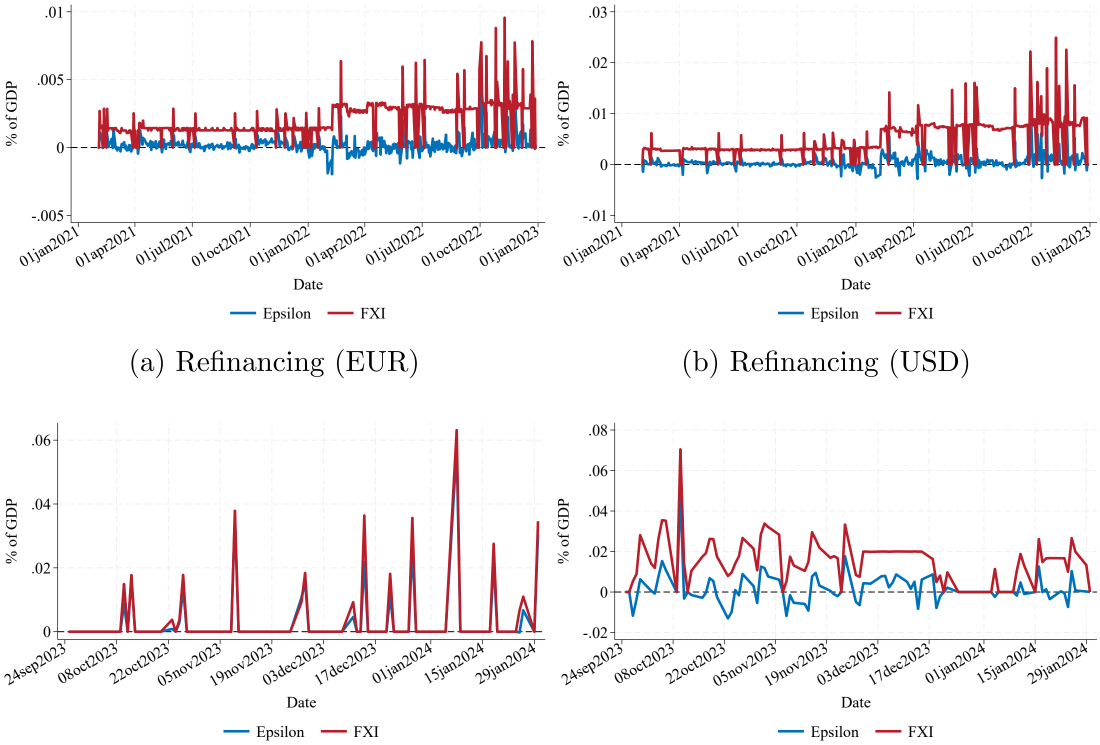
	EUR RF	USD RF	EUR HDG	USD HDG
$\varepsilon_{i,t}$				
LB p-value	0.00	0.86	0.42	0.82
ADF p-value	0.00	0.00	0.00	0.00
$e_{i,t}$				
LB p-value	0.68	0.91	0.30	0.83
ADF p-value	0.00	0.00	0.00	0.00

Note: LB p-value is the p-value from the Ljung-Box white noise test under the null hypothesis that the residuals follow a white noise process. ADF p-value reports the p-value from the Augmented Dickey-Fuller unit root test for stationarity of the residuals under the null hypothesis that the series has a unit root. All test statistics are reported using five lags.

The top panel of Table A.6.1 reports statistics from the the residual from running the OLS regression in Equation 5, $\varepsilon_{i,t}$. While we are able to strongly reject the null hypothesis that the shock series has a unit root across specifications, the residuals for the EUR series in the reserve financing period displays evidence of remaining serial correlation. The bottom panel instead shows the same test statistics from the residual from equation 6,

[8] We test for remaining correlation using the Ljung-Box test under the null hypothesis that the residuals follow a white noise process. The resulting test statistic indicates that for some residuals, we fail to reject the null at any conventional significance level.

in which the null hypothesis of a unit root is strongly rejected across specifications. The resulting shock series are plotted in Figure A.6.1.



(a) Refinancing (EUR) (b) Refinancing (USD)

(c) Hedge (EUR) (d) Hedge (USD)

Figure A.6.1: Panel shock series and net transaction amounts

Note: The figure plots the estimated shock series (Epsilon) against the original net transaction amount series (FXI). The shock series are the residuals from estimating Equation 6.

Similarly to the main analysis, we also run placebo regressions to verify that the one-step ahead shock series is not able to predict the current exchange rate. Unconditional, and conditional, results are presented in Table 4.

Table A.6.2: Placebo regressions

	RF	RF	HDG	HDG
$\text{FXI}_{i,t+1}$	12.45	0.00	0.03	0.00
	(2.21)	(0.00)	(0.27)	(0.00)
Controls	NO	YES	NO	YES
N	1000	1000	184	184

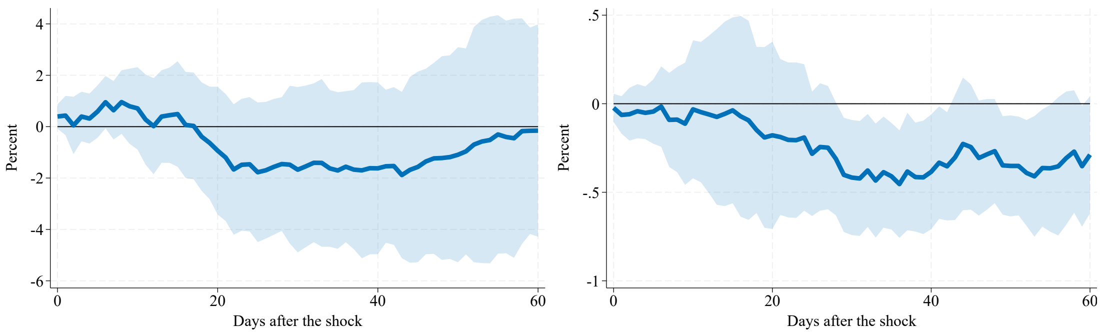
Note: The dependent variable is the log of the nominal exchange rate, EURSEK or USDSEK. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Controls are those specified in Table 1.

As evidenced in Table A.6.2, none of the coefficients are statistically significant. We use the shock series $\epsilon_{i,t}$ to estimate impulse response functions using the following local projection specification,

$$y_{t-1+h} - y_{t-1} = \alpha_{(h)} + \beta_{(h)}\epsilon_{i,t} + \theta_i + \gamma_{(h)}\boldsymbol{X}_{i,t} + u_{(h),t-1+h} \ , \tag{7}$$

where $y_{i,t}$ denotes the log exchange rate (SEK per EUR or USD), $\epsilon_{i,t}$ is the FX operation shock identified in the first stage, θ_i are currency-pair fixed effects and $\boldsymbol{X}_{i,t}$ is a vector of control variables, as specified in Table 3. The resulting impulse response functions are presented in the subsequent sections, jointly and for each of the currency pairs separately.

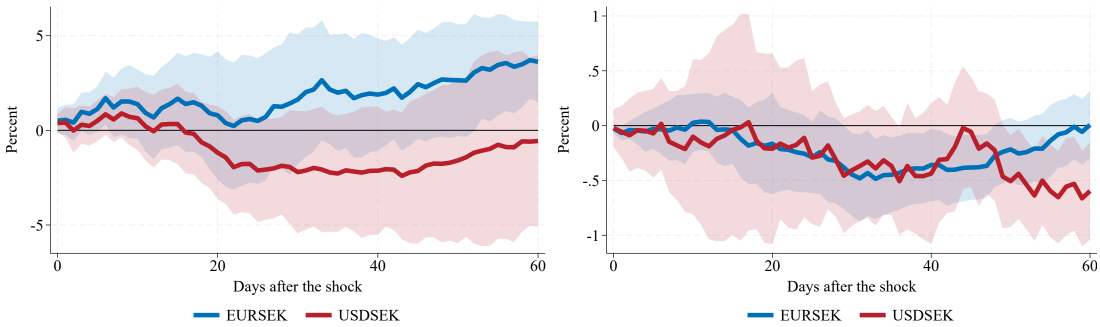
A.6.1 No controls



(a) Refinancing (b) Hedge

Figure A.6.2: Impulse response functions. Joint Estimates

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP. The shock variable is the actual net transaction amount. The results are generated from estimating Equation 2 with the full set of controls presented in Table 3, less the RF shift dummy. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.



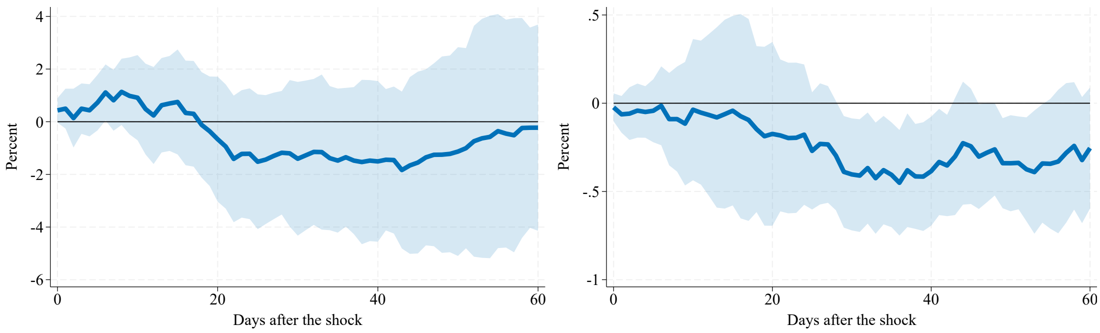
(a) Refinancing (b) Hedge

Figure A.6.3: Impulse response functions per currency pair

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The shock variable is the actual net transaction amount. The results are generated from estimating Equation 2 with the full set of controls presented in Table 3, less the RF shift dummy. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

A.6.2 Limited controls

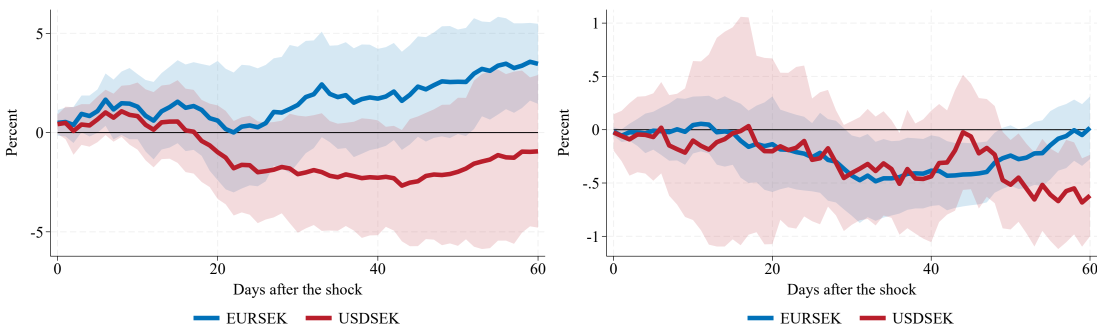
Includes controls for the change in the 1-month OIS differential and the VSTOXX index.



(a) Refinancing (b) Hedge

Figure A.6.4: Impulse response functions. Joint Estimates

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP. The shock variable is the actual net transaction amount. The results are generated from estimating Equation 2 with the full set of controls presented in Table 3, less the RF shift dummy. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.



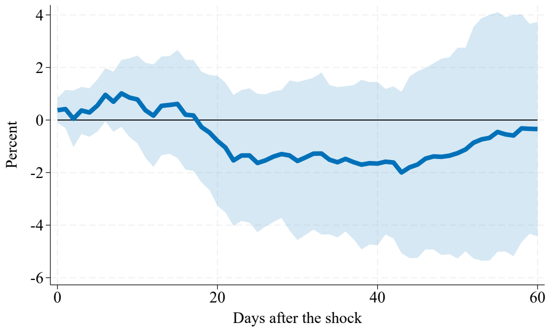
(a) Refinancing (b) Hedge

Figure A.6.5: Impulse response functions per currency pair

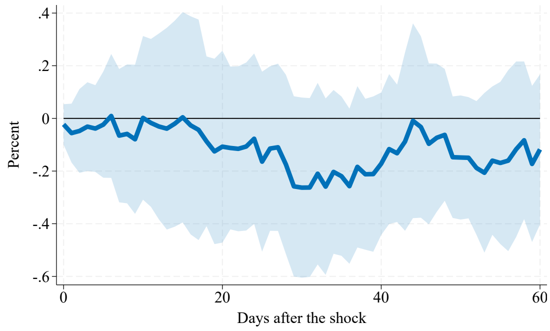
Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The shock variable is the actual net transaction amount. The results are generated from estimating Equation 2 with the full set of controls presented in Table 3, less the RF shift dummy. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

A.6.3 Extended controls

Includes all controls from Table 3, with the exception of polynomials and lags longer than one lag.



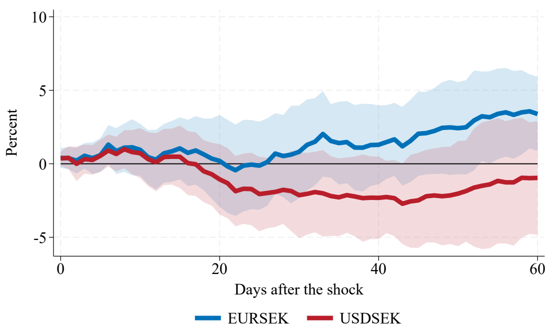
(a) Refinancing



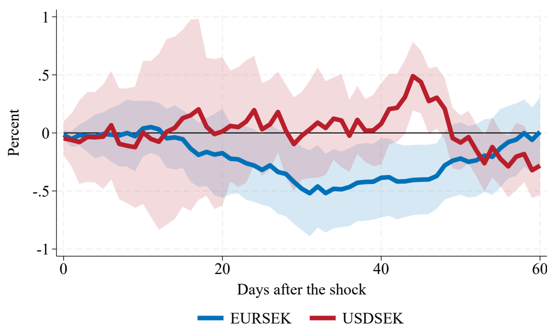
(b) Hedge

Figure A.6.6: Impulse response functions. Joint Estimates

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP. The shock variable is the actual net transaction amount. The results are generated from estimating Equation 2 with the full set of controls presented in Table 3, less the RF shift dummy. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.



(a) Refinancing



(b) Hedge

Figure A.6.7: Impulse response functions per currency pair

Note: The figure plots the cumulative impulse response function of an FX operation shock corresponding to one percent of GDP for the EURSEK and USDSEK exchange rates. The shock variable is the actual net transaction amount. The results are generated from estimating Equation 2 with the full set of controls presented in Table 3, less the RF shift dummy. Panel (a) presents the results for the Reserve Refinancing period while panel (b) presents the results for the Hedging period. The shaded areas represent 95 percent confidence bands around the point estimates.

B Data Appendix

Table B.0.1 presents the sources for all variables in our dataset along with notes relevant to their interpretation and calculation.

Table B.0.1: Variables and Data sources

Variable	Source	Notes
FX purchases/sales	Sveriges Riksbank	Daily net transaction amounts.
Exchange rate	Bloomberg	SEK per EUR, SEK per USD, and USD per EUR spot rates.
VSTOXX index	Macrobond (STOXX)	
Bid-ask spread	Bloomberg	Calculated as the difference between the ask and bid price relative to the bid price for EURSEK and USD-SEK.
Policy rate	Bloomberg, Macrobond (Sveriges Riksbank, ECB)	Calculated as the difference between the EA/US policy rate and the Swedish policy rate (Sveriges Riksbank). The US policy rate is the federal funds effective rate (Bloomberg) and the EA policy rate is the ECB deposit facility effective rate (ECB).
1-month interest rate differential	Bloomberg	Calculated as the difference between the 1st federal funds futures or the 1-month ESTR OIS and the 1-month STINA.
2-year govt. bond differential	Bloomberg, Macrobond	Calculated as the difference between U.S. (Bloomberg) or German 2-year government bond yields (Macrobond) and Swedish 2-year government bond yields (Bloomberg).
2-year interest rate differential	Bloomberg, Macrobond (TraditionData)	Calculated as the difference between the 2-year SOFR futures (Bloomberg) or 2-year EURIBOR 3-month swaps (Macrobond) and the 2-year STIBOR 3-month swaps (Macrobond).
3-month risk reversal	Bloomberg	Risk reversals refers to the difference between implied volatility out-of-the-money call and put options. A positive risk reversal indicates that the market is speculating for the EURSEK or USDSEK to rise in the next 3 months, equivalent to an expected depreciation of the Swedish krona.
1-quarter-ahead labour productivity forecast	OECD	Measured as the projected real gross domestic product per worker in Sweden one quarter into the future. We use this as a proxy for expected productivity growth.
Brent crude spot	Bloomberg	
Inflation surprise	Bloomberg	Calculated separately for Sweden, the EA and the U.S as the difference between actual outcomes of year-on-year inflation and the expected outcome based on Bloomberg surveys. For Sweden, we use CPIF; For the U.S, we use CPI; For the EA, we use HCPI. In days with no economic releases, the variable takes a value of 0.
GDP surprise	Bloomberg	Calculated separately for Sweden, the EA and the U.S as the difference between actual outcomes of quarter-on-quarter GDP growth and the expected outcome based on Bloomberg surveys. In days with no economic releases, the variable takes a value of 0.
Unemployment surprise	Bloomberg	Calculated separately for Sweden, the EA and the U.S as the difference between actual outcomes of the monthly unemployment rate and the expected outcome based on Bloomberg surveys. In days with no economic releases, the variable takes a value of 0.

Note: The table presents all variables in the dataset, their sources and any notes on calculation.

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