Staff memo

Is there state-dependence in the exchange rate pass-through to inflation in Sweden?

Märta Almgren and Dmytro Stoyko

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Summary

Inflation has recently been high in Sweden and somewhat higher than the average in the Euro area. At the same time, the Swedish krona has trended weaker. This has raised questions about what role the exchange rate has played in this development. One hypothesis is that the exchange rate pass through (ERPT) has been unusually large.

In this Staff Memo, we provide estimates about the magnitude of the ERPT to several indexes of consumer prices in Sweden and investigate whether the pass-through varies with the state of the economy. Our focus is on periods of heightened geopolitical uncertainty, high levels of domestic and foreign inflation, depreciations of the Swedish krona as opposed to appreciations, as well as episodes of relatively persistent or large depreciations.

Our linear estimate of the ERPT to the CPIF inflation is in line with the empirical literature and the Riksbank's prior estimates. However, this measure masks important state-dependence. We find that a depreciation of the domestic currency is likely to lead to a significantly higher ERPT during periods of heightened geopolitical uncertainty, when domestic inflation is above target or when historically large depreciations occur. Conversely, during periods of high foreign inflation and periods of persistent depreciation of the Swedish krona, the ERPT lies close to the linear estimate. Finally, we also show that the ERPT to different subgroups of the CPIF index displays different degrees of state-dependence.

Overall, our results complement the literature on the ERPT and highlight the importance of integrating the use of linear estimations with more granular research. Our findings about the state-dependence of the ERPT might be helpful in improving inflation forecasting and in the formulation of monetary policy.

Författare: Märta Almgren and Dmytro Stoyko. Märta Almgren has previously interned at the Monetary Policy Department. Dmytro Stoyko works as an Economist at the Monetary Policy Department.[1]

[1] Märta Almgren is currently a Ph.D. candidate affiliated with Institute for International Economic Studies (IIES) in Stockholm. Part of this work was conducted during her Ph.D. internship with the Riksbank's Monetary Policy Department. We would like to thank Vesna Corbo, Marie Hesselman, Jens Iversen, Mathias Klein, Stefan Laséen, Henrik Lundvall, Pär Stockhammar, Ingvar Strid, Ulf Söderström, David Vestin, Anders Vredin for helpful and constructive comments. All the remaining errors are our own. The opinions expressed in this Staff Memo are those of the authors and are not to be seen as the Riksbank's view.

1 Introduction

Inflation has recently been high both in Sweden and abroad due to supply and demand disruptions following the Covid-19 pandemic and Russia's invasion of Ukraine. Several studies show that firms' pricing behavior might have changed during this period. Large shocks, high inflation and elevated geopolitical uncertainty seem to have led to a greater propensity for firms to pass on costs to prices (Carriére-Swallow et al., 2023, Cheikh et al., 2023, Borio et al., 2023 and Cavallo et al. 2023). In Sweden, inflation has been somewhat higher than the average in the Eurozone. At the same time, the Swedish krona has trended weaker in this period.[2] This has raised the question about whether the exchange rate pass through (ERPT) has been unusually large.[3]

Linear estimations of the ERPT across different types of shocks and states are common in both the academic and policy-oriented literature on the ERPT.[4] An example of a linear estimation utilized as an informal benchmark at the Riksbank is that a permanent 10 percent depreciation of the Swedish krona is associated with a 0.5 percentage points higher inflation after 12 months.[5] Importantly, this result represents an average. If firms are more inclined to pass on costs stemming from higher import prices following a depreciation of the Swedish krona when the economy is subject to large shocks, this rule of thumb can underestimate the importance of the exchange rate for inflation.[6] The potential non-linear dynamics of inflation has recently been pointed out as one of the current most current critical issues for monetary policy (BIS, 2002; Borio et al., 2023 and Gopinath, 2023).

Focusing on Sweden, this study complements the existing literature by providing additional estimates about the magnitude of the ERPT and examines whether the ERPT is state-dependent. Specifically, we investigate whether the ERPT to different groups of consumer prices is larger during periods of high inflation, elevated geopolitical uncertainty and across episodes of historically large or somewhat persistent depreciations of the Swedish krona. To capture a potential non-linear ERPT, we use a common Local Projection approach (Jordá, 2005). This method relates cumulative changes in exchange rate to cumulative changes in consumer prices.

Our results can be summarized as follows. First, the linear ERPT to the CPIF index is in line with the previous estimates by the Riksbank and with the estimates commonly

[2] The possible reasons behind the recent weakening of the krona are discussed in the Article "Why has the krona weakened this year?" in Monetary policy report, November 2022, Sveriges Riksbank, as well as Belfrage, Hansson and Vredin (2023), "How to see the development of the krona", Sveriges Riksbank.

[3] An ERPT to consumer prices that materializes faster is an alternative hypothesis. Our estimates of the ERPT to various consumer prices in Chapter 3 allow inferring whether the ERPT materializes faster in certain states of the economy. However, the paper focuses mainly on the magnitude of the ERPT.

[4] For example, see Campa and Goldberg (2005), Carrière-Swallow et al. (2023) for the IMF, Savoie-Chabot and Khan (2015) for the Bank of Canada and Bergset et al. (2016) for Norges Bank.

[5] The Monetary Policy Report, December 2016, provides more details about the derivation of this result and discusses the many limitations to an indiscriminate applicability of this estimation. Notably, the main DSGE model utilized at the Riksbank, MAJA, entails a linear and symmetric ERPT whose magnitude is in the neighborhood to the one implied by the rule-of-thumb (see Corbo and Strid, 2020).

[6] A given depreciation of the Swedish krona and the associated increase in costs for a firm could be perceived as more persistent in some instances. This may prompt firms to pass along an unusually large share of increase in costs to their customers, which in turn may give rise to a non-linear ERPT.

found in the literature for advanced economies. As our sample includes the high inflation period of the early 2020s, we find the robustness of this result across time and studies reassuring. Second, we find that the ERPT might be significantly larger in times of elevated geopolitical stress or when the CPIF inflation is above the 2 percent target. The level of domestic inflation appears to be more important than the foreign inflation for the determination of state-dependence. We do not find that the ERPT behaves asymmetrically across appreciations and depreciations but our estimates indicate that historically large depreciations of the Swedish krona lead to a higher ERPT. In addition, a depreciation of the Swedish krona for three consecutive months does not lead to a statistically higher ERPT.[7] Finally, we uncover different degrees of state-dependence across different CPIF subgroups and observe that state-dependence is magnified in those CPIF subgroups that are characterized by a greater share of imports.

Our robustness tests include an examination of the role of the currency depreciation for those results that concern state-dependence. In addition, by excluding the observations belonging to the early 2020s, we also make sure our results are not solely driven by the unique macroeconomic volatility of this period. Overall, we find that our estimates display a good degree of robustness.

The relationship between exchange rates and inflation is a well-researched area in the economic literature. Overall, the estimated ERPT varies depending on the time, the country and econometric specification.[8] For Sweden, Corbo and Di Casola (2022) find an unconditional ERPT to consumer prices close to the Riksbank's estimate. They also show that the ERPT varies substantially across different types of shocks driving the exchange rate fluctuation. The literature on state-dependent ERPT has predominantly focused on inflation dynamic and credibility of monetary policy.[9] These papers find theoretical ground in Taylor (2000), who suggested that ERPT is endogenous to the credibility of monetary policy. A growing body of empirical literature in recent years have examined other non-linearities in ERPT. Cheikh et al. (2023) analyze the influence of geopolitical uncertainty on ERPT in a sample of advanced and emerging economies. They find that recent adverse geopolitical events seem to have led to higher rates of ERPT to both import and consumer prices. Carrière-Swallow et al. (2023) investigate how the ERPT varies with several states of the economy, using a sample of 46 countries. They find a low pass-through on average. However, during periods of elevated uncertainty and high inflation, the pass-through might be about two to three times as large. Our study confirms the results in Cheikh et al. (2023) and Carrière-Swallow et al. (2023), as we find that high inflation and geopolitical uncertainty are associated with a larger ERPT in Sweden.

[7] We define a somewhat persistent episode of depreciation as three consecutive months of positive growth of the KIX-2 index vs. the Swedish krona. This definition implies that in other periods the Swedish krona might appreciate or even depreciate, but in this case the depreciation is relatively short lived. See the Section 3.2 for additional details.

[8] For example, Carrière-Swallow et al. (2021) estimate pass-through coefficients to consumer prices to be 0.12 percentage points for advanced economies and 0.60 for emerging economies between 1995 and 2019, whereas Gagnon and Ihrig (2004) report a coefficient of 0.05 for the US.

[9] See, for example, Choudri and Hakura (2006) and Carrière-Swallow et al. (2021).

Related to our study is also Linderoth and Meuller (2024), who investigate state-dependence of the ERPT to import and consumer prices in Sweden. Using a logistic smooth-transition vector-autoregressive model, they find that the ERPT in a high inflation regime is about two times as large as in the low inflation regime.[10] Our findings are qualitatively similar to their result. Compared to their work, we provide a greater abundance of results, as we analyse state-dependence across multiple state variables and are able to unmask heterogeneity in a selected numbers of CPIF subgroups. Finally, we use Local Projections, which facilitates the interpretation of some results and necessitates of a smaller number of parameters to be calibrated.

From a theoretical perspective, several models can explain a non-linear ERPT. In menu cost models, firms raise prices when costs become too large to absorb. In line with this model, Cavallo et al. (2023) find an increased frequency of price changes following the large shocks in 2022 and 2023 for European and US firms. Ahlander et al. (2023) also find empirical support for the pricing behaviour among Swedish firms being consistent with the menu cost model. Another theoretical framework that can explain a non-linear ERPT is Calvo pricing. According to Calvo models, firms change their prices with an exogenously given probability in each period. Prices are raised when costs have increased, or are expected to increase. In line with this theory, Taylor (2000) argues that companies are more likely to pass on increased costs to consumer prices when the cost increases are expected to be more persistent. This is often the case in periods of high inflation. Several empirical studies examining state-dependent ERPT find their basis in this theory (e.g., Choudri and Hakura (2006) and Carriére-Swallow et al. (2023)).

In this paper, our focus is on the empirical side, where we utilize aggregate macroeconomic data. We recognize the potential utility of both Calvo and menu costs pricing models in explaining a state-dependent ERPT, which a more micro-driven empirical exercise can help to better uncover. We nevertheless remain agnostic as to which theoretical model is best to explain our results.

This Staff Memo has the following structure. In Chapter 2, we discuss our empirical strategy and data. In Chapter 3, we present our results for the linear and state-dependent ERPT for several indexes of consumer prices. A short discussion in Chapter 4 concludes the paper.

[10] Linderoth and Meuller (2024) define a high regime in inflation at time t when quarterly annualized inflation is above ≈ 3.3 percent at time $t-2$.

2 Empirical Specification

2.1 Local Projections

To evaluate the pass-through from exchange rate depreciations to consumer prices we estimate Local Projections (Jordá, 2005). Our baseline specification for the linear ERPT consists of a set $h \in \{0, \ldots, H\}$ of regressions defined by:

$$p_{t+h} - p_{t-1} = \alpha_h + \beta_h \Delta ER_t + \sum_{l=0}^{L} \theta_l M_{t-l} + \epsilon_t \qquad (1)$$

where p_t is the log of the consumer price index of interest (CPIF, CPIF excluding Energy (CPIFxe) or the subgroups of the CPIF index) and ΔER_t is the change in the natural log trade weighted nominal exchange rate index against the Euro and the US dollar (KIX-2).[11] The coefficient β_h captures the cumulative pass-through of a one percentage point change in the trade weighted exchange rate index today onto consumer prices up to a horizon of *h* months, conditional on the controls. This definition of the ERPT implies that for each horizon h, the statistical significance can be assessed by standard inference on β_h. For this purpose, we employ Newey-West correction for heteroscedasticity and serial correlation.[12]

The vector M_{t-l} contains control variables and L lags of each. In order to control for possible serial dependence, we include lagged changes in the exchange rate. To control for demand-side factors in Sweden and abroad we include the industrial production index (IPI) for Sweden and the trade weighted industrial production index for the Eurozone and the US. We control for cost-push shocks and external price pressure by including the monthly change in the Swedish Producer Price Index (PPI) and the trade weighted average of monthly inflation for the Eurozone and the US. We also control for the oil price as it has an immediate effect on production costs. Finally, we aim to capture the effect of heightened financial and geopolitical uncertainty, which can affect prices through multiple channels. To this end, we include a financial volatility index (VIX). In addition, we control for an index for geopolitical uncertainty (GPR) by Caldara and Iacoviello (2022), which is a measure of adverse political events and associated risks and is based on a tally of newspaper articles covering geopolitical tensions.

[11] CPIF is the consumer price index with fixed interest rate and CPIFxe is the consumer price index with fixed interest rate excluding Energy. The subgroups of the CPIF index are Food, Goods, Services, Energy and Capital stock. The weights in the KIX-2 index are approximately 85/15 percent, respectively, for the Euro and the US dollar during the time period we investigate.

[12] This definition of ERPT is in line with recent studies on state-dependent ERPT, such as Ortega and Osbat (2020), Colavecchio and Rubene (2020) and Carrière-Swallow et al. (2023). However, this measure of ERPT differs from the measure used in the literature on shock-dependent ERPT, where the cumulative change in prices is adjusted for the cumulative change in the exchange rate (see e.g., Shambaugh (2008) or Corbo and Di Casola (2022)), controlling for potential feedback effects. See Section 3.5.1 for additional discussion around the definition of ERPT.

Our approach for estimating the ERPT does not rely on identification of a shock to the exchange rate in the data or using an instrument for movements in the exchange rate. Instead, we rely on simple local projections and OLS. An important concern with this approach is potential endogeneity between movements in the exchange rate and inflation. It is possible that movements in the exchange rate are not exogenous and correlated with the error term. This issue could be solved by using an instrument for movements in the exchange rate or estimating a structural VAR. However, none of these solutions are satisfactory from a practical point of view. First, it is difficult to find a good instrument for the rate of depreciation because most exogenous variables are not highly correlated with changes in the nominal exchange rate (see e.g. Meese and Rogoff, 1983 and Edwards, 2006). It is even more difficult to find a single instrument that has variation across all states that we consider. Using multiple instruments is not feasible because different underlying shocks leads to different pass through (see e.g Corbo and Di Casola, 2022 and Shambaug, 2008). Second, identification conditions for a structural VAR require making assumptions about the timing of the effects of the exchange rate on prices that are not particularly convincing (Edwards, 2006). For these reasons, we follow most recent studies on exchange rate pass through that relies on least squares methods (see, e.g., Carriére-Swallow et al. 2023; Caselli and Roitman, 2016; Campa and Goldberg, 2002 and Gagnon and Ihrig, 2004).

After having established the linear ERPT, we consider a non-linear specification to investigate if the pass-through varies with the state of the economy. Specifically, we investigate if the ERPT is different in periods of high geopolitical uncertainty, high domestic inflation, high foreign inflation and during periods of large or persistent depreciations of the Swedish krona. For this purpose, we introduce an indicator variable D_t to our baseline specification. This indicator variable takes on the value 1 when the state variable considered is above a pre-specified threshold level, and zero otherwise:[13]

$$p_{t+h} - p_{t-1} = \alpha_h + D_t \left[\beta_h^{high} \Delta ER_t + \sum_{l=0}^{L} \theta_l^{high} M_{t-l} \right] + (1 - D_t) \left[\beta_h^{low} \Delta ER_t + \sum_{l=0}^{L} \theta_l^{low} M_{t-l} \right] + \epsilon_t \qquad (2)$$

As before, p_t is the log of the consumer price index of interest (CPIF, CPIFxe and the subgroups of the CPIF index) and ΔER_t is the change in the log trade weighted exchange rate index against the Euro and the US dollar (KIX-2). The coefficients β_h^{high} and β_h^{low} will capture the response of prices when the economy is in a high versus low state according to the pre-specified threshold level. The set of control variables is the same as in the baseline specification (1) and interacted with the state-dummy to allow also the controls to have a different pass-through in each state.

[13] A description and motivation of our threshold values can be found in Section 3.2.

2.2 Data

Our empirical analysis is based on monthly data covering February 2000 to October 2023. The monthly frequency allows us to capture the immediate effect of changes in the exchange rate on consumer prices, which is important for understanding the short-term dynamics of the ERPT.

If not otherwise stated, all our series are retrieved through Macrobond and Riksbank's databases. We use as dependent variable the consumer price index with fixed interest rate (CPIF), its equivalent that excludes Energy and the CPIF subgroups: Food, Goods, Services, Energy and the Capital stock. Before estimation, we take the natural logarithm of each index and seasonally adjust it. We focus our analysis on the CPIF index since CPI does not include a fair picture of inflationary pressures in periods with substantial interest rate changes, as during our sample period. The CPIF is also the formal inflation target variable for monetary policy in Sweden. When using the CPIF inflation as a state variable, we simply calculate the year-on-year percentage change from the CPIF index.

Our measure for the exchange rate is a trade weighted index for the Swedish krona against the Euro and the US dollar, called KIX-2 index. In conjunction with the use of the GPR index as a control and state variable it is more suitable to use the KIX-2 index instead of the broader KIX index. This is because the latter includes currencies of other small open economies and may therefore dilute the negative impact of adverse geopolitical events on the Swedish krona. The weights for the EUR and the USD are based on the weights in the aggregate KIX index and rescaled to fit the KIX-2 index. The construction of the KIX-2 index is created by taking the weighted sum of the change in EUR/SEK and USD/SEK indexes in each period.

The domestic variables that we include as controls are the Industrial Production Index (IPI) and the Producer Price Index (PPI). The IPI index measures the development of Swedish industrial production on a monthly basis while the PPI index tracks the average changes in selling prices received by domestic producers for their output. Before estimation, we de-trend the IPI index by removing its mean growth rate, while the PPI index is transformed to yearly percentage change to make it stationary.

The global variables we include are KIX-2 weighted inflation and Industrial Production, the VIX index, the GPR index and the oil price. The KIX-2 weighted inflation is calculated as the weighted sum of the monthly Euro Area HICP All-Items Index and the United States Consumer Price Index All-Items Index. Industrial Production is the weighted sum of the percentage changes in the detrended Industrial Production Index for the Eurozone and the US.[14, 15] The VIX index and the GPR index are used in deviation from median during the sample period.[16] Finally, the data for the oil price is the Brent Oil Spot price converted to monthly growth rate before estimation.

[14] Detrending is done by removing the mean growth rate from each index before weighting.

[15] The weights for KIX-2 inflation and KIX-2 industrial production are the same as in the construction of the KIX-2 exchange rate measure.

[16] Both the VIX and GPR index series are characterized by excess kurtosis. Taking the deviation of the series from it historical median appears therefore more robust than using the deviation from the mean.

3 Results

In this chapter, we illustrate our main results. First, in Section 3.1, we show our estimations of the linear ERPT to CPIF inflation, CPIF inflation excluding Energy and to the five subgroups in the CPIF index. Second, in Sections 3.2 – 3.3, we show under which conditions and to what extent a selected number of the CPIF groups are characterized by state-dependence. A discussion around the economics of the results and a comparison with the previous literature, in Section 3.4, closes the chapter.

3.1 Linear ERPT

Figures 1 and 2 below illustrate the linear ERPT for the CPIF and CPIF excluding Energy for two different lag specifications: $L = 3$ and $L = 12$. These results are derived using the specification in eq. (1). In this chapter, if not otherwise stated, our estimations illustrate the reaction in percentage change of a given price index following a 1 percent shock to the KIX-2 index.

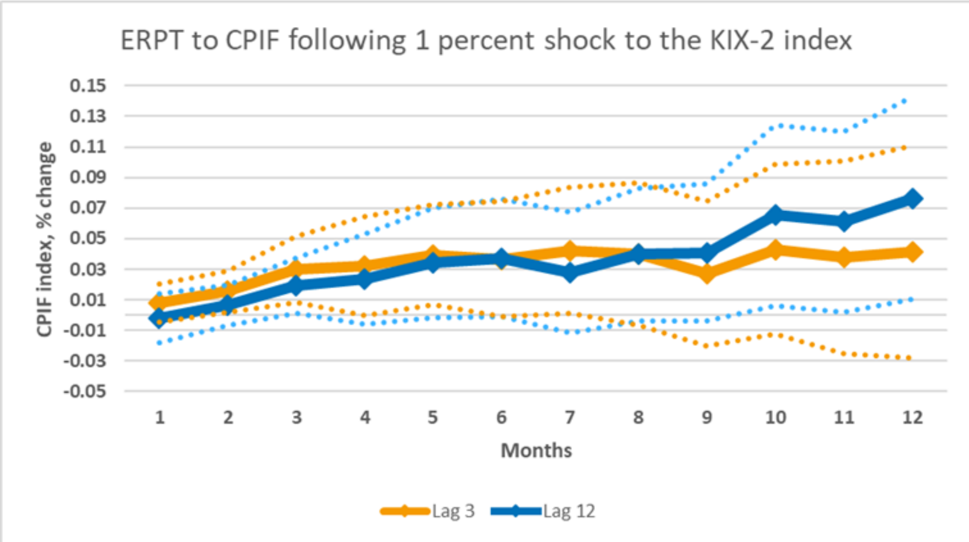
We observe that for $L = 12$, the ERPT to CPIF and CPIF excluding Energy is positive and statistically significant. The point estimates for the linear ERPT are around 0.07 and 0.05 percent after 12 months for the CPIF and the CPIF excluding Energy respectively. The linear ERPT for the CPIF index appears to reach 0.05 after five months. It stays at this level for a quarter before increasing to 0.07 in the last quarter of the estimation horizon. In contrast, the ERPT to the CPIF index excluding Energy oscillates around zero in the first quarter and reaches its peak of approximately 0.05 more linearly. This behaviour can be explained by the exclusion of the typically volatile energy prices, which have been found to change relatively frequently as opposed to the stickier prices that characterize the other subgroups in the CPIF index.[17]

We provide estimates for the same variables using $L = 3$. This will be our preferred specification in Section 3.3 for reasons related to the nature of our data. Here, it is helpful to observe that the results above remain robust when setting $L = 3$. While the confidence intervals are too wide to claim statistical significance of a positive ERPT to CPIF and CPIF excluding Energy, the point estimates are only marginally different from the case of $L = 12$.

[17] Ewertzh et al. (2022) find that the frequency of the price changes in the Energy subgroup is considerably larger as compared, for example, to the frequency in the Services or Food subgroups. In turn, this may be one of the factors leading to the higher volatility we observe in the Energy inflation, as opposed to the other subgroups.

Figure 1. Linear ERPT to CPIF

Percentage points

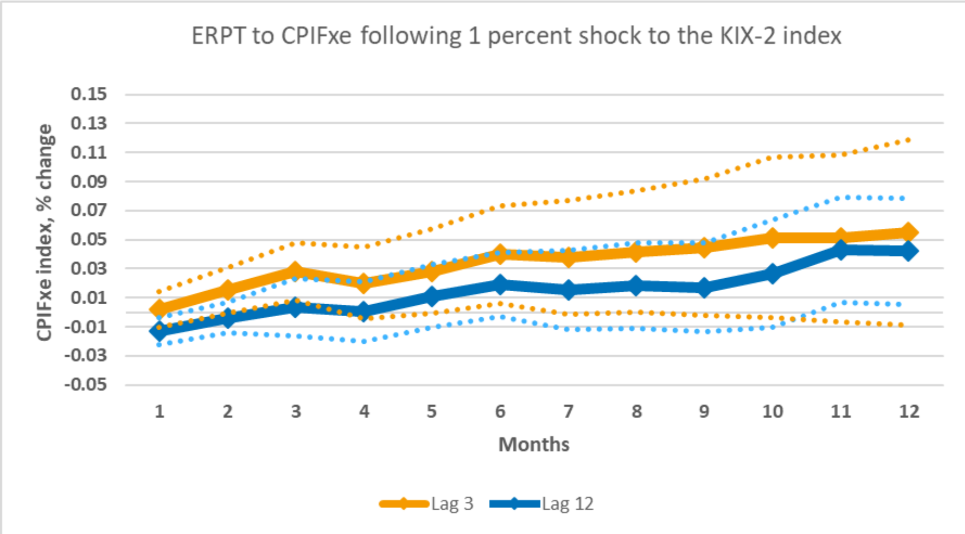


Note: The solid lines in the figure show estimates of β_h in eq. (1) for $h = 1, \dots, 12$. The blue colour refers to the $L = 12$ specification in eq. (1), while the yellow colour stands for $L = 3$. The blue and yellow dotted lines represent, respectively, the 90 percent confidence for the blue and yellow solid lines. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using the 'lpirfs' package in 'R', developed by Adämmer (2019), where we use the 'lp_lin_panel' and 'lp_nl_panel' functions with one variable on the left hand side to perform a time-series estimation. Data are collected from Macrobond and the Riksbank. This applies to all the figures in the paper, unless otherwise stated.

Figure 2. Linear ERPT to CPIF excluding Energy

Percentage points



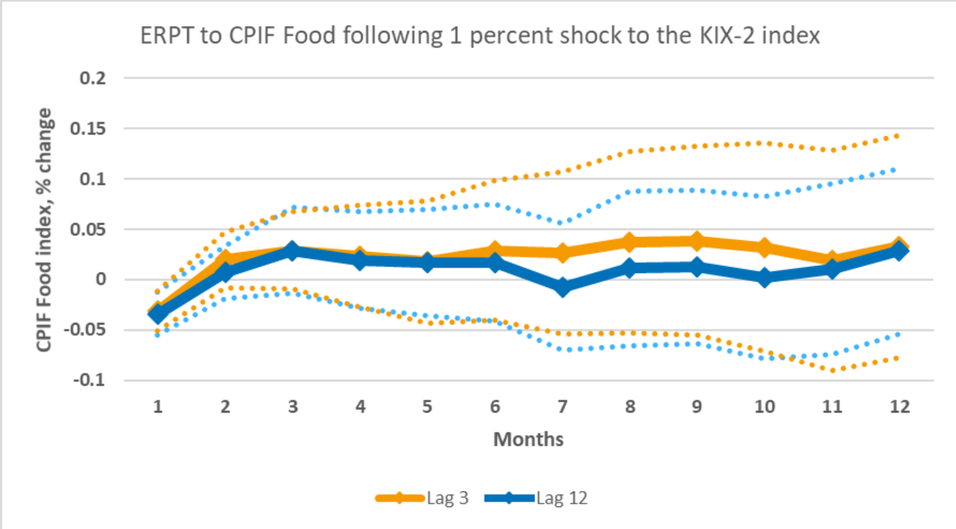
Note: The solid lines in the figure show estimates of β_h in eq. (1) for $h = 1, \ldots, 12$. The blue colour refers to the $L = 12$ specification in eq. (1), while the yellow colour stands for $L = 3$. The blue and yellow dotted lines represent, respectively, the 90 percent confidence for the blue and yellow solid lines. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

We now present our estimates of the linear ERPT for the five subgroups of the CPIF index: Food, Goods, Services, Capital Stock and Energy.

Figure 3. Linear ERPT to CPIF Food

Percentage points

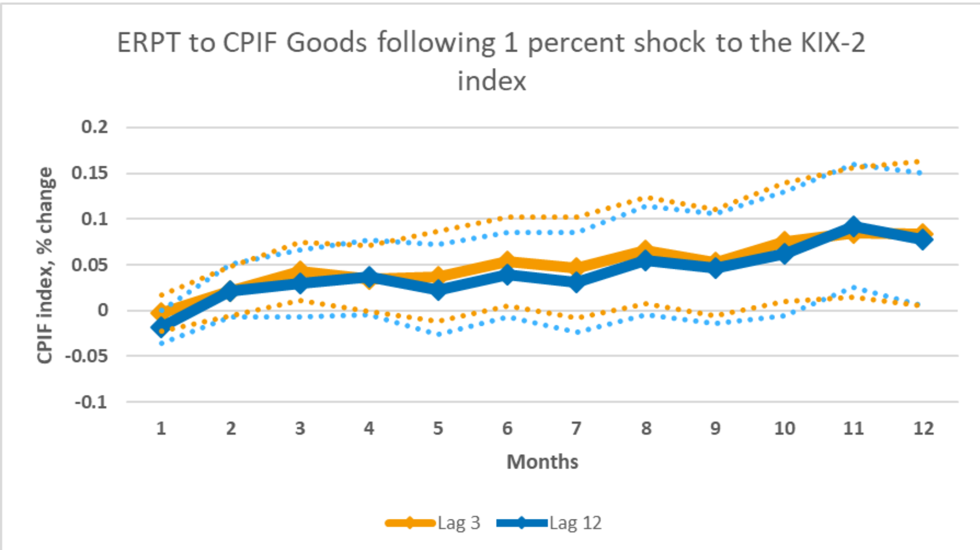


Note: The solid lines in the figure show estimates of β_h in eq. (1) for $h = 1, \ldots, 12$. The blue colour refers to the $L = 12$ specification in eq. (1), while the yellow colour stands for $L = 3$. The blue and yellow dotted lines represent, respectively, the 90 percent confidence for the blue and yellow solid lines. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

Figure 4. Linear ERPT to CPIF Goods

Percentage points

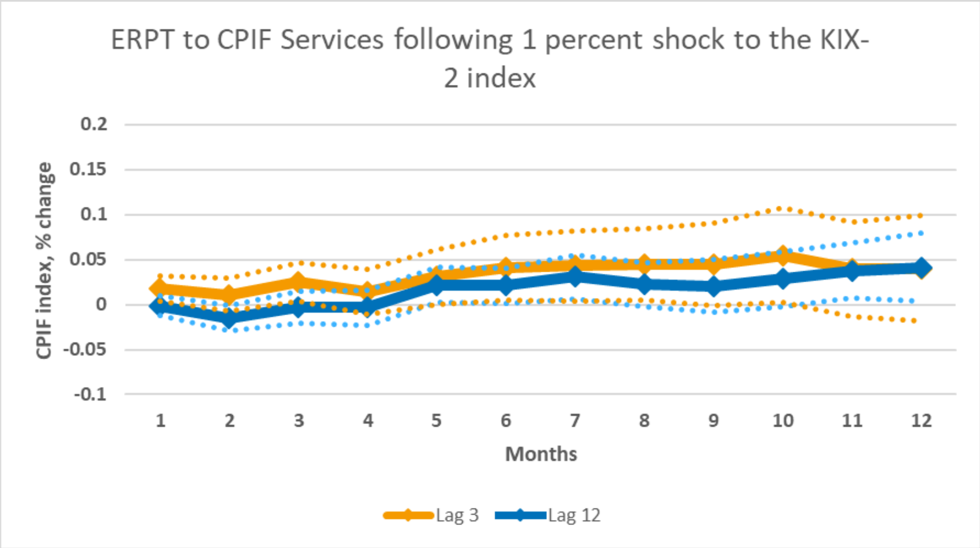


Note: The solid lines in the figure show estimates of β_h in eq. (1) for $h = 1, \ldots, 12$. The blue colour refers to the $L = 12$ specification in eq. (1), while the yellow colour stands for $L = 3$. The blue and yellow dotted lines represent, respectively, the 90 percent confidence for the blue and yellow solid lines. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

Figure 5. Linear ERPT to CPIF Services

Percentage points

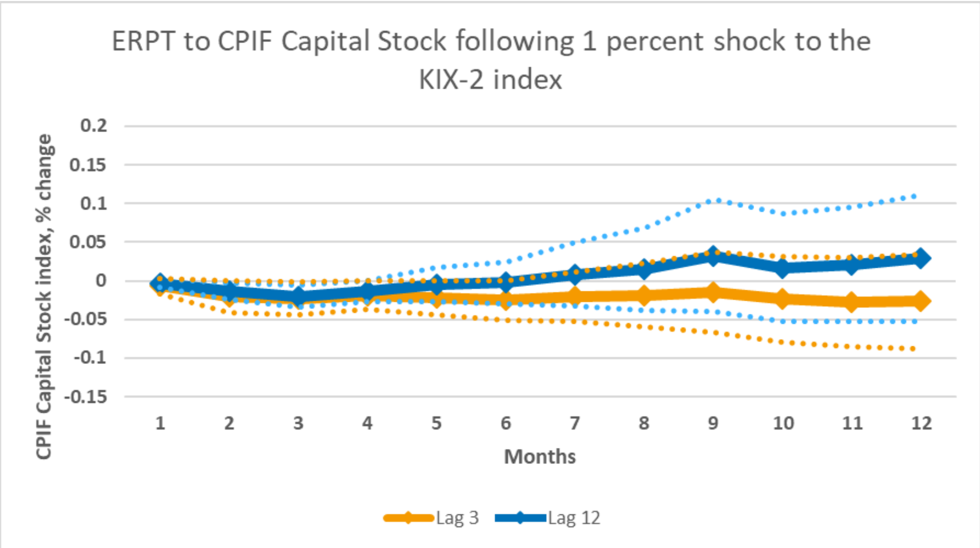


Note: The solid lines in the figure show estimates of β_h in eq. (1) for $h = 1, \ldots, 12$. The blue colour refers to the $L = 12$ specification in eq. (1), while the yellow colour stands for $L = 3$. The blue and yellow dotted lines represent, respectively, the 90 percent confidence for the blue and yellow solid lines. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

Figure 6. Linear ERPT to CPIF Capital Stock

Percentage points

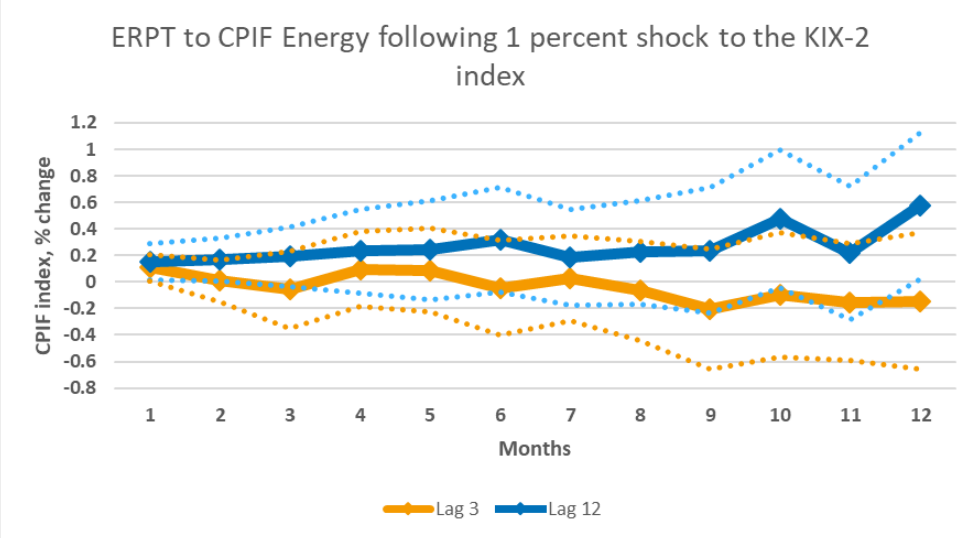


Note: The solid lines in the figure show estimates of β_h in eq. (1) for $h = 1, \ldots, 12$. The blue colour refers to the $L = 12$ specification in eq. (1), while the yellow colour stands for $L = 3$. The blue and yellow dotted lines represent, respectively, the 90 percent confidence for the blue and yellow solid lines. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

Figure 7. Linear ERPT to CPIF Energy

Percentage points



Note The solid lines in the figure show estimates of β_h in eq. (1) for $h = 1, \ldots, 12$. The blue colour refers to the $L = 12$ specification in eq. (1), while the yellow colour stands for $L = 3$. The blue and yellow dotted lines represent, respectively, the 90 percent confidence for the blue and yellow solid lines. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

We observe that in the case of three subgroups CPIF Goods, CPIF Services and CPIF Energy the ERPT appears positive and statistically significant. Using $L = 12$ leads to a positive linear ERPT across all the subgroups where the point estimates are between 0 and 0.10 after 12 months.

Energy – the most volatile CPIF subgroup – is the exception. With 12 lags, the linear ERPT for CPIF Energy is positive. While the ERPT after 12 months is roughly 0.60 and statistically significantly different from zero, the confidence intervals are wide. However, the ERPT for CPIF Energy is positive and statistically significant at different points of the estimation horizon. For example, in the first two months it is close to 0.20 percent.

3.2 State-dependence: definitions and calibration

In this section, we investigate whether the ERPT to consumer prices in Sweden is state-dependent. We first discuss our state variables. We then present the results of our exercise for the CPIF, CPIF excluding Energy index and a selected number of CPIF subgroups CPIF Food, CPIF Goods and CPIF Services.[18]

[18] Focusing on these subgroups only is done to ensure tractability. Moreover, at the time of writing, the sum of the weights of the CPIF subgroups we consider accounts for about 88 percent of the CPIF index.

We consider the following variables for the definition of states: the Geopolitical Risk (GPR) index by Caldara and Iacoviello (2022), level of CPIF inflation in Sweden (YoY), level of inflation in the countries included in the KIX-2 index (YoY). In addition, using the change of the Swedish krona relative to the KIX-2 index, we are able to isolate episodes of relatively persistent depreciation of the Swedish krona, as well as large depreciations and discriminate between the sign of the change of the index. The choice of these state variables is motivated as follows.

Sweden is a small open economy and developments abroad are often of great importance for domestic conditions. [19] In this sense, the use of the GPR index as a state variable is meant to capture the effects of geopolitical volatility on the Swedish economy. In fact, geopolitical stress may negatively affect the currencies of small open economies and lead to a negative supply shock via higher commodities prices and political frictions, such as the impositions of sanctions or embargoes. [20]

To observe a large persistence of inflation when the level of inflation is high is a rather uncontroversial empirical finding. In turn, a larger persistence of inflation may lead to changes in firms' price-setting behaviour.[21] Thus, in line with a large branch of the literature on state-dependence of the ERPT, it appears natural to investigate whether the ERPT depends on the level of inflation in Sweden or abroad. In addition, the level of inflation is particularly relevant for the early 2020s, when inflation reached historical peaks globally.

There is evidence that periods of appreciations or depreciations may lead to different dynamics of the ERPT.[22] For example, in a sample of advanced and emerging economies, Carriére-Swallow et al. (2023) find the ERPT materializes faster following depreciations of the domestic currencies as opposed to appreciations. Similarly, Colavecchio and Rubene (2020) find that while the ERPT is symmetric across depreciations and appreciations, large changes in the exchange rate lead to a proportionally larger ERPT in the Euro area. Thus, the connection between these findings and our work appears an interesting step.

We define a high regime when the state variable is above a certain threshold for three consecutive months in our data, which includes the current period. Our formulation can be expressed as follows:

$$\begin{cases} if\ x_t > x_t^* \ \wedge\ x_{t-1} > x_{t-1}^* \wedge x_{t-2} > x_{t-2}^* \ \rightarrow\ High\ Regime \\ \qquad\qquad\qquad otherwise \rightarrow Low\ Regime \end{cases}$$

where x_t is the state variable at time t and x_t^* is a threshold level at time t. Specifically, we choose the following calibration:

---

[19] See, for example, Corbo and Strid (2020) and Thomas (2023).

[20] See, for example the Article "Why has the krona weakened this year?" in Monetary Policy Report, November 2022, by the Riksbank.

[21] See, among others, Taylor (2002) and Choudri and Hakura (2006).

[22] For example, some episodes of depreciation of the domestic currency may be perceived more persistent than others and lead to a greater willingness of firms to pass on increased costs to their customers, as in Taylor (2000). Similarly, historically large depreciations may turn to be too large to absorb by firms, as in Cavallo et al. (2023).

Table 1. State variables, regimes, thresholds and statistics

Absolute values and percentages

State Variable	Threshold at time t	Threshold at time $t-1$	Threshold at time $t-2$	Mean / Median in the sample	Frequency high regime in the sample
GPR index	≈ 116	≈ 116	≈ 116	106 / 92	14.4 %
Domestic In-flation -	2.00 %	2.00 %	2.00 %	1.96 % / 1.53 %	22.8 %
Foreign Infla-tion	2.5 %	2.25 %	2.00 %	2.16 % / 1.99 %	24.9 %
(a) KIX-2/SEK	> 0	> 0	> 0	≈ 0	12.6 %
(b) KIX-2/SEK	-	> 0	-	≈ 0	50.5 %
(c) KIX-2/SEK	-	> 1.84 %	-	≈ 0	15.8 %

Note: The thresholds for KIX-2/SEK refer to the rate of change of this variable.

Source: Authors' calculations based on data from Macrobond and Riksbank.

The threshold for the GPR index is chosen so that the threshold value corresponds to the median of the GPR index for the past 2 years, that is, between September 2021 and October 2023. This calibration is meant to ensure that the magnitude of the geopolitical stress experienced by the Swedish and global economies in the past two years is properly reflected in the high regimes in the series across time.

The threshold for the domestic inflation is calibrated so that inflation stays higher than the Riksbank's two percent CPIF inflation target for three consecutive months. As inflation in Sweden has been somewhat below the target for a considerable amount of time in the 2010s, defining the high regime as inflation above target helps to ensure that the high regime has sufficient observations for the Local Projections to deliver meaningful estimates.

The threshold for KIX-2 inflation is similar to the Swedish case. However, we calibrate this case in such a way that KIX-2 inflation threshold is increasing over the conditioning horizon. We see such a calibration as a conservative and general way of capturing a somewhat persistent increase of inflation across time, which the nature of our sample is able to accommodate.[23] Importantly, as seen in Table 1, this calibration allows defining the high regime in inflation so that the frequency of these episodes are roughly identical between Sweden and the foreign economy.

Finally, when it comes to exchange rate, we analyse three different cases. First, in case (a), we define three consecutive months of depreciation of the Swedish krona as our threshold. This specification helps us to assess whether somewhat persistent depreciations in the domestic currency lead to state-dependence in the ERPT, while ensuring symmetry with how the high and low regimes are classified in the cases of the GPR index and inflation. In addition, in the KIX-2/SEK cases (b) and (c), we extend our

[23] The KIX-2 countries experienced marginally higher levels of inflation in our sample, which is visible in a higher mean and median as compared to the Swedish case. Therefore, to define our threshold so as to include inflation increasing across time is possible without prejudice to the Local Projections estimates.

exercise to include an analysis of *sign* and *size* state-dependence of the ERPT. Specifically, in the case (b), we consider whether the ERPT is symmetric across appreciations and depreciations, where we use the direction of the change in the exchange rate index in the previous period as a threshold. In the case (c), we instead focus on those episodes where the observed depreciation of the Swedish krona in the previous period is greater than one standard deviation in our sample. This corresponds to an increase of the KIX-2 index of roughly 1.84 percent.

In the Appendix, we show a timeline with the episodes of high regimes for each state-variable that we consider.

A final note about the specification of eq. (2) in the results that follow in the rest of this section. As the observations across the high regimes tend to be less numerous than in the low regime, we set $L = 3$. This to ensure that the Local Projection algorithm delivers non-explosive results in the high regimes.

3.3 State-dependent ERPT

In this section, we present our results for state-dependence of the ERPT for the CPIF, CPIF excluding Energy and for a selected number of CPIF subgroups: Food, Goods and Services.

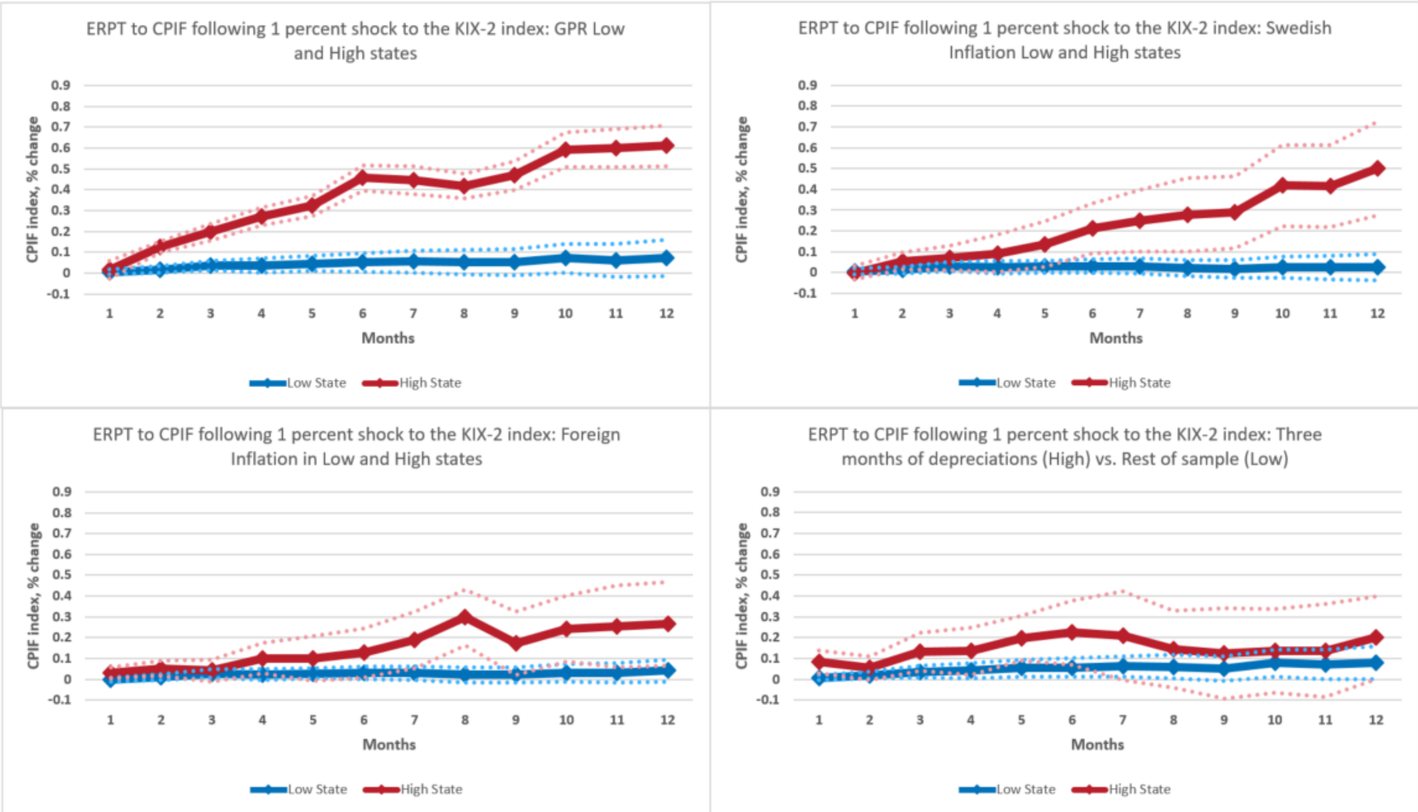
3.3.1 CPIF index

The figure below illustrates the case of the CPIF. We first note that the ERPT for the CPIF is state-dependent in the GPR index. Episodes of geopolitical stress as defined in the calibration of Table 1 lead to a total percentage change of the CPIF index equal to 0.60 percentage points after 12 months following a 1 percent depreciation of the Swedish krona. [24] This result is statistically significant.

[24] See Section 3.4 for a discussion of this and other coefficients introduced in Section 3.3.

Figure 8. State-Dependence in ERPT to CPIF

Percentage points



Note: The solid lines in the figure show estimates of β_h^{High} [red colour] and β_h^{Low} [blue colour] in eq. (2) for $h = 1, \dots, 12$, where $L = 3$. The blue and red dotted lines represent, respectively, the 90 percent confidence for the estimates shown with the blue and red solid lines. The South-East panel refers to the case a) in Table 1. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

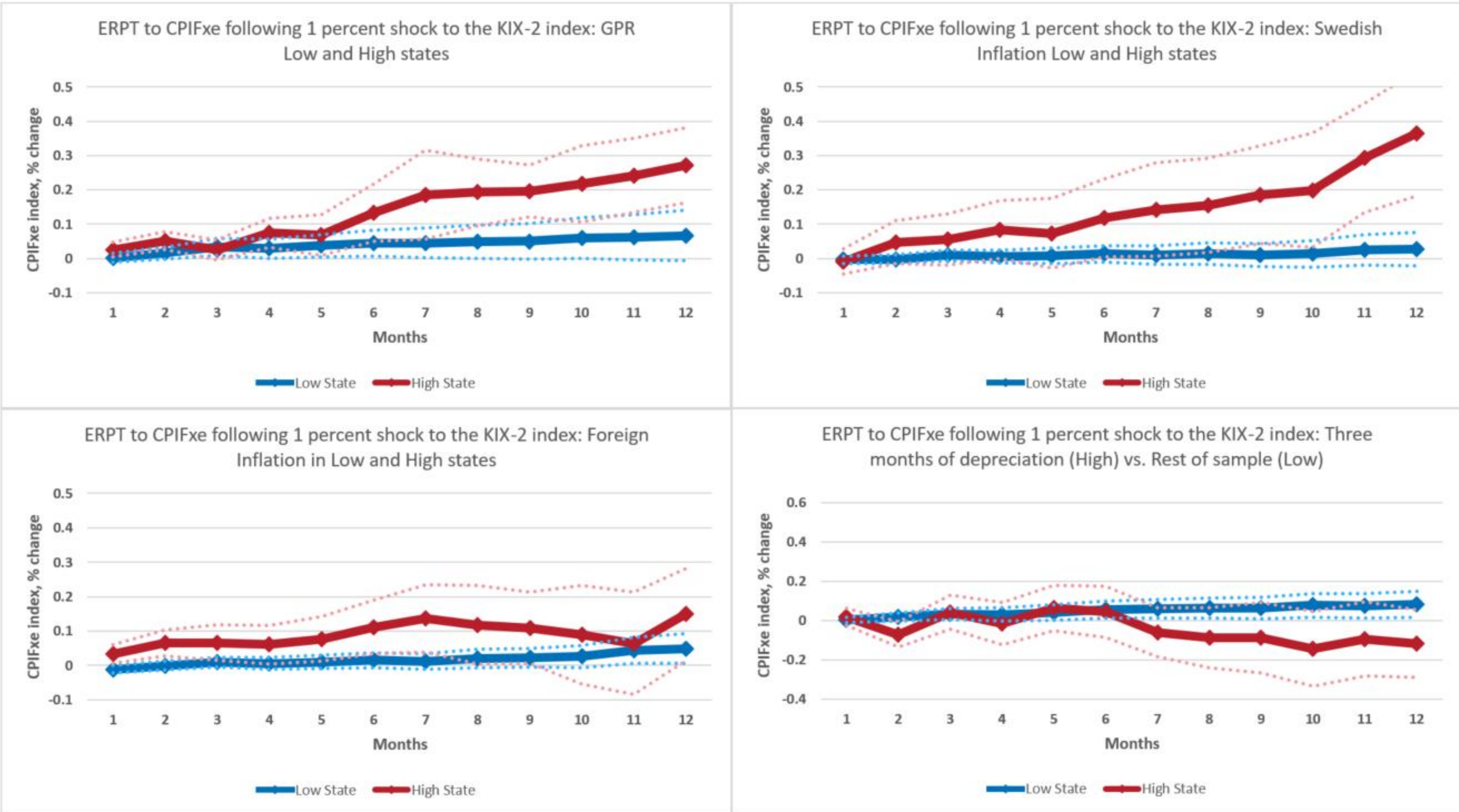
We also observe that the level of domestic and foreign inflation matters. First, in the high regime of domestic inflation the percentage change of the CPIF index stemming from a 1 percent depreciation is around 0.50 after 12 months. This result is statistically significant. In the case of high regime of foreign inflation, the evidence is weaker. Somewhat surprisingly, despite the more stringent requirements for the definition of the high regime, the point estimate indicates an ERPT of 0.25. This result is very close to statistical significance. When the Swedish krona depreciates for three consecutive months against the KIX-2 index, we observe a point estimate for the ERPT of 0.20. However, this result is not statistically significant.

3.3.2 CPIF excluding Energy index

We now move to the discussion of the CPIF excluding Energy. The following figure shows that, from a qualitative perspective, the case of the state-dependence of the CPIF excluding Energy is similar to the case of the CPIF. Specifically, the point estimates for the high regime indicate that the ERPT to the CPIF excluding Energy is higher in times of geopolitical stress, as compared to the respective low regimes. This is also the case when the level of inflation is higher than the 2 percent target in Sweden or in the foreign economy. It remains not possible to claim that, after 12 months, the ERPT is statistically significantly larger when foreign inflation is in the high regime. We observe, however, that in this specific case the ERPT is larger on impact and that a larger ERPT materializes faster in the high regime after 6 and 7 months. Both the results are statically significant. When the Swedish krona depreciates for three consecutive months, the ERPT is not statistically different from zero.

Figure 9. State-Dependence in ERPT to CPIF excluding Energy

Percentage points



Note: The solid lines in the figure show estimates of β_h^{High} [red colour] and β_h^{Low} [blue colour] in eq. (2) for $h = 1, \ldots, 12$, where $L = 3$. The blue and red dotted colours lines, respectively, the 90 percent confidence for the blue and red lines. The South-East panel refers to the case a) in Table 1. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

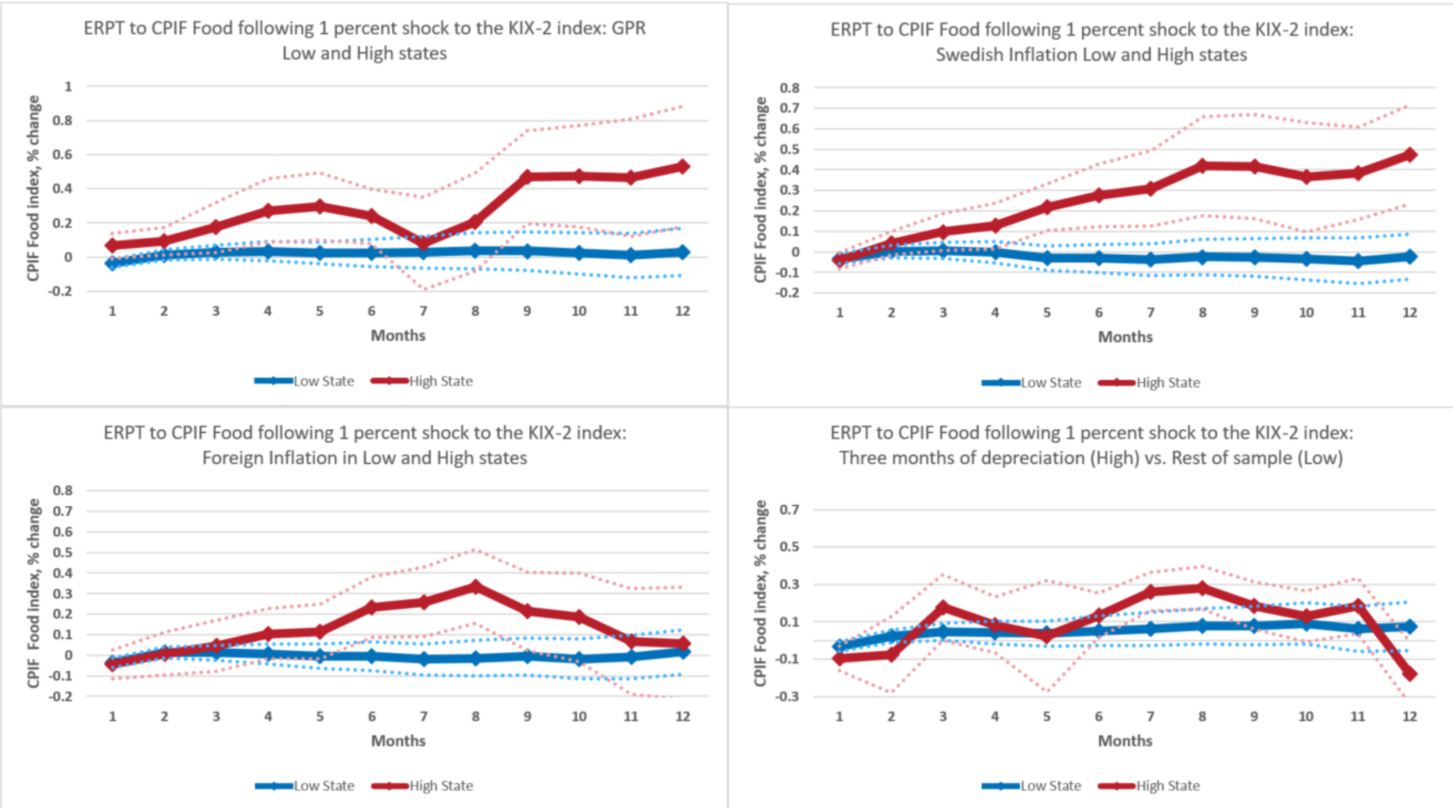
Finally, we observe that excluding the most volatile Energy subgroup from the CPIF leads to a smaller magnitude of the ERPT in the high regimes.

3.3.3 CPIF Food index

We now turn to the case of state-dependence of the CPIF Food subgroup. The following figure shows that the state of GPR index and the level of inflation in Sweden exert the greatest influence on the ERPT to the CPIF Food inflation.

Figure 10. State-Dependence in ERPT to CPIF Food

Percentage points



Note: The solid lines in the figure show estimates of β_h^{High} [red colour] and β_h^{Low} [blue colour] in eq. (2) for $h = 1, \dots, 12$, where $L = 3$. The blue and red dotted lines represent, respectively, the 90 percent confidence for the blue and red lines. The South-East panel refers to the case a) in Table 1. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

In both cases, the ERPT is larger in the high state at the end of our estimation horizon, being close to 0.50. In the case of domestic inflation being in the high state, our estimation point to a larger ERPT throughout the whole estimation horizon. In the regime of elevated level of foreign inflation, the ERPT to the CPIF Food is statistically significantly higher 6 to 8 months following the shock to the KIX-2 index. However, we cannot claim that at the end of the estimation horizon the two results are different. Finally, we cannot claim that the ERPT is significantly larger or asymmetric when comparing periods of somewhat persistent depreciations of the Swedish krona vs. the rest of the sample.

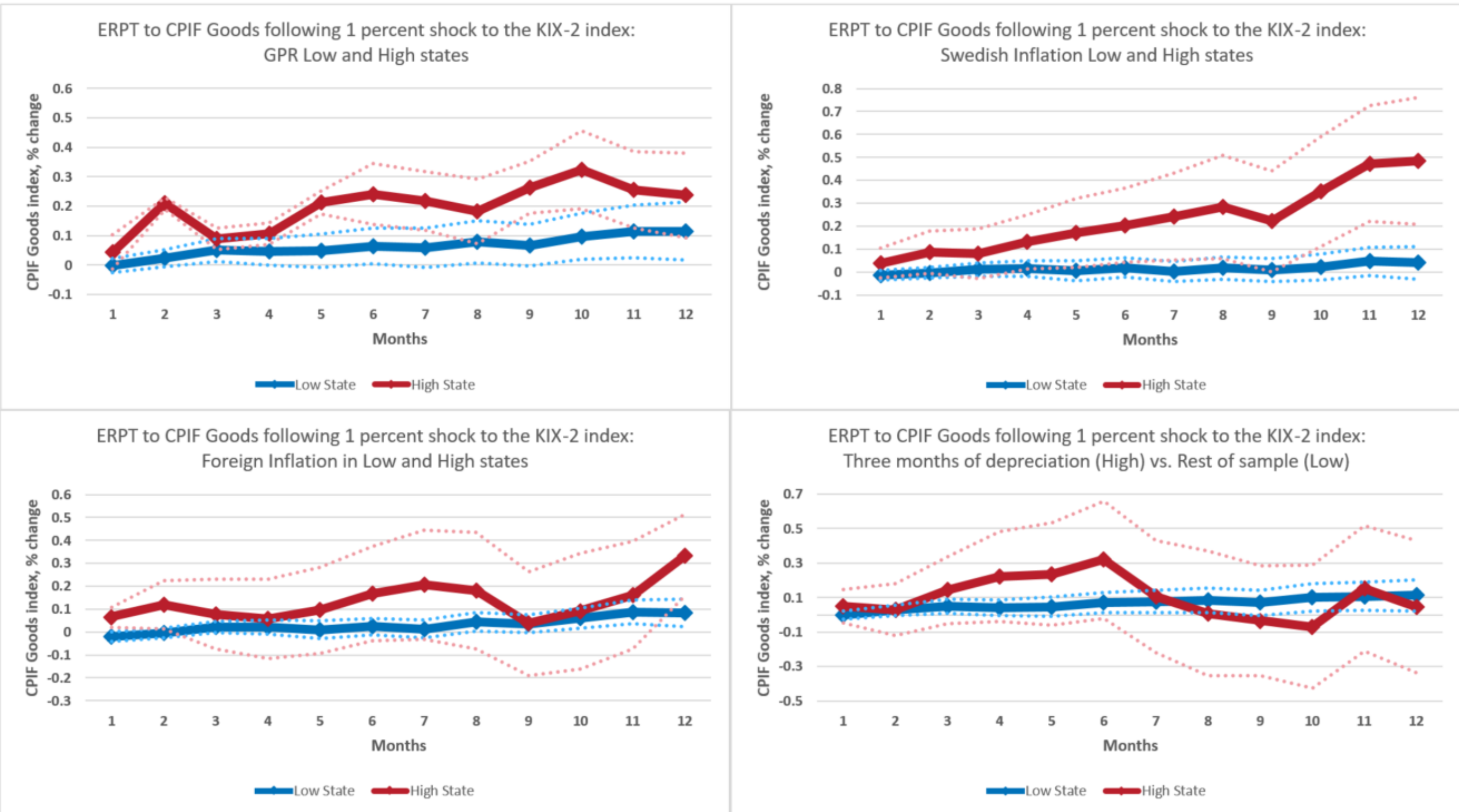
3.3.4 CPIF Goods index

Figure 11 below shows the results of our estimation for the CPIF Goods index. The subgroup is characterized by some degree of state-dependence. We observe that a higher point estimate for the high regime is statistically significant for the cases of domestic and foreign inflation being above target.

The high regime in the GPR index exerts an upward pressure on the ERPT, especially in the first half of the estimation horizon, where it is statistically significant. We also note that a period of a persistent depreciation of the Swedish krona does not appear to conduct to a larger ERPT. In this case, the point estimate is markedly higher in the first half of the estimation horizon. However, because of the high uncertainty surrounding the estimates, it is not possible to claim that this result is statistically significantly different from zero.

Figure 11. State-Dependence in ERPT to CPIF Goods

Percentage points



Note: The solid lines in the figure show estimates of β_h^{High} [red colour] and β_h^{Low} [blue colour] in eq. (2) for $h = 1, \ldots, 12$, where $L = 3$. The blue and red dotted lines represent, respectively, the 90 percent confidence for the blue and red lines. The South-East panel refers to the case a) in Table 1. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

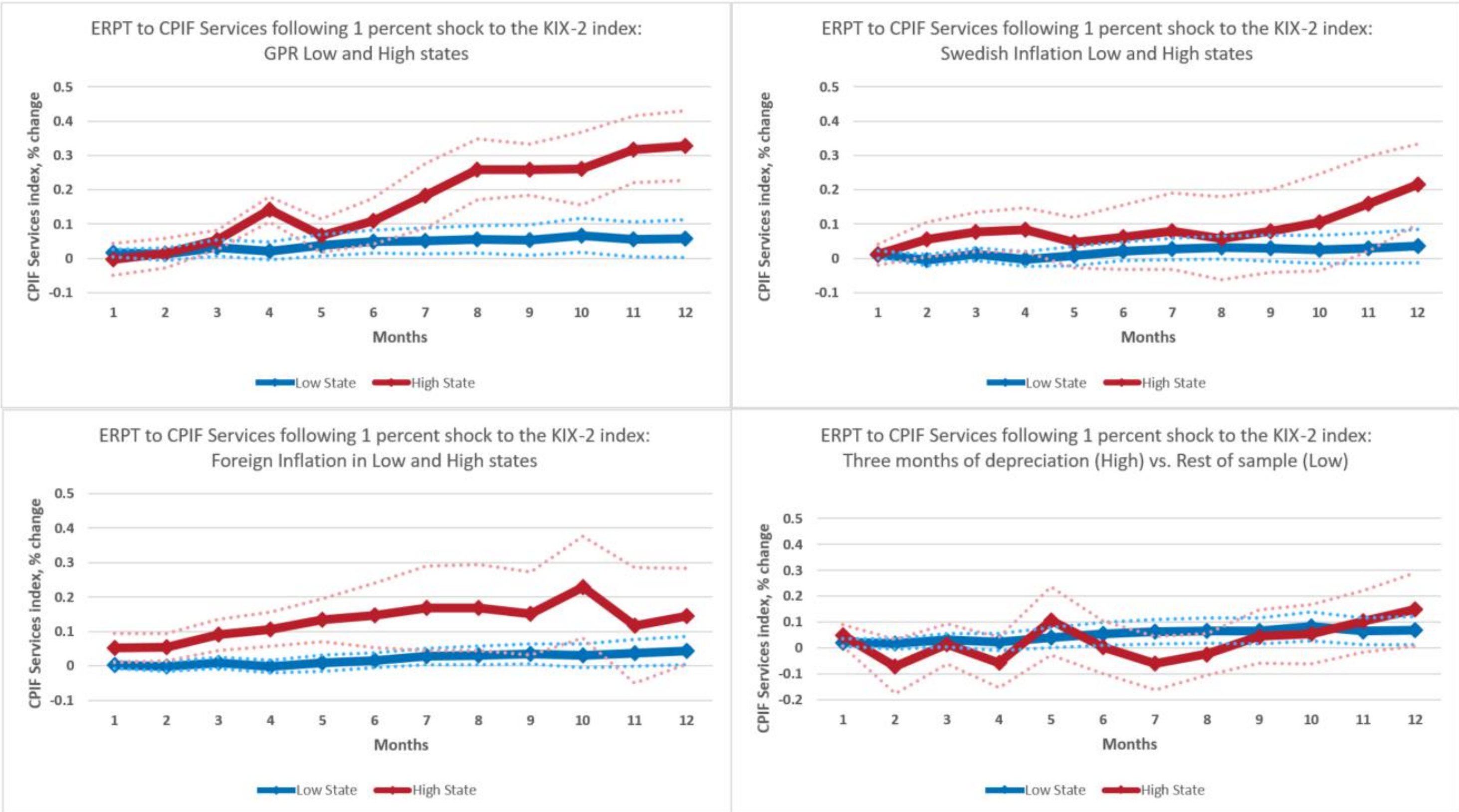
Source: Own calculations using data from Macrobond and Riksbank.

3.3.5 CPIF Services index

Figure 12 below presents our estimates for the case of the CPIF Services subgroup. We observe roughly the same pattern of the previous subgroups. A high regime in the GPR index or in domestic inflation leads to a higher ERPT at the end of the estimation horizon. In both cases, the result is statistically significant. We also note that for both of these cases, the spread between the point estimates of the high and low regime is low.

Figure 12. State-Dependence in ERPT to CPIF Services

Percentage points



Note: The solid lines in the figure show estimates of β_h^{High}[red colour] and β_h^{Low}[blue colour] in eq. (2) for $h = 1, \dots, 12$, where $L = 3$. The blue and red dotted lines represent, respectively, the 90 percent confidence for the blue and red lines. The South-East panel refers to the case a) in Table 1. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

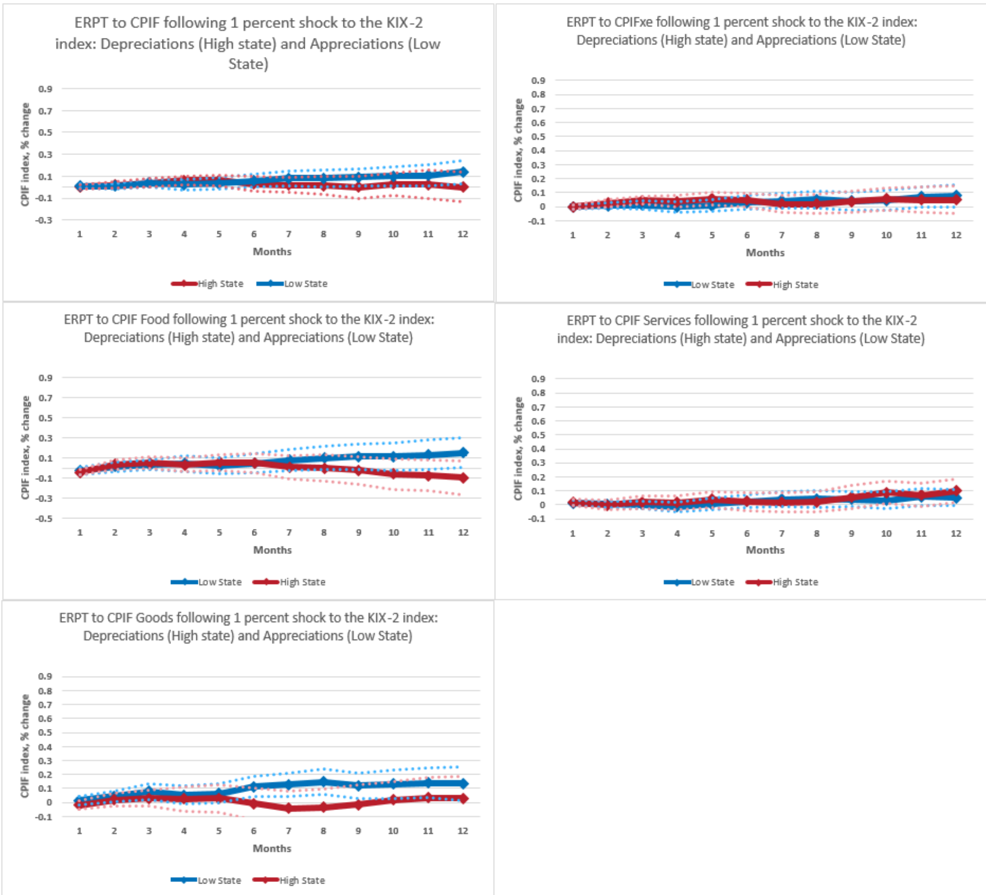
Source: Own calculations using data from Macrobond and Riksbank.

Conversely, there is not enough evidence to claim that the ERPT to CPIF Services is higher in high regimes of foreign inflation and following three consecutive months of depreciation of the Swedish krona. The spread between the point estimates across the high and low regimes is also low.

3.3.6 Appreciations and Depreciations of the Swedish krona

In this section, we analyse whether the ERPT is symmetric across periods of appreciations and depreciations of the Swedish krona, that is, whether there is *sign* non-linearity in the ERPT. We categorize periods of depreciations (high regime) at time t as periods preceded, at $t-1$, by a positive growth rate in the KIX-2/SEK index (and vice versa for the low regime).

Figure 13. State-Dependence in the ERPT following appreciations and depreciations
Percentage points



Note: The solid lines in the figure show estimates of β_h^{High} [red colour] and β_h^{Low} [blue colour] in eq. (2) for $h = 1, \dots, 12$, where $= 3$. The blue and red dotted lines represent, respectively, the 90 percent confidence for the blue and red lines. All the panels refer to the case b) in Table 1. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

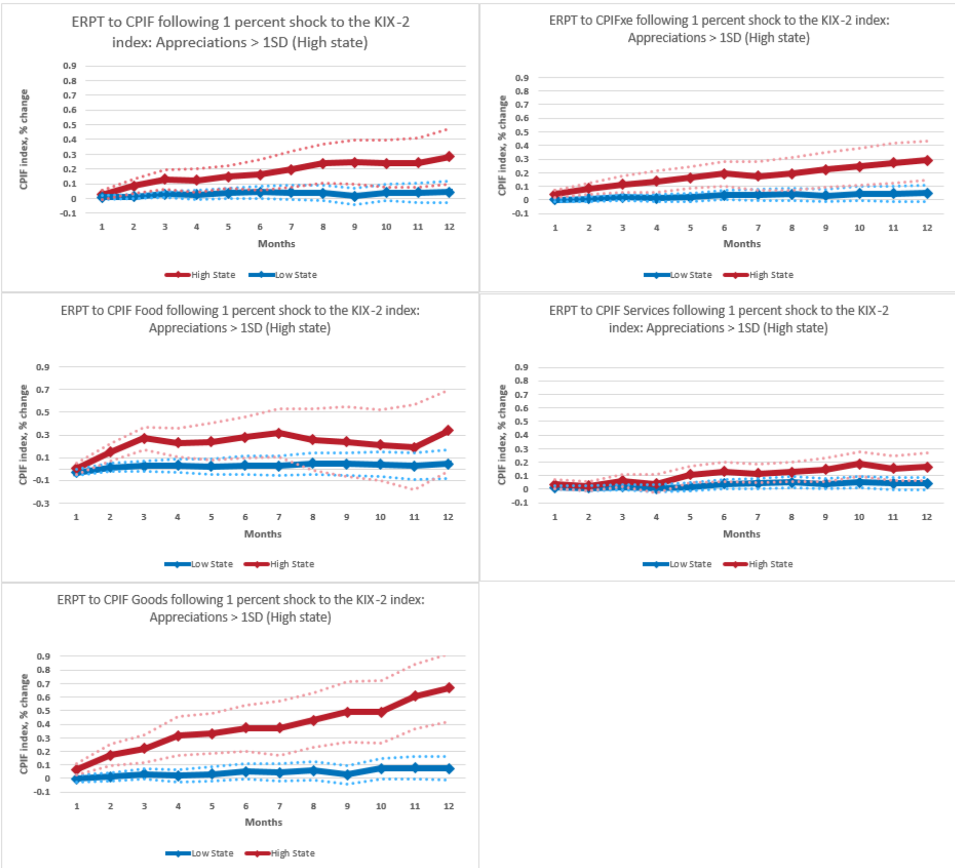
Figure 13 shows that there is no sign non-linearity in the ERPT to consumer prices in Sweden. From a statistical point of view, there is not enough confidence to claim that the ERPT is different in the periods that follow a depreciation of the Swedish krona, as opposed to periods following an appreciation.

3.3.7 Episodes of large depreciations of the Swedish krona

In this section, we analyse whether the ERPT to consumer prices is state-dependent in the *size* of the depreciation of the Swedish krona. To this end, we collect episodes of depreciations of the Swedish krona against the KIX-2 index, so as to isolate depreciations that are greater than 1 standard deviation in the sample. In our data, this is equivalent to monthly depreciations such that KIX-2/SEK > 1.84 %, which we define as high regime.

Figure 14. State-Dependence in the ERPT following appreciations and depreciations

Percentage points



Note: The solid lines in the figure show estimates of β_h^{High} [red colour] and β_h^{Low} [blue colour] in eq. (2) for $h = 1, \ldots, 12$, where $L = 3$. The blue and red dotted lines represent, respectively, the 90 percent confidence for the blue and red lines. All the panels refer to the case c) in Table 1. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

Figure 14 shows that the size of depreciations leads to a higher ERPT to the CPIF, CPIF excluding Energy and CPIF Goods indexes. In these cases, the point estimates are different across the high and low regimes. In the case of the CPIF Food, the ERPT is larger and materializes faster in the first three months of the estimation horizon. However, as for the case of the CPIF Services, we cannot claim that the difference of the ERPT across the high and low regime are statistically significant.

3.4 Discussion

Overall, our results can be summarized as follows. First, we find that, following a 1 percent depreciation of the Swedish krona vs. the KIX-2 index, the linear ERPT to CPIF inflation is positive and in the neighbourhood of 0.07 percent after 12 months. This estimate is in line with previous work at the Riksbank, where a similar exercise leads to an ERPT to inflation of 0.05 percentage points after 12 months. It is also coherent with the calibration of the Riksbank's DSGE model MAJA. Finally, our estimate is also in line with Corbo and Di Casola (2022), where the unconditional ERPT to inflation after four quarters is positive and in the neighbourhood of 0.05. In contrast to these studies, our results include the early 2020s, characterized by heightened macro-economic volatility. Thus, we find the previous estimates of the ERPT to be rather robust across time and across a different type of macroeconomic regime as observed after 2020.

Similarly to the case of the CPIF inflation, we find that the excluding the Energy sub-group from the CPIF leads to a positive but slightly lower linear ERPT of 0.05. Previous studies have found that price changes for products related to the energy sector are more frequent than products in the goods or services sectors.[25] This is likely reflected in the dynamic of our estimate for the linear ERPT for the CPIF excluding Energy. It appears less volatile, stays close to zero in the first quarter and reaches its peak more smoothly than the CPIF index.

Investigating the state-dependence of ERPT, we find that the linear estimate masks important non-linearity. In periods of heightened geopolitical uncertainty, the ERPT reaches 0.60 percentage points following a 1 percent depreciation of the krona after 12 months. The contrast between the magnitude of the ERPT between the different regimes is in line with recent research on ERPT and heightened economic and geopolitical uncertainty. Cheikh et al. (2023) find an ERPT about 0.17 percentage points in times of heightened geopolitical uncertainty, statistically different from the ERPT in the low regime. Using an index of economic uncertainty, Carriére-Swallow et al. (2023) find an ERPT about 0.22 percentage points after 12 months in a high regime. These studies are based on a sample of different countries, which also include large economies or economies being part of monetary unions. Therefore, it is plausible that the ERPT in Sweden is higher in periods of geopolitical uncertainty, as opposed to a sample of both large and small advanced economies.

In the high regime of domestic inflation, our estimated ERPT reaches 0.50 percentage points after 12 months. This is statistically different from the low regime, which is not different from zero. Carriére-Swallow et al. (2023) find an ERPT coefficient about 0.30 percentage points in the high regime in inflation for a sample of countries, whereas Linderoth and Meuller (2024) find a corresponding estimate about 0.17 percentage points for Sweden. This is qualitatively in line with our findings, and with the quantitative difference likely being the result of different econometric approaches and data.

In addition, our results show that only relatively large depreciations in the Swedish krona lead to a larger ERPT. The ERPT does not display sign-dependence and therefore

[25] See Ewertzh, Klein and Tysklind (2022).

appears symmetric across depreciations and appreciations. Similarly, a period of three consecutive months of depreciation of the Swedish krona, which is our proxy for a somewhat persistent depreciation, does not lead to a statistically different ERPT. These results are in line with Colavecchio and Rubene (2020). Using Local Projections, they find that the ERPT in the Euro area is symmetric across appreciations and depreciations but displays size-dependence. In other words, the ERPT is larger following historically larger changes of the exchange rate.[26] Our results are also broadly in line with Carrière-Swallow (2023), who show that the ERPT is symmetric across appreciations and depreciations after 12 months in a panel of advanced and emerging markets economies. At a theoretical level, these results appear to be in line with Cavallo et al. (2023), who find that large shocks especially are those that cause firms to change prices more frequently.

In the Riksbank's DSGE model MAJA, the overall import share in the CPIF index is calibrated to be in the neighbourhood of 35 percent.[27] In light of this calibration, we note that that our point estimates for the ERPT in the high regime of the GPR index and domestic inflation might therefore be regarded as surprisingly high. The two results can be partially reconciled as follows. Because we do not use an identified exchange rate shock, we do not aim to precisely pin down the magnitude of the ERPT.[28] Our target, instead, is to show that an exogenous exchange rate shock might be associated with different magnitudes of changes in the price level in specific states. Furthermore, we note that the import share of the consumer prices indexes is a parameter that is time-varying and notoriously difficult to estimate precisely.[29, 30] Finally, our estimates for the ERPT to the CPIF excluding Energy is lower than the corresponding estimate for the CPIF index. This may lead to conclude that the Energy subgroup could be the component driving our results for the CPIF index. However, simulations of eq. (2) with additional control variables such as the Natural Gas prices or an index of Electricity prices in Sweden do not affect the results.[31]

In reference to the CPIF subgroups, we find the following estimates. First, when considering the spread between the point estimates of the ERPT in high and low regimes, the CPIF subgroup Services appears as the less responsive to different states among those we consider. Conversely, the CPIF Goods subgroup displays a more marked tendency to state-dependence in high regimes of domestic and foreign inflation, as well

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[26] This result is based on quarterly data but utilizes the same threshold to define historically large movements in the Euro that we here utilize for the Swedish krona.

[27] Specifically, the import share of non-Energy consumption is calibrated to 27 percent in MAJA. The energy share of consumption is calibrated to 7.5 percent, with an import share of 50 percent (see Corbo Strid (2020, p.54)).

[28] Rather, by utilizing a broad set of controls in our regressions, we attempt to mimic the set-up of a structural shock as close as possible. This does not totally rule out the possibility that a certain degree of endogeneity between inflation and the exchange rate might remain in our regression. See Section 2.1 for further discussion.

[29] In this sense, we note that the estimations in Corbo and Strid (2020) are based on input-output tables compiled for the period between 1995 and 2014.

[30] Hanson and Johanson (2007) discuss some of the practical challenges in assessing the extent to which inflation is generated by domestic forces, as opposed to international forces. In this regard, they make the example of the cucumber, which is generally classified as a domestic product but that is likely to be predominantly imported in some seasons of the year and whose price might heavily depend on the developments abroad, such as the variability in weather or transportation costs.

[31] The estimates for these simulations are available upon request.

as during periods of geopolitical stress. Similarly, at the end of the estimation horizon, the CPIF Food subgroup is characterized by state-dependence in two of the state variables considered. This result appears coherent with previous analysis that found that the CPIF Goods and the CPIF Food subgroups include a larger share of imported products, as opposed to CPIF Services. [32] A higher share of imported products might lead to a higher sensitivity of the prices of those products to fluctuations in the Swedish krona. One could posit that geopolitical tensions, under the form of sanctions or acts of aggression leading to a limitation of the usage of commercial routes, may reduce the supply and raise the costs of these products. In this type of scenario, the combination of a persistent geopolitical shock together with a likely depreciation of the domestic currency may lead firms to pass costs to a greater extent than usual.

3.5 Robustness

3.5.1 Discussion of an alternative definition of the ERPT

The definition of the ERPT in eq. (1) is not the only one possible, despite being widely employed and regarded as the traditional definition.[33] In fact, a branch of the literature has identified the so-called Price-to-Exchange-Rate-Ratio (PERR) as a possible alternative: [34]

$$PERR_{j,h} = \frac{\sum_{t=1}^{h} IRF_j(\Delta p_t)}{\sum_{t=1}^{h} IRF_j(\Delta s_t)} = \frac{IRF_j(p_t)}{IRF_j(s_t)} \quad (3)$$

where p is the price index of interest, s is the nominal exchange rate, j denotes the type of shock (e.g., foreign or domestic supply) and h is estimation horizon.

The definition of the ERPT as β_h in eq. (3) is typically utilized in the literature that investigates whether and how the ERPT might be shock-dependent (e.g., Forbes et al. (2018) and Corbo and Di Casola (2022)). As throughout our simulations we utilize only one type of shock, the exchange rate shock, we tend to view the use of PERR as largely redundant in our context.[35]

An analysis of state-dependence of the ERPT using the definition in eq. (3) might raise the question about what role the depreciation of the exchange rate really plays in a given state. In other words, one could ask whether a higher percentage change in the price index of interest, following a shock to the exchange rate in a certain state, is the result of a higher ERPT or the result of a larger depreciation in a specific state. To address this issue, we analyse the response of the KIX-2 index in the case of our analysis

[32] See Hanson and Johanson (2007).

[33] See, for example, Ortega and Osbat (2020).

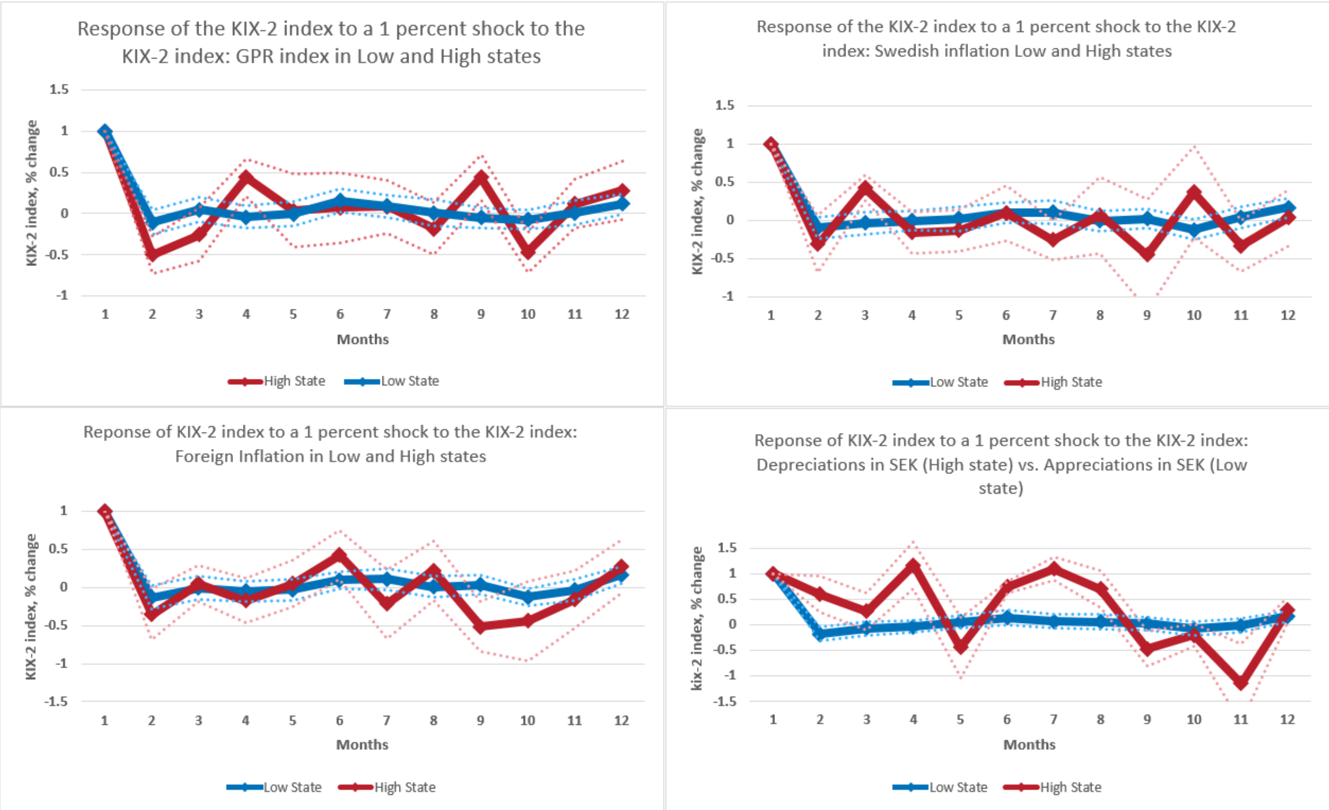
[34] Here the PERR is referred using the notation by Ortega and Osbat (2020). In the case of Corbo and Di Casola (2022), the PERR is labelled as the Conditional-ERPT; this emphasizes its purpose of discriminating between various types of shocks in the analysis of the ERPT.

[35] In addition, we observe that the use of PERR appears more compatible with the use of a Vector Auto-Regression (VAR), as opposed to Local Projections. This is because the IRFs generated with the help of Local Projections are estimated at every point of the estimation horizon. In contrast, with a VAR, one typically 'extrapolates' IRFs into the estimation horizon. Thus, Local Projections may lead to less stable and 'wobbly' IRFs, which in turn can make the interpretation of the PERR challenging.

of the CPIF index in Section 3.3.1. The Figure 15 below illustrates how the exchange rate reacts to the shock:

Figure 15. State-Dependence in ERPT to the change of the Swedish krona

Percentage Points



Note: The solid lines in the figure show estimates of β_h^{High} [red colour] and β_h^{Low} [blue colour] in eq. (2) for $h = 1, \ldots, 12$, where the KIX-2 index are the CPIF index switched, respectively, from the right hand side to the left side of the equation, and vice-versa. The blue and red dotted lines represent, respectively, the 90 percent confidence for the blue and red lines. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2023m10.

Source: Own calculations using data from Macrobond and Riksbank.

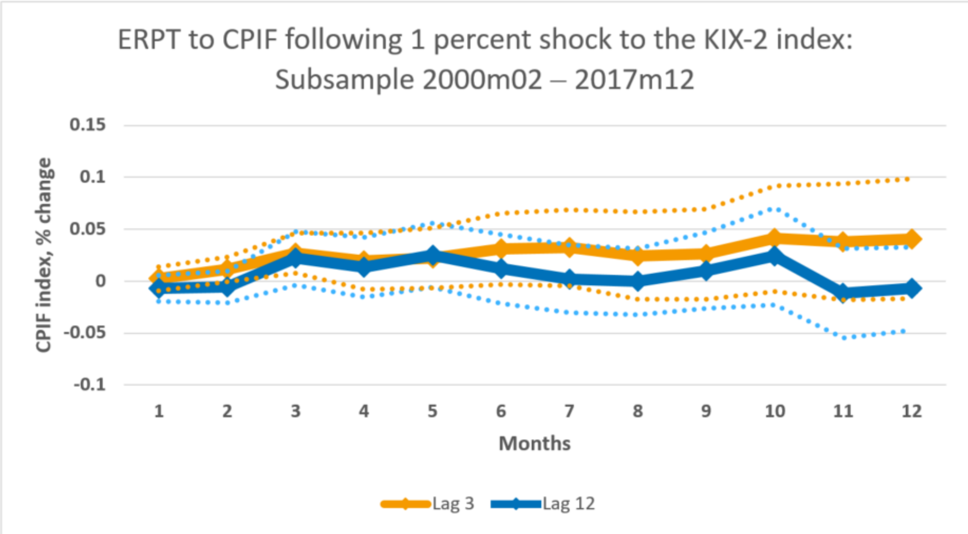
We observe that in the cases of GPR index, domestic and foreign inflation the response is not statistically significantly different across the two states across the whole estimation horizon. In the high state, the confidence intervals are wider, which we regard as a reasonable feature stemming from a lower number of observations. Finally, we note that that the responses of the Swedish krona to the exogenous shock is indeed partly statistically significantly different across the two states (South-East panel). However, we observe that after 12 months it is not possible to claim that the original shock led to a cumulative response that is statistically different across the two states.

3.5.2 Using the subsample 2000m02 – 2017m12

In this section, we illustrate our results for the subsample that includes data up to December 2017. This is potentially an interesting exercise to verify whether our estimates are not driven exclusively by the period of heightened geopolitical and macroeconomic volatility of early 2020s. We choose to truncate our sample in 2017 in order to improve comparability with Corbo and Di Casola (2022) and, to keep this exercise tractable, present our results for the CPIF index only.

Figure 16. Linear ERPT to CPIF: Subsample 2000m02 – 2017m12

Percentage points

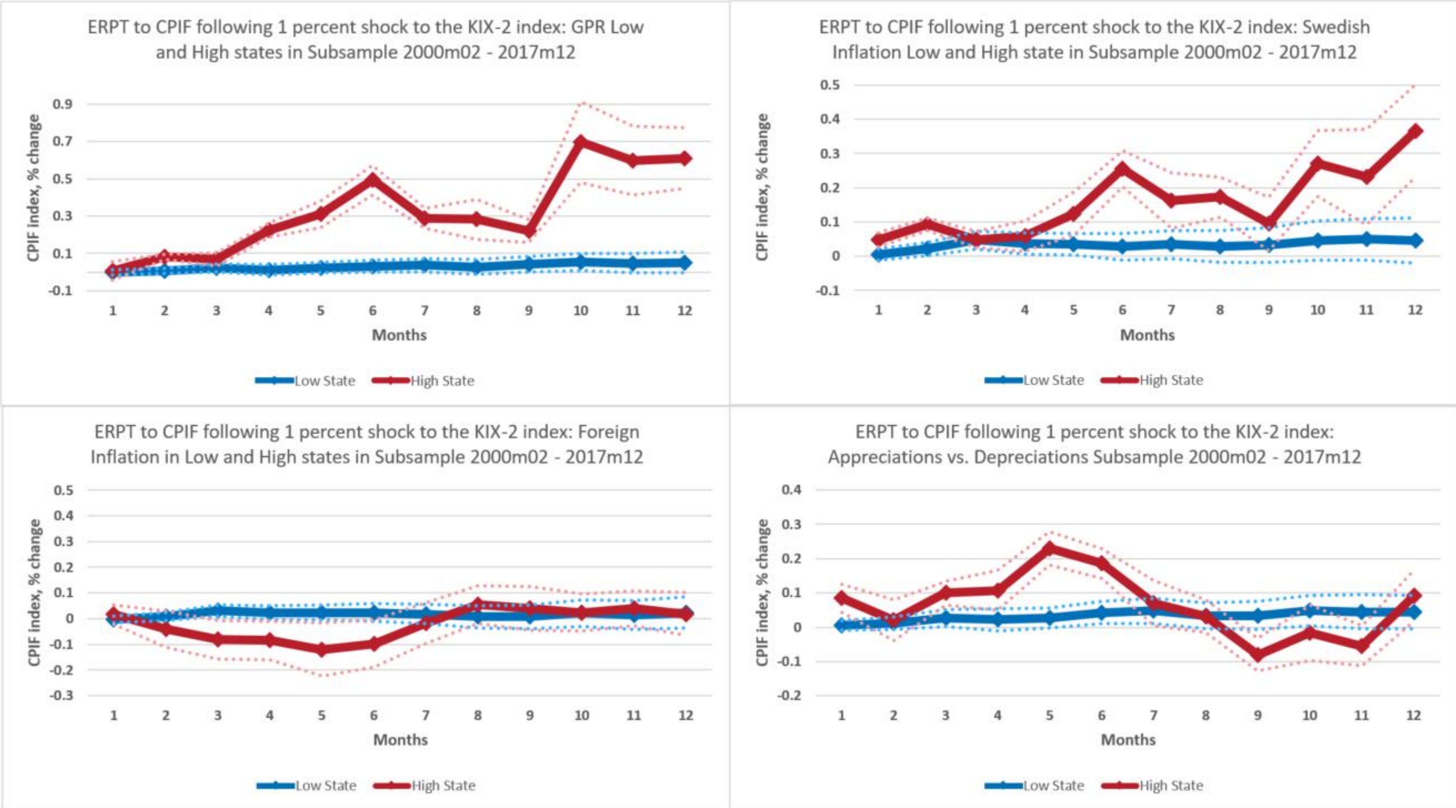


Note: The solid lines in the figure show estimates of β_h in eq. (1) for $h = 1, \ldots, 12$. The blue colour refers to the $L = 12$ specification in eq. (1), while the yellow colours stands for $L = 3$. The blue and yellow dotted lines represent, respectively, the 90 percent confidence for the blue and yellow lines. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2017m12.

Source: Own calculations using data from Macrobond and Riksbank.

Figure 17. State-Dependence in ERPT to CPIF: Subsample 2000m02 – 2017m12

Percentage points



Note: The solid lines in the figure show estimates of β_h^{High} [red colour] and β_h^{Low} [blue colour] in eq. (2) for $h = 1, \ldots, 12$, where $L = 3$. The blue and red dotted lines represent, respectively, the 90 percent confidence for the blue and red lines. Standard errors are calculated with the Newey-West (1987) method. The sample includes monthly data between 2000m2 and 2017m12.

Source: Own calculations using data from Macrobond and Riksbank.

A comparison between Figures 1 and 14 reveals that the linear ERPT could have been marginally lower in this subsample, as compared to the full sample. While using the $L = 3$ specification leads to roughly unchanged point estimates, the $L = 12$ calibration points to an ERPT of zero. Interestingly, the state-dependence results appear compatible with the evidence we find in the full sample. Specifically, state-dependence in the GPR index and domestic inflation is essentially unchanged. We also find some weak evidence of state-dependence in foreign inflation and depreciation. We observe a moderately negative ERPT in times of high regimes of foreign inflation in the first part of the estimation horizon. Similarly, three consecutive months of depreciation of the Swedish krona lead to a higher ERPT in the first half of the estimation horizon. However, in both cases the cumulative effect on the ERPT at the end of the estimation horizon is not different across both cases.

Overall, we therefore find that the results on state-dependence appear to be robust in a different subsample.

4 Conclusion

In this Staff memo, we utilize Local Projections to provide an estimate of the ERPT to a number of indexes of consumer prices. Furthermore, we investigate whether the magnitude of the ERPT varies across different states of the economy. To do this, we select a number of measures, which include states of high geopolitical stress and states of high domestic and foreign inflation. In addition, we study whether the ERPT is symmetric across periods of appreciations as opposed to depreciations, whether it is larger following large depreciations of the Swedish krona and whether somewhat persistent depreciations lead to a higher ERPT.

Our results show that the linear ERPT in Sweden is unlikely to be different from the previous estimates by the Riksbank and in line with the estimates commonly found in the literature for advanced economies. Specifically, given a depreciation of 1 percent of the Swedish krona, the linear ERPT to the CPIF and CPIF excluding Energy indexes is in the neighbourhood 0.07 percent after 12 months. In line with previous literature on state-dependent ERPT, we find that the ERPT might be significantly larger in times of elevated geopolitical stress, when inflation in Sweden is above the two percent target for a period of time and when historically large depreciations of the Swedish krona occur. Conversely, we do not find significant evidence of state-dependence when inflation is high in the KIX-2 countries or when the Swedish krona experiences three consecutive months of depreciation.

To further unmask non-linearity, we conduct the same analysis for a selected number of CPIF subgroups. As for the aggregate CPIF indexes, episodes of geopolitical stress and periods of high domestic inflation exert the strongest influence on the ERPT. Finally, we observe that among those subgroups that we analyse, the degree of state-dependence might be a function of the share of imported products in each subgroup.

Our approach does not make use of a purely identified exogenous shock to the exchange rate. Rather, by using a reasonable and broad set of controls, our aim is to get as close as possible to an identified shock and in so doing limit potential endogeneity between the change of the price level and the exchange rate. Future research might focus on isolating an exogenous and identified exchange rate shock.

Overall, our results complement the literature on the ERPT and shed light on the importance of integrating the use of rules-of-thumb based on averages with more granular research. We also believe that our evidence about state-dependence of the ERPT might be helpful to improve inflation forecasting and be useful in the conduct of monetary policy.

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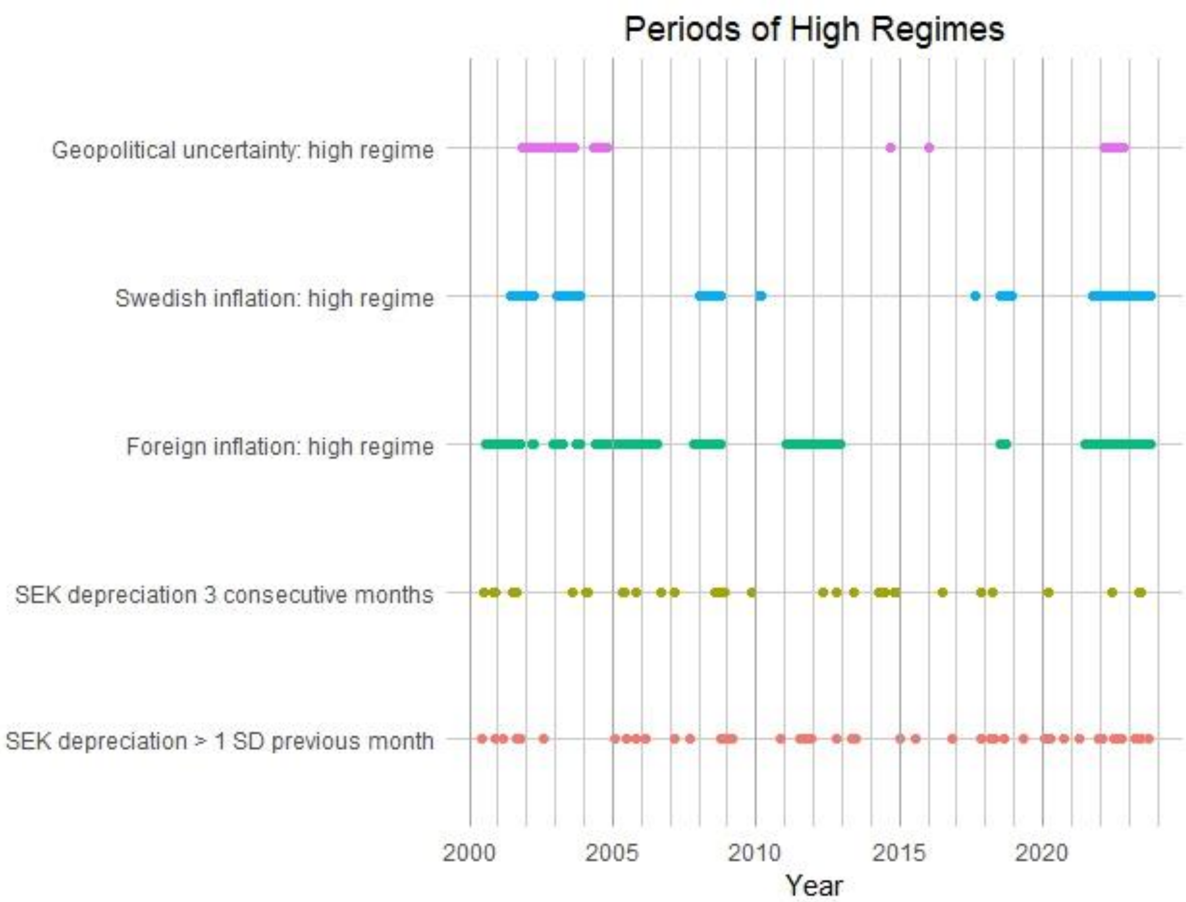
APPENDIX

Distribution of high regimes across time

Figure 18. Timeline for high regimes across state variables
Months and Years



Note: The filled dots correspond to high regimes according to the definitions in Table 1.

Source: Own calculations using data from Macrobond and Riksbank.

SVERIGES RIKSBANK
Tel +46 8 - 787 00 00
registratorn@riksbank.se
www.riksbank.se

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