Exchange Rate Fluctuations in the Swiss Franc and their Effect on the Swiss Economy

Fabio Stohler (30126)

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Supervisors: João B. Duarte, Adhemar Villani Junior

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Resumo

Esta dissertação usa um modelo vectorial autoregressivo estrutural (SVAR) para investigar os efeitos das flutuações da taxa de câmbio nas variáveis macroeconómicas da Suíça. Para identificar o modelo, as hipóteses básicas macroeconómicas são ampliadas a uma abordagem narrativa baseada numa análise dos anúncios da política monetária do Banco Central da Suíça. Controlado pelas mudanças na taxa de juros e intervenções cambiais, este trabalho inclui uma série de instrumentos reguladores normalmente não usados nos estudos empíricos. Os resultados indicam uma resposta deflacionária do produto à valorização das taxas de câmbio, enquanto que, as intervenções do banco central no mercado do câmbio resultam numa expansão temporária da produção, e numa depreciação temporária do câmbio. Porém, ambos os choques não afetam o nível dos preços significativamente. Além disso, uma análise contrafactual mostra que choques na taxa do câmbio e intervenções no mercado cambial podem acumular efeitos substanciais ao longo do tempo. Como resultado, este trabalho poderá contribuir para a literatura, identificando as taxas de câmbio como fontes potenciais de choques para uma economia pequena e as intervenções cambiais como uma possível ferramenta política.

**Palavras-chave:** Taxa de cambio; Flutuações macroeconómicos; Vetorial Autoregressivo estrutural; Análise Contrafactual; Economia Aberta
Abstract

This paper uses a structural vector autoregression (SVAR) to investigate the effect of exchange rate fluctuations on macroeconomic variables of the Swiss economy. For identification of the system, common macroeconomic identification assumptions are extended by a narrative approach based on an analysis of the policy announcements of the Swiss national bank. Controlling for interest rate changes and interventions in the foreign exchange (FX) market, this work includes a wider set of policy instruments than normally employed in empirical studies. The results indicate a deflationary response of output to an exchange rate appreciation, whereas foreign exchange interventions result in transient responses in production and the exchange rate. Both shocks do not cause significant fluctuations in inflation. Furthermore, a counterfactual analysis indicates that exchange rate shocks and foreign exchange interventions can accumulate substantial welfare effects over time. As a result, the work contributes to the literature identifying exchange rates as potential sources of shocks and FX interventions as a possible policy tool.

Keywords: Exchange Rates; Macroeconomic Fluctuations; Structural Vector Autoregression; Counterfactual analysis; Open economy

1 Introduction

During the last two decades, exchange rates have shown considerable volatility in response to the financial crisis, the European-debt-crisis, as well as political uncertainty. Looking at a sample from 1999 to 2015, Siklos (2018) finds that emerging market currencies suffered from depreciation of up to 100%, while safe-haven currencies appreciated up to 50% against the U.S. Dollar. Although these fluctuations are large and Claessens and Kose (2017) review a wide range of structural models which elaborate potential mechanisms, the exchange rate is only rarely considered a source of shocks to macroeconomic variables in empirical work (Kappler et al., 2013). A potential reason for this is that empirical work investigating these models only recover few regularities because the overall effect of exchange rate fluctuations on aggregate variables depends on the sum of
contradicting effects. While the Marshall-Lerner condition states that appreciations result in output contractions, evidence exists for both, contractionary and expansionary effects (Kappler et al., 2013; Manalo et al., 2015; Habib et al., 2016). While wealth effects (Bénétrix et al., 2015; Bruno et al., 2018) and lower import prices (Goldberg, 1993; Landon, and Smith, 2009) can result in capacity increases, reduced external competitiveness and demand substitution can result in reduced domestic and foreign demand (Bahmani-Oskooee, and Ratha, 2004; Manalo et al., 2015).

Besides impacting the real side of the economy, exchange rate shocks pass-through to domestic prices (Casas, 2019). An appreciation generally generates a reduction in import prices, which likely results in a deflationary tendency for the economy, however, the response of prices is highly heterogeneous across sectors (Auer et al., 2018). As Dedola et al. (2018) show, the exchange rate is an important channel through which nominal shocks impact the economy. Moreover, the exchange rate directly affects lending conditions due to their impact on international lending rates through the risk-taking channel (Gourinchas, and Rey, 2013; Kearns and Patel, 2016; Hofmann et al., 2019), which can result in inflationary or deflationary pressure (Bruno, and Shin, 2015; Blanchard et al., 2016; Georgiadis, and Zhu, 2019). Therefore, central banks should take the exchange rate into account, as well (Engel et al., 2007).

To prevent their economies from the effects illustrated above, central banks around the world use foreign-exchange-interventions to stabilize their exchange rates. They achieve this by buying or selling currencies in the foreign exchange market to influence the valuation of the exchange rate. The intervention normally extends the central bank balance sheet, altering money aggregates and potentially interest rates. Recent contributions like Chamon et al., (2017) and Fratzscher et al. (2019) analyze the effectiveness of these interventions and conclude that they are effective tools to reduce excess volatility and stabilize the exchange rate around desired valuations. However, only looking at the effects of FX interventions on the exchange rate can result in misguided policy. FX

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1Interventions, which alter the money supply and interest rates are referred to as nonsterilized interventions. In contrast to nonsterilized interventions, during sterilized interventions, the central bank undertakes neutralizing actions, resulting in no changes in money supply and interest rates (Engel, 2014). This work only considers nonsterilized interventions; for reviews on sterilized interventions consult Sarno, and Taylor (2001), as well as Menkhoff (2013). For empirical studies consult Chen et al. (2012).
interventions have a comparable effect as an expansionary monetary policy since the central bank increases its balance sheet during the intervention. Besides the direct effect through the expansion of the balance sheet, interventions have an indirect impact on macroeconomic variables due to the changed exchange rate valuation (Sarno, and Taylor, 2001; Soyounk, 2003). Therefore, Villamizar-Villegas (2016) highlights that the use of FX interventions alongside ordinary monetary policy can lead to offsetting effects on the aggregate variables. While there exists empirical literature investigating the effects of exchange rate fluctuations and FX interventions, there is only few literature which evaluates both aspects in a joint analysis.

This work combines the areas of research on the effects of exchange rate fluctuations, as well as FX interventions on macroeconomic variables of the Swiss economy. The Swiss economy is chosen due to three reasons. First, the Swiss Franc (CHF) experienced an appreciation of 40% between June 2010 and September 2011. This sharp appreciation is expected to have led to detectable real effects. Second, in response to the financial and the European-debt-crisis, the SNB intervened in the FX market, making the CHF a desirable object for investigation. Finally, for the Swiss economy already exists research confirming the effects of the appreciation. Siliverstovs (2016) investigates the effects of exchange rate shocks before 2015 and concludes that they have an impact on the real economy for up to 12 months. Galli (2017) extends the analysis using a dynamic factor model to show that the Swiss business cycle reacted with a contraction in response to the exchange rate appreciations in 2011 and 2015. Bonadia et al. (2018) find that the exchange rate appreciations resulted in the reduction of import prices, as well as the reduction of the prices of traded domestic consumer goods. As a result, consumer increased their expenditure for imported goods by 3.6% resulting in lower domestic demand (Auer et al., 2018).

This work differentiates from former contributions by taking into account a full set of monetary policy instruments in the analysis of exchange rate movements. The paper accomplishes this by employing an identification strategy adjusted to the monetary policy conducted by the Swiss National Bank (SNB). Impulse response analysis and variance decomposition determine the contribution of exchange rate shocks to fluctuations in macroeconomic variables, while a counterfactual studies
the effects FX interventions had on the Swiss economy. The impulse response functions (IRFs) indicate that an exchange rate appreciation leads to a deflationary effect on production. The estimated reaction is small, but the exchange rate has an empirically observable impact on the variable over different time horizons. The variance decomposition highlights that the variance of production is up to 20% influenced by the shocks of the exchange rate, whereas the price level is largely unaffected by the exchange rate. IRFs for FX interventions show a short term expansion of production, accompanied by a depreciation of the exchange rate. However, the variance decomposition shows that shocks to the FX do not explain movements in production or prices. The counterfactual analysis extends these results by analyzing how production would have developed if no exchange rate shocks and no FX interventions would have occurred during and after the financial crisis. The result indicates that the shocks did not contribute significantly to the development of production; however, they can potentially lead to large accumulative effects.

The results have implications for policymakers. For the example of Switzerland, previous research is confirmed insofar that the exchange rate can be a potential source of shocks, however, is only of lower relevance. Nevertheless, its second-order importance, ignoring the shocks, can result in large accumulated welfare losses. Therefore, prolonged negative exchange rate shocks should be prevented, as the SNB tried correctly with its FX interventions. FX interventions are potential tools to influence exchange rates, even though they have only limited potential as an expansionary tool. Consequently, the concern of Villamizar-Villegas (2016) can be confirmed partly, since from the IRFs and the counterfactual it can be concluded that interventions have an impact on production, while the variance decomposition neglects this.

This work is structured as follows: Section two describes the monetary policy of the SNB over the analyzed period and concludes with a description of the empirical methodology. Section three reports the results of the structural analysis and the historical decomposition. Finally, section four discusses the results, while section five concludes.
2 Empirical Strategy

This section analyses the monetary policy of the SNB to motivate the identification strategy for the SVAR. At first, the monetary policy of the SNB is portrayed, before explaining the empirical model, and the structural analysis.

2.1 Monetary Policy of the Swiss National Bank

The analysis covers the 92 policy announcements the SNB published after its monetary policy meeting for the time from January 2000 to December 2018. The most relevant policy instruments and their application are illustrated hereafter. The SNB has the mandate to ensure price stability, which the SNB defines as annual inflation below 2%. To achieve this goal, it uses a structural conditional inflation forecast, and a target range for the 3-month CHF-LIBOR. Based on the forecast, the SNB sets interest rates to keep inflation in the long term under the specified target. Because the Swiss economy is an export-orientated, small open economy, which is integrated into international capital markets, the SNB includes global developments in its forecast. Between 2000 and September 2008, the SNB employed only the target rate as a policy instrument. To explain the monetary policy, Figure 1 illustrates the Swiss real Gross Domestic Product (GDP), as well as the price level and relates it to the 3-months CHF-LIBOR-rate. Real GDP (black) and the price level (blue) are scaled on the left axis according to their index level, whereas the 3-month CHF-LIBOR (red) is scaled on the right axis in percent.

The development of the interest rate before 2008 is inversely related to the economic conditions in Switzerland. In response to low external demand between 2000 and 2003, real GDP and prices stagnated (Galli, 2017). In response, the SNB reduced the interest rate in 2001 to stimulate the economy. After the GDP level recovered in 2004, and inflationary pressure increased, the SNB started slowly to tighten monetary conditions in 2005. At the beginning of 2006, the Swiss economy experienced increasing external demand, which helped the economy to expand during

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2 The analysis is based on the publications of the SNB accessible under SNB (2019).
3 Before 2000, the SNB targeted values for monetary aggregates. With the change of the policy came a considerable reduction of the volatility in the three months LIBOR. This change in monetary policy behavior, therefore, limits the period for the investigation to after 2000.
the following three years. In 2008 the global shocks finally reached the Swiss economy, resulting in a plunge of real GDP and prices, as well as an appreciation of the CHF due to its safe-haven status (Ranaldo and Söderlind, 2010). In response, the SNB lowered the LIBOR target rate five times in the last quarter of 2008. The reduction of the LIBOR marked the end of the ordinary phase of monetary policy. While real GDP recovered fast after the financial crisis, the Swiss economy suffered from continuous deflation. In effect, the nominal GDP of Switzerland stagnated after the financial crisis, unaffected by the expansionary monetary policy of the SNB.

After the SNB reduced the LIBOR in 2008, the SNB was limited in its ability to counteract deflationary pressure by ordinary policy instruments. However, further appreciation of the CHF resulted in additional deflationary pressure on the economy (Blanchard et al., 2016). To prevent further appreciation, the SNB intervened in the FX market in September 2008 by buying foreign currencies against the CHF. To illustrate the relation between the exchange rate development and FX inter-
ventions, Figure 2 depicts the development of the nominal effective exchange rate (NEER) of the CHF and relates it with the net stock of foreign currencies held by the SNB after the financial crisis. The net foreign asset positions of the SNB can be used as a proxy for the FX interventions of the SNB because the position directly relates to transactions of the SNB in the FX market. Therefore, Figure 2 illustrates that the SNB increased its interventions in the FX market with increasing appreciation of the CHF. The first vertical line in Figure 2 marks the beginning of the interventions in 2008. After the intervention, the CHF temporary stopped the appreciation. The SNB continued with these measures during 2009 until they were discontinued in 2010 after the Swiss economy recovered slightly.

Figure 2: Net foreign currency positions (Left Axis in Million CHF) and NEER (Right Axis as Index)

4 The NEER is a trade-weighted average of all exchange rates against which the CHF denotes. The NEER is defined as $\text{NEER} = \frac{\text{CHF}}{\text{Foreign Currencies}}$, with an increase in the NEER implying depreciation of the CHF against the foreign currencies.

5 The appreciation of the NEER is a trade-weighted appreciation of the CHF against all currencies it denotes. The appreciation implies a loss of competitiveness for the Swiss economy, which the SNB tried to counteract with its interventions.
The second vertical line in the graph depicts January 2010, when the rating of Greek federal bonds fell below investment rating. Due to increased uncertainty on the stability of the Eurozone, capital entered Switzerland due to the safe-haven characteristic of the CHF, resulting in further appreciation (Yesin, 2016). As a reaction to increased uncertainty, global demand plunged. To halt the appreciation and the reduction in external demand, the SNB set the interest rate effectively to zero while providing 200 billion of additional liquidity to the CHF money market. Additional intervention in the FX market stopped the appreciation of the currency only temporarily. As the CHF continued to appreciate, in September 2011, the SNB introduced a minimum exchange rate of 1.20 CHF per EUR, to limit further deflationary pressure on the economy. The sharp depreciation of the exchange rate, as well as the increase in net foreign assets, which resulted from the introduction of the minimum exchange rate, are shown at the third vertical line. While being restrained in its appreciation to the EUR, the CHF continued to appreciate against other major currencies, resulting in a prolonged appreciation of the NEER. In the period from 2011 until 2015, the Swiss economy benefited from a global upswing in demand, while the situation in the Eurozone normalized. Consequently, in January 2015, the SNB did not consider the high value of the CHF to be a threat to the Swiss economy anymore and abandoned the minimum exchange rate. As indicated by the fourth vertical line, hereafter the CHF temporarily appreciated strongly. Although not announcing it officially, the SNB continued to extend its foreign currency holdings in the following, implying prolonged FX interventions to support the CHF until today.

In summary, the SNB used a combination of monetary policy tools. Besides the conventional monetary policy, which reacted to inflationary pressure, there have been further unconventional measures, including the intervention in the FX market. The interventions were intended to stabilize the CHF and to prevent deflationary pressure resulting from appreciation. As a result, the empirical strategy employed for the following analysis needs to model the reaction of the interest rate to macroeconomic variables, as well as the reaction of FX interventions to exchange rate movements.
2.2 Statistical Model and Data

To model the behavior of the SNB, a SV AR, incorporating FX interventions, as well as conventional monetary policy instruments, is used. The monetary policy of the SNB, as well as former contributions in the area (Soyoung, 2003; Artis, and Ehrmann, 2006), motivate the empirical approach. The economy is assumed to follow the structural form equation:

\[ Ay_t = A_1^* y_{t-1} + \ldots + A_p^* y_{t-p} + B \varepsilon_t \]  

(1)

where \( A, A_i^* \) and \( B \) are \( n \times n \) matrices with \( n \) being the number of endogenous variables in \( y_t \) and \( p \) being the number of lags. \( \varepsilon_t \) is a \( n \times 1 \) vector of structural shocks. The structural shocks are assumed to be uncorrelated and to have a variance-covariance-matrix equal to the \( n \times n \) identity matrix. The structural form of equation (1) cannot be estimated directly. However, the SVAR can be recovered from the reduced-form VAR of the equation:

\[ y_t = A(L)y_{t-1} + u_t \]  

(2)

where \( A(L) = A^{-1}A_1^* + \ldots + A^{-1}A_p^* \), and \( u_t = A^{-1}B\varepsilon_t \), with \( var(u_t) = \Sigma \). \( A(L) \) is the coefficient matrix for the lagged variables \( y_t \) and \( u_t \) are linear combinations of the structural shocks. Since \( u_t = A^{-1}B\varepsilon_t \), this implies that \( var(u_t) = A^{-1}B\Sigma (BA^{-1})^T \). It is necessary to use restrictions on the \( A \) or \( B \) matrix to identify the system. This work imposes restrictions on the \( B \) matrix while assuming that \( A = I_{n \times n} \) to identify the structural shocks. It is necessary to impose at least \( n(n-1)/2 \) restrictions on the matrix \( B \) to recover the structural shocks. The model uses the endogenous variables \( y_t = [i_p, ppi_t, nfx_t, LIB_t, e_t] \), referring to an industrial production proxy\(^6\), a producer price index \(^7\), the SNB net foreign currency position, the 3-month CHF LIBOR rate, and the Swiss NEER\(^8\).

\(^6\)Switzerland only reports GDP, and Industrial Production on quarterly basis. As a proxy for these measures, this work uses the KOF economic barometer, which is a leading indicator for the Swiss business cycle. For more information on the indicator refer to KOF (2019).

\(^7\)From a theoretical perspective, producer prices and exchange rate are expected to have a stronger statistical relation because producer prices include more tradeable goods than ordinary consumer price indexes (CPI) (Taylor and Taylor, 2004). The results presented below however are indifferent to the type of index employed.

\(^8\)The data and its sources are presented in the Appendix.
on the group of variables. The restricted model can be written as follows:

\[
\begin{bmatrix}
  ip_t \\
  ppi_t \\
  nfx_t \\
  LIB_t \\
  e_t
\end{bmatrix}
= A(L) \
\begin{bmatrix}
  ip_{t-1} \\
  ppi_{t-1} \\
  nfx_{t-1} \\
  LIB_{t-1} \\
  e_{t-1}
\end{bmatrix}
+ \begin{bmatrix}
  b_{11} & 0 & 0 & 0 & 0 \\
  b_{21} & b_{22} & 0 & 0 & 0 \\
  0 & 0 & b_{33} & 0 & b_{35} \\
  b_{41} & b_{42} & b_{43} & b_{44} & 0 \\
  b_{51} & b_{52} & b_{53} & b_{54} & b_{55}
\end{bmatrix}
\begin{bmatrix}
  \epsilon_{ip} \\
  \epsilon_{ppi} \\
  \epsilon_{nfx} \\
  \epsilon_{LIB} \\
  \epsilon_{e}
\end{bmatrix}
\tag{3}
\]

In the following, the restrictions are elaborated further. Production and inflation do not react contemporaneously to nominal shocks since nominal shocks are assumed to translate only with a lag into these variables. Inflation reacts to production shocks, following a Phillips curve. As highlighted in the previous section, the FX interventions depend only on exchange rate movements, however, do not contemporaneously respond to shocks in output and inflation. The SNB sets the interest rate according to a Taylor rule while also taking into account the FX interventions. The intuition behind this identification of the nominal variables is that the FX interventions are not expected to be impacted by interest rate decisions, as long as the interest rate does not affect the exchange rate. On the other hand, the SNB sets its ordinary monetary policy taking into account extraordinary measures as FX interventions. Lastly, as a forward-looking asset price, the exchange rate is affected by all variables.

### 2.3 Counterfactual Analysis

This work adds a counterfactual analysis based on the methodology of Kilian and Lee (2014) to the traditional structural analysis to evaluate the impact of the exchange rate shocks and FX intervention. The counterfactual is an artificial time series generated under the assumption that specific structural shocks are set to zero. In the following, the methodology for calculating the counterfactual is illustrated in the manner of Kilian and Lüthkepol (2016). The estimated VAR in (3) can be transformed into the following form:

\[
x_t = \sum_{s=0}^{t-1} \Theta_s B \epsilon_{t-s} + \sum_{s=t}^{\infty} \Theta_s B \epsilon_{t-s}
\tag{4}
\]
$x_t$ is a $n \times 1$ vector of time series, $\Theta_s$ is the $n \times n$ moving average (MA) coefficient for the lag $s$, $B$ is the $n \times n$ restricted matrix from (3), and $\varepsilon_{t-s}$ is the $n \times 1$ vector of structural shocks at time $t-s$. The first sum on the right-hand side illustrates the contributions of the structural shocks, estimated for the sample period until $t$, to the data series $x_t$. The second sum corresponds to the contribution of the structural shocks of the pre-sample period to the realization of $x_t$. Because the MA-coefficient dies out over time, the original series can be approximated by:

$$\hat{x}_t = \sum_{s=0}^{t-1} \Theta_s B \varepsilon_{t-s}$$

(5)

As the MA-coefficient needs time to vanish, the approximation gets better with increased $t$. The approximated time series can then be used to generate cumulative contributions of single shocks to the series $x_t$. Supposing the target is to extract the cumulative contribution of the first structural shock to the first variable of the series, the following formula applies:

$$\hat{x}_{1t} = \sum_{s=0}^{t-1} \Theta_{1s} B_{11} \varepsilon_{1,t-s}$$

(6)

The series $\hat{x}_{1t}$ describes the part of the series $x_{1t}$, which is attributed to the first structural shock $\varepsilon_{1,t}$. Therefore, the series of accumulated contribution can be used to generate counterfactuals. Assuming the counterfactual series aims to evaluate how the series would have developed without the first structural shock occurring, the following generates the counterfactual series $x_{1t}^{\text{count}}$:

$$x_{1t}^{\text{count}} = x_t - \hat{x}_{1t}$$

(7)

In the most simple case, the counterfactual excludes the contribution of the whole series of a structural shock. However, the calculation of $\hat{x}_{1t}$ can be adapted in such a way that shocks after a specific period are excluded. For example, the counterfactual applied in this work mutes the structural shocks for the exchange rate and the FX interventions in the aftermath of the financial crisis.
3 Results

The following process of model estimation, model checking, and structural analysis follows the structure proposed by Lüthkepol (2011) for VARs in level. The model is estimated for the period from January 2000 until December 2018 using monthly data, a constant and a deterministic trend. All variables enter in their logarithm, except for the interest rate which enters in levels. The variables are not used in differences with the purpose to use the long-run information, as demonstrated by Sims (1980), Sims et al. (1990), Christiano et al. (1996), and Phillips (1998). This approach is valid for the case at hand since the following analysis is not concerned with hypothesis testing but with structural analysis of the relationship between the variables. For the lag selection, the Akaike information criterion and the Schwarz information criterion are applied. A minimum of 12 lags is chosen to incorporate seasonal behavior. Both criteria favor models with lower lags. Therefore, 12 lags are chosen as the alternative with the lowest information criterions. Portmanteau and Breusch-Godfrey-LM tests are used to examine the autocorrelation of the residuals of the VAR to test the model’s validity. Both tests examine the zero hypothesis of no residual autocorrelation against the alternative hypothesis of at least one autocorrelation being non-zero. If the zero hypothesis is not rejected, the residuals still suffer from autocorrelation, and the model is misspecified. For different lag lengths used in both tests, the zero hypothesis of no autocovariance is not rejected at a 5% confidence level. This implies that further analysis is possible with the selected model.

Figure 3 and Figure 4 display the impulse response functions (IRFs) to an appreciation of the NEER and a FX intervention. Each graph portrays the median impulse response over 60 months, and the 95% confidence intervals generated by bootstrap with 5000 runs. The names of the variables are portrayed on the top of each panel. All reported responses are in percent changes, except the interest rate (LIBOR) whose responses are in percentage points change. For visibility, the IRFs for PPI and the exchange rate are scaled in the same manner as production, whereas FX and the LIBOR are scaled independently.
The exchange rate shock results in a persistent appreciation of the exchange rate. Although not being significant, the increase of FX positions of the SNB potentially halts the appreciation. In response to the appreciation industrial production falls temporarily before reversing after a year and returning to its initial value. Both responses are marginally significantly different from zero in the short run, suggesting that the exchange rate drives the economy only temporarily. The IRFs for FX, prices, and the LIBOR all are not significant, indicating that the exchange rate shocks influence these variables less. This result is puzzling for the FX since the identification directly links exchange rate shocks with the FX. However, the wide bootstrapped confidence intervals can be explained by the high variance of the residuals, which result from the non-linear behavior of the FX stock. The overall direction of the responses is in line with the expected effects of an exchange rate appreciation and with former empirical contributions (Artis, and Ehrmann, 2006), whereas the
effect on prices cannot be confirmed. Figure 4 shows the IRFs to an increase of one percent of FX, portraying a FX intervention. The variables are scaled in the same manner as in Figure 3.

![IRFs to a one percent FX increase](image)

Figure 4: IRFs to a one percent FX increase

The intervention results in a temporary increase in FX. As already noted in Figure 3, the IRFs are marginally significant for a few periods. In response to the intervention, industrial production increases temporarily, before reversing and returning to its initial level. Furthermore, the intervention results in a persistent depreciation of the exchange rate, achieving the desired outcome concerning the exchange rate. While the impact of the intervention on output and the exchange rate is marginally significant for up to 14 periods, the reaction of prices and the LIBOR are insignificant along all time horizons. Again, the responses are in line with former contributions (Soyoung, 2003).

To further understand the importance of exchange rate and FX interventions, a variance decompo-
results supplements the results presented so far. Table 1 shows the results of the variance decomposition for industrial production, and the producer price index at impact, after one, as well as after five years. The table shows which percentage of the total variance of industrial production and producer prices is explained by the structural shocks to the endogenous variables.

<table>
<thead>
<tr>
<th>Months</th>
<th>$\varepsilon_{ip}$</th>
<th>$\varepsilon_{ppi}$</th>
<th>$\varepsilon_{fx}$</th>
<th>$\varepsilon_{LIB}$</th>
<th>$\varepsilon_{e}$</th>
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</table>

<table>
<thead>
<tr>
<th>Months</th>
<th>$\varepsilon_{ip}$</th>
<th>$\varepsilon_{ppi}$</th>
<th>$\varepsilon_{fx}$</th>
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<td>26.4342</td>
<td>2.2464</td>
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</table>

Table 1: Variance decomposition of industrial production and the producer price index

By construction only shocks to industrial production influence industrial production on impact. Its shocks explain the most significant part of the series through all periods. After five years, industrial production shocks still explain 36.9% of the variance. Inflation, LIBOR, and the exchange rate explain 18.1%, 21.5%, and 19.4% of the total variance, respectively. Even though the nominal variables in total explain almost 60% of the long-run variation of output, their contribution stays behind the contribution of output shocks. This is in line with the theory that production, in the long run, is mainly a real phenomenon. The exchange rate has a hump-shaped contribution to the variance of production. It increases sharply in the short run and slowly decays in the long run. Exchange rate shocks explain 20.2% of the variance of production after one year, confirming the result of the IRFs that production is influenced in the short run by the exchange rate. The contribution of producer prices and the interest rate have similar behavior, while their contributions peak in the second year. FX interventions only explain a neglectable part of the variance, contrasting the
result obtained from the IRFs.

Along time, the price shocks contribute the most substantial part of the variance of prices. Only after five years, production explains more of the variance than the shocks to the price level, itself. FX intervention explains a neglectable part of the variance, whereas the LIBOR and the exchange rate have an increasing contribution along time. The contribution of the exchange rate is, however of second-order relative to the interest rate. The high contribution of production is somewhat puzzling since prices are supposed to be primarily influenced by nominal shocks in the long run. The second variance decomposition implies that the exchange rate only has a small contribution to explaining the movements in prices, supporting the results from the IRFs. FX interventions again do not have a significant contribution. Consequently, from the variance decomposition can be concluded that exchange rate shocks impact industrial production in the short run, whereas prices are mostly unaffected. FX interventions do not have an essential contribution to either production or prices variance.

In the following the structural analysis is complemented by the counterfactual analysis as given by equation (7). Figure 5 portrays the generated counterfactuals without structural exchange rate shocks (left panels) and structural shocks to FX (right panels). The financial crisis is chosen as a starting point because both shocks become prominent during and after the crisis. Therefore the counterfactual simulates how production would develop without an appreciation of the CHF-EUR or FX interventions by the SNB. The upper panel shows the original series and the counterfactuals, whereas the lower panel shows the accumulated difference between the observed series and the counterfactual. If the observed series lies above the counterfactual, this implies that the structural shock had a positive contribution to production and vice versa. The difference between the series is accumulated to understand the accumulated contribution of the shocks. A positive accumulated difference is interpreted as a positive cumulative contribution of the structural shocks to the production series.
During the financial crisis, the counterfactual without exchange rate shocks lies below the observed series. Therefore, exchange rate shocks were expansionary during the financial crisis. Contrary to the financial crisis, during the Euro crisis, the counterfactual lies above the series, indicating that the shocks had a contractionary effect. This effect is reasonable since, during the Euro crisis, the CHF appreciated strongly against most currencies, resulting in deflationary effects on the economy. In 2012 the contribution of the shocks became contractionary again until the SNB liberated the floor of the EUR-CHF exchange rate. As a result of the sharp appreciation in January 2015, the counterfactual series without the shocks lies above the original series. The adverse effects of this shock almost lasted for two years. After 2018, the exchange rate depreciated, resulting in positive shocks to production, as can be observed by the counterfactual decreasing below the real series.
The counterfactual without FX shocks is mainly above the observed series during the financial crisis. Only for a few periods, the counterfactual lies below the observed series, indicating that the FX interventions did have a negative impact on production during this period. This only reversed in 2012. After that, the counterfactual lies on average below the observed series, indicating that the FX interventions and the floor to the EURCHF had expansionary effects on output. The result indicates that the FX-interventions during and in the aftermath of the European-debt-crisis were more beneficial as during the financial crisis.

4 Discussion

In this section, the results obtained from the structural analysis are gathered to answer the research questions. At first, the role of exchange rate fluctuations is evaluated, before turning to the role of FX interventions of the SNB. The IRFs confirm that exchange rate shocks have a small, but temporarily significant impact on production. Production decreases by a maximum of 0.8% after three months, before returning to its former level. The appreciation does not affect prices nor FX. The variance decomposition supports these results. Exchange rate shocks account for around 19% of the variance of production and only for 12% of the variance of prices. The exchange rate primarily influences industrial production on the medium run, explaining up to 20% of the variance after one year. Therefore, the structural analysis provides evidence in favor of the argument that the exchange rate potentially influences production. However, as stated, the effects are rather small. Thus, the question emerges whether exchange rate shocks are relevant for policymakers. The investigation of the counterfactual confirms the relevance. Assuming that there would have been no exchange rate shocks after the financial crisis, the generated counterfactual and the original series differ only to a low degree. However, the contribution of the shocks accumulates over time. As the accumulated difference in Figure 5 shows, the difference can sum up to 60 index points. Translating this into GDP or income, ignoring the accumulated contribution of the differences can result in sizeable adverse welfare effects for the economy. As a result, the analysis can confirm the research on the Swiss economy.
linking exchange rate fluctuations and production, but cannot confirm the literature relating the exchange rate and price fluctuations.

For FX interventions, the results are more limited. While the IRFs report a temporary expansionary effect of up to 0.6% for production and a depreciation of 0.7% for the exchange rate, its impact on the other variables is not significant. Furthermore, the variance decomposition highlights that FX interventions explain only a neglectable fraction of the variances of production and prices. The counterfactual supports the results of the IRFs. As for the counterfactual of the exchange rate shocks, the difference between the counterfactual generated and the observed series is small. However, from the accumulated differences, it is possible to conclude that the interventions caused expansionary effects after 2012. Furthermore, from the limited impact of FX onto production and prices, it can be concluded that the effect of interventions in the FX market come at a limited cost to macroeconomic variables. As the structural analysis illustrates, for the case of Switzerland, FX interventions can be expected to impact majorly the exchange rate. As a consequence, employing interventions to prevent exchange rate appreciations does not seem to cause harmful effects for the macroeconomy.

Moreover, the IRFs reported above are the median responses of the variables under investigation to a specified shock. Hence, the IRFs take into account the reaction of FX interventions on exchange rate fluctuations, as well. Consequently, the appreciation simulated in the IRFs is met by a FX intervention, potentially reducing the impact generated in the IRFs. This can potentially amplify the effect an appreciation would have in the absence of FX interventions, raising the question, whether the results reported here are dependent on the inclusion of FX interventions. Hence, future contributions could investigate whether the response to an exchange rate shock is amplified in economies without FX interventions. Alternatively, a regime-switching VAR could be used to analyze the different reactions which occur conditionally on central banks’ intervention in the FX market.
5 Conclusion

The paper investigates the role of exchange rate fluctuations and FX interventions for macroeconomic variables in Switzerland. The findings gathered from a SVAR, confirm the branch of the literature concerned with the exchange rate as a potential source of shocks, however, limit its order of magnitude. The results of the structural analysis show that exchange rate movements influence Swiss production temporarily. FX interventions influence the exchange rate and production in the short term, while only explaining neglectable parts of the variance of production and prices. From the counterfactual analysis, it can be concluded that, although the contribution of the individual shocks is neglectable, their cumulative effect can lead to welfare losses. Since FX interventions have only limited impact on production, they can be used to counteract exchange rate appreciation. These results could motivate policymakers to consider the exchange rate as a potential source of shocks to the economy, and FX interventions as a potential policy tool. This work, consequently, motivates further research about the impact of exchange rate fluctuations on the real economy, as well as FX interventions as a policy tool.

References


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Appendix: Data description

The table below reports the name in the data used, the name in the original data series, the time period used, and the source. All variables can be downloaded on the website of the institutions using the "Name in Source".

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Name in Source</th>
<th>Period</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP</td>
<td>KOF Economic Barometer</td>
<td>Jan/2000 - Dec/2018</td>
<td>KOF Swiss Economic Institute</td>
</tr>
<tr>
<td>PPI</td>
<td>Producer and Import Prices - Total</td>
<td>Jan/2000 - Dec/2018</td>
<td>State Secretary of Economic Affairs</td>
</tr>
<tr>
<td>NFX</td>
<td>Foreign Currency Investments</td>
<td>Jan/2000 - Dec/2018</td>
<td>Swiss National Bank</td>
</tr>
<tr>
<td>NFX</td>
<td>Foreign Currency Liabilities</td>
<td>Jan/2000 - Dec/2018</td>
<td>Swiss National Bank</td>
</tr>
<tr>
<td>LIB</td>
<td>3-Months LIBOR-CHF</td>
<td>Jan/2000 - Dec/2018</td>
<td>Swiss National Bank</td>
</tr>
<tr>
<td>NEER</td>
<td>Nominal exchange rate index - Monthly Average</td>
<td>Jan/2000 - Dec/2018</td>
<td>Swiss National Bank</td>
</tr>
</tbody>
</table>

Table 2: Description of Data Sources

The final variable $nfx$ is constructed by subtracting the foreign currency liabilities from the foreign currency investment position.

For the Swiss economy there exists no monthly proxy for industrial production, only the quarterly real GDP. Therefore this work uses the the KOF economic barometer as a proxy for industrial production on the monthly basis. Finally, producer prices are seasonally adjusted using a loess decomposition.