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How is the Swiss economy coping with the CHF appreciation after the SNB's exit?

Bachelor thesis

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Declaration of Authorship

I hereby declare that I compiled this thesis independently under the leadership of my supervisor.

I hereby declare that all sources and literature used have been properly cited.

I hereby declare that the thesis has not been used to obtain a different or the same degree.

Prague, May 18, 2017

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Extent of the Thesis

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Abstract

The objective of this thesis is to describe the situation in the Swiss economy before the SNB discontinued the minimum exchange rate. Furthermore, the aim is to analyse the impact of the abandonment of the exchange rate floor on key macroeconomic indicators such as GDP, year-on-year changes in consumer and producer prices or unemployment rate. The interactions between CHF/EUR exchange rate and real GDP, CPI and 3-month LIBOR are examined using VAR model on quarterly data from 1999 to 2016. The results suggest that the CHF/EUR exchange rate appreciation has temporary dampening effects on GDP, CPI and 3-month LIBOR. These results are consistent with the developments in macroeconomic variables after the discontinuation of the minimum exchange rate.

JEL Classification C5, E24, E31, E43, F31

Keywords exchange rate, gross domestic product, consumer price index, interest rate, vector autoregressive model

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Abstrakt

Cílem této práce je popsat situaci ve švýcarské ekonomice předtím, než SNB zrušila minimální hladinu měnového kurzu. Cílem je dále zanalyzovat dopad opuštění minimální hladiny měnového kurzu na klíčové makroekonomické ukazatele jako např. HDP, meziroční změny ve spotřebitelských a výrobních cenách nebo míra nezaměstnanosti. Vztahy mezi měnovým kurzem CHF/EUR a reálným HDP, indexem spotřebitelských cen a tříměsíční úrokovou sazbou LIBOR jsou zkoumány pomocí modelu VAR na čtvrtletních údajích od roku 1999 do roku 2016. Výsledky naznačují, že posilování měnového kurzu CHF/EUR má dočasné tlumící účinky na HDP, index spotřebitelských cen a tříměsíční úrokovou sazbu LIBOR. Tyto výsledky jsou v souladu s vývojem makroekonomických proměnných po opuštění minimální hladiny měnového kurzu.

JEL klasifikace	C5, E24, E31, E43, F31
Klíčová slova	měnový kurz, hrubý domácí produkt, index spotřebitelských cen, úroková sazba, vektorová autoregrese
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Bachelor Thesis Proposal

Author	Roman Borufka
Supervisor	doc. Mgr. Tomáš Holub, Ph.D.
Proposed topic	How is the Swiss economy coping with the CHF appreciation after the SNB's exit?

Topic characteristics:

In January 2015, the Swiss National Bank (SNB) discontinued the exchange rate floor of 1.20 Swiss francs (CHF) per Euro (EUR) that was maintained for over three years. Simultaneously with this change, the SNB lowered the interest rate on certain deposits to -0.75 percent.

The aim of this thesis is to study the intervention of the SNB in the foreign exchange market and to observe the Swiss economic performance before, during and after this policy. The impact on various macroeconomic indicators such as gross domestic product, inflation, consumer price will be examined.

In the first part, I will introduce the Swiss economy as a whole and study the SNB's monetary policy. Moreover, I will describe the economic background of the SNB's interventions in the foreign exchange market – introduction and abandonment of the exchange rate floor. Subsequently, the situation before the SNB discontinued the minimum exchange rate will be described and briefly analyzed. The next part will analyze the immediate and gradual impact of SNB's exit on the Swiss economy. Eventually, the econometric analysis, studying the impacts of changes in exchange rate on key macroeconomic indicators, will be conducted.

Outline:

1. Introduction
2. The Overview of Switzerland
3. From Global Crisis to the Introduction of the Currency Floor
4. Period of Minimum Exchange Rate
5. The End of Minimum Exchange Rate Period

6. Empirical Part

7. Conclusion

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Acronyms

ADF Augmented Dickey-Fuller

AIC Akaike Information Criterion

AR Autoregression

BG Breusch-Godfrey

BP Breusch-Pagan

CHF Swiss Franc

CI Confidence Interval

CPI Consumer Price Index

CZK Czech Koruna

CZSO Czech Statistical Office

EU European Union

EUR Euro

FCA Federal Customs Administration

FDFA Federal Department of Foreign Affairs

FEVD Forecast Error Variance Decomposition

FH Federation of the Swiss Watch Industry

FPE Final Prediction Error

GDP Gross Domestic Product

HQ Hannah-Quinn Information Criterion

IR Impulse Response

LIBOR London Inter Bank Offered Rate

SC Schwarz Information Criterion

SNB Swiss National Bank

UNDP United Nations Development Programme

US United States of America

USD United States Dollar

VAR Vector Autoregression

Chapter 1

Introduction

Switzerland has been always regarded as an independent and stable country in the heart of Europe, often considered as safe haven for many foreign investors worldwide. However, the recent events in the Swiss economy such as introduction and abandonment of the minimum exchange rate have been subject to many economic debates since the fourth quarter of 2011. The reason why it attracted attention is the unilateral exchange rate restriction and the abrupt and unpredictable nature of the discontinuation of this extraordinary monetary policy. This topic has been broadly discussed in the Czech Republic as well, because in November 2013 the Czech National Bank began intervening at the foreign exchange market in order to weaken the currency and as a result the Czech economy got into similar position as the Swiss economy.

On 6th September 2011, the Swiss National Bank (SNB) introduced the exchange rate floor of 1.20 Swiss francs per 1 Euro and indicated that it was ready to buy unlimited quantities of foreign currency in order to prevent further appreciation of CHF. The purpose of the SNB's move was to avert the adverse impact of strengthening franc on Swiss economy in form of threats of deflation or recession and furthermore to protect domestic exporters of goods and services. The minimum exchange rate lasted more than 3 years and 4 months. On 15th January 2015 the SNB made a surprising decision of abandoning the exchange rate floor. That day, the Swiss franc soared dramatically and the euro fell by approximately 40 per cent to roughly CHF 0.8/EUR 1, before stabilizing around CHF 1/EUR 1. This action caused an immediate chaos both in Swiss and European financial markets and shocked many investors worldwide who had previously regarded CHF as a safe

haven currency. The medium-term impacts of this policy were: strong currency, negative interest rates and deflation.

The objective of this thesis is to summarize the Swiss economy during the period from global financial crisis to the abandonment of the minimum exchange rate and to analyse both the positive and negative impacts of the SNB's discontinuation of the exchange rate floor on the key Swiss macroeconomic indicators such as gross domestic product (GDP), interest rate, inflation or unemployment rate. The effects of this action on key Swiss sectors such as export of goods and services will be also examined. The next part is the econometric analysis studying the effects of the CHF/EUR exchange rate on GDP, CPI and interest rate.

The thesis is structured as follows: Chapter 2 will describe the Switzerland from macroeconomic point of view, and the monetary policy of the SNB will be studied along with the description of its conventional and unconventional instruments. Chapter 3 will analyse the situation before the introduction of the minimum exchange rate in September 2011 and Chapter 4 will describe why the exchange rate floor was introduced and it will also focus on the analysis of the situation during the period of maintaining the exchange rate floor. Chapter 5 will study the immediate impacts of the SNB's exit in January 2015 on Swiss economy as well as the long-term effects of abandonment of the exchange rate floor on aforementioned macroeconomic indicators. Chapter 6 is the empirical part, where the dataset will be described and the econometric analysis studying the impacts of exchange rate appreciation will be conducted. Finally, Chapter 7 makes a conclusion and presents and compares the results of the macroeconomic part and the empirical part.

Chapter 2

The Overview of Switzerland

In this chapter, the Swiss economy as a whole will be analysed and the key economic sectors that contribute to the growth of Switzerland will be determined. Afterwards, the monetary policy of the SNB will be studied in general along with the description of its conventional and unconventional instruments, one of which is the intervention at the foreign exchange market.

2.1 Economy of Switzerland

The economy of Switzerland is considered to be one of the most developed economies in the world. In fact, the Swiss Human Development Index was the 2nd highest in the world in 2015 [UNDP, 2016] and Swiss GDP at purchasing power parity per capita was 9th highest in the world in 2015. [The World Bank, 2017]. The key economic sector of Switzerland is undoubtedly its service (tertiary) sector, which accounted for 73.6% of GDP generated in 2015. The industrial (secondary) sector contributed to 25.7% of GDP in 2015, while the agricultural (primary) sector comprised only 0.7% of GDP in 2015. [Statista, 2017]

The growth of Swiss economy relies primarily on its highly developed export sector, which generated 211 billion CHF in 2016, which meant 32.6% of GDP that year¹. [FCA, 2017]. The most important trading partner of Switzerland is the European Union (EU), 54% of Swiss exports went to the EU², while 72% of imports came from there in 2016. [FDFA, 2017]. The exports to the United States (US)

¹The exports in the Czech Republic comprised 85.3% of Czech GDP in 2015. [CZSO, 2016]

²83.2% of Czech exports went to the EU in 2015. [CZSO, 2016]

comprised 14.9% in 2016. [FCA, 2017]. As a result, the export sector is influenced by changes in CHF/EUR exchange rate to certain extent³.

The most important products exported from Switzerland are chemical and pharmaceutical products, which comprised 44.8% of exports in 2016. The machines and electronics had 14.7% share in exports in 2016 and watches made up 9.2% of Swiss exports. [FCA, 2017]. Swiss watch industry is of high importance, because Switzerland is the leading watch exporting country worldwide by export value with value of 19.1 billion USD in 2016 and it ranked 3rd in the number of watch units exported with more than 25 million units in 2016. [FH, 2017]

Another very important branch of Swiss economy is the financial sector, which has been growing steadily since the beginning of the new millennium. It contributes considerably to Swiss GDP and is connected to other economic sectors as well. The Swiss financial sector main focus is the private banking and wealth management for clients all over the world. [BAKBASEL, 2015]. In history, the Swiss currency was considered to be safe haven often sought-after by international investors even during the times of recessions, owing to its history of political and macroeconomic stability and safe fiscal and monetary policy. Because CHF fulfils the properties of safe haven currency, large capital inflows to Swiss economy are expected especially in times of economic turmoil and crises. Consequently, the currency is likely to appreciate in difficult times and that might cause severe damage to the domestic economy. [SNB, 2015c]

From previous information it can be seen that the Swiss economy focuses mainly on exports of luxurious goods with low price elasticity. As a result, the impact of the CHF appreciation on prices of these goods might not be as large as in case of goods with higher price elasticity.

2.2 The SNB's Monetary Policy

The SNB acts as an independent central bank in conducting the monetary policy of Switzerland. Its main goal is to guarantee price stability and to maintain an appropriate environment for economic prosperity. [SNB, 2017a]

³The Swiss export sector is less impacted by the changes in CHF/EUR exchange rate than the Czech export sector because of the more diversified trade.

The monetary policy strategy of the SNB is based on three pillars. In the first place, the SNB formulates its definition of price stability, which is an increase in consumer prices of maximum 2% per year. In the second place, the monetary policy is implemented based on medium-term inflation forecast. Finally, the SNB conducts its monetary policy by determining the amount of liquidity in circulation and applying the interest rates on sight deposits, which, in turn, affects the general level of interest rate. For the purpose of reference interest rate, the SNB sets a target range for the three-month Swiss franc LIBOR. [SNB, 2017a]

Quarterly, the SNB conducts the monetary policy assessment, which leads to the publication of the target range for the three-month LIBOR and the medium-term conditional inflation forecast. These statistics are available in SNB's quarterly monetary policy report, which is part of the Quarterly Bulletin. The monetary policy assessment is also available in SNB's Annual Reports.

2.2.1 The SNB's Monetary Policy Instruments

The SNB makes use of two conventional monetary policy instruments to manage the liquidity on the money market – the open market operations and the standing facilities. The open market operations, which consist of the SNB Bills issuance, repo transactions and their consecutive sale or repurchase, are initiated by the SNB itself. On contrary, for the standing facilities i.e. liquidity-shortage financing facility and the intraday facility, the commercial banks have to take the initiative in order to obtain the short-term liquidity. [SNB, 2015b]

The SNB can however use a list of unconventional monetary policy instruments in order to influence the amount of liquidity. One of such instruments is a foreign exchange swap i.e. purchase or sale of foreign currency at the current date and the simultaneous sale or repurchase in the future. Another example of this instrument is the foreign-exchange intervention. [SNB, 2015b]. Intervention in the context of monetary policy means central bank's purchase or sale of foreign currencies in order to influence exchange rates. [Humpage, 2003]. To describe the process more in detail, the act of purchasing foreign currency leads to the expansion of the monetary base, which, in turn, induces changes in monetary aggregates, interest rates, and eventually the exchange rate. [Taylor and Sarno, 2001] Nevertheless, when the money supply does not grow with the increase in the monetary base, the foreign

exchange interventions might be less effective.

Chapter 3

From Global Crisis to the Introduction of the Currency Floor

In this chapter, the situation since global crisis until the SNB's introduction of the minimum exchange rate will be analysed along with the reasons behind introduction of such currency floor. The impacts on key macroeconomic indicators such as GDP, inflation and unemployment will be examined as well as the monetary policy actions of the SNB in each year.

The roots of Swiss currency floor date back to 2008. During this time, the global economic growth declined considerably and many advanced economies worldwide fell into recession. The origin of the recession was attributable, first, to the international financial crisis, which arose in the US in 2007 followed by bankruptcy of Lehman Brothers and second, to the sharp increase in the price of oil in the first half of 2008. [SNB, 2009]

The following table shows the movements in chosen macroeconomic indicators from 2008 to 2011:

	2008	2009	2010	2011
GDP	2.1	-1.9	3.0	1.8
Consumption	1.4	1.4	1.6	0.8
Investment	0.5	-4.9	4.4	4.3
Exports	3.1	-8.6	7.9	3.5
Inflation	2.4	-0.5	0.7	0.2
Unemployment	2.6	3.7	3.5	2.8

Table 3.1: The Movements in GDP and Its Components, Inflation and Unemployment from 2008 to 2011

Source: The SNB

3.1 The Beginning of Recession in Switzerland

The economic crisis also hit the Swiss economy and as a consequence the Swiss economic growth started declining in the first half of 2008 and even stopped in the second half of that year. The exporting sector suffered a sharp decrease in the fourth quarter of 2008 because of decreased global demand and the investment decreased as well. The Swiss growth in consumption, however, remained stable thanks to an increase in real wages in 2008. [SNB, 2009]

The inflation surged during the year owing to the increase in the price of oil, but from the third quarter it started to fall considerably. The seasonally adjusted unemployment rate in Switzerland maintained its decreasing trend in the first half of the year, but the second half of the year was also accompanied by the increase in the unemployment rate. Regarding the exchange rate, the CHF appreciated sharply from 1.62 EUR/CHF in January to 1.43 EUR/CHF in October and ended the year at 1.54 EUR/CHF in December. [SNB, 2009]

The SNB decided to relax the monetary policy in order to prevent deepening of the economic crisis and took four extraordinary monetary policy decisions in the fourth quarter of 2008 that lowered the target range for the 3-month LIBOR from 2.25%-3.25% in October 2008 to 0.0 – 1.0% in December 2008. [SNB, 2009]

3.2 The Course of Recession in Switzerland

In 2009, the Swiss economy experienced the major slump in economic activity as a whole, until the third quarter that year, when GDP started to grow again. The Swiss exports continued to decrease sharply in the first half of 2009, while in the second

half they recovered because of the increase in global demand. The investment also decreased in 2009 as a whole, but rose in the third quarter of 2009. The consumption component of GDP continued to grow owing to the upsurge in real salaries that persisted from 2008. [SNB, 2010]

The inflation declined to negative values in the first half of 2009, but in the end of the year it was pushed up to positive values. The seasonally adjusted unemployment rate was increasing throughout the whole year and did not stop at the end of the year. The CHF/EUR exchange rate remained relatively stable during the whole year, as the SNB continued to supply the economy with large amounts of liquidity during 2009. [SNB, 2010]. As a result, the implicit CHF 1.50/EUR 1 prevailed in the Swiss economy in 2009.

The SNB maintained the expansionary monetary policy in order to avert the possible deflation that could arise as a result of the economic crisis and the appreciation of the CHF. In March 2009, the SNB moved the target range for the 3-month LIBOR from 0.0 – 1.0% to 0.0 – 0.75%. To achieve this, the SNB began using different monetary policy instruments ranging from repos with longer terms to foreign exchange market interventions. [SNB, 2010]

3.3 Swiss Recovery from the Recession

During 2010, the Swiss economy recovered the growth it previously lost in the crisis and GDP attained its pre-crisis level. The export industry surged considerably in the whole year, while losing its pace in the second half of the year owing to the appreciation of the CHF. The Swiss investment, which experienced a significant downturn during the recession, eventually recovered in 2010. The consumption increased only slightly because of the marginal increase in incomes. [SNB, 2011a]

The inflation was increasing in the first half of 2010 and since then it was slowly declining throughout the rest of the year. The seasonally adjusted unemployment rate was decreasing that year, however, it still remained higher than its level before crisis. The CHF appreciated significantly in 2010 from 1.48 CHF/EUR in January to 1.28 CHF/EUR in December. [SNB, 2011a]

In this period, the SNB continued to relax its monetary policy. No changes occurred to the 3-month LIBOR that was set at 0.0 – 0.75%. The reasonable ap-

preciation of the CHF during the first half of 2010 caused downward pressure on inflation and since the interest rate was already approaching the zero, the SNB intervened in the foreign exchange market to prevent deflation. The second half of the year did not require any intervention, because SNB stated that the appreciation of the CHF did not threaten the price stability anymore. [SNB, 2011a]

3.4 Situation in Switzerland until September 2011

Following year, the European sovereign debt crisis escalated and the majority of European countries experienced slowdown in economic growth. In the first half of 2011, the Swiss economy sustained its growth level from 2010. During the middle of the year, the CHF appreciated sharply and consequently it negatively affected the growth in the second half of the year. The growth in export of goods and services was weakening and eventually reached negative values in the third quarter of 2011. The investment declined as a whole during the first three quarters of 2011. The consumption experienced a weaker growth in comparison to previous year. [SNB, 2012]

The inflation in the first three quarters of 2011 remained positive, however, it declined as the year progressed and approached zero in September. The seasonally adjusted unemployment decreased in 2011. The CHF appreciated considerably in the first half of 2011. In July the appreciation was even more dramatic and the CHF reached its peak at CHF 1.01/EUR 1 on 9th August of 2011. [SNB, 2012]

In 2011, the SNB continued in conducting its expansionary monetary policy. The massive appreciation of CHF in 2011 forced the SNB to take three extraordinary measures in order to stop the CHF from appreciating further. Firstly, on 3rd August the SNB reduced its 3-month LIBOR target range from 0.0 – 0.75% to 0.0 – 0.25% and increasing the amount of banks' sight deposits from CHF 30 billion to CHF 80 billion. Furthermore, on 10th August the sight deposits were expanded to CHF 120 billion. Moreover, on 17th August the sight deposits were increased to CHF 200 billion. [SNB, 2012]

Chapter 4

Period of Minimum Exchange Rate

4.1 Summary of the Situation Pre-September 2011

During the period described in the previous chapter, the CHF experienced a dramatic appreciation against many world currencies as a result of large amounts of capital inflow to Switzerland during the European sovereign debt crisis. Against EUR, the CHF appreciated from monthly average of CHF 1.62/EUR 1 in August 2008 to CHF 1.12/EUR 1 in August 2011 (see Figure 4.1). Against USD, the rise in value was from monthly average of CHF 1.08/USD 1 in August 2008 to CHF 0.78/USD 1 in August 2011 (see Figure 4.2).

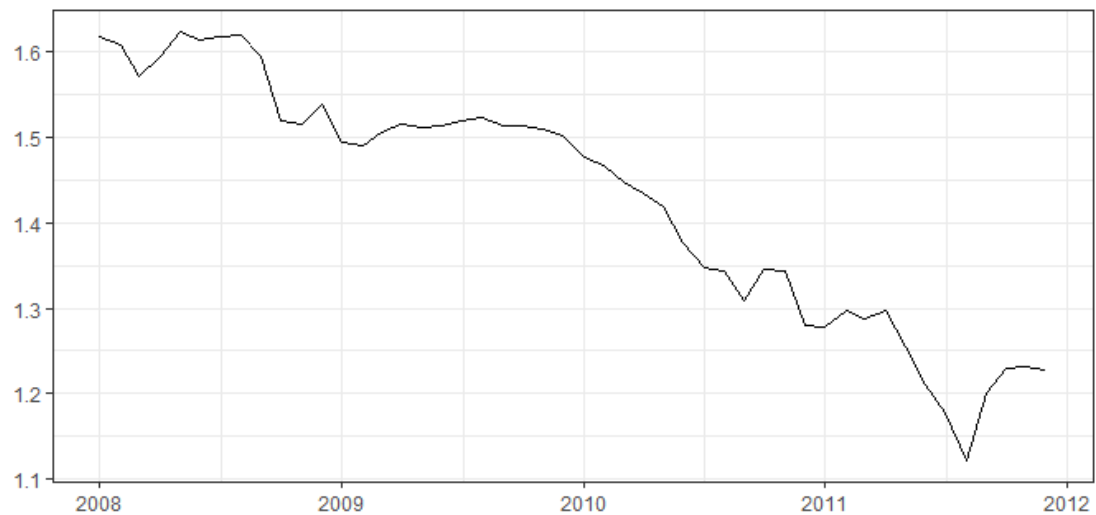


Figure 4.1: CHF/EUR Exchange Rate Developments from 2008 to 2011

Source: Author based on the SNB

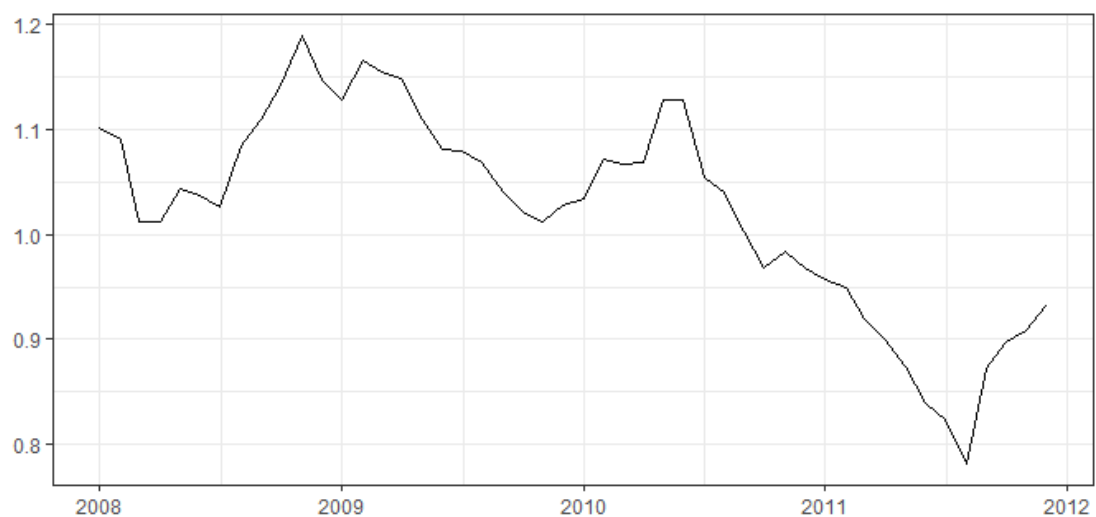


Figure 4.2: CHF/USD Exchange Rate Developments from 2008 to 2011

Source: Author based on the SNB

In attempt to alleviate the impacts of the massive appreciation, the SNB eased the monetary policy and intervened in foreign exchange markets. The SNB's foreign exchange reserves surged considerably in this period, from approximately CHF 57 billion in May 2009 to CHF 232 billion in May year later, which meant a 400 per cent year on year increase in foreign exchange reserves. Afterwards, the foreign exchange reserves were declining slightly until August 2011, when they increased sharply to CHF 255 billion from the previous month's level of CHF 184 billion (see Figure

4.3). These foreign exchange interventions were accompanied by aforementioned exceptional measures influencing the interest rate and the amount of banks' sight deposits.

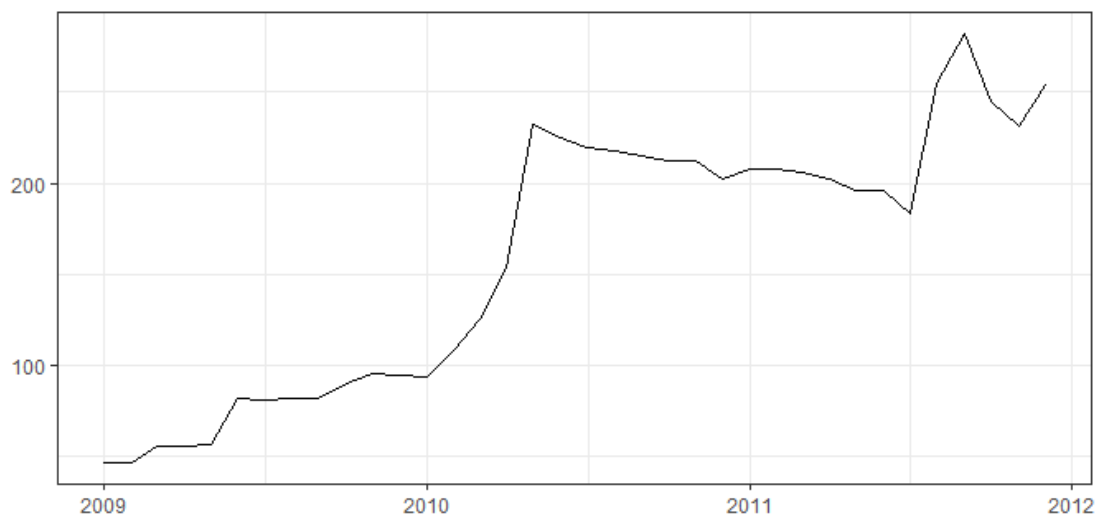


Figure 4.3: SNB's Foreign Exchange Reserves Developments from 2009 to 2011 (in billion CHF)

Source: Author based on the SNB

4.2 The Initial Impact of Introduction of the Minimum Exchange Rate

On 6th September 2011, the SNB announced its decision to set minimum exchange rate at CHF 1.20 per euro. The exchange rate floor was to be sustained at all costs by buying foreign currency in unlimited quantities. The SNB stated that even at this rate the CHF is still overvalued and it should depreciate. In case of risk of deflation, the SNB was determined to take further steps to guarantee price stability. [SNB, 2011b]

The exchange rate floor was implemented to prevent further appreciation of the Swiss currency as well as to prevent the risk of deflation, when it was not possible to decrease short term interest rates. In case of on-going free float of the CHF, the appreciation would continue to impact the Swiss economy adversely and therefore might have suppressed the economic growth. From this perspective and the uncertainty of global economic situation, the SNB concluded that the introduction of

the exchange rate floor was essential. Thanks to this unconventional monetary policy decision, Swiss companies were able to plan their economic activities in advance without worrying about risks that might have arisen from the CHF appreciation. As a consequence, the part of economy that primarily benefited from the minimum exchange rate was the export sector. [SNB, 2013]

The following table shows the movements in chosen macroeconomic indicators from 2012 to 2014:

	2012	2013	2014
GDP	1.1	1.8	1.4
Consumption	2.2	2.2	1.3
Investment	2.9	1.2	2.1
Exports	3.0	2.0	4.2
Inflation	-0.7	-0.2	0.0
Unemployment	2.9	3.2	3.0

Table 4.1: The Movements in GDP and Its Components, Inflation and Unemployment from 2012 to 2014

Source: The SNB

In 2012, the European sovereign debt crisis peaked and therefore this led to downturn of economic activity in the euro area. The Swiss economy continued to grow, however, at slower pace than the previous year. The slowdown in growth was mainly attributable to the substantial decrease in growth of investment and exports. As a result of surge in incomes and the exchange rate floor, consumption experienced stronger growth in comparison to 2011. The seasonally adjusted unemployment rate was increasing throughout the 2012 slowly. In the fourth quarter of 2011, the Swiss economy entered deflation for the first time since the recession in 2009 that endured the whole year 2012. [SNB, 2013]

The monetary policy of the SNB in this period was characterized by sustaining the minimum exchange rate and by three-month LIBOR near lower bound in order to prevent the risks of deflation and recession. In the middle of 2012, the SNB was forced to buy large quantities of foreign currency as there was strong upward pressure on the CHF and exchange rate was dangerously close to CHF 1.20/EUR 1. [SNB, 2013]. The foreign exchange reserves of the SNB increased by more than 180 billion CHF from April to August in 2012.

4.3 The Swiss Economic Development in 2013

The growth in the Euro area remained negative in the first half of 2013, but in the second half the recession was finally overcome. The Swiss economy experienced moderate growth in GDP in 2013. The export sector continued to grow at a slower pace because of the weak global demand and as a consequence the growth in investment was only marginal. The consumption grew steadily during the whole year. The seasonally adjusted unemployment rate retained its increasing trend during this period and the inflation returned close to zero in the second half of the year thanks to the minimum exchange rate policy, which limited the decrease in prices of imported goods. [SNB, 2014]

In 2013, the SNB continued to maintain the exchange rate floor. The three-month LIBOR remained close to zero at this period and the CHF depreciated slightly and therefore SNB was not obliged to purchase as large amounts of foreign currency as it did the previous year. [SNB, 2014]

4.4 Last Year of Enforcement of Exchange Rate Floor

In 2014, the euro area experienced stable growth in economic activity. The growth of Swiss economy, however, remained unchanged. The exports increased significantly in the first half of the year and continued to grow in the second half of the year. The consumption component of GDP continued to grow more slowly because of the lower growth in incomes. The investment continued to stagnate in growth and the seasonally adjusted rate of unemployment remained unchanged as well. The inflation fluctuated around zero during the 2014, again, owing to the minimum exchange rate. [SNB, 2015d]

The SNB continued to enforce the exchange rate floor throughout 2014. However, the drop in price of oil, the ECB's decision of June 2014 to introduce negative interest rates and consecutive decrease of these interest rates together with the Russian currency crisis that was accompanied by the collapse of Russian rouble caused a very strong upward pressure on the CHF at the end of the year. It became increasingly more difficult for the SNB to sustain the exchange rate floor and as

a result it intervened in foreign exchange markets extensively. Foreign exchange reserves of the SNB increased approximately by 30 billion CHF in December 2014. On 18th December 2014, the three-month LIBOR target range was extended from 0.0-0.25% to -0.75-0.25% and therefore returned to its original range of 1 percentage point. Furthermore, the SNB set a negative interest rate of -0.25% on sight deposits at the SNB. After these actions, the three-month LIBOR moved to negative territory. [SNB, 2015d]

In January 2015, the CHF continued to be pressured heavily and it was obvious that the minimum exchange rate could be maintained only in case of on-going interventions in the foreign exchange market, which had already caused massive expansion of the SNB's balance sheet. [SNB, 2015d]. In fact, the SNB's balance sheet accounted for more than 80% of Swiss GDP in December 2014. The existing pressure on the CHF and the quantitative easing programme of the European Central Bank, which was planned to be launched in the beginning of 2015, meant that the SNB would have to purchase tremendous amounts of foreign currency up to several times of GDP to maintain the exchange rate floor. [Straubhaar, 2015]. The exchange rate floor was according to the SNB implemented in times of extraordinary strengthening of the CHF in order to protect the Swiss economy from great losses. However, the minimum exchange rate already fulfilled its purpose and the overvaluation of the CHF softened. The increasing differences in monetary policies of the US and the EU resulted in substantial depreciation of the EUR against the USD and as a consequence the CHF depreciated against the USD as well. For these reasons, the SNB decided that enforcing the minimum exchange rate is not justified anymore¹. [SNB, 2015e]

¹The Swiss trade was more diversified than the Czech trade and therefore the Swiss economy could afford to stop maintaining the exchange rate floor.

Chapter 5

The End of Minimum Exchange Rate Period

In this chapter, the situation since the abandonment of the minimum exchange rate will be analysed. The impacts of this policy on key macroeconomic indicators such as GDP, inflation, exchange rate and unemployment will be examined in detail and the subsequent monetary policy actions of the SNB will be described.

On 15th January, the SNB announced the discontinuation of the minimum exchange rate of CHF 1.20/EUR 1. That day, the three-month LIBOR target range was moved from between -0.75% and 0.25% to between -1.25% and -0.25%. Simultaneously, the interest rate on sight deposits was reduced to -0.75%. The reasoning behind lowering the interest rates was to alleviate the tightening effects on monetary conditions, which accompanied the abandonment of the exchange rate floor. The SNB also stated that it will continue to intervene in foreign exchange markets if necessary. [SNB, 2015e]

5.1 The Impact on Exchange Rate and Interest Rate Development

The discontinuation of the minimum exchange rate resulted in an immediate and considerable appreciation of the exchange rate. On 15th January, the CHF strengthened sharply up to CHF 0.85/EUR 1, but later that day it recovered and stabilized near CHF 1/EUR 1 in the afternoon. During the January, the CHF was depreci-

ating and at the end of January 2015, the exchange rate was CHF 1.05/EUR 1. This level of exchange rate persisted until the middle of the year. Afterwards, the CHF weakened and from August until the end of the year it fluctuated around CHF 1.09/EUR 1. [SNB, 2016]. In 2016, the CHF/EUR exchange rate remained stable throughout the whole year. Only at the end of the year, it slightly appreciated to CHF 1.07/EUR 1. [SNB, 2017b]. The following graph depicts the developments in the monthly average CHF/EUR exchange rate from 2014 to 2016:



Figure 5.1: CHF/EUR Exchange Rate Developments from 2014 to 2016

Source: Author based on the SNB

After removing the exchange rate floor, the CHF appreciated against the USD sharply as well from CHF 1.02/USD 1 to CHF 0.87/USD 1. However, the CHF depreciated significantly afterwards and reached parity again in March 2015. In the second quarter of 2015, the CHF strengthened again, but since then it weakened again and at the end of 2015 it reached its level of previous year – CHF 1/USD 1. [SNB, 2016]. In the first half of 2016, the CHF/USD exchange rate appreciated slightly, but in the second half of that year, the CHF weakened against the USD and at the end of the year the exchange rate stood at CHF 1.02/USD 1. [SNB, 2017b]. The following graph depicts the developments in the monthly average CHF/USD exchange rate from 2014 to 2016:



Figure 5.2: CHF/USD Exchange Rate Developments from 2014 to 2016

Source: Author based on the SNB

The target range for three-month LIBOR remained unchanged in both 2015 and 2016. The three-month LIBOR almost reached -1% in January 2015, but then it settled down between -0.75% and -0.8%, where it remained for the rest of the year and during the whole 2016. The following graph shows the developments in the daily LIBOR and its target range from 2014 to 2016:



Figure 5.3: Three-Month LIBOR Developments from 2014 to 2016 (in %)

Source: Author based on the SNB

5.2 The Impact on Overall Economic Growth

The appreciation of the CHF, which was caused by the abandonment of the minimum exchange rate, negatively impacted the GDP growth. In 2015, the GDP increased by 0.9% against previous year as opposed to 1.4% growth in 2014. [SNB, 2016]. In 2016, the growth in GDP rose slightly again to 1.3% in comparison to the previous year. [SNB, 2017b]. From previous information, it can be seen that GDP growth experienced certain slowdown during 2015. However, in the next year, the economic growth returned to the values of the exchange rate floor period and therefore it can be concluded that the effects of the CHF appreciation on GDP growth were only short-lived. The following graph depicts the developments of year-on-year percentage change in real GDP for quarterly data from 2014 to 2016:



Figure 5.4: Year-on-Year Change in Real GDP from 2014 to 2016 (in %)

Source: Author based on the SNB

Regarding the individual components of GDP, the growth in consumption was only modest in both 2015 and 2016. Investment growth slowed down in 2015, but recovered in 2016. The export sector will be examined more in detail after next section. [SNB, 2016] [SNB, 2017b]

5.3 The Impact on Companies at Microeconomic Level

To examine the effects of currency appreciation at the microeconomic level, the SNB published a survey identifying the effects of the CHF appreciation among 182 companies. The results of the survey showed that 70% of companies were negatively impacted after the discontinuation of the exchange rate floor. A proportion of 22% of companies did not experience any negative or positive effect and the remaining 8% of companies felt the positive effects on their business activities. The economic sectors that were most severely affected according to this survey were the manufacturing sector and the service sector. The negative effects of the appreciation were mainly felt through reduced profits and decreased sales prices. [SNB, 2015a]

5.4 The Impact on Key Export Industries

The growth of export sector declined in the first quarter of 2015. Despite the unfavourable conditions, the exports continued to grow more rapidly for the rest of 2015 and resulted in the annual growth of 3.3%. The increase in exports was mainly attributable to the upsurge in exports of chemical and pharmaceutical products. [SNB, 2016]. The Swiss pharmaceutical industry experienced only a small decline in its economic activity. The overall value of exports decreased only by 0.6% in 2015, when compared to the previous year. [Interpharma, 2016]

On the other hand, one of the key export sectors in Switzerland, the watch-making industry experienced a significant downturn arising from the exchange rate appreciation. In 2015, the value of watch exports decreased by 3.6%, which was primarily caused by the decreased demand for watches from the largest watch importer - Asia. Despite the strong CHF, the European watch sales in 2015 continued to grow. [FH, 2016]

In 2016, the exports of goods and services continued to grow at a rate of 4.5%. The exports of chemical and pharmaceutical products again contributed heavily to this growth. [SNB, 2017b]. The exports of watches in 2016 fell further by an additional 9.8% against the value of previous year. The sales of watches in Asia slumped dramatically that year and the amount of watches sold in the European

watch markets dropped significantly as well. [FH, 2017]

As a result, it can be concluded that the CHF appreciation slowed down the growth in exports of goods and services only temporarily as the Swiss export industry as a whole recovered in 2016. However, certain export sectors such as the watch industry suffered heavily from the discontinuation of the exchange rate floor and it might take them longer to recover. The following graph shows the developments of year-on-year percentage change in real exports of goods and services for quarterly data from 2014 to 2016:

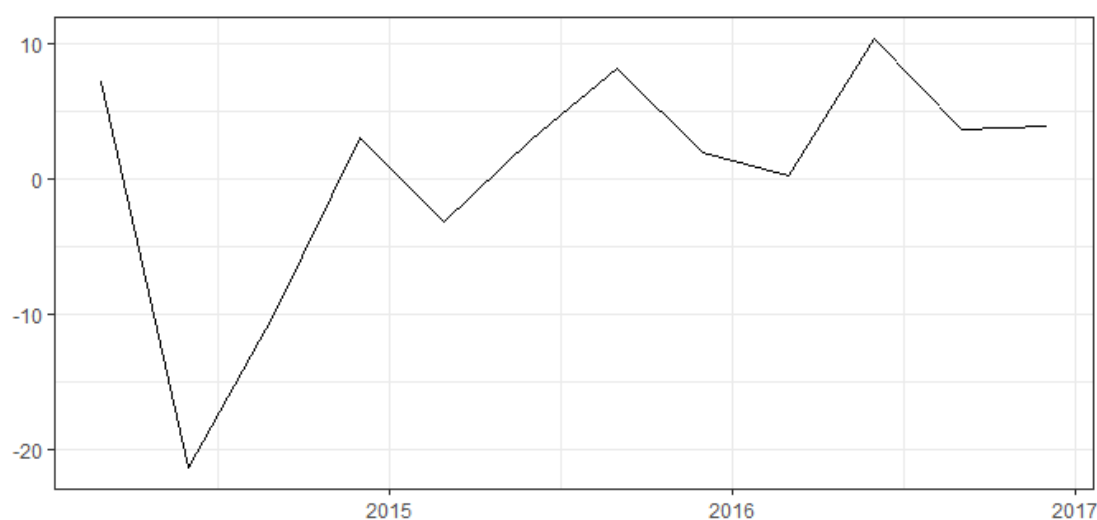


Figure 5.5: Year-on-Year Change in Real Export of Goods and Services from 2014 to 2016 (in %)

Source: Author based on the SNB

5.5 The Impact on Price Development

The overvaluation of the CHF and the oil shock caused a downward pressure on prices in this period. In 2015, the producer and import prices together fell by 5.4%, following a 1.1% decrease in 2014. [SNB, 2016]. The impact on import prices was felt more than on the producer prices, since the CHF appreciation against the EUR implied the reduction in prices of imports from the EU.

Similarly, the consumer price index, which measures the annual rate of inflation, decreased by 1.1% in 2015 in comparison to value of 0.0% in previous year. Again, the fall in prices for imported goods was greater than the drop in prices for domestic

goods. The value of core inflation, which is calculated without the goods with the highest and lowest price changes, was -0.4% in 2015. Therefore, the impact on core inflation was less visible than in case of CPI measured inflation. [SNB, 2016]

In 2016, the producer and import prices stabilised at -1.8% after the shock from previous period. The annual inflation rate recovered to -0.4% that year and the core inflation rose to -0.2%. [SNB, 2017b]. The development in prices could imply that the impact of discontinuation of the minimum exchange rate followed by the appreciation of the CHF had only short-term effects on Swiss economy as it was accompanied neither by deferred consumption nor by the threat of deflationary spiral.

The following graph depicts the developments of year-on-year percentage change in producer and import prices, consumer prices and core inflation for monthly data from 2014 to 2016:

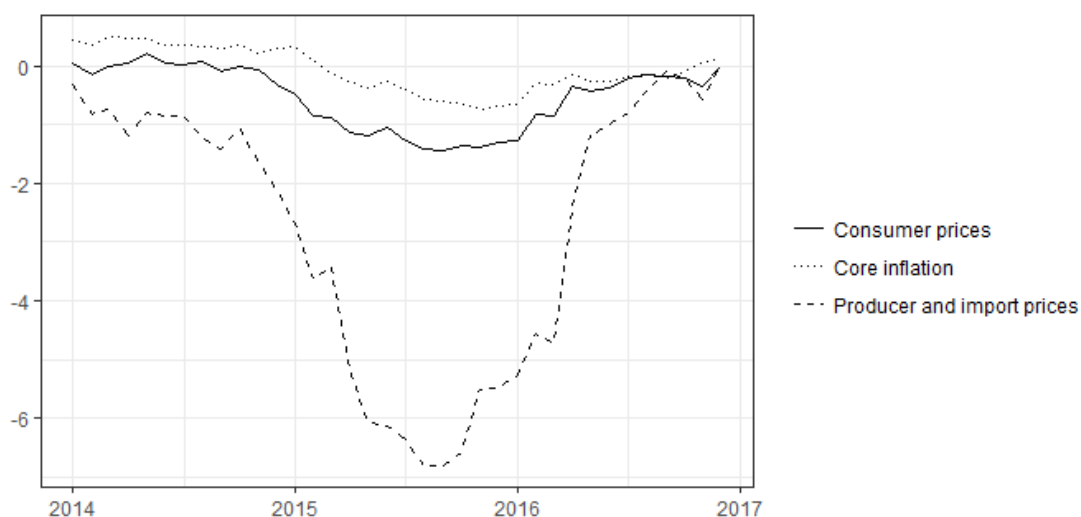


Figure 5.6: Changes in Producer and Import Prices, Consumer Prices and Core Inflation from 2014 to 2016 (in %)

Source: Author based on the SNB

5.6 The Impact on Unemployment Rate

In 2015, after the discontinuation of the minimum exchange rate, the unemployment started to increase and the yearly seasonally adjusted rate of unemployment rose slightly to 3.2%. In the second half of 2016, the unemployment reached its peak and

since then it was marginally decreasing. As a result the seasonally adjusted rate of unemployment in 2016 was 3.3%. The negligible impact on the unemployment rate might be attributable to only small changes in GDP. The developments of the seasonally adjusted monthly unemployment rate from 2014 to 2016 can be seen in the following graph:

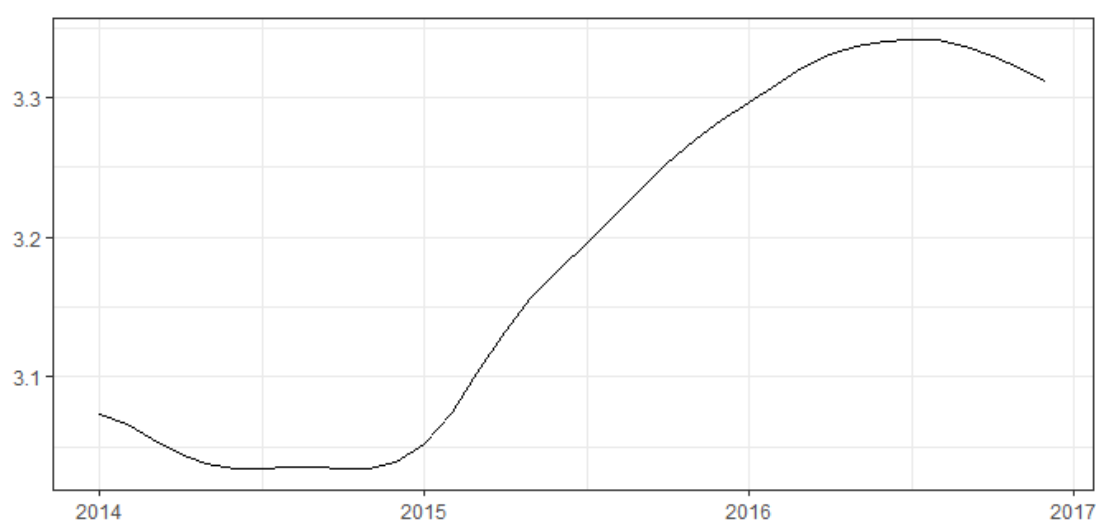


Figure 5.7: Seasonally Adjusted Unemployment Rate Developments from 2014 to 2016 (in %)

Source: Author based on the SNB

5.7 Further Foreign Exchange Interventions

Although, the SNB discontinued the minimum exchange rate, it remained active in the foreign exchange market. In 2015, the SNB intervened by buying a total of CHF 86.1 billion in foreign currency. The largest proportion of these interventions was made in January 2015 so as to sustain the minimum exchange rate and to slow down the sharp appreciation of the CHF arising from the abandonment of the exchange rate floor. [SNB, 2016]. The decision of the United Kingdom to leave the EU in 2016 caused uncertainty on international markets and was followed by the investments to CHF, which was still regarded as a safe investment. As a consequence, in 2016, the SNB continued to intervene by purchasing a total of CHF 67.1 billion in foreign currency. [SNB, 2017b]. To sum up, the increasing trend of SNB's foreign exchange reserves remained unchanged despite the abandonment of the exchange rate floor.

The following graph depicts the developments of the SNB's foreign exchange reserves from 2014 to 2016:

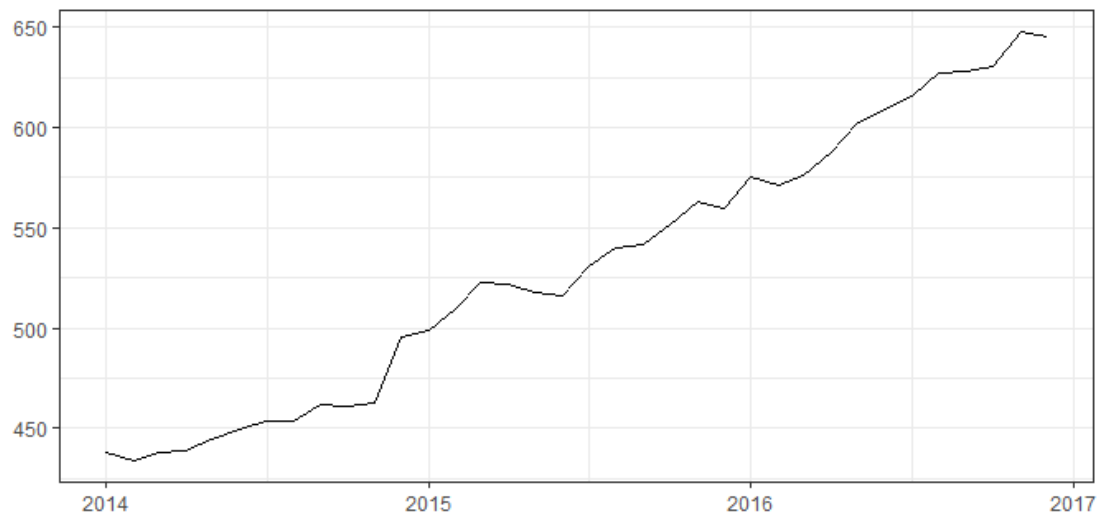


Figure 5.8: SNB's Foreign Exchange Reserves Developments from 2014 to 2016 (in billion CHF)

Source: Author based on the SNB

Chapter 6

Empirical part

In this chapter, the effects of CHF/EUR exchange rate on selected macroeconomic variables i.e. GDP, inflation and interest rate will be examined in detail. For the purpose of our analysis, the Vector autoregression model will be used. Firstly, the VAR will be described and its main advantages and disadvantages will be mentioned. Afterwards, the dataset used in our analysis will be introduced. Moreover, there will be a series of tests performed on our model to identify its properties. Eventually, the results of our econometric model will be presented and the conclusion will be made.

6.1 Methodology

6.1.1 Vector Autoregression Model

The VAR, which first became publicized by Sims (1980), is a systems regression model (with two or more dependent variables) that resembles both the time series models with a single dependent variable and the simultaneous equation models. [Brooks, 2008]. The VAR is widely used for the analysis of the relationships of economic and financial time series and it can be used for time series forecasting as well. [Sims, 1980]

The simplest example of the VAR is the bivariate VAR, which consists of only two equations with two dependent variables y_{1t} and y_{2t} , whose current values are regressed on previous k values of both variables. [Brooks, 2008]. The bivariate

model is defined as following:

$$y_{1t} = \beta_{10} + \beta_{11}y_{1t-1} + \cdots + \beta_{1k}y_{1t-k} + \alpha_{11}y_{2t-1} + \cdots + \alpha_{1k}y_{2t-k} + u_{1t} \quad (6.1)$$

$$y_{2t} = \beta_{20} + \beta_{21}y_{1t-1} + \cdots + \beta_{2k}y_{1t-k} + \alpha_{21}y_{2t-1} + \cdots + \alpha_{2k}y_{2t-k} + u_{2t} \quad (6.2)$$

where $t = 1, \dots, T$ and u_{it} is the white noise disturbance term with two particular properties. The expected value of the error term equals zero:

$$E(u_{it}) = 0, \quad i = 1, 2 \quad (6.3)$$

The covariance of the error terms in each equation equals to zero as well:

$$E(u_{1t}u_{2t}) = 0 \quad (6.4)$$

In case of extension the model to n -variables, it can be written as following:

$$Y_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \cdots + \Pi_k Y_{t-k} + \varepsilon_t \quad (6.5)$$

where $t = 1, \dots, T$, $Y_t = (y_{1t}, y_{2t}, \dots, y_{nt})'$ is a $(n \times 1)$ vector of time series variables, Π_t are coefficient matrices and ε_t is a $(n \times 1)$ vector with unobservable zero mean white noise disturbances and c is a $(n \times 1)$ vector of intercepts. [Zivot and Wang, 2003]

6.1.2 Benefits and Drawback of Vector Autoregression

Model

Using the VAR models over autoregression (AR) models with one dependent variable or simultaneous equations structural models is advantageous in many aspects. Firstly, all variables in the VAR are treated as endogenous and as a result there are no problems with identification of the equations as in the simultaneous equations structural models. Furthermore, the VAR can depend not only on their own lagged values or combinations of disturbances, but also on the lagged values of other variables and therefore it might be able to describe the relationships between variables more precisely than the AR model. The other benefit of VAR model lies in the possibility of estimating the parameters of each equation separately by Ordinary Least Squares (OLS) in case of absence of contemporaneous terms in the right hand

side of the equation. Moreover, it was shown in many other studies that the VAR forecasts for some variables lead to more accurate results than forecasts in other structural models. [Brooks, 2008]

On the other hand, the VAR models also have several drawbacks, which have to be accounted for. First of all, the VAR models are a-theoretical, because they do not use much theoretical information about the variable relationships. Additionally, the interpretation of the coefficient estimates is not straightforward. Furthermore, the determination of the appropriate number of lags is a difficult issue to deal with, as the number of parameters that have to be estimated in equation (6.5) equals $n + kn^2$. Therefore, in order to avoid a huge number of parameters, which might cause large standard errors, an optimal number of lags have to be chosen. [Brooks, 2008]

6.2 Data Characteristics

As previously mentioned, the VAR model was chosen for the purpose of the econometric analysis. Now it is necessary to decide which variables will appear in the model. Since data for many Swiss macroeconomic variables are not available monthly, the quarterly data from 1999 to 2016 were used i.e. 72 observations. However, the number of observations decreased to 68, because one observation was lost by taking the first difference of each variable and three observations were lost because of using three lags in our model, as it can be seen later in this thesis. The endogenous macroeconomic variables that were chosen for this analysis are following:

- Gross domestic product (GDP) – is the value of Swiss overall output of goods and services. The quarterly data on Swiss real GDP in the CHF were obtained from the SECO¹. These data were already seasonally and calendar adjusted.
- Consumer price index (CPI) – measures changes in the price level in Switzerland. The data on Swiss CPI were retrieved from the SNB². They were calculated with the base month December 2015 = 100 and are not seasonally adjusted. These data were then averaged quarterly and seasonally adjusted to fit the data into the model.

¹<https://www.seco.admin.ch/seco/en/home/wirtschaftslage—wirtschaftspolitik/Wirtschaftslage/bip-quartalsschaetzungen-/daten.html>

²[https://data.snb.ch/en/topics/uvo#!/cube/plkopr?fromDate=1999-01&toDate=2016-12&dimSel=D0\(LD2010100\)](https://data.snb.ch/en/topics/uvo#!/cube/plkopr?fromDate=1999-01&toDate=2016-12&dimSel=D0(LD2010100))

- Interest rate – for the purpose of this analysis, the 3-month LIBOR, which the SNB uses as its reference interest rate was used. The data on this variable were gathered from the SNB³ and then averaged to achieve quarterly observations in our dataset.
- Exchange rate – the CHF/EUR exchange rate was used as the observed variable in the following model. The data were downloaded from the SNB⁴ and then averaged quarterly again.

In figures 6.1 to 6.4 the developments in these variables can be seen. All charts were generated from the aforementioned data by using statistical software R.

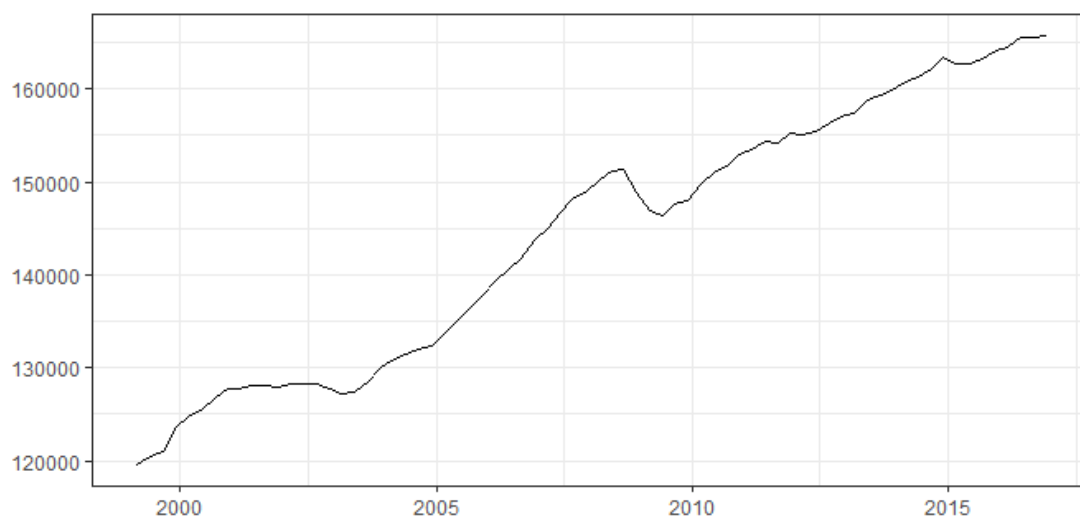


Figure 6.1: Real GDP Developments from 1999 to 2016 (in CHF)

Source: Author based on the SECO

³[https://data.snb.ch/en/topics/ziredev#!/cube/zimoma?fromDate=1999-01&toDate=2016-12&dimSel=D0\(3M0\)](https://data.snb.ch/en/topics/ziredev#!/cube/zimoma?fromDate=1999-01&toDate=2016-12&dimSel=D0(3M0))

⁴[https://data.snb.ch/en/topics/ziredev#!/cube/devkum?fromDate=1999-01&toDate=2016-12&dimSel=D0\(M0\),D1\(EUR1\)](https://data.snb.ch/en/topics/ziredev#!/cube/devkum?fromDate=1999-01&toDate=2016-12&dimSel=D0(M0),D1(EUR1))

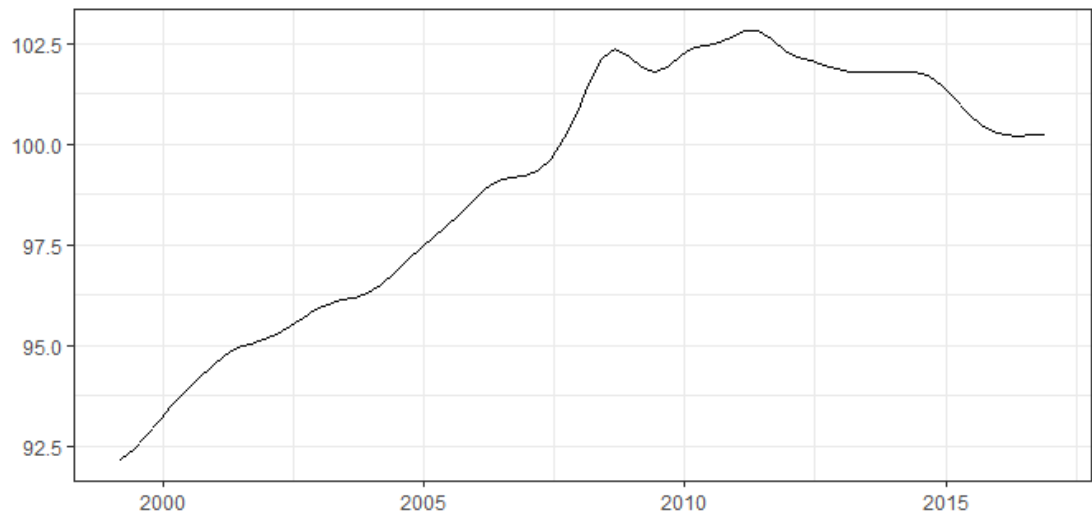


Figure 6.2: CPI Developments from 1999 to 2016 (Base December 2015 = 100)

Source: Author based on the SNB

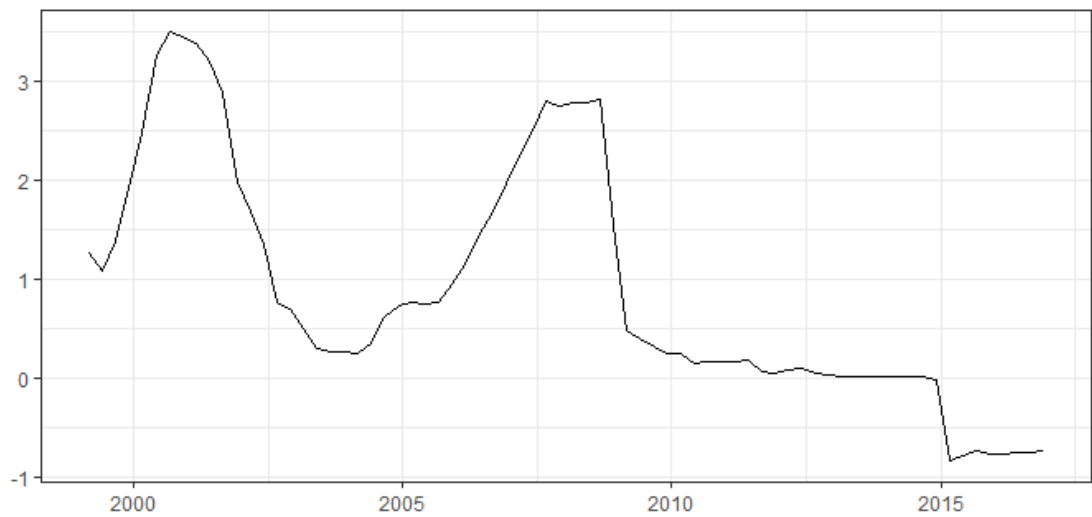


Figure 6.3: Three-Month LIBOR Developments from 1999 to 2016 (in %)

Source: Author based on the SNB



Figure 6.4: CHF/EUR Exchange Rate Developments from 1999 to 2016

Source: Author based on the SNB

6.3 Vector Autoregression Model Specification

In order to interpret the model accurately through methods of impulse responses and forecast error variance decomposition, which will be described later, the variables need to be ordered according to their exogeneity. The most exogenous variable should be the first one, while the most endogenous variable should be last in the model. The final ordering of the variables, which will be used in this model is following: exchange rate, GDP, CPI and interest rate.

After studying the basic properties of the dataset and ordering the variables, it is now important to focus on another important aspect of the variables – stationarity. In order to make statistical inference about each equation of the model separately i.e. assessment of the statistical significance of individual variables, each variable should be stationary. To check for stationarity, the Augmented Dickey-Fuller (ADF) test will be performed. The null hypothesis of ADF test states that the time series is not stationary. On the other hand, the alternative hypothesis is that the variable is stationary. The results of the ADF test showed that exchange rate is non-stationary with p -value = 0.7359, GDP is non-stationary as well with p -value = 0.3784, CPI is non-stationary with p -value higher than 0.99, interest rate is not stationary at 5% significance level with p -value = 0.0772 and. One way how to correct for non-

stationarity of the data is to take the first difference of each variable. As a result, the model is defined as following:

$$\Delta Y_t = c + \Pi_1 \Delta Y_{t-1} + \Pi_2 \Delta Y_{t-2} + \dots + \Pi_k \Delta Y_{t-k} + \varepsilon_t \quad (6.6)$$

where $\Delta Y_t = (\Delta ExchangeRate_t, \Delta GDP_t, \Delta CPI_t, \Delta InterestRate_t)'$ is a $(n \times 1)$ vector of time series variables with $\Delta Y_t = Y_t - Y_{t-1}$

After selecting the number of variables, choosing the suitable ordering of the variables and transforming them to stationary, the next important step for estimation of the VAR model is to ensure that appropriate number of lags is used in the model. For this purpose, multivariate information criteria are widely used and the optimal number of lags is the one with the minimum value of this criteria. The statistical software R, in which the analysis is conducted, produces results of 4 IC - Akaike IC (AIC), Hannan-Quinn IC (HQ), Schwarz IC (SC) and Final Prediction Error (FPE). Additionally, the maximum number of lags allowed is set to 10. The AIC recommended 8 lags, the SC suggested using 2 lags, the SC opted for only one lag and the FPE advised 3 lags. After studying the values of individual criteria, 3 lags were chosen as optimal for the purpose of this analysis. As a result, the model with 4 endogenous variables with 3 lags, characterised by equation (6.7), will be estimated.

$$\Delta Y_t = c + \Pi_1 \Delta Y_{t-1} + \Pi_2 \Delta Y_{t-2} + \Pi_3 \Delta Y_{t-3} + \varepsilon_t \quad (6.7)$$

The model has already been specified and therefore the parameters can be estimated. Since the right-hand side of the equation does not include any contemporaneous terms, the model can be simply estimated by OLS per equation. For the estimation of the parameters, the statistical software R was used again. The results of the estimation can be found in tables 6.1-6.4.

	Estimate	Std. Error	t-value	Pr(> t)	
$\Delta\text{ExchangeRate}_{t-1}$	0.0696	0.1451	0.48	0.6335	
ΔGDP_{t-1}	-0.0000	0.0000	-1.30	0.1975	
ΔCPI_{t-1}	0.1488	0.0505	2.94	0.0047	**
$\Delta\text{InterestRate}_{t-1}$	0.0265	0.0199	1.34	0.1868	
$\Delta\text{ExchangeRate}_{t-2}$	0.1033	0.1436	0.72	0.4751	
ΔGDP_{t-2}	-0.0000	0.0000	-0.98	0.3294	
ΔCPI_{t-2}	-0.2571	0.0843	-3.05	0.0035	**
$\Delta\text{InterestRate}_{t-2}$	-0.0007	0.0198	-0.04	0.9712	
$\Delta\text{ExchangeRate}_{t-3}$	0.0976	0.1411	0.69	0.4924	
ΔGDP_{t-3}	-0.0000	0.0000	-0.36	0.7169	
ΔCPI_{t-3}	0.1213	0.0529	2.29	0.0259	*
$\Delta\text{InterestRate}_{t-3}$	0.0115	0.0187	0.61	0.5411	
Intercept	0.0071	0.0091	0.79	0.4356	

Table 6.1: Estimated Parameters for Exchange Rate and Its Standard Errors, t-value, p-value and Significance Levels

Source: Author

	Estimate	Std. Error	t-value	Pr(> t)	
$\Delta\text{ExchangeRate}_{t-1}$	-2908.8570	3155.7912	-0.92	0.3607	
ΔGDP_{t-1}	0.2237	0.1585	1.41	0.1638	
ΔCPI_{t-1}	2879.4930	1099.4029	2.62	0.0114	*
$\Delta\text{InterestRate}_{t-1}$	857.7937	432.1165	1.99	0.0521	.
$\Delta\text{ExchangeRate}_{t-2}$	76.7151	3124.5362	0.02	0.9805	
ΔGDP_{t-2}	0.0050	0.1632	0.03	0.9756	
ΔCPI_{t-2}	-3872.8328	1832.9974	-2.11	0.0392	*
$\Delta\text{InterestRate}_{t-2}$	-61.7435	431.6466	-0.14	0.8868	
$\Delta\text{ExchangeRate}_{t-3}$	2790.0384	3070.8488	0.91	0.3675	
ΔGDP_{t-3}	-0.1166	0.1610	-0.72	0.4720	
ΔCPI_{t-3}	872.5223	1151.8693	0.76	0.4520	
$\Delta\text{InterestRate}_{t-3}$	306.1273	406.8398	0.75	0.4550	
Intercept	604.2659	196.9805	3.07	0.0033	**

Table 6.2: Estimated Parameters for GDP and Its Standard Errors, t-value, p-value and Significance Levels

Source: Author

	Estimate	Std. Error	t-value	Pr(> t)	
$\Delta\text{ExchangeRate}_{t-1}$	0.2951	0.3408	0.87	0.3902	
ΔGDP_{t-1}	-0.0000	0.0000	-0.05	0.9576	
ΔCPI_{t-1}	1.8202	0.1187	15.33	0.0000	***
$\Delta\text{InterestRate}_{t-1}$	0.0041	0.0467	0.09	0.9308	
$\Delta\text{ExchangeRate}_{t-2}$	0.1376	0.3374	0.41	0.6849	
ΔGDP_{t-2}	0.0000	0.0000	0.34	0.7349	
ΔCPI_{t-2}	-1.4861	0.1979	-7.51	0.0000	***
$\Delta\text{InterestRate}_{t-2}$	-0.0001	0.0466	-0.00	0.9983	
$\Delta\text{ExchangeRate}_{t-3}$	0.3914	0.3316	1.18	0.2429	
ΔGDP_{t-3}	-0.0000	0.0000	-0.47	0.6372	
ΔCPI_{t-3}	0.5480	0.1244	4.41	0.0000	***
$\Delta\text{InterestRate}_{t-3}$	0.0094	0.0439	0.21	0.8317	
Intercept	0.0184	0.0213	0.86	0.3913	

Table 6.3: Estimated Parameters for CPI and Its Standard Errors, t-value, p-value and Significance Levels

Source: Author

	Estimate	Std. Error	t-value	Pr(> t)	
$\Delta\text{ExchangeRate}_{t-1}$	-0.6284	1.1881	-0.53	0.5990	
ΔGDP_{t-1}	0.0000	0.0001	0.40	0.6938	
ΔCPI_{t-1}	1.2841	0.4139	3.10	0.0030	**
$\Delta\text{InterestRate}_{t-1}$	0.4254	0.1627	2.61	0.0115	*
$\Delta\text{ExchangeRate}_{t-2}$	-1.7328	1.1763	-1.47	0.1464	
ΔGDP_{t-2}	0.0000	0.0001	0.70	0.4882	
ΔCPI_{t-2}	-1.8173	0.6901	-2.63	0.0109	*
$\Delta\text{InterestRate}_{t-2}$	-0.0026	0.1625	-0.02	0.9872	
$\Delta\text{ExchangeRate}_{t-3}$	1.3455	1.1561	1.16	0.2495	
ΔGDP_{t-3}	-0.0000	0.0001	-0.32	0.7466	
ΔCPI_{t-3}	0.4249	0.4336	0.98	0.3315	
$\Delta\text{InterestRate}_{t-3}$	0.1340	0.1532	0.87	0.3855	
Intercept	-0.0436	0.0742	-0.59	0.5588	

Table 6.4: Estimated Parameters for Interest Rate and Its Standard Errors, t-value, p-value and Significance Levels

Source: Author

6.4 Vector Autoregression Model Tests

Now, the parameters of the VAR model are estimated, several tests have to be performed in order to make sure the model is appropriate. The first such test is

the test of stability. If the modulus of all eigenvalues of the coefficient matrices are smaller than 1, then the model is supposed to be stable. [Lütkepohl, 2005]. Therefore the VAR model specified above is considered to be stable, because the values are all smaller than 1:

$$|z| = \begin{pmatrix} 0.8369221 & 0.7721956 & 0.7417492 & 0.7417492 \\ 0.5752380 & 0.5752380 & 0.5201792 & 0.5201792 \\ 0.4012314 & 0.4012314 & 0.2571136 & 0.2571136 \end{pmatrix} \quad (6.8)$$

Next, in order to make statistical inference about the model, testing for the serial correlation of the disturbances in the sample will be done. Since, the model was estimated by OLS per equation, the autocorrelation will be examined individually for each equation by performing the Breusch-Godfrey (BG) test. The null hypothesis of the BG test states that there is no serial correlation in the errors. On contrary, the alternative hypothesis is that the disturbances are autocorrelated. The results of the BG test showed that the errors in the equation estimating the effect on exchange rate are uncorrelated with p -value = 0.7711, the errors in equation for GDP are uncorrelated with p -value = 0.5488, the disturbances in equation for CPI are also uncorrelated with p -value = 0.128 and finally, the errors of interest rate do not exhibit presence of serial correlation at 5% significance level with p -value = 0.0788. As a result, it can be concluded that the serial correlation is not present in any equation estimated by OLS.

Another important aspect ensuring correct computation of the standard errors and therefore the correct t-statistics and F-statistics is the homoscedasticity assumption i.e. the constant variance of disturbances. To test whether any equation violates this assumption, the Breusch-Pagan (BP) test will be used. The null hypothesis of the BP test states that homoscedasticity is assumed. Conversely, the alternative hypothesis rejects homoscedasticity and assumes the presence of heteroscedasticity. The results of the BP test demonstrated that the errors in the equation estimating the effect on exchange rate are homoscedastic with p -value = 0.119, the GDP equation is characterised by the homoscedastic errors as well with p -value = 0.1003, the disturbances in equation for CPI are homoscedastic with p -value = 0.2178 and the errors in the interest rate equation have constant variance as well with p -value =

0.3153. As a result, it can be concluded that the homoscedasticity assumption is not violated in any equation estimated by OLS.

6.5 Vector Autoregression Model Interpretation

After conducting the necessary tests for stability, serial correlation of errors and homoscedasticity, the interpretation of the coefficients of the model and their statistical significance can be made. The models 6.2-6.4, which study the impact of lagged values on GDP, CPI and interest rate proved to be statistically jointly significant at 5% significance level. On the other hand the model 6.1, however, did not exhibit the property of joint significance at this level (significant only at 15% level) and therefore there is no evidence that exchange rate is explained by any of lagged values of GDP, CPI, interest rate or exchange rate. Fortunately, the aim of this model is to explain the effect of exchange rate on other variables and as a result, the joint significance of the model 6.1 is not required.

In general, the straightforward interpretation of the coefficients in the VAR model with larger number of estimated parameters is rather difficult. In the first place, we will perform Granger-causality test, which examines the correlation between the current value of one variable and the previous values of other variables in the model. The null hypothesis of Granger-causality test states that one variable does not Granger-cause the other variables. The alternative hypothesis is that the Granger-causality is present in the model. The results of this test showed that exchange rate does not Granger-cause the other variables with p -value = 0.5368. However, the statistical software R also produces the result of instantaneous causality test, which demonstrated that there exists and instantaneous causality between exchange rate and other variables with p -value = 0.005. According to Brooks (2008), it is also possible to interpret the model by the impulse responses (IR) and the forecast error variance decompositions (FEVD), which will be introduced in the next subsections.

6.5.1 Impulse Responses

Interpretation of the model by the IR is based on detection of the responsiveness of the dependent variables to shocks to each variable. [Brooks, 2008]. In case of measuring the IR, the variables need to be ordered appropriately, as mentioned

previously. In this model only the shocks to the exchange rate will be analysed, therefore 3 IR will be analysed – the response of GDP, CPI and interest rate.

Firstly, figure 6.5 depicts the IR of GDP to exchange rate. As it can be seen from the graph, the positive shock to exchange rate, which means depreciation of the CHF against the EUR, leads to the increased growth for the first seven quarters after the shock with respect to the previous period. Analogously, the appreciation of the CHF would lead to the decline in GDP growth for the first year and the first half of the second year. As a result, this effect confirms the analysis from previous chapter.

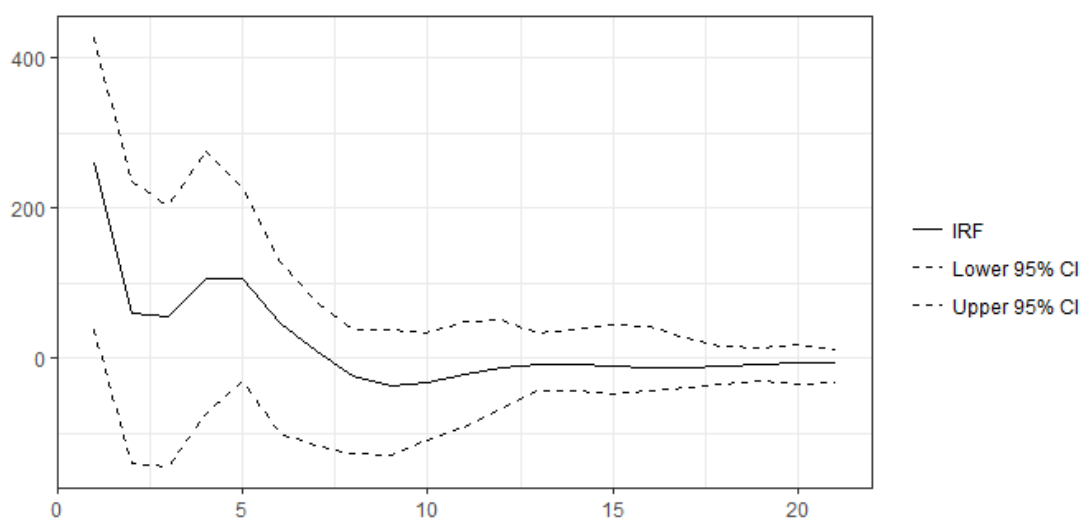


Figure 6.5: Impulse Response of GDP from Exchange Rate for 20 Periods with 95% CI

Source: Author

Next, figure 6.6 shows the IR of CPI to exchange rate. Again, the weakening of the CHF against the EUR causes an upward pressure on CPI, which leads to higher inflation in the first few periods. Conversely, the strengthening of the CHF results in the decline of CPI growth and therefore threats of deflation. Result of this IR is also justifiable, as the danger of currency appreciation usually lies in the risks of negative inflation.

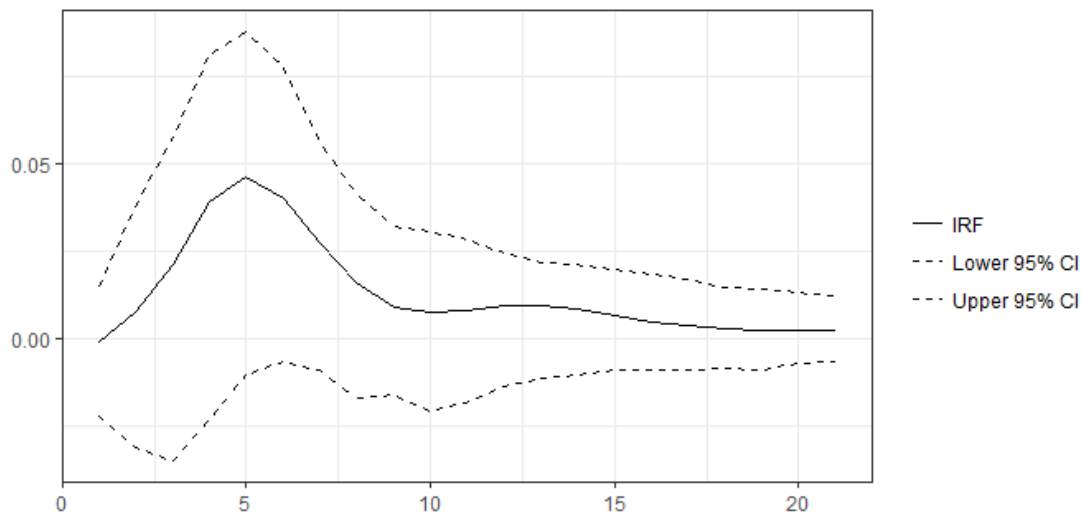


Figure 6.6: Impulse Response of CPI from Exchange Rate for 20 Periods with 95% CI

Source: Author

In figure 6.7 the IR of interest rate to exchange rate can be observed. In this IR function, it can be observed that the depreciation of the CHF against the EUR would lead to increasing of the interest rate. On the other hand, the appreciation of the CHF would mean lowering the interest rate. This is in accordance with SNB's policy to decrease interest rates in order to prevent the CHF appreciation as it could be seen in the analysis in previous chapters.

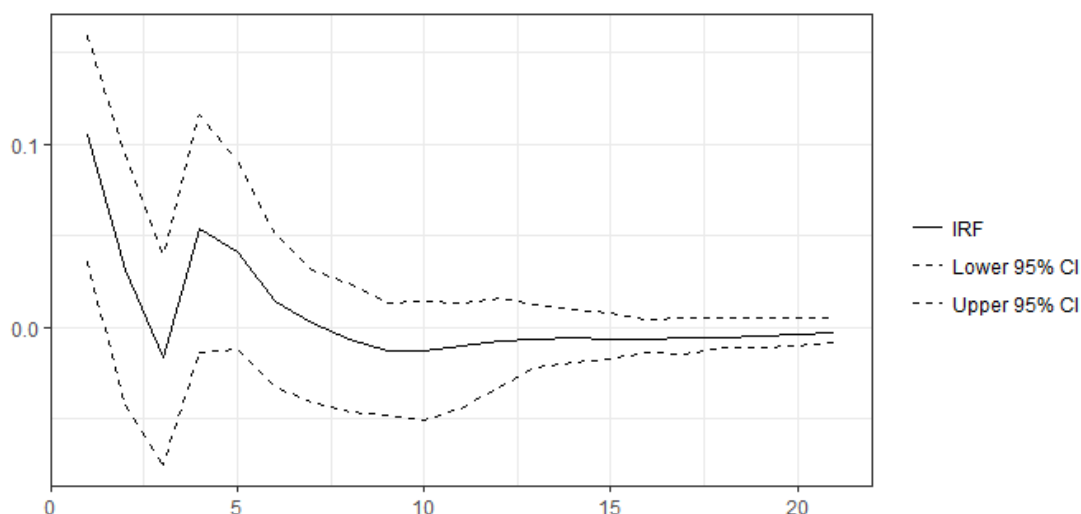


Figure 6.7: Impulse Response of Interest Rate from Exchange Rate for 20 Periods with 95% CI

Source: Author

6.5.2 Forecast Error Variance Decomposition

In comparison to the IR, the FEVD examines the VAR model by comparing the proportions of the movements in the dependent variables resulting from their own shocks and the shocks to other variables. [Brooks, 2008]. For correct results of the FEVD, the variables also need to be ordered appropriately. Again, only the FEVD for GDP, CPI and interest rate will be analysed.

In figure 6.8 the impact of shocks on GDP can be seen. The shocks to the exchange rate have the biggest impact on GDP in the first few periods, apart from GDP shocks. Next, CPI shocks seem to have importance in seventh period and later, while the shocks to interest rate seem to be only marginal.

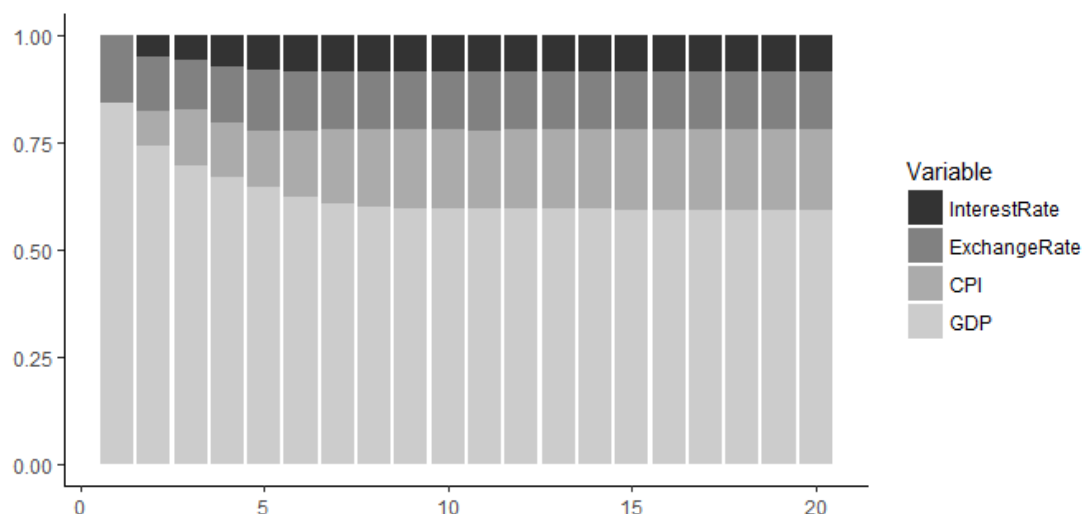


Figure 6.8: Forecast Error Variance Decomposition of GDP for 20 Periods

Source: Author

Figure 6.9 depicts the shock effects on CPI. The exchange rate shocks, again, account for the biggest effect on CPI, excluding CPI shocks. The shocks to GDP have a minor impact on CPI and the interest rate shocks are negligible in this case.

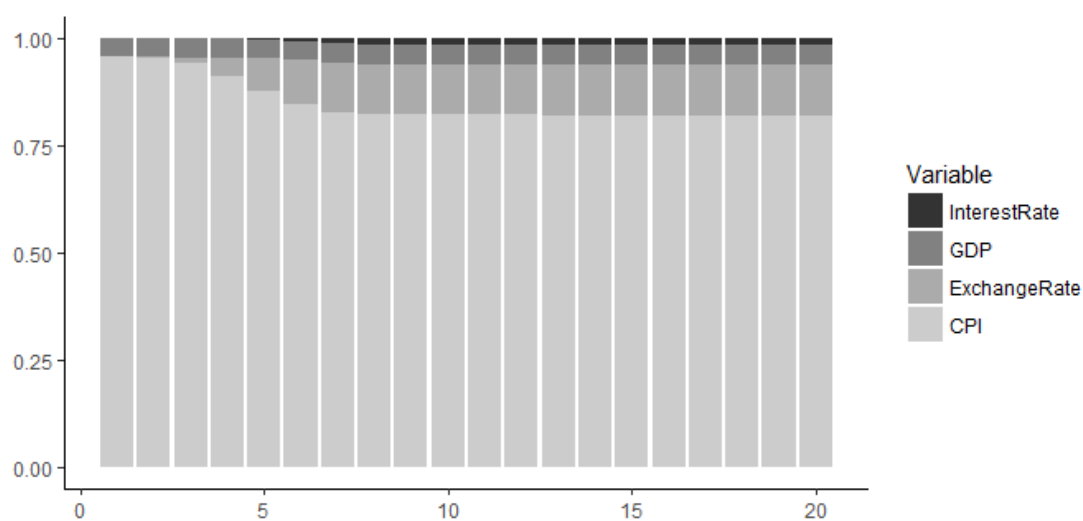


Figure 6.9: Forecast Error Variance Decomposition of CPI for 20 Periods

Source: Author

Finally, in figure 6.10 the impacts on the interest rate are shown. The shocks to each variable have considerable effect on the interest rate. This is mainly caused by the ordering of the variables, as the interest rate is in the last place in the VAR model.

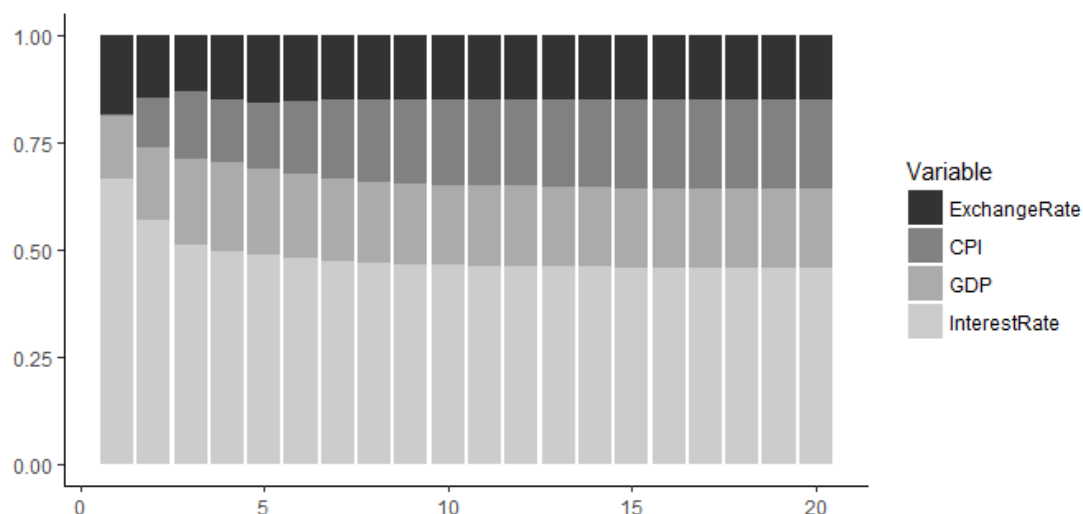


Figure 6.10: Forecast Error Variance Decomposition of Interest Rate for 20 Periods

Source: Author

6.6 Summary of the Empirical Part

In this part, the econometric analysis, which was based on the VAR model, was conducted. The impact of CHF/EUR exchange rate on GDP, CPI and interest rate was analysed. Firstly, tests for stationarity and optimal lag length were performed in order to ensure the desirable properties of the dataset. Moreover, several other tests e.g. heteroscedasticity tests or tests for serial correlation of disturbances were conducted in order to allow for correct interpretation of the VAR model. Regarding the interpretation, the tests of causality and instantaneous causality were conducted. Eventually, through impulse response functions and forecast error variance decomposition, the direct impact of exchange rate on other variables was observed. This confirmed the hypothesis that the recent CHF/EUR exchange rate appreciation influenced the GDP, CPI and interest rate.

Chapter 7

Conclusion

The primary objective of this thesis was, firstly, to summarize the information about the movements of the main macroeconomic variables during since the global financial crisis until the discontinuation of the exchange rate floor. Furthermore, the focus of this thesis was the analysis of the impact of the abandonment of the minimum exchange rate on the CHF appreciation against EUR and USD, gross domestic product, value of exports, consumer price index, producer price index, unemployment rate and on companies at microeconomic level. Finally, the econometric analysis – more specifically the VAR model, studying the effect of CHF/EUR exchange rate on GDP, CPI and interest rate, was conducted.

Regarding the findings in the macroeconomic part of the thesis, it was shown that the discontinuation of the minimum exchange rate was followed by a strong CHF appreciation against many world currencies such as EUR or USD. Consequently, this resulted in temporary slowdown in economic growth, which persisted through 2015. However, the Swiss economy managed to recover from this shock in 2016. The strong CHF also directly impacted the export industry as a whole, which also experienced temporary slowdown in 2015, but recovered year later. Certain export sectors, such as the watch industry, however, did not recover and continued declining even in 2016. Since the abandonment of the exchange rate floor, the import and producer prices went down considerably in 2015, again, because of the strong CHF. The same applied for the consumer prices and prices of imported goods that year and as a result the inflation reached negative values. In 2016, the shock effects on prices almost disappeared and the price level decreased only marginally against the value of previous year. There was also a temporary effect on the rate of unemployment,

which was increasing in 2015. Eventually, the unemployment rate started to decrease in 2016.

In the econometric part of the thesis, firstly, the VAR model was introduced and the dataset was described. The quarterly data from 1999 to 2016 on GDP, CPI, interest rate and CHF/EUR exchange rate were used in this analysis. The interpretation of the model by impulse responses demonstrated that the GDP exhibited a temporarily decreasing growth in case of the CHF/EUR exchange rate appreciation. The inflation rate, measured by growth in CPI, was shown to have reached negative values in case of appreciation of the currency. The effects on interest rate in this model appeared to be in accordance with the SNB's monetary policy as well. The results of the forecast error variance decomposition showed that the effects of exchange rate on each individual variable were not negligible and consequently, the exchange rate appreciation certainly impacted the development of the Swiss economy.

As a result, the findings from the macroeconomic part of the analysis were well in accordance with the results of the econometric model. The recent CHF appreciation had a temporary dampening effect on Swiss economy in form of decreased GDP growth and deflation.

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