Mendel University in Brno
Faculty of Business and Economics

The Effects of CNB's Foreign Exchange Interventions on Manufacturing Production

Diploma Thesis

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Declaration

I hereby declare that, this thesis entitled "**The Effects of CNB's Foreign Exchange Interventions on Manufacturing Production**" was written and completed by me. I also declare that all the sources and information used to complete the thesis are included in the list of references. I agree that the thesis could be made public in accordance with Article 47b of Act No. 111/1998 Coll., Higher Education Institutions and on Amendments and Supplements to Some Other Acts (the Higher Education Act), and in accordance with the current Directive on publishing of the final thesis.

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Abstract

Březinová, K., Bc., The Effects of CNB's Foreign Exchange Interventions on Manufacturing Production. Diploma thesis. Brno: Mendel University, 2017.

This thesis investigates the effects of the Czech National Bank's foreign exchange interventions (approved on November 2013) on manufacturing industry activity in the Czech Republic and empirically evaluates whether the expectations of the CNB regarding the stimulated output were fulfilled. Substantial heterogeneity in the impact of foreign exchange intervention across sectors is identified in the literature. Employing structural breaks testing and VAR / VECM framework to evaluate impulse response functions and Granger causality provides the evidence on the extent and speed of the impact of foreign exchange intervention on the industrial production activity in the CZ-NACE C manufacturing sector. The results show no significant effect of the CNB's foreign exchange intervention on the activity of manufacturing sector as such, the CNB's expectations were not fulfilled.

Keywords

Foreign exchange intervention; Monetary policy; VAR model; Exchange rate; Reaction function

Abstrakt

Březinová, K., Bc., Vliv devizových intervencí ČNB na zpracovatelský průmysl. Diplomová práce. Brno: Mendelova Univerzita, 2017.

Tato práce zkoumá vlivy devizových intervencí České Národní Banky (zahájeny v listopadu 2013) na aktivitu zpracovatelského průmyslu v České Republice a empiricky hodnotí, zdali je očekávání ČNB v podobě oživení zpracovatelské výroby naplněno. Literatura ukazuje významnou heterogenitu v dopadu devizové intervence napříč odvětvími. Testování strukturálních zlomů a použití VAR a VECM modelu, především funkce impulzních odezev a Grangerovské kauzality, umožňuje prokázat rychlost a rozsah vlivu devizových intervencí na aktivitu průmyslové výroby CZ-NACE C zpracovatelského odvětví. Výsledky neprokázaly zásadní vliv devizových intervencí na aktivitu zpracovatelského průmyslu jako takového, což vyvrací očekávání ČNB.

Klíčová slova

Devizové intervence; Měnová politika; VAR model; Měnový kurz, Reakční funkce

Table of Contents

1 Introduction

1.1 Introduction

The Czech economy experienced a period of economic downturn in 2012-2013, which adversely reflected in the increase of unemployment, declining income and consumption of households, as well as profits and investments of firms. At the end of 2012, the Czech National Bank (CNB) responded to the negative development by using its main monetary policy tool and lowering the interest rates to technical zero (0.05%). In accordance with its statutory mandate, the aim of the CNB has always been to keep the price stability, based on moderate growth of overall prices that should contribute to a stable development of the Czech economy. In the same year, the CNB proclaimed to use the foreign exchange interventions for subsequent monetary policy easing in order to stimulate the inflation and speed up recovering of Czech economy from the recession. Finally on 7 November 2013, the CNB has started to weaken the Czech crown with a chosen exchange rate around 27 CZK / EUR. Both of these monetary tools, i.e. real exchange rate depreciation and lowering of real interest rates, should have strengthened inflation pressures, improved a situation on labour market and revived the Czech economy.

Besides the aforementioned inflation acceleration, the CNB expected a positive effect of intervention on the Czech export as well. Since the Czech export is largely formed by manufactured commodities, the increased activity of manufacturing sector is anticipated by the CNB. Theoretical approaches (e.g. Dornbusch, 1976; Hahn, 2007) suggest that weakening of domestic currency leads to an increase in import prices and thus to an increase in general price levels. At the same time, the weaker exchange rate causes lower prices of exports and thereby encourage a demand for these. However, the reverse argument indicates that in type of economy, where manufacturing sectors are significantly dependent on imported inputs, the real exchange rate depreciation may increase the costs of these inputs and the weaker exchange rate hence would lead to an adverse effect on domestic production (e.g. Krugman and Taylor, 1978). According to Johnson (1976), the impact of exchange rate depends on following – the depreciation may be expected to increase the output in case there is labour force available in the labour market; otherwise the weaker currency will lead to a rise in domestic prices. Thus, the asymmetry in impact of currency intervention depends on reactions of the system on such volatility.

It is evident the theory does not provide clear-cut guidance on the interventions effects. This thesis provides such an answer based on observed data. This thesis examines the impact of the CNB's foreign exchange intervention on the Czech manufacturing industry and evaluates whether the expectations of the CNB in terms of stimulated output were fulfilled. The theoretical basis summarizes the macroeconomic background behind the exchange rate and monetary policy intervention in context of

its tools, approaches and channels. Moreover, the impossible trinity concept is included to clarify the relationship among exchange rate regime, capital flows and monetary policy in general. Furthermore, a chapter dedicated to the CNB's foreign exchange intervention shows the motives for conduct and further implementation of the intervention.

The literature review brings conclusions of existing studies engaged in the problematic of exchange rate impact on economy´s output or trade balance. These conclusions are put into a summarizing table, which enables to see dual implications of the interventions, i.e. positive or negative impact of the foreign ex. intervention. The theoretical basis is closed by the description of the Czech manufacturing industry - as a subject of this thesis - in terms of its structure, development, foreign trade and future perspective. The analysis of the intervention impact itself consists of a description of the examined data, which cover the period from I.Q 2000 till I.Q 2016, and methods employed, which are mainly econometric tests performed in Gretl. The empirical results bring conclusions of these tests and imply whether the manufacturing industry reacted on the foreign exchange intervention and hence whether the purpose of the foreign exchange intervention was fulfilled. The obtained conclusions are further discussed and put into confrontation with results of existing studies and macroeconomic theory, as well as into comparison with expectations of the Czech National Bank.

1.2 Aim of the Thesis

As the Czech National Bank anticipates an improvement in the Czech export volumes, a majority of which is manufactured products, a stimulation of the performance of manufacturing sector is expected. The goal of this thesis is to investigate on real data whether the foreign exchange intervention affects the activity of Czech manufacturing industry. The resulting implications will further extend the empirical evidence of monetary interventions' impact on the economy and may serve as an evaluation of the CNB's intervention efficiency. Structural breaks in the development of the series are tested for their significance in ARIMA model framework. The Johansen cointegration analysis accompanied by unit root tests detects the number of potential cointegrating relationships and represents another method to evaluate the intervention impact. The Vector Error Correction Model (VECM) together with the impulse response functions further describes the impact of intervention on individual examined variables. Using a Vector Autoregression (VAR) framework, especially Granger causality and impulse response function as well, the scope and speed of the impact of exchange rate volatility on activity in the manufacturing sector is identified. The methods employed should provide sufficient range for the detection of the impact of foreign exchange intervention on the manufacturing sector's activity with respect to control variables.

2 Theoretical Basis

The theoretical basis deals with macroeconomic implications in context of exchange rate and monetary interventions. The chapter reviewing the theory of exchange rate describes the parity concepts (i.e. purchasing power parity and interest rate power parity theory) and thus clarifies the relationships among exchange rate, interest rate, inflation and arbitrage opportunities. This section is followed by the chapter regarding the impossible trinity hypothesis, which explains connections among the monetary policy's main objectives and partly outlines the implications for central bank in terms of monetary interventions. These are further described from the point of view of their instruments, purpose, expected outcome (behaviour), channels through which they act, as well as of their potential failure. In connection to monetary interventions, a separate chapter describing the Czech National Bank's foreign ex. intervention is included in order to provide practical background to this thesis. The CNB's interventions are explored from the aspect of the central bank's motivation for conduct and further implementation.

2.1 Theory of Exchange Rate

For the purpose of this thesis, it is important to define and clarify how the equilibrium exchange rate is determined and what are the occasions causing the exchange rate fluctuations, i.e. why it appreciates or depreciates. Theories of exchange rate determination have changed since the exchange rate shifted to floating exchange rate regimes. Traditional theories which were developed during the period of fixed exchange rate systems, such as elasticity approach and the absorption approach (described in the chapter Expected Behaviour) focused mainly on the real sector. However, nowadays in a period of floating exchange rates, the monetary sector represents another important factor that determines the exchange rates (Ogawa, 1987).

The main economic theories in terms of the foreign exchange primarily deal with parity conditions. Based on factors such as inflation and interest rates, the parity condition determines a price at which two currencies should be exchanged. In case the parity condition does not hold, an arbitrage opportunity exists for market agents. Nevertheless, arbitrage opportunities are quickly discovered in the markets and eliminated before even giving the individual investor a possibility to capitalize on them.

Following sub-chapters review both the parity theories of exchange rate plus the arbitrage opportunity. This theoretical background will help to understand the context of the exchange rate movement in terms of monetary interventions and will provide theoretical implications for the subsequent chapter regarding the impossible trinity.

2.1.1 Absolute Purchasing Power Parity Theory

Krugman and Obstfeld (1991) define the absolute version of purchasing power parity (PPP) as the exchange rate between two states' currencies to be equal to the rate of the states' price levels. They state that the domestic purchasing power of a country's currency is reflected in the price level of country. Hence, the theory foretells that a fall in a domestic purchasing power of currency (followed by an increase in the domestic price level) will be accompanied with a corresponding depreciation of currency in the foreign-exchange market. Conversely, within the PPP theory an increase in the currency's domestic purchasing power parity will be associated with a proportional appreciation of the currency. However, the simplicity of this model is redeemed by its restricted validity only in the long term. By the time, there were created 2 versions of PPP – absolute and relative.

The mathematical expression of the absolute purchasing power parity based on the relationship that nominal exchange rate of the country should respond to the ratio of domestic and foreign price level has following form:

$$E = P / P^*$$

where E represents nominal exchange rate;

P represents average price level on domestic market (i.e. in domestic currency);

P^* represents average price level abroad (i.e. in foreign currency).

2.1.2 Relative Purchasing Power Parity Theory

Opposite to the absolute version is the relative one, which indicates that the change in two countries' expected inflation rates, is reflected to the change in their exchange rates, since the inflation is assumed to reduce the real purchasing power of a nation's currency. If a country has an annual inflation of 10%, then the country's currency will be able to purchase 10% less of real goods at the end of the year. In other words, the relative purchasing power parity clarifies the relative changes in price levels between the two countries and maintains that exchange rates will change to offset the inflation differentials.

The mathematical expression implies that a percentage change of nominal exchange rate (i.e. depreciation of domestic currency) is defined by difference of inflation rates in two observed countries. It means that in case the domestic price level grows faster compared to the foreign price level, the depreciation of domestic currency occurs. The mathematical equation of relative PPP has following form:

$$\%\Delta E = \Pi - \Pi^*$$

where Π and Π^* represent a percentage inflation rate in observed countries.

Both versions of purchasing power parity evolve from the same assumption – the parity. However, large disparities in the prices of goods between two countries create space for arbitrage.

2.1.3 Interest Rate Parity Theory

Interest rate parity (IRP) theory states that the interest rate differential between the two countries is equal to the differential between the forward exchange rate and the spot exchange rate. The IRP concept is based on certain assumptions. Firstly, it is assumed that capital is mobile, i.e. investors can easily exchange domestic assets for the foreign assets. Second assumption indicates that assets have perfect substitutability, rising from their similarities in riskiness and liquidity. This theory plays an essential role in connecting interest rates, spot exchange rates and foreign exchange rates in foreign exchange markets. Within the foreign exchange market equilibrium, the IRP condition indicates that the expected return on domestic assets will equalize the exchange rate-adjusted expected return on foreign currency assets. Thus, by borrowing in a country with a lower interest rate level, then exchanging to foreign currency and investing in a foreign country with a higher interest rate level the investors cannot gain arbitrage profits, since the exchange back to their domestic currency at maturity brings gains or losses. The interest rate parity is distinguished in two forms - uncovered interest rate parity and covered interest rate parity.

- *Uncovered interest rate parity* – The interest rate parity is said to be uncovered if the no-arbitrage condition is satisfied without any use of hedging (e.g. a forward contract) against the exposure to exchange rate risk.
- *Covered interest rate parity* - Refers to a theoretical condition within the relationship between interest rates and the spot and forward exchange rates of two countries are in equilibrium. In the covered interest rate parity situation, the no-arbitrage condition is satisfied with the use of hedging, i.e. forward contracts. As a result, there are no arbitrage opportunities regarding the interest rate between these two currencies.

In case both covered and uncovered interest rate parity hold, this relationship suggests that the forward exchange rate is an unbiased predictor of the future spot exchange rate. Moreover, if the uncovered interest rate parity and purchasing power parity hold jointly, they explain a real interest rate parity, which proposes that expected real interest rates interpret the expected adjustments in the real exchange rate. Generally, this relationship holds mainly among emerging market countries and over longer terms.

2.1.4 Arbitrage

In context of economics, arbitrage is a process of taking an advantage of a price difference between two or more markets. It represents seeking of a combination of matching deals that capitalize upon the imbalance, while the profit is the difference between the market prices. In other words, arbitrage is a transaction involving no negative cash flow at any temporal state and a positive cash flow in at least one state. It is the opportunity of a risk-free profit after transaction costs. In the academic framework, the arbitrage is a risk-free transaction. However, in practice there are always risks associated with arbitrage, either minor or major, such as fluctuation of prices which decrease profit margins or devaluation of a currency or derivative. In academic concept, the arbitrage involves taking advantage of differences in price of single good or identical cash-flows. The arbitrage is possible when one of three following conditions is fulfilled (Wikipedia, 2017):

1. The same asset does not trade at the same price on all markets ("the law of one price").
2. Two assets with identical cash flows do not trade at the same price.
3. An asset with a known price in the future does not today trade at its future price discounted at the risk-free interest rate (or, the asset has significant costs of storage; as such, for example, this condition holds for grain but not for securities).

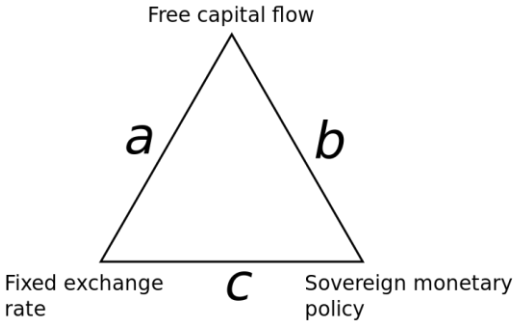
However, arbitrage is not simply just action of purchasing a product in one market and selling it in another for a higher price afterwards. The transactions must happen simultaneously in order to avoid vulnerability to market risk, or the risk that product prices might change on one market before both transactions are finalized. In real terms, this is generally feasible only with securities and financial products which can be traded electronically, and even so, when each part of the trade is performed the prices in market may have changed. The “true” arbitrage supposes that there is no market risk involved.

Consequently, the arbitrage causes that the currency exchange rates, the price of goods, and the price of securities in different markets tend to converge. The velocity at which they converge is a measure of market efficiency. Arbitrage tends to lower the price discrimination by encouraging economic agents to buy a commodity where the price is low and resell it where the price is high. This holds as long as the buyers are not prevented or prohibited from resale and the transaction costs associated with buying, holding and reselling are low relative to the difference in prices in the different markets. Therefore, the arbitrage moves different currencies toward purchasing power parity.

2.2 Impossible Trinity

The impossible trinity[1], also known as the “central bank's trilemma”, is a concept in international economics which indicates that it is impossible for nation to have an independent monetary policy, an open capital account and a fixed foreign exchange rate at the same time. It represents a hypothesis set up on the uncovered interest rate parity condition, and also a finding from empirical studies where governments which have attempted to simultaneously pursue all of the three goals have failed. Even though the central bank has three policy combination options under the impossible trinity concept, it can pursue only two from the above-mentioned policies simultaneously.

The formal model is based on the hypothesis of uncovered interest rate parity condition stating that in absence of a risk premium, an arbitrage will secure that the appreciation or depreciation of domestic currency vis-a-vis foreign will be equal to the nominal interest rate differential between them. In case that country is under a peg, its exchange rate cannot alter and consequently, the two countries' nominal interest rates have to be equalised. In turn, this implies that the pegging country has no possibility to set its nominal interest rate independently, and thus no independent monetary policy. The only way how the country can have both the fixed exchange rate and the independent monetary policy is when it can preclude the occurrence of arbitrage in the foreign exchange rate market, for example by establishing capital controls on international transactions.



Picture 1 The Impossible Trinity or "The Trilemma"
Adapted from: Wikipedia (2017)

Regarding the picture above, the policy options for central banks are following:

- Option “a”: The central bank prefers to maintain a stable (fixed) exchange rate and free capital flows. But an independent monetary policy must remain omitted, since setting a domestic interest rate at different level compared to the world interest rate level would undercut a stable exchange rate owing to appreciation or depreciation pressure on the domestic currency. In such case, the domestic interest rate

[1] It was first uncovered by Nobel Prize winner, the economist Robert Mundell in the early 1960s.

level must copy the development of foreign one. Most of the Eurozone countries have adopted this model.

- Option “b”: An independent monetary policy and free capital flows are maintained as a tradeoff for stable exchange rate. Generally most of small open economies opted for such openness to capital flows together implementing of an independent monetary policy, including the Czech Republic, where the Czech National Bank accepted floating exchange rate regime in 1998.
- Option “c”: To maintain the stable exchange rate and independent monetary policy, the central bank must restrict the free capital flows, which requires for example use of capital controls. Nowadays, such central bank implementing this option is the Central Bank of the Republic of China.

However in reality, central banks do not purely select between the two "peaks", but the compromise between them is rather chosen. The central bank intervention in the framework of floating exchange rate regimes indicates that the flexible regime does not provide complete independence to the monetary policy, as it might seem at first glance. The problem with flexible exchange rates is that although the central bank can set the interest rate as it pleases, it does not have to be sufficient to determine the capital flows. This leads to situations, when the capital flows affect the set up of monetary conditions, even if the central bank does not intervene against the development of the exchange rate. For example, large capital inflows are often associated with the appreciation of the real exchange rate and thus worsening of the balance of current account payments, leading to a reduction in bank deposits and interest rates. With these inflows, even the short-term or long-term GDP growth may occur. Foreign capital can contribute to economic growth and competitiveness, because it leads to an accumulation of financial funds with aim to conduct a business and make a profit, which shapes the country's GDP. Indeed, it depends on what kind of capital is involved; whether it concerns the foreign direct investment or short-term capital, also known as speculative. Policymakers are forced to react to these fluctuations, since a threat of temporary overheating of the economy associated with a loss of competitiveness due to the appreciation of the domestic currency increases, which makes the country more vulnerable to potential crisis. Consequently, the actions of central bank may disrupt the impossible trinity, for example if the central bank intervenes against the appreciation of domestic currency.

Nowadays, the impossible trinity is still valid, but is associated with certain modifications influenced mainly by the globalized financial market, which is reflected in increasing accumulation of foreign exchange reserves in the hands of central banks, especially in emerging countries. The increase of foreign reserves is mostly related to the global threat of negative shocks; it serves as a self-insurance in case of necessity to stabilize the markets (Aizenman, 2013). Even in developed economies a new phenomenon can be observed - liquidity support program provided by central banks. Central

banks often try to absorb this liquidity through sterilization operations, for example by purchasing government bonds on the secondary market.

2.3 Monetary Interventions

Monetary or currency intervention, also known as foreign exchange market intervention represents one of basic monetary policy's tools used by monetary authority (central bank or government) to maintain the inflation target or to influence the balance of trade. Dutta and Hyginus (2002) define the foreign ex. intervention as any set of policy measures conducted with aim of affecting the real exchange rate, including periodic devaluations, central bank foreign exchange market transactions and interest rate changes. It is a process in which foreign exchange transactions take place in order to influence the nominal exchange rate. To do so, government or central bank buys or sells foreign currency in exchange for their own domestic currency. Generally, policymakers may intervene in foreign exchange markets with aim to advance a variety of economic objectives, such as inflation controlling, full employment establishment, maintaining of competitiveness, or maintaining of financial stability by preventing currency crises, such as large depreciation or appreciation swings. The decision of central bank about its objectives is likely to depend on the stage of a country's development, the degree of financial market development and international integration, as well as on the country's overall sensitivity to shocks.

The theoretical approaches in terms of impact of monetary policy's foreign exchange intervention and on economy's output suggest dual consequences. The most traditional theory (Dornbusch, 1976; Hahn, 2007) assumes that the real exchange rate depreciation associated with monetary intervention induces a substitution of imports with domestic goods and in the meantime makes the export of domestic goods more competitive, which will lead to trade balance improvement. The reverse approach suggests that the depreciation may have contradictory impact on economy´s output (e.g. Krugman and Taylor, 1978; Wang and Rogers, 1995). There is also asymmetry regarding the efficiency of foreign ex. intervention from the perspective of persistence. Šimánková and Stavárek (2014) indicate that most of analyzed product groups affected by the exchange rate depreciation were in the long term, while the short term coefficient revealed almost no relationship. This economic phenomenon is called "The Exchange Rate Disconnect Puzzle", concerning a weak short-term link between the exchange rate and rest of the economy (Obstfeld and Rogoff, 2001).

The following chapters are dedicated to the monetary interventions within their main purposes, types, instruments, approaches, and channels through which they act on economic fundamentals and economic agents. Also the circumstances under which the interventions are implemented by the monetary policy are described. Besides this, reasons why the intervention may not work as intended or may fail are clarified as well.

2.3.1 Monetary Intervention's Instruments

The foreign exchange intervention is employed by central bank in order to achieve the objectives of general economic policy, such as full employment, price stability, economic growth, or balance of payment equilibrium. Since the exchange rate intervention or foreign exchange intervention affects the relationship between supply and demand on the foreign exchange market, the monetary policy may so regulate the level of the exchange rate of the domestic currency to foreign currencies. The intervention is aimed on dampening of foreign exchange market volatility and/or easing the monetary policy. The foreign exchange intervention is not a regularly used tool within the inflation targeting regime; as the standard instrument is rather used the interest rates. Nevertheless, foreign ex. intervention is used under certain circumstances, for example when the monetary policy sets the interest rates to "technical zero". Further monetary policy easing can be achieved by weakening the domestic exchange rate.

Below are summarized the types of foreign exchange intervention in context of its mechanism and monetary policy tools.

- **Indirect intervention** – The central bank changes the discount rate, which then through the interest rate influences the outflow and inflow of foreign capital. If the domestic interest rate increases, the investors are attracted and by inflow of capital, the domestic currency appreciates (under assumption of floating exchange rate regime). Moreover, the indirect interventions may include capital controls and exchange controls as well.
- **Direct intervention** – The central bank buys or sells the domestic currency for a foreign currency. This exchange causes a change in demand or supply of a foreign currency to a domestic currency with an impact on the exchange rate. Purchase of domestic currency by central bank leads to an increase in demand of domestic currency and hence a growth in the supply of the foreign one, which reflects as the appreciation of the domestic currency. On the other hand, sales of domestic currency are devaluing for the domestic currency.

The direct interventions are further divided into sterilized and non-sterilized:

- The sterilized one is conducted in order to influence the exchange rate without changing the monetary base. The procedure is a combination of two operations. Firstly, the central bank makes a non-sterilized intervention by buying (or selling) the foreign currency bonds using the domestic currency that it issues. Subsequently, to sterilize the effects on the monetary base, the central bank sells (or buys) a corresponding quantity of domestic-currency-denominated bonds to absorb the initial increase (or decrease) of the domestic currency. The net effect of the sterilized intervention is the same as a swap of bonds in domestic currency for bonds in foreign currency with no change in the money supply. Within sterilization, any purchase of foreign exchange is offset by an equally-valued sale of domestic bonds and vice versa. According to Kim (2003), the ster-

ilized intervention may influence the exchange rate by affecting investor's expectations on future movements in variables or by signaling future changes in the monetary policy.

- Within the non-sterilized intervention, the monetary policy alters the monetary base. It means that the central bank affects the exchange rate through purchasing or selling foreign currency or bonds with domestic currency. For example, monetary policy aiming to decrease the exchange rate or price of the domestic currency will purchase foreign currency bonds. This transaction ensures that the extra supply of domestic currency will pull down the domestic currency price, while the extra demand for foreign currency will raise the price of foreign currency. As a result, the exchange rate falls.

2.3.2 Purpose of Interventions

There are several arguments why a country's monetary authority may want to intervene in the foreign exchange market. Chutasripanich and Yetman (2015) grouped them as following:

• **Volatility management** - Central banks intervene in foreign exchange markets to limit the exchange rate volatility and smooth out the trend path of the exchange rate. Such stabilization of exchange rate reduces excessive short-term volatility, which disrupts the market confidence and hence affects both the financial market and the real goods market. The inordinate exchange rate instability generates extra costs and reduces profits for firms; as a consequence, investors are reluctant to make investment in foreign financial assets. Moreover, the exchange rate fluctuation can potentially spill over into the financial markets, which would in turn endanger the stability of the financial system and make the monetary policy goals more difficult to attain.

• **Influencing the exchange rate level** - Too high exchange rate can injure a country's competitiveness, while too low can result in unsustainable growth and inflation. Accordingly, central banks may wish to intervene in the foreign exchange market if they observe that the current exchange rate turn out to be either overvalued or undervalued.

• **Accumulating FX reserves management** - The experienced Asian financial crisis showed the importance of accumulated reserves of central banks, as they have insurance value when the central bank faces currency pressures (Adler and Tovar, 2011). Some central banks officially announced that the purpose of their intervention would be building of reserves, for example Turkey, South Africa and Chile and Mexico. Adler and Tovar (2011) stated that publicly available information points to around 50% of central banks conducting interventions in foreign exchange markets during 2004-2010 were motivated at least partially by the desire to accumulate reserves.

• **Ensuring liquidity** - Due to shallow foreign exchange markets, some central banks may lead the intervention to ensure an adequate liquidity in order to face disorderly markets and avoid financial stress, especially during stressful episodes (Chutasripanich and Yetman, 2015).

2.3.3 Intervention Channels

The central bank's intervention may affect the exchange rates and so the wider economy through number of different channels. Chutasripanich and Yetman (2015) summarize these as following:

a. *Portfolio-balance channel*: When economies have relatively closed financial markets, the replaceability between domestic and foreign assets is likely to be weak. If the central bank affects the supply or demand of financial assets via its own trading activities, the other market participants are likely to rebalance their financial asset portfolios. This channel may be effective for certain emerging market economies, particularly if the size of foreign exchange interventions is large.
b. *Signaling or expectations channel*: This channel works through the adaptation of expectations about the future central bank's policy. A highly-published transaction in foreign exchange markets may be perceived as setting a precedent for future intervention, or uncovering of information about the exchange rate level desired by policymakers.
c. *Order-flow or microstructure channel*: This channel assumes that the central bank has superior information over the other market participants. Such information advantage of the central bank may be then used to shape the market. However, one constraint for this channel to become effective is that the size of intervention must be large enough relatively to overall market turnover.

To determine the intervention strategy, the central bank observes the overall effect of other transactions in the foreign exchange market, which might be considered as consistent with the order-flow channel. Additionally, the foreign exchange intervention will affect the exchange rates via the signaling channel. Furthermore, the central bank's interventions will be assumed to stick to a rule that is known by other market participants, who react rationally in determining the nature and size of their own transactions.

2.3.4 Expected Behavior

This subchapter reviews the major theories of balance of payments and output adjustments in context of exchange rate intervention guided by central bank or monetary authority. These theories are represented by conventional approach (or the conventional wisdom, presumed also by the Czech National Bank), elasticities and absorption approaches associated primarily with Keynesian theory and the monetarist approach. Regarding the elasticity and absorption approaches, the focus is on the trade balance

improvement with unemployed resources in the economy. On the contrary, in the monetarist approach, the attention is on the balance of payments with full employment equilibrium. In the terms of output growth, given the foreign ex. intervention, monetarists allow a short-run deviation from the full employment equilibrium, but believe that the economy tends to turn back to a full employment growth path relatively quickly though. On the other hand, Keynesians believe that the economy will follow a new growth path, which is different from the original one. These differing views about the expected outcome of foreign exchange intervention under individual approaches will provide range of the foreign exchange intervention's possible effects and hence will supply an extended background enabling to evaluate the results of the thesis according to each approach.

I. Conventional Approach

Most theoretical treatments regarding the devaluation, optionally exchange rate depreciation conclude that it stimulates the economic activity and thus improves the trade balance (Sawyer and Sprinkle, 1987). This conventional wisdom is also with the accordance of CNB, which expects the depreciation induced by foreign exchange intervention to help the exporters and thus stimulate the Czech economy to growth. To generate this outcome, the foreign exchange intervention and the associated depreciation must increase the price of tradable goods relatively to the price of non-traded goods. This relative price effect cause a reduction in imports and a rise in exports, and hence generates an excess demand for the domestic production. As a result of this, the domestic output grows and/or domestic prices increase depending on the capacity utilization. However, by weakening the exchange rate, the foreign exchange intervention can lead to inflation in the economy. Even when it succeeds in improving the country's balance of payments, the devaluation is likely to raise the domestic incomes in export and import-competing industries. Nevertheless, such increased incomes will affect the balance of payment directly by raising the demand for imports, and indirectly by raising the overall demand and thus increasing the prices within the country. The induced inflation is however consistent with CNB's expectation and conversely, it was the primary goal of the foreign exchange intervention.

II. Keynesian Approach

a. Income-Absorption Approach

Under this theory, the balance of payment is defined as the difference between national income and domestic expenditure (Alexander, 1952). If a state has a deficit in its balance of payments, it means that people are “absorbing” more than is produced in economy. Under the absorption concept, the balance of trade may be improved by either increasing domestic income or reducing the absorption. For this object, Keynesians advocates devaluation because it acts both ways. Firstly, devaluation raises exports and reduces imports, thereby increases the national income. The additional income generated by weaker currency will further raise the income through the multi-

plier effect. This will lead to an increase in domestic consumption. Thus, the net effect of the increase in national income on the balance of payments is the difference between the total increase in income and the induced increase in absorption. This mechanism holds under conditions of idle resources in the economy; otherwise, there will be rise in prices instead of improved trade balance.

b. Elasticity Approach

Devaluation reduces the domestic prices of exports expressed in foreign currency. With low prices, the country's competitiveness increases and so the exports. But the extent to which the devaluation will succeed is dependent on the country's price elasticities of domestic demand for imports and foreign demand for exports. This is closely connected with Marshall-Lerner condition. On their basis, the devaluation works only when sum of both elasticities is greater than unity (one). In such case, the devaluation will improve the balance of payments of a country which devalues its currency.

III. Monetarist Approach

Under monetarist concept, the exports finance imports and there is no link between imports and income. The monetarist full-employment assumption leaves no place for autonomous changes in imports to affect income (Ardalan, 2013). Undoubtedly, an autonomous decrease in imports might induce output to grow in the short run. However, over the time, the economy will be pushed back to its original full-employment equilibrium and there will be no long-run impact on the output. This adjustment process can be likened to an inward move of the economy within the production possibility frontier in the short-run, but returning back to it in the long run. Reformulated, the monetarists believe that an economy's response to currency devaluation will be through an adjustment in relative prices with no long-run impact in employment and output.

2.3.5 Potential Failure of Interventions

Policymakers may intervene in foreign exchange markets in order reach the intended economic objectives, such as controlling inflation, maintaining of competitiveness within foreign trade, or maintaining financial stability. The success of intervention depends on many factors, e.g. stage of a country's development and economic situation, the degree of financial market development, the degree of international integration, and the country's overall sensitivity to real or monetary shocks. This subchapter clarifies the circumstances under which the foreign exchange intervention may not work as intended, i.e. under which terms the contractionary effect or even neutral effect of depreciation in economy's output occurs.

- **Negative trade balance** - According to Krugman and Taylor (1978), in case the devaluation takes place with an already existing trade deficit, the price growths of traded goods instantly reduce the real income domestically and thus increase it

abroad, because the foreign currency payments exceed receipts. In the home country, the value of "foreign savings" increases ex ante, aggregate demand falls ex post, and imports drop along with it. The larger the initial deficit, the greater the contractionary effect.

- **Pattern of traded goods** - Since the exchange rate depreciation raises the cost of imported inputs, it contributes to an increase in the production cost and thus limit the aggregate supply. If the decrease in aggregate supply more than offsets the increase in aggregate demand, the depreciation will result as a drop in domestic production. Besides this, in such types of economies, where imported inputs are traded domestically rather than dedicated to export, both output and trade balance will face to contractionary effect as well.
- **Marshall-Lerner condition** – These conditions may explain the short-term deterioration and long-term improvement of trade balance in terms of currency depreciation likewise. Under this condition, an exchange rate devaluation or depreciation will only cause a balance of trade improvement in case the absolute sum of the long-term export and import demand elasticities is greater than unity. In case the price elasticities of exports and imports are very weak, the trade balance expressed in terms of domestic currency may deteriorate causing a recessionary effect in the economy. On the other hand, if the sum of export and import demand elasticity exceeds 1, the ex, rate depreciation will positively influence the trade balance. Generally, the Marshall–Lerner condition is not met in the short run and the depreciation deteriorates the trade balance initially, because goods tend to be inelastic in the short run. In the long run, consumers can adjust to the new prices, and trade balance will improve (Junz and Rhomberg, 1973). The short run deterioration and long run improvement after depreciation resemble the letter "J".
- **J-curve** - A well-known economic phenomenon when a country's trade balance initially gets worse on the account of realized devaluation or depreciation of its currency. The higher exchange rate first inflicts more expensive imports and less valuable exports, causing a bigger initial trade deficit or smaller surplus. Owing to the relatively low-priced and thus competitive exports, the affected country's export starts to grow as the external demand for the lower-priced option increases. Domestic consumers also purchase less of the more costly imports and focus on home goods, since the exchange rate makes the certain locally produced commodities more affordable than the imported counterpart. The trade balance eventually accelerates to preferable condition compared to pre-devaluation state. The J-curve might be another explanation for the short-run deterioration of the trade balance. In such case, the contractionary effect of exchange rate depreciation is supposed to be temporary, followed by further trade balance improvement in the long-run.
- **Labour market situation** - Lin (2004) explains the effect of currency devaluation on the domestic output in context of multiple equilibria in the labor market, i.e. low or high employment. Lin pointed out that if the labor market is in the high-

employment equilibrium, the exchange rate depreciation will depress the economy's output causing the impact to be contractionary. In reverse case, the currency devaluation or exchange rate depreciation will encourage the national output when the labor market is in the low-employment equilibrium, means that there is still some labour force available within the labour market. This conclusion provides another explanation for the mixed effect of the currency devaluation on domestic output in the empirical studies. The same approach is shared by Johnson (1976) as well, who added that in case there is no labour force available, the devaluation will raise the domestic prices if there aren't.

- **Imperfect information model** - In case the short-run production increases but the devaluation influence is not proven, the reason could be in the producers' imperfect information within absolute and relative prices. This confusion influences the decisions of producers in terms how much output to produce and hence builds a positive relation between the price level and output in the short run.
- **Inflation offsets the positive effect** – In the short term, the central bank's monetary expansion tend to increase the level of real output and employment. However, the monetarists argue that the inflation, which is induced by exchange rate interventions, consumes the expansionary effect of depreciation and so the corresponding output increase in the long run. In terms of monetarist view, money is neutral in the long-run, i.e. change in the amount of money does not affect real variables in the economy (such as the level of real output, employment), adjusting only the price level. The depreciation thus has no effect within the long run.
- **Long-run inefficiency** - In the post-depreciation period, the increased profitability of firms in the home market may attract new entrants into competition, either home or foreign. The new entrants cause aggregate supply to rise and the industry prices to decline. Of course, the possibility of entry will influence the pricing policy of existing firms and hence limit the price response to depreciation.
- **Short-run inefficiency** - "The exchange rate disconnect puzzle" in a sense of Obstfeld and Rogoff (2001) refers to a missing short-term link between exchange rates and the macroeconomic essentials, which the international macroeconomics theory suggests should be the driving power of the exchange rates. Particularly, it seems that macroeconomic variables are not capable to explain not only a current level of exchange rates but even their fluctuations. This unsolved economic phenomenon refers to two various situations. The first points out the "exchange rate determination puzzle", meaning that exchange rate cannot be explained by the corresponding shifts in macroeconomic fundamentals. The essence of this issue is that no so far known monetary model is able to overcome a naive random walk model of exchange rate. The second situation describes the extreme (or excessive) volatility of exchange rates regarding to other macroeconomic fundamentals. The exchange rate disconnect puzzle problem may account for neutral short-run depreciation effect mentioned for example by Šimánková and Stavárek (2014). Dutta and

Hyginus (2002) also pointed out that even when the exchange rates are volatile, at the same time the real exchange rate volatility appears to be neutral regarding the output.

- **Wage level and marginal propensity to save** – According to Krugman and Taylor (1978), even when the foreign trade is initially balanced, the exchange rate depreciation boosts the prices of traded goods relatively to home goods, leading to windfall profits in export and import-competing industries. As far as the money wages lag the price increase and as the marginal propensity to save from profits is higher than from wages, ex. ante national savings raises up. The extent of the resulting contraction depends on the difference between savings propensities of labour class and non-labour class.
- **Credit channel effect** - According to Hausmann (2000), the depreciation affects the output and inflation through three different channels. Firstly, the depreciation directly influences the rate of inflation depending on the level of the pass-through. Second, the weaker exchange rate affects output through a balance sheet effect - the depreciation increases the cost of debt repayment denominated in foreign currency, reducing earnings in this period and hence the capital stock and output in the second period. Third, since the reduction in interest rates mitigates the credit constraint, a larger depreciation increases output in the second period (called as credit channel effect). The overall depreciation effect on output depends on which of the two channels prevails. If the credit channel dominates over the balance sheet channel, the depreciations act expansionary. Otherwise, they are contractionary.

2.4 CNB's Foreign Exchange Interventions

On 7 November 2013, the CNB involved in massive volume of foreign exchange market operations in order to artificially weaken the value of Czech Crown against euro by bringing down the exchange rate of Czech crown by approximately 5% to rate of 0.037 EUR per 1 CZK. Since the introduction of exchange rate commitment, which the CNB taken due to fear of deflation and thus of slowing the Czech economy, to its termination on 6th April 2017, the total volume of foreign exchange reserves reached over 2,000 billion Crowns, which represents almost 70 percent of the Czech GDP. Just for illustration, before the foreign exchange intervention launch the volume of foreign exchange reserves was approx. 20% of GDP. According to the classification of the International Monetary Fund (IMF), the Czech National Bank left free-floating exchange rate regime and replaced it with “other managed floating" with an inflation-targeting framework and since 2015 “stabilized rate regime” throughout the intervention period (IMF, 2014). However, with ending of foreign exchange interventions in April 2017, the CNB moves back to inflation targeting combined with a managed float.

The following chapters regarding the motivation of CNB's Bank Board to initiate the foreign exchange intervention and the way it implemented the associated measures will provide further background for the problematic of this thesis. Moreover,

the reasons why the CNB accepted the interventions are built up on the previously-described macroeconomic theory concerning the approaches of monetary interventions and the exchange rate theory.

2.4.1 Motivation

Since the law obliges the CNB to maintain the price stability, the CNB's target is to keep inflation at 2% with a tolerance band of ±1 pp (ČNB, 2015), see Figure 1. However, during 2012 the Czech economy experienced falling of the domestic inflation gradually due to both external and domestic macroeconomic reasons. Close to the end of the year, the CNB's prognosis for the next quarters began to signal that in order to maintain inflation from dropping below 1%, the monetary policy approach should be relieved enough to lower the market interest rates almost around zero percentage point (Figure 2). On top of lowering the interest rates, the Bank Board officially communicated also the possibility of implementing a further monetary policy easing by influencing the exchange rate of the Czech Crown. Continuing to 2013, existing forecasts estimated that inflation would tend to fall even lower than had been already expected, which means attaining zero or even a mildly negative values for a short time during the first quarter of 2014. Therefore, the risk of devaluation ceased to be negligible, implying the risk of a subsequent deflation spiral not different from the one observed about 10 years earlier in Japan.

Figure 1 Inflation target development with target bands, Q1 2000 – Q1 2015
Adapted from: ČNB, Currency Intervention and Forex Reserves – the Czech Perspective (2015)

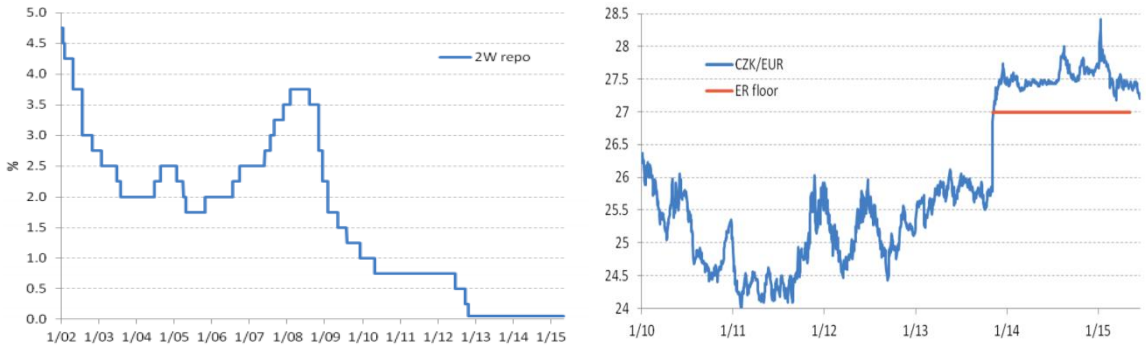


Figure 2 (left) REPO rate development
Figure 3 (right) CZK/EUR exchange rate development
Both adapted from: ČNB, Currency Intervention and Forex Reserves – the Czech Perspective (2015)

The CNB, as an inflation-targeting central bank, reacted on the given economy's development by further easing of monetary policy by the weakening of the Czech crown to 27CZK/EUR through foreign exchange intervention. The CNB stated that without further monetary policy easing the previous relatively stable exchange rate development (shown in Figure 3) would discontinue and the crown would significantly strengthen. At the same time, the decline in inflation expectations of businesses, households and financial markets intensified. Hence, the CNB's effort to loosen monetary conditions (i.e. to weaken the real exchange rate and lower the real interest rates) could be reversed without any further action. Such undesired tightening of monetary policy would further intensify the disinflationary tendencies in the economy, i.e. slowed down or completely stopped the incipient recovery as well as improvement in the labor market, and plunge the economy into another wave of recession or even into deflation.

The fall in prices of purchased goods and services, which is at the level of individuals (consumers) seemingly positive fact, is at the level of the national economy extremely negative and unwelcome phenomenon. The CNB quoted that the central banks around the world makes every effort to prevent risks of such development. In anticipation of a decline in prices many businesses or households postpone their purchases for a later time, which basically leads to a lack, respectively to postponed demand in time. If there is no demand, there is no need to produce as much and firms dismiss, household incomes fall as well as corporate profits, which pushes prices to fall further leading deflation-recession spiral from which there is no easy way to get out. The CNB therefore, in line with its mandate to care for price stability, decided to act so to eliminate the aforementioned risks, i.e. to ensure a faster return of inflation to the 2% targets representing a safe distance from the deflationary waters.

Below are summarized real economic circumstances which strengthened the CNB in its decision to launch the foreign exchange intervention:

- falling inflation (Figure 1);
- weak domestic demand (Figure 4);

- output gap estimated in October 2013 between -2% and -4% (Figure 6);
- sizeable fiscal consolidation and savings glut;
- stagnating nominal wages (Figure 5);
- monetary policy already reached repo rate at "technical zero" (Figure 2);
- CNB was concerned about deflationary expectations and actual demand-driven deflation.

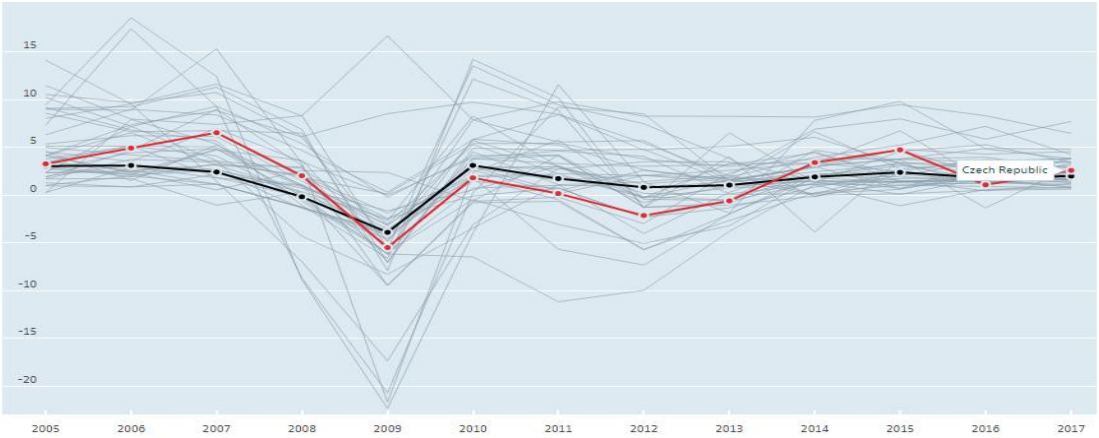
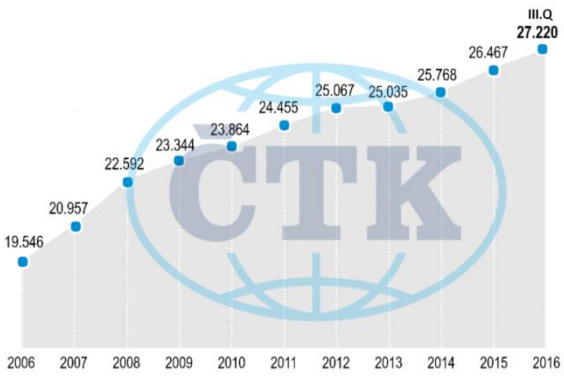


Figure 4 Domestic demand development compared to OECD countries; Annual growth rate (%), 2005–2018
Adapted from: OECD



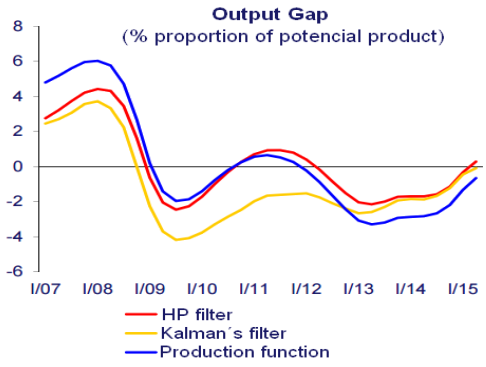


Figure 5 (left) Average nominal wage development in CZK in the Czech Republic, 2006-2016
Adapted from: ČTK
Figure 6 (right) Output gap in the Czech economy, 2007-2015
Adapted from: ČNB, Hodnocení makroekonomické situace a její výhled, vývoj na trhu práce (2015)

2.4.2 Implementation

In 2013 throughout, the Bank Board kept stressing the possibility of foreign exchange interventions, but the effect of these verbal initiatives seemed to disappear gradually. Under those circumstances, on 7 November 2013, the Bank Board decided to implement actual foreign exchange interventions with immediate effect, when it publicly announced the intention to artificially depreciate the value of Czech Crown against Euro so that the exchange rate will not fall below border of €1 = CZK27. Formally, these interventions were fully transparent, without a pre-specified termination, and asym-

metrical in the sense of keeping the domestic currency's exchange rate vis-a-vis the euro from appreciation below a certain rate.

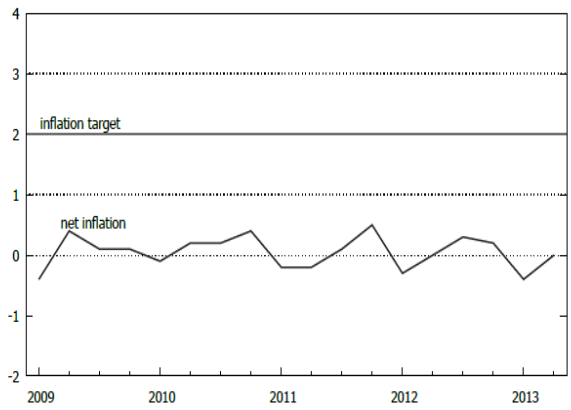
Due to doubts that several market participants initially had about the CNB's commitment to reach the given exchange rate, it took several hours before the exchange rate actually attained the 27 CZK per euro level. By three days, the volume of the Czech crowns that the CNB had to sell in the foreign exchange market to maintain the exchange rate from falling below determined level dropped to almost zero. The resultant increase in the CNB's holding of foreign exchange reserves between end of September and December 2013 was about 20% - by far the highest quarterly increase in foreign ex. reserves in the CNB's twenty years history. First important aspect of the CNB's foreign exchange intervention was that they were initiated even though the CNB did not recognize the exchange rate as moving too far from a level consistent with the inflation differential and the equilibrium real exchange rate vis-a-vis the main trading partners of the Czech Republic. Instead, the interventions were utilized as a supplementary tool to achieve the monetary policy target after using its primary tool – the policy interest rate, which did not bring the hoped results in time the CNB imagined. Even though the inflation-targeting theory gives very little guidance regarding the foreign ex. interventions, because in this concept the monetary policy affects the exchange rate through the interest rate, such temporary implementation of the exchange rate to break free from a deflationary trap and to reach the inflation target once the interest rate has hit the zero level is fully consistent with the recommendations based on the theory of inflation targeting. The only way the exchange rate joins the whole process is by the future inflation forecast's influencing the interest rate. Moreover, the exchange rate often works as shocks silencer that impinge on economy. Also the adaptation through the exchange rate is smoother and less painful than through influencing the real variables, such as employment or wages.

The second aspect of intervention is that the CNB's decision about commitment in late 2013 was followed by an intense adverse reaction of public. This backlash was partly fuelled by market analysts who admitted that the intervention's effects might be negligible or even contractionary (opposite to those that the CNB expected), but also the public feared a rise in the prices of both imported and domestic goods and services. This was an indirect evidence for the CNB that a deflation-plus-appreciation mindset had actually started to become extensive in the Czech economy, and that some type of inflation-promotion action, such as forceful foreign exchange intervention, was needed in order to push the general inflationary expectations back toward the 2% inflation target.

However, the inflation measured by the Consumer Price Index (CPI) has not been the primary concern for the CNB. It is neither wise nor common practice for a central bank to establish its monetary policy with a long-term horizon based on a development of the general CPI, since the composition of food and energy prices tends to exhibit considerably more volatile compared to the other factors, which in turn makes

the index unreliable or even uninformative. Consequently, the so called core or net inflation becomes much more relevant for any policy maker or central banker in general. Beside the net inflation, the CNB's monetary policy observes also a monetary policy-relevant inflation, which is defined as the headline inflation adjusted for first-round effects of changes to indirect taxes. The CNB reacts so that the monetary policy-relevant inflation is close to its inflation target at the monetary policy horizon, taking into consideration the developments in real economic activity and stability on the financial markets.

The Figure 7 below shows the development of the annual core inflation compared to the change in the regular CPI, while the Figure 8 illustrates the monetary policy-relevant inflation. Both of these developments led the CNB to implement the foreign exchange intervention with aim to keep the price stability and thus fulfill its 2% inflation target.



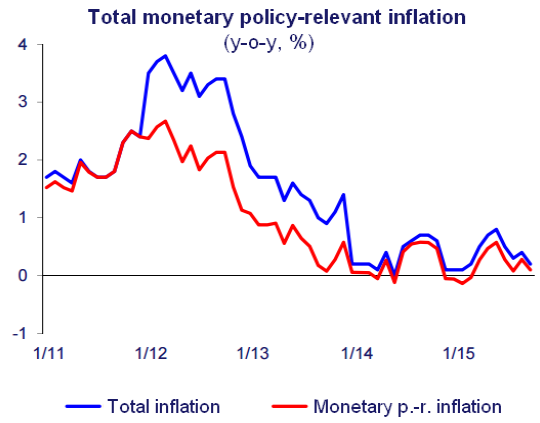


Figure 7 Net inflation rate in the Czech Republic, 2009-2013
Figure 8 Total monetary policy-relevant inflation, 2011-2015
Adapted from: ČNB, Hodnocení makroekonomické situace a její výhled, vývoj na trhu práce (2015)

The CNB assumed the using of exchange rate as a tool of monetary policy and concurrently the stability of interest rates at the current exceptionally low levels until the end of 2016, when it forecasted the headline inflation to increase to 2% at the monetary policy horizon and in 2017 will be slightly above it. The CNB supposed that the inflation will be driven primarily by growth in domestic costs, especially wages. It should be added that the CNB fulfilled its promised and on 6 April 2017 ended its operations on foreign ex. market and hence finished its foreign exchange intervention. The CNB's governor announced that the exchange rate commitment accomplished its task as well as the expectations, and there is no to prolong the intervention period any further.

3 Literature Review

Papers researching the effect of exchange rate movements on domestic output or trade balance show ambiguous outcomes since various empirical analyses detect positive, negative or even no effect. The ambiguity exists because the demand-side effect works against the supply-side effect (Mills and Pentecost, 2000). On the demand-side, a depreciation of the real exchange rate is expected to improve the competitiveness and enhance the demand for output, resulting in its increase. The positive impact is referred as the conventional wisdom. Whereas the reverse approach suggests that the supply-side effect causes the output to fall as the competitiveness improves due to more expensive imported inputs, and hence raising the cost of production. This chapter brings an overview of existing studies engaged in proving of short-term or long term effect of exchange rate volatility on economy's output, and thus helps to broaden the knowledge regarding problematic of monetary interventions effects. A table summarizing key contributions of below mentioned studies is added at the end of this chapter.

3.1 Conventional Wisdom

The conclusions of positive effect of exchange rate on domestic output brought for example R. Dornbusch (1976). In Dornbusch's framework it continues to be true that in the short run, an increase in the nominal quantity of money, which is indeed presented by foreign exchange interventions, is an increase in real quantity of money and accordingly, the monetary expansion has the conventional effect of increasing the level of output and inducing the inflation. However, this applies only in short-run. Since the inflation, which is induced by the real output expansion, serves to raise over time the general price level, real balances will decline back to their initial level until the monetary expansion is fully matched by raised prices and output has returned back to the full-employment level in the long run. Dornbusch's analysis of monetary expansion confirms the Mundell-Fleming model that under conditions of full capital mobility and flexible rates, a small country may conduct an effective monetary expansion in the short run. Thus, the exchange rate proves the function as a critical channel for the transmission of monetary changes to an increase in output. Unlike in the Mundell-Fleming world, the long-run extension of the analysis shows that the effects of monetary expansion are only transitory, because the inflation induced by output increase serves to lower the real balances and therefore return the relative prices to their initial level.

Similar study was executed by Ekholm, Moxnes and Ulltveit-Moe (2012), who investigated the effect of the sharp appreciation of the Norwegian crown in the early 2000s in order to evaluate the impact of a real exchange rate shock on the Norwegian industrial performance. The central bank of Norway accepted the inflation targeting in March 2001 and its decision to increase the interest rate created a large gap vis-à-vis

foreign rates. Since 2000 till 2002, the real exchange rate appreciated by around 17% and led to higher competitive pressure for both exporters and for import-competing firms. To identify the impact of the shock, Ekholm, Moxnes and Ulltveit-Moe estimated equations using seemingly unrelated regressions (SURE), as they anticipate that residuals might be correlated across outcome variables. The baseline specification included firm controls and industry variables. Finally, results of the study suggest that within the appreciation period, the real output declined in sectors that experienced higher import competition. Even though the results proposed that changes in competitive pressure due to exchange rate appreciation matters for industrial performance, the specific mechanisms behind these remain to be further investigated.

Šimánková and Stavárek (2014) examined the short run and long run effects of exchange rate changes on trade flows in terms of disaggregated industry data of the Czech trade balance. For this intention, the Johannsen cointegration test to analyze the long-term relationship and the vector error correction model to detect the short term effects were employed. The industries examined are chosen on the basis of SITC classification; the dataset used in this study covers period from 1993 to 2013. The major trading partners of the Czech Republic were considered as well. The findings suggest that the most of product groups are related with the exchange rate in the long term. Moreover, the positive impact of depreciation was revealed for most of the product categories. However, the short term coefficient detected almost no relationship.

The comprehensive study for emerging European countries (Bulgaria, Croatia, Cyprus, Czech Republic, Hungary, Poland, Romania, Russia, Slovakia, Turkey and Ukraine) was provided by Bahmani-Oskooee and Kutan (2006). They employed monthly data over the period January 1990 and June 2005 and applied ARDL cointegration approach and a corresponding error correction model. They discovered empirical support for the J-curve, which bring deterioration of trade balance in the short run combined with the long run improvement, specifically in Bulgaria, Croatia and Russia. In the rest of the countries, including the Czech Republic, real depreciation had short-term effect, which did not last into the long run though. These results suggest that policymakers in such countries may not use the foreign exchange interventions to promote large surpluses in trade balance and hence economic growth, especially in the long run. Since the real depreciation is not effective in the long-run, the adopting euro could bring benefit for these countries.

Hahn (2007) investigated the influence of exchange rate shocks on the activity of industrial sectors in the euro area during 1985-2004. For each of the sectors, a separate VAR model is estimated. The impulse response analysis is employed to determine and compare the extent and speed of the exchange rate volatility impact on exchange rate shock across sectors. According to Hahn's results, the main industrial sub-sectors affected by the impact on production were the manufacturing sub-sectors. Following a one percent appreciation of the exchange rate of the euro, the industrial production was estimated to fall by 0.3 percentage point after one and 0.45 after two years. The

most sensitive sub-sectors were the "machinery and equipment" with 0.8 percentage point change and "motor vehicles" with 0.51 p. p. change. The appreciation of real exchange rate thus had negative impact on manufacturing activity within Eurozone countries. Hahn also provided results on the adjustment speed of individual manufacturing sectors production to an exchange rate appreciation. Slow adjustment was a common feature for the absolute majority of capital goods producers, e.g. "machinery and equipment" and "office machinery and computers". Overall, the Hahn's results propose the following macroeconomic implications for the economy of euro area: The sectors industry, trade and transportation contribute by almost 70% of the overall impact of an exchange rate shock on euro area GDP. Within the industry, the main industrial groups' capital and intermediate goods account for 90% of the impact on production, while among the main sub-sectors the whole impact comes via the manufacturing sector.

The study of Jamil, Streissler and Kunst (2012) explored the effect of exchange rate volatility on industrial production for 11 Eurozone countries before and after the introduction of common currency and for four European countries (Denmark, Norway, Sweden and the United Kingdom) that have not adopted euro yet. The analysis incorporated monthly data of exchange rate and macroeconomic variables from January 1980 to April 2009. Jamil, Streissler and Kunst employed AR(k)-EGARCH(p,q) models for estimation of volatility in growth rate of nominal and real exchange rates for all countries before and after the accepting of common currency separately. The introduction of euro provided a new impulse for research whether the accepting of common currency helped to reduce the volatility of exchange rate for Eurozone members and whether the exchange rate volatility affected the industrial production similarly in all the analyzed countries. Results revealed that most of the countries which have adopted euro are able to decrease variations in the volatility of the nominal exchange rate after the introduction of common currency. On the other hand, an increase in the standard deviation of the volatility of nominal exchange rate after the introduction of Euro is detected for all countries that have not adopted euro. Similar to before the introduction of common currency, volatility in nominal exchange rate negatively influence the industrial production for both groups of the countries. However, the strength of the negative impact of the exchange rate volatility on industrial production decreased numerously after the introduction of Euro for both groups of countries. The conclusion based on study's findings is that countries benefited more after adopting the common currency even if they find a rise in the real exchange rate volatility.

According to Fang, Lai and Miller (2006) the exchange rate depreciation positively affects the export, however the associated exchange rate risk effect may offset the positive effect, leading to an overall negative net effect. Fang, Lai and Miller investigate the net effect of foreign exchange intervention on eight Asian countries (Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand) applying a dynamic conditional correlation bivariate GARCH-M model that concurrently estimates

time varying correlation and exchange rate risk. To measure the net effect, they employed monthly time-series data on bilateral exports from eight Asian countries to the U.S. from 1979 to 2003. The purpose of the study is to examine whether the intervention stimulate exports by depreciating the currency or by reducing exchange rate fluctuations and thus the exchange rate risk. Within the results, both arguments figure. Conclusion for this study is that ignoring the exchange rate risk, depreciation typically stimulates exports across Asian economies; the depreciation effect proves significant for all of countries, apart from Singapore. Moreover, the real exchange rate risk produces significant impact, either negative or positive, on exports for seven of the eight countries examined. High degrees of risk evoke efforts to avoid its effect and thus, exchange rate risk stimulates exports in Malaysia and the Philippines, leading to positive net effects. In the other case, the depreciation alone stimulates exports, but exchange rate risk showed a negative effect for six countries, resulting as negative net effects in Indonesia, Japan, Singapore, Taiwan and zero net effects in Korea and Thailand. Fang, Lai and Miller pointed out that exchange rate depreciation typically accelerates exports, but its overall contribution is generally small. Therefore, policy makers should carefully consider exchange market intervention as the associated change in exchange risk may offset any positive effects of depreciation.

Al-Rashidi and Lahiri (2012) found expansionary effects on ASEAN+3[2] manufacturing output likewise, when they analyzed the asymmetry of appreciation and depreciation effects. They used an industry-specific trade weighted real exchange rate, which they evaluated as better indicator to forecast movements of industry output compared to the standard real exchange rate. The used data sample covered the period from 1992 to 2004 and analyzed the industry output for the ASEAN+3 countries. When Al-Rashidi and Lahiri allowed the asymmetry in the effects of appreciation and depreciation, they found that real exchange rate depreciation weighted by the importance of export destinations does have a positive impact on output, although the corresponding appreciation does not have a significant negative effect. However, the effect of appreciation and depreciation is found to be symmetric for the ASEAN+3 countries when the importance of the origin of the imports is taken into account in terms of real exchange rate indicators. Thus, this study is extended the empirical basis regarding the complex relationship between the real exchange rate and manufacture output through the use of real exchange rate indices that reflect the variety of each industry's trade pattern.

[2] Association of South East Asian Nations comprising of Brunei, Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam, Laos, Myanmar and Cambodia. Additionally China, Japan, and South Korea have been cooperating with the ASEAN member countries, resulting in what is commonly called the ASEAN+.

3.2 Reverse Approach

Berument and Pasaogullari (2003) evaluated the effects of real depreciation on the economic performance of Turkey applying quarterly data from 1987:I to 2001:III. Turkey was hit by financial crisis several times and in 1994 and 2001, the nominal domestic currency depreciated by 62% and 53% respectively. In 1994, output declined by 6.2% after the financial crisis and sharp devaluation, preceding current account deficits and high interest rates. Firstly, the bivariate analysis was set up to reveal a negative correlation between output and the real exchange rate depreciation. However, employing the Granger causality test, Berument and Pasaogullari did not find a significant causality between the variables, likely due to the inability of the test to eliminate the effects of other exogenous variables. The finding that there exists a long-run relationship among the real exchange rate, inflation and output led to use of VAR models. After employing various VAR models for the sample period, the response of output was found to be negative and permanent after a real devaluation. These findings suggest that to limit the harmful devaluation impact, the overvaluation of a currency must be precluded.

Another reverse approach is presented by Wang and Rogers (1995), who observed the sources of output fluctuation and inflation for Mexico. They estimated an equilibrium model for a small open economy, in which motions of inflation and output are managed by several fundamental disturbances. Wang and Rogers employed monthly data from January 1977 to June 1990, thus right after the 1976 inflation crisis in Mexico. The performed analysis of impulse responses and variance decompositions examined the dynamic effects of fiscal, real, monetary, exchange rate, and asset shocks on the deficit, output, and inflation. The results suggest that output is influenced primarily by real shocks, while the inflation is explained in part by all five shocks, when fiscal and money growth shocks being the most influential. Exchange rate shocks were proven as significant, however, the support for the balance-of-payments we shown as weaker and only indirect.

Mills and Pentecost (2000) estimated the response of output to changes in the real exchange rate in four transitional economies, i.e. the Czech Republic, Hungary, Poland and Slovakia over the period 1992 to 1998. They employed a structural macroeconomic model incorporating the supply-side response to changes in the real exchange rate, based on an extended IS-LM framework. The econometric estimation proved that the response of GDP in these four economies to a real depreciation is divergent. In particular, only Poland showed sustained output gains while a real depreciation occurred. On the other hand, for the Czech Republic and Hungary, which are more open economies, the impact of greater exchange rate rigidity would have no long run consequences for output. Only short run real appreciation led to a temporary decline in output growth in both the Czech Republic and Slovakia. Regarding Slovakia, a persistent real depreciation served to reduce domestic output as the costs rose relative to de-

mand. These very different output responses to real exchange rate suggest that for policy makers, it would be a mistake to treat all the economies equally.

The neutral long-term effect on output regarding the exchange rate devaluation brought for example study of Edwards (1985), which analyzed 12 developing countries (India, Malaysia, Philippines, Sri Lanka, Thailand, Greece, Israel, Brazil, Colombia, El Salvador, South Africa and Yugoslavia) during 1965-80. The employed Khan and Knight model was extended to empirically address the question of contractionary devaluations and considered the effect of money surprises, fiscal factors, terms of trade changes and devaluations on the level of real output. The results, obtained by variance components procedure on data for the developing countries, provided support to the short-run contractionary devaluation hypothesis, i.e. the devaluation generated a decline in aggregate output in the short run. The further evidence suggests that in the long run, devaluations did have no effect on output.

An, Kim and Ren (2014) analyzed the effects of real exchange rate changes on real output growth for 16 countries belonging to three groups - Latin American countries, Asian countries, and non-G3 developed countries with using of quarterly data from 1973 to 2012. The sample countries also run different exchange rate regimes, e.g. Latin American and Asian generally have had fixed regimes, while Australia, Canada, Switzerland, and New Zealand had floating exchange rate regime for major time of the sample period. Austria, the Netherlands and Portugal belong among the Eurozone members. Studying the countries with diverse exchange rate regimes allowed a direct comparison of the output-exchange rate relationship throughout different groups of economies, and thus enabled to explore the contractionary effects of devaluation in certain groups of countries. To do so, a fairly comprehensive vector autoregression (VAR) model was employed, as it allows consideration of the exchange rate endogeneity. The results disclosed that output movements after a real devaluation had little to do with current account improvement/deterioration. Moreover, while contractionary devaluation is fairly a homogeneous occurrence for the countries of Latin American, the output-reduction effect of devaluation is not a function of exchange rate regimes, neither type of economies. Contractionary devaluation may occur in developing countries as well as in developed countries. Based on the mentioned results, An, Kim and Ren attempt to offer several policy implications. States with contractionary devaluation (as Latin American countries) should not count on exchange rate depreciation to stimulate the economy. The authors concluded that currency depreciation tends to reduce the growth potential of the economy as well as to introduce an additional uncertainty which operates as the discouragement for investment needed to build production capacity.

Upadhyaya (1999) estimated the effect of currency devaluation on the aggregate output level in six Asian countries (India, Pakistan, Sri Lanka, Thailand, Malaysia, and the Philippines) covering the period of 1963–1993 and using the autoregressive distributed lag model. The short run effect of currency devaluation was shown to be

positive in India and the Philippines, but is negative in Pakistan. For the rest of the countries the short-term devaluation effect was insignificant. On the other hand, the long run effect of currency devaluation on the aggregate economic activity is neutral in four of six countries examined. The rest two - Pakistan and Thailand, experienced contractionary effect of devaluation in the long run.

Chou and Chao (2001) applied the ARDL test procedure and real exchange rate volatility data to reveal both long-run and short-run relationship of the devaluation with output. Authors focused on period of the Asian financial crisis in the summer of 1997 for those crisis-affected economies, namely Indonesia, Malaysia, the Philippines, South Korea and Thailand. The analysis showed that the currency devaluation led to a short-run contractionary effect for the all the examined. However, the devaluation had no impact on aggregate output in the long run (except for Indonesia). The short-run contractionary effect of devaluation may be explained by the decline in aggregate demand induced by the higher price level. In the long-run, the contractionary effect may be alleviated or offset by the expansion of the export sector. Chou and Chao therefore recommend precluding from unfavorable impact on the demand side of the economy by policies that directly help and stimulate the export sector, such as tax rebates.

3.3 Summary

Following table aims to recapitulate the main conclusions of above-mentioned studies. Naturally, the estimation techniques, sample periods and examined economies in studies differ across each other and thus the results brought divergent outcomes. These might be affected also by circumstances mentioned in sub-chapter 2.3.5.

Authors	*Tools*	*Conclusion*
Dornbusch (1976)	Macroeconomic model	SR: positive devaluation ef. LR: neutral devaluation ef.
Ekholm, Moxnes, Ulltveit-Moe (2012)	Seemingly unrelated regression	LR: Negative appreciation ef.
Šimánková, Stavárek (2014)	Vector error correction model	SR: no effect LR: positive depreciation ef.
Bahmani-Oskooee, Kutan (2006)	ARDL cointegration approach	SR: negative devaluation ef. LR: positive devaluation ef.
Hahn (2007)	VAR model	LR: negative appreciation ef.
Jamil, Streissler, Kunst (2012)	AR(k)-EGARCH(p,q) models	LR: negative volatility ef.
Fang, Lai, Miller (2006)	Bivariate GARCH-M model	SR: positive depreciation ef. LR: neutral ef.
Al-Rashidi, Lahiri (2012)	Regression model	LR: positive depreciation ef., neutral appreciation ef.
Berument, Pasaogullari (2003)	VAR models	LR: negative depreciation ef.
Wang, Rogers (1995)	Equilibrium model estimation	No direct effect
Mills, Pentecost (2000)	Conditional error correction model	SR: negative appreciation ef. LR: no effect
Edwards (1985)	Equation estimation w. variance components proc.	SR: negative devaluation ef. LR: neutral effect
An, Kim, Ren (2014)	VAR model	LR: no effect or negative devaluation ef.
Upadhyaya (1999)	Autoregressive distributed lag model	SR: negative devaluation ef. LR: neutral or negative d. ef.
Chou and Chao (2001)	ARDL test procedure	SR: negative devaluation ef. LR: no effect

Table 1 Summary of Literature Review
Source: Own processing

4 Manufacturing Industry in the Czech Republic

This chapter will clarify the structure and recent development of the Czech manufacturing industry, which serves as the objective and analysing sample for this thesis. Even though the primary purpose of the CNB's intervention was the promotion of inflation and not the trade promotion, the CNB admitted that weaker exchange rate should encourage the Czech export and thus partially contribute to intended economy's recovery as well. Since the Czech export is largely formed by manufactured goods, the increased performance of the Czech manufacturers during intervention period is expected. Following subchapters will describe the Czech manufacturing industry in context of it structure, recent development and foreign trade; concluding subchapter deals with the perspective of Czech manufacture and attempts to estimate its further development in terms of foreign exchange intervention termination and the associated threats.

Manufacturing is the second most important branch of the national economy and a crucial source of gross domestic product generation. It has a long tradition within the Czech Republic and its development has demonstrated its ability to maintain its position in the competitive environment, mainly due to the entry of foreign capital and participation in regional and global value chains (Ministry of Industry and Trade, 2016). In 2015, it employed over 1 234 830 workers, which represents almost 27.3% of the economically active population in the Czech Republic. Above that, the manufacturing industry has a crucial importance for the domestic economy as a key source of gross value added (GVA)[3]. In 2015, the gross value added increased by 3.9%, while the contribution of the manufacturing industry accounted for 2.1 percentage point. This implies that approximately half of the economic growth in the country was directly associated with the development of the manufacturing industry. This ranks the Czech Republic among the EU 28 countries with the highest proportion of manufacturing industry on GVA (Ministry of Industry and Trade, 2016).

Dominant sector in the Czech manufacturing is the automotive industry, which also acts as a multiplier factor for the development of other related industries. An important part of the automotive industry is the production of auto parts and accessories, which are the substantial export commodity, and which are mounted in foreign, mostly luxury cars, heading to the world market to third countries. The following chapter concerning a structure of Czech manufacturing industry describes the progress of automotive sector including intervention period and also bring comparison of its recent performance within other Central European car producers. Among the other relevant segments belong certainly aircraft, steel, heavy machinery, ships, tools, dies clothing, chemicals, computers, consumer electronics, electrical equipment and furniture.

[3] GVA provides a dollar value of goods and services that have been produced, reduced by the cost of all inputs and raw materials which are directly assignable to that production. It measures a contribution to overall GDP.

The magnitude of manufacturing industry within the Czech economy is confirmed by data on foreign trade. In total national export, the manufactured goods represent almost 95% share (Ministry of Industry and Trade, 2016). At closer look, dominant component of the Czech export are apparently motor vehicles with share over 50%, followed by computers, machinery and electrical equipment. From a territorial point of view, the export of manufacturing commodities aim largely to Germany (32%), through which the commodity is part of the Czech part of German exports to third countries

Nowadays, the manufacturing sector also plays important role as a carrier of technology development, knowledge and jobs. However, the high level of integration and connection to foreign trade make the Czech manufacturing branches very sensitive to exchange rate shocks.

4.1 Structure of Manufacturing Industry

Manufacturing industry refers to such industry, where products from raw materials are transformed into finished or semi-finished goods with use of manual labor or machinery equipment, usually performed systematically with a division of labor in manufacturing processes. The finite products may either serve as a finished good for sale to purchasers or as intermediate goods used in further production process. Under a more limited meaning, manufacturing signifies a production or assembly of components into finished products on a fairly large scale.

A composition of the Czech manufacturing industry is best illustrated in the CZ-NACE classification[4], specifically in section "C". Annex 1 shows all the 24 subcategories of economic activities which form the Czech manufacture. The most fundamental component of the manufacturing segment important for the Czech economy is definitely the automotive industry (CZ-NACE 29 Manufacture of motor vehicles). In recent years, its representation within the manufacturing industry is steadily increasing; its sales (Figure 11), number of employees (Figure 10) and export (Figure 9) grow and start to reach the pre-crisis values. In 2015, the branch's share on national export was approximately one-third and it contributed to employment by 14% (Ministry of Industry and Trade, 2015). Investment in the automotive industry represents almost 20% of all investments in the manufacturing industry. As below figures show, since the start of foreign exchange intervention in 2013, both the amount of export and turnover were growing rapidly. To what extend acted the weaker Czech crown is subject of this thesis.

[4] NACE is a Classification of Economic Activities in the European Community used by European Union since 1970; CZ-NACE is national version of NACE.

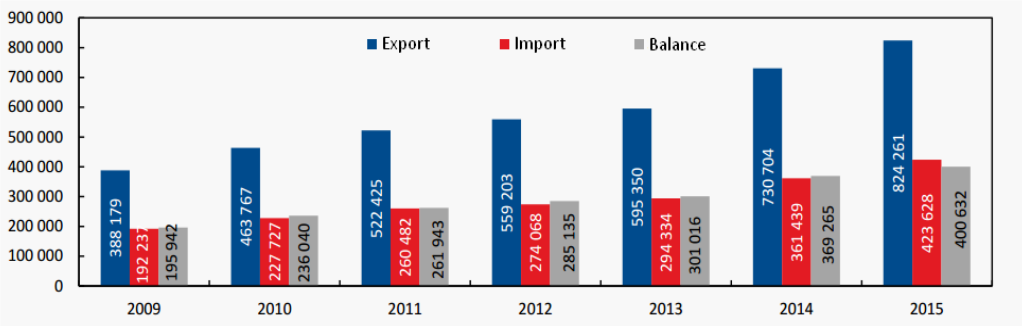


Figure 9 Exports, imports and balance of foreign trade with the products according to CZ-CPA 29 (mil. CZK)

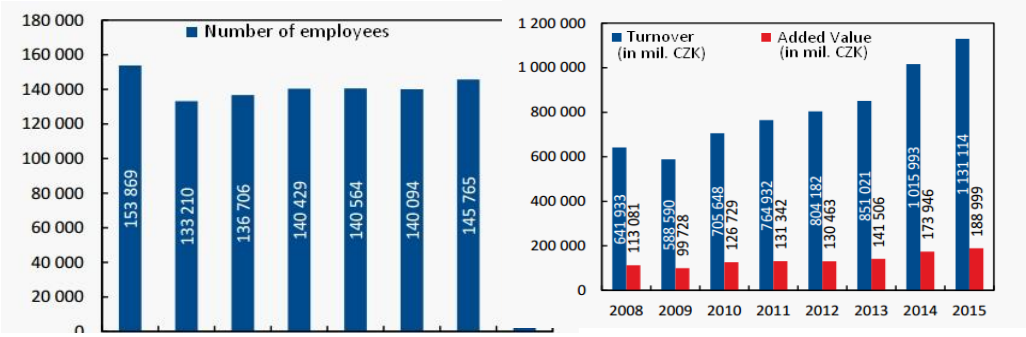


Figure 10 (left) Number of employees in CZ-NACE-29
Figure 11 (right) Yearly turnover and added value for CZ-NACE-29
All adapted from: Panorama of the manufacturing industry of the Czech Republic, Ministry of Industry and Trade (2015)

Moreover, the Czech automotive industry belongs among the most important automotive sectors within Central Europe. A broader comparison brings the following Figure 12, where is obvious that the Czech automotive manufacture prevails over the Polish, Slovak and Romanian in terms of annual production of passenger cars.

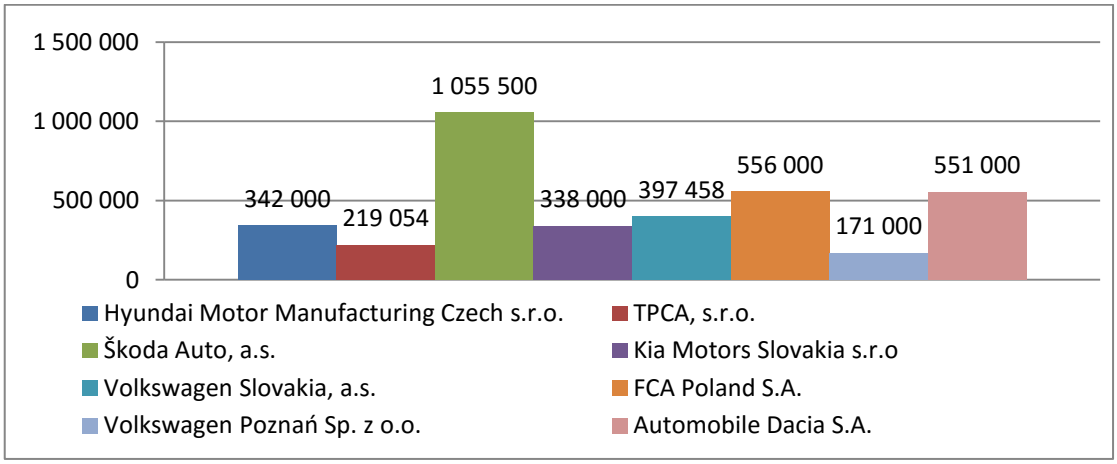


Figure 12 Passenger cars production in 2015
Source of data: Panorama of the manufacturing industry of the Czech Republic, Ministry of Industry and Trade (2015), own processing

4.2 Development of Manufacturing Industry

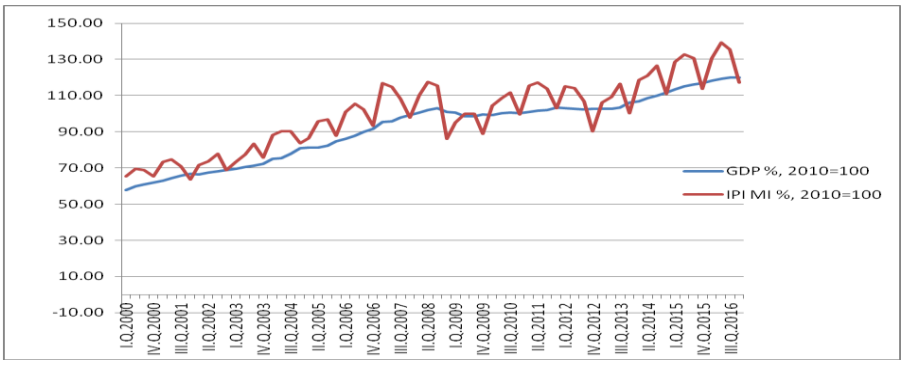
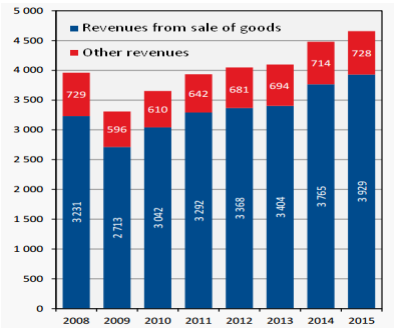


Figure 13 Development of GDP and IPI for manufacturing industry in 2000-2016, (%, 2010=100)
Source of data: the Czech National Bank – ARAD database number 28788/30872 and 21766/3540, own processing



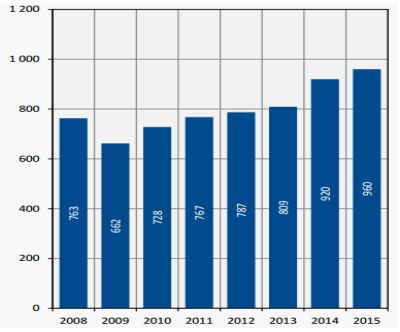


Figure 14 (left) Revenues of manufacturing industry in 2008-2015
Figure 15 (right) Development of added value of manufactured commodities in 2008-2015
Both adapted from: Panorama of the manufacturing industry of the Czech Republic, Ministry of Industry and Trade (2015)

The overall performance of the manufacturing industry may be properly shown on development of the industrial production index[5], as one of the major economic indicator. An important milestone for Czech manufacturers occurred in 2004, when MI's increased output was caused by the continuing high performance of private companies under foreign control and by many new production capacities that were put into operation. Substantial contribution had also the accession of the Czech Republic to the EU, which triggered a wave of interests from foreign investors and thus raised the investment activity, mainly FDI (Foreign Direct Investment) inflows. The entry contributed to relatively stable economic environment likewise. Last but not least, the Czech manufacturing industry benefited from the access to the EU Single market and the associated breakdowns of trade barriers. Consequently, the foreign trade with manufactured commodities was also highly developing.

Relatively favorable economic climate until 2008 resulted in the dynamic development of the Czech manufacturing industry, mainly due to faster real growth of gross value added in industry compared to services (see Figure 15). Even then, the

[5] IPI measures the amount of output from the manufacturing industries, i.e. CZ-NACE 10 to 33.

main leaders of MI were the production of motor vehicles (CZ-NACE 29) and the manufacture of computers, electronic and optical devices and equipment (CZ-NACE 26). However, in the second half of 2008 the so far favorable development began to show signs of economic recession, which fully hit the manufacturing branches in 2009 (see Figure 14). A similar trend was also recorded in most EU countries (see Figure 17), when the EU's industrial production fell by almost 14%, similarly as in Czech Republic (Ministry of Industry and Trade, 2015). In time of economic crisis, the existing segment's leader – the automotive industry (CZ-NACE-29) stepped away from its leading position, while CZ-NACE 26 still remained in the foreground. The understandable stagnation of FDI inflows in course of crisis decelerated the MI's development just as well. Thanks to the revival of economic growth in the EU and the improvement in frequency of international trade, a slight recovery in the Czech manufacturing industry occurred in 2010. Gross value added, sector's revenues, FDI and industrial performance indicators started to achieve the pre-crisis values promisingly (see Figure 13).

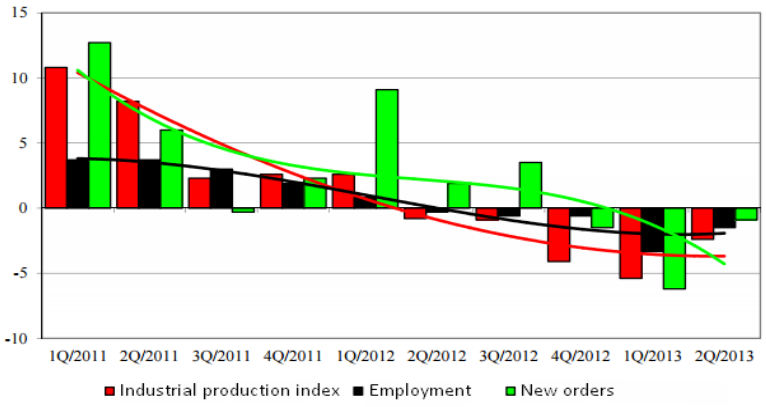


Figure 16 Development of IPI, employment and new orders in the Czech man. industry, y-o-y (%)
Adapted from: Panorama of the manufacturing industry of the Czech Republic, Ministry of Industry and Trade (2013)

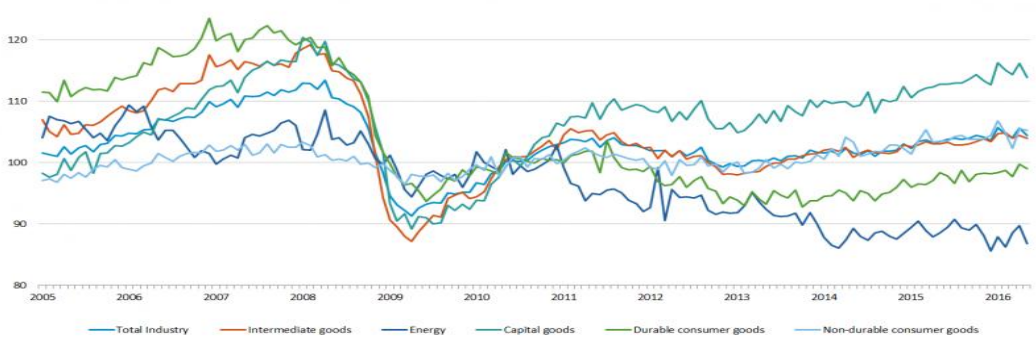


Figure 17 EU-28 Industrial production total
Adapted from: Eurostat (2017)

After the first phase of the recession in 2009 and subsequent very moderate rebound (or stagnation) in 2010-2011, the Czech economy fell in the second quarter of 2012 into a new recession and the unemployment rate fluctuated around 7% (see Figure 16). That time, the Czech economy faced with the consequences of the longest re-

cession in its history. Further performance of the Czech manufacturing branches slightly decreased in 2012, especially due to weaker economies of EU's member states and their stuck industry growth, as shown in Figure 17. Furthermore, a weak foreign demand negatively affected the domestic one and the export lagged as well, which slowed the recovery of Czech economy after the crisis even more. The volume of new export orders was declining at the fastest pace since July 2009. The view on the further improvement of Czech economy was not optimistic; the risk of deflation was present enough so that in 2013, the Czech National Bank decided to intervene on the foreign exchange market due to non-fulfillment of the inflation target. The aim was to weaken the Czech crown to around 27 crown per euro so long and in such volumes that will be needed to achieve the inflation target. Coincidentally, the same tactics as the CNB chose the European Central Bank (ECB) too and surprisingly lowered its base interest rate by a quarter percentage point to a new record low of 0.25 percent. Thus, the weaker euro partly balanced the fall of the crown against the euro. However, considering the positive results of trade balance in 2012, this step of CNB was not necessary. Although the interventions have not been primarily intended to support exports, of course, this decision was welcomed by the Czech exporters.

The further sector activity continued to grow since 2014, when after two years of decline it has returned to growth period. According to Ministry of Industry and Trade (2015), its favorable development is credited with not only the growth in foreign orders, but also increasing household consumption reflecting the decline in unemployment, real wage growth and low inflation. How important role has played the foreign exchange intervention and the associated weak Czech crown on the manufacturing industry will be analyzed in the practical part of thesis.

4.3 Manufacturing Industry and Foreign Trade

The essential role of manufacturing industry within international trade is predominant for the Czech economy and welfare. The Czech Republic has always been a small open economy with heavily export-oriented industries. The industry accounts for roughly a third of Czech GDP, which is among the highest in EU. As was already mentioned, the partial goal of CNB's foreign exchange intervention is to support Czech export, which is mainly formed by manufactured commodities. The volatility of the Czech crown against the euro, which in earlier years reached to an average of 10%, has been lowest in its history since keeping the exchange rate (Association of Exporters, 2015). This brings is a huge benefit to both exporters and importers, since they could provide accurate planning of costs and revenues within their business. As to 2016, the available statistical data and calculations of Association of Exporters shows that current interventions of CNB have brought to the Czech export and economy clearly benefits. This conclusion will be questioned in the analytical part of the thesis.

Foreign trade development in terms of manufacturing production is best presented in the concept of transboundary statistics by commodities, i.e. by CZ-CPA[6], unlike from economic activities, which are reported by CZ-NACE. Indeed, the manufactured goods have formed a crucial part of Czech export for many years. In 2015, when Czech foreign trade was extremely successful, 95% of national export was actually made up by manufactured goods. On the other hand, the import of manufactured goods then represented around 90% of its total value. Figure 18 shows the balances between import and export of CZ-CPA manufactured goods (MI) mapped since 2008 to 2015. It is visible that in these years, the balance of manufactured goods in foreign trade was positive.

Concerning the composition of foreign trade regarding the CZ-CPA commodities in 2015, the most imported commodities were computers, motor vehicles, chemicals and metals, which also exhibited negative balance within the foreign trade. On the contrary, manufactured goods with the largest positive balance were motor vehicles, followed by machinery, electrical equipment and metal constructions.

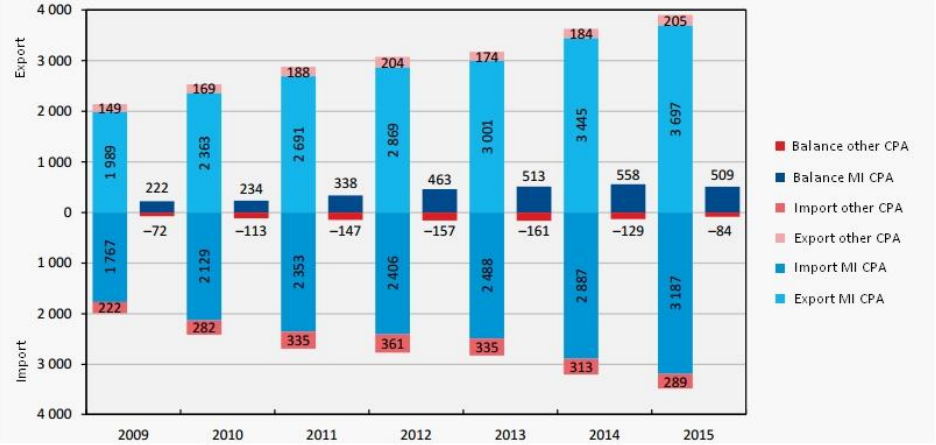


Figure 18 Export, import, and balance 2008-2015 (mld. CZK)
Adapted from: Panorama of the manufacturing industry of the Czech Republic, Ministry of Industry and Trade, 2015

From the territorial point of view, the position of the most important trading partner is steadily held by Germany - the most essential business destination for Czech export. In 2015, the majority of the Czech export has traditionally been realized with advanced market economies (90.8%), which largely constituted from member States of the European Union. In that year, the manufacture commodities were exported mainly to Germany (32%), through which is the part of the commodities exported to third countries as well. Germany is followed by other countries, especially neighboring Slovakia (8%), Poland (6%), and Great Britain, (5%), France (5%), Italy (4%) and

[6] The Statistical Classification of Products by Activity (CPA) is the classification of products (goods and services) at the level of the European Union. The subject of CPA is a production, i.e. the result of economic activities. CZ-CPA is used in the Czech Republic since 2008.

neighboring Austria (4%). These exports territories according to percentage shares are depicted in Figure 19 below.

Figure 19 Export territories for manufactured commodities in 2015
Adapted from: Panorama of the manufacturing industry of the Czech Republic, Ministry of Industry and Trade, 2015

Mentioned shares on exports affirm that the Czech Republic is dependent on the cooperation with European Union and the economic situation in these countries strongly influences the performance of Czech economy. This dependency is shown in Figure 20, where the industrial production of the Czech Republic, Germany and the EU is depicted quarterly since 2011 to 2013. Undoubtedly, the Czech economy is relatively heavily dependent on foreign demand as well, which further strengthens the indirect effects of exports on domestic exporters. Thus, the favourable export development after the CNB's intervention in 2013 may not only be credited with weaker crown, but also with positive development in other EU countries, which figure as export territories for the Czech manufacture.

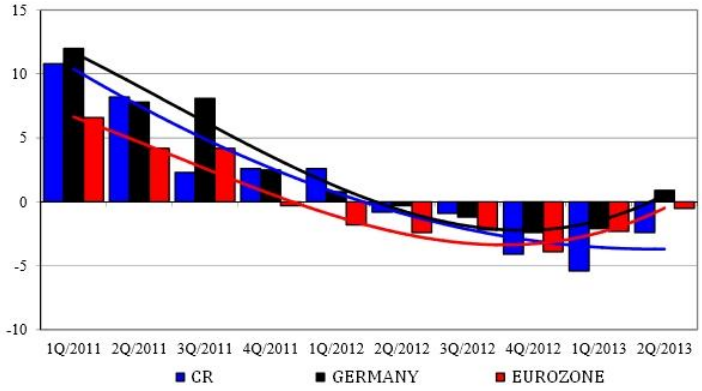


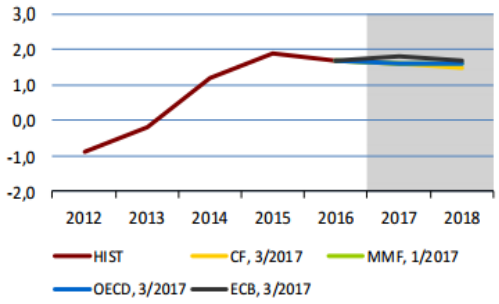
Figure 20 Development of industrial production in the Czech Republic, Germany and Eurozone including trend (y-o-y change, %)
Adapted from: Panorama of the manufacturing industry of the Czech Republic, Ministry of Industry and Trade, 2014

4.4 Perspective of Manufacturing Industry

The relatively high growth rate of exports occurs primarily due to long-term favorable situation on the European car market, which was further supported by weakened crown maintaining the competitiveness of domestic producers. Along with the low prices of imported raw materials, which compress their import prices and thereby dampen the dynamics of import's growth, provide favorable results consisting of faster growth in exports than imports and thus further growth in the trade balance. The long-term positive results of Czech manufacturing industry confirms significant competitiveness of Czech companies and the ability to maintain a position in foreign markets, particularly in demanding European markets. Simultaneously, the foreign orders for industrial enterprises are still growing and raise the expectations that the Czech exports will continue to expand in the rest of year 2017. The German economy still remains in good condition (Figure 22), which in turn positively affects the development of demand for Czech manufactured commodities mainly intended to export. According to Ministry of Industry and Trade (2016), the effect of artificially maintained weakening of Czech crown has not vanished so far and yet still has a positive effect on the Czech export as well as on the Czech manufacturers. This thesis will reveal whether the positive development in manufactured goods export was encouraged by currency depreciation and therefore whether the expectations of the CNB have been fulfilled.

Furthermore, the Czech manufacturers will have to cope with a stronger exchange rate after scheduled termination of intervention in the middle of 2017[7] though. So far, the CNB secured the fixed exchange rate around 27 CZK/EUR and need of hedging was minimal for the manufacturers. After the termination, they will need to succeed in a competitive environment without crutches made by the Czech National Bank in the form of a depreciated currency. The long-lasting issue for the Czech manufacturing industry has been also competitive Chinese production, which in fact impedes the prices and worsens the situation on international markets for Czech manufactures. An acute shortage of employees in medium-skill positions on the domestic labor market (see Figure 24) and too slow system of granting work visas practically disabling to attract workers from abroad may slow down the sector's progression likewise. Possible risk for the development of foreign trade as a whole, especially in terms of cooperative ties represents a slowing economy in China (see Figure 23), as well as signals of weakening global economic growth, deflationary threat in the Eurozone (Figure 21), but also the migration crisis. Although the data indicate manufacturing industry's overall healing and recovery, the Czech industry is strongly dependent on the external environment. Future developments, particularly the in the EU economies will be decisive for further condition of the Czech manufacture.

[7] The CNB' foreign exchange interventions ended on April 6 2017



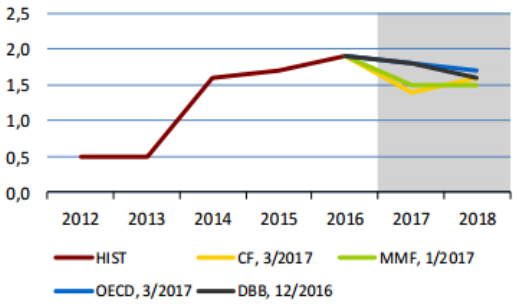
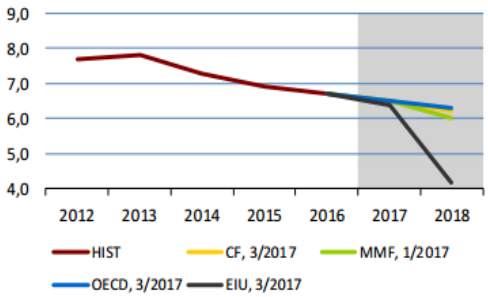


Figure 21 (left) GDP growth of Eurozone, %
Figure 22 (right) GDP growth of Germany, %
Both adapted from: Global Economic Outlook, ČNB (March 2017)



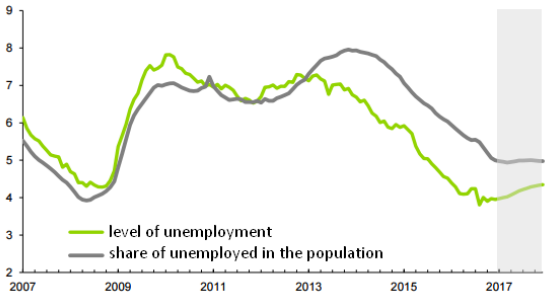


Figure 23 (left) GDP growth of China, %
Adapted from: Global Economic Outlook, ČNB (March 2017)
Figure 24 (right) Unemployment in the Czech Republic, %
Adapted from: Czech economic outlook for 2017, Deloitte (2016)

5 Data and Methods

The text below will clarify the methods used to detect the relationship between the CNB's foreign exchange intervention on manufacturing industry employing the below-described data. The development of time series will be illustrated by time series plots, with particular attention to potential structural breaks associated with the intervention period. The structural breaks represented as dummy variables and interaction variables with deterministic time trend will be estimated through ARIMA model framework to detect the potential changes to the intercept and deterministic time trend of a series and the significance of two structural breaks, with a special attention to the one representing the CNB's foreign exchange intervention period. The main focus of the ARIMA framework is to investigate whether the changes in individual time series are noticeable with onset of the intervention period. As time series are often characterized by high degree of persistence, the order of integration or the stationarity of each series will be determined by applying Augmented Dickey-Fuller (ADF, 1979) and Kwiatkowski-Phillips Schmidt-Shin (KPSS, 1992) unit root tests. In case the order of integration of the series is the same, it is possible that these series are cointegrated. The cointegration will be tested using Johansen cointegration test (1990), which will detect whether the examined series are mutually cointegrated. The number of cointegrating relationships among the variables will create a base for VEC model estimation. Employing the VECM will enable to identify what variables adjust to the cointegration disequilibrium, as well as estimate the impulse response functions. Consequently the VAR model is estimated to test for Granger causality (1969) regarding the exchange rate.

The aforementioned methods and data are closely described in following subchapters. All the econometric and statistical tests were performed using Gretl software with considering 5% level of significance throughout.

5.1 Data

The selection of the variables included in the VAR model is derived from the model of Hahn (2007), who focused on a scenario, i.e. the impact of exchange rate volatility on industrial activity in Euro area. As some authors point out, the standard exchange rate cannot indicate the impact sufficiently (see e.g. Al-Rashidi and Lahiri, 2012). The exchange rate in the following models is demonstrated by the real effective exchange rate of the Czech crown (*ex*). In order to manage for indirect channels of influence, the models will include control variables such as euro area industrial production index (IPI_t) and price variables, represented by the real GDP (y_t), inflation ($hicp_t$), and short term interest rate (i_t) in the Czech Republic. The interest rate is defined as the official discount rate set by the CNB. The sample period of the sector models is selected according to data availability of the sector variables in order to assure the highest possible precision of the estimates.

Data cover the period from I.Q 2000 to I.Q /2016 with quarterly frequency, provided by the Czech National Bank, especially from ARAD[8] and the European Central Bank, mainly its Statistical Data Warehouse (SDW). Majority of model's variables were already seasonally adjusted from their source, however $hicp_t$ and s_t had to be additionally adjusted using TRAMO analysis (Time series Regression with ARIMA noise, Missing values and Outliers), see Annex 2. Following table summarizes the data specification, type of their measurement and data source.

Variable	*Type of measurement*	*Source and Series Key*
IPI_t	IPI of Euro area 19 (fixed composition); Total Industry (excl. construction); Working day and seasonally adjusted, 2010=100; Average of observations through period	SDW *(STS.M.I8.Y.PROD.NS0020.4.000)*
ex_t	REER of CZK in industrial producer prices deflated by foreign trade turnover in groups 5-8 SITC[9]	ČNB, ARAD *(15192/1365)*
y_t	Expenses on GDP (%); Seasonally adjusted; Constant prices	ČNB, ARAD *(28832/31047)*
$hicp_t$	2015 = 100; Average of observations through period; Neither seasonally nor working day adjusted	SDW *(ICP.M.CZ.N.000000.4.INX)*
s_t	IPI for categories CZ-NACE C; %, 2010=100	ČNB, ARAD *(15192/1365)*
i_t	Official discount rate of CNB (%); Monthly average	ČNB, ARAD *(108/1062)*

Table 2 Data Measurement and Sources
Source: own processing

5.2 Methods

Time series plots are used to identify whether any structural break appears in the development of each variable. These structural breaks will be formally tested by the inclusion of dummy and interaction variables in the ARIMA model in order to detect the changes in the mean and deterministic time trend in the respective time series. Then, the order of integration or the stationarity of each series will be identified using ADF and KPSS unit root tests. To test for the cointegration, the Johansen cointegration test will be employed in its both versions; i.e. with restricted and unrestricted constant. On

[8] ARAD is a public database, constituting a part of the Czech National Bank's information service. It is a unified system consisting time series of aggregated data for individual statistics and financial market areas.

[9] SITC 5-8 groups include Chemicals and related products, Manufactured goods classified chiefly by material, Machinery and transport equipment and Miscellaneous manufactured articles.

the basis of detection of cointegrating relationships, the VEC model together with impulse response function will be constructed. In order to capture also the linear interdependencies among the examined time series, the VAR model with impulse response function and Granger causality will be employed likewise.

The employed methods are described in more details in the following subchapters.

5.2.1 Time Series Plots

Initially, look at the time series plotted in figures will provide a rough assessment of each variable's development after launch of CNB's foreign exchange intervention at the end of 2013, especially whether any variable reacted volatile after this launch. Additionally, each time series plot is supplied with Hodrick–Prescott filter (Hodrick and Prescott, 1997) in order to remove the time series' cyclical component from the raw data, and thus see the long-term trend of each time series – in particular, to help in visualizing the potential change in the trend component of the series beginning with the period of CNB's interventions. Employing the Hodrick–Prescott filter (H-P filter) will help to obtain a smoothed-curve represented by a time series more sensitive to long-term fluctuations rather than to short-term through the adjustment of the sensitivity of trend.

5.2.2 Integrated Process ARIMA(*p, d, q*)

From the time series plots it is visible at a first sight which variable experienced unexpected decline or rise in its development. These obvious jumps represent important phenomenon that should be considered to be further analyzed. Within a time-series application, the subsamples are typically defined by time (Verbeek, 2014). For example, the coefficients in the model may develop differently before and after a major change in macroeconomic policy. Such situation with the change in regression coefficients is referred to a "structural break". Employing the integrated autoregression process of moving averages ARIMA(*p, d, q*) will help to determine whether the time trend or structural break is present in the time series. Considering the variables development depicted in time series plots, as such structural breaks may be indeed considered the financial crisis in 2008 as well as the CNB's foreign exchange intervention at the end of 2013. In order to permit the possibility of structural breaks in time series, two dummies representing the intervention period (*D_intervention*) and crisis period (*D_crisis*) were constructed. Moreover, to allow the changes of the deterministic trend, two new interaction variables *Dinttime* and *Dcristime* were added with purpose to capture the change in the deterministic trend after a change of dummy to 1. According to Verbeek (2004), the interacting dummy variables with other explanatory variables present a useful instrument to permit the marginal effects in the model to be different across subsamples.

The time trend or structural break is present in the examined time series if the p-value associated with the significane test of the particular dummy, interaction variable or time trend is lower than the 5% significance level. The significance of aforementioned dummy and interaction variables will be estimated in ARIMA model framework, it will hence make sense to include the trend and constant into following unit roots test.

5.2.3 Testing for Unit Roots

With economic time series it is crucial to distinguish between stationary and non-stationary time series. Stationary time series are often referred to time series with short memory, whereas non-stationary time series are referred to series with long memory (Arlt, 1998). With stationary time series, the impact of the shock of the past period is gradually disappearing over the time, while the non-stationary series is being constantly reflected by the shock. Differences in the nature of these time series are caused by the fundamental differences in their generating processes.

The cointegration analysis serves for a purpose of analysis of non-stationary variables or time series. However, before the Johansen cointegration analysis itself is performed, the time series order of integration need to be determined. The order of integration corresponds to the number of unit roots present in time series (Adamec, 2014). Order of non-stationary process integration is consequently determined by the number of differencing which induce drop in variance of series. Since the data were not stationary at level, the first differences of each variable were determined in order to gain the stationarity. To verify the stationarity, the data after first order differences were questioned by so called unit root tests, especially ADF and KPSS statistical tests. Testing the unit roots serves to define the type of random variable, i.e. whether the variable is a:

- stationary at level, i.e. I (0);
- non-stationary at level, but stationary after first order differences, i.e. I (1);
- non-stationary at level, but stationary after second order difference, i.e. I (2).

The assumption that the variables are stationary, i.e. have no unit root, is crucial for the properties of standard estimation and testing procedures (Verbeek, 2004).

In the first instance the Augmented Dickey-Fuller test for unit root, especially its version without constant is employed. Under the ADF test, the null hypothesis assumes that time series has unit root, while the alternative assumes no unit root in time series. Both the null and alternative hypothesis of the ADF test is defined as:

$$H_0: \textit{time series has unit root}$$
$$H_1: \textit{time series has no unit root}$$

It holds that if p-value is lower than the chosen level of significance, the null hypothesis is rejected and time series are stationary (Adamec, 2014).

Another test employed to detect the unit roots is the KPSS test (Kwiatkowski, Phillips, Schmidt and Shin, 1992), in which the null hypothesis is opposite to that in the ADF test: under the null hypothesis, the questioned series has no unit root; the alternative hypothesis assumes unit root. Within KPSS test, it holds that the null hypothesis is rejected if the test-statistics exceeds the critical value (Adamec, 2014). Both hypotheses are defined below:

$$H_0: \textit{time series has no unit root}$$
$$H_1: \textit{time series has unit root}$$

The obtained results of both unit roots test should indicate whether there is stationary of data already at the first order of integration I (1), or whether there is need to perform further differences of data. The finding about data stationarity will be important for the following Johansen cointegration analysis.

5.2.4 Johansen Cointegration Test

The previous procedures regarding the unit root tests prepared grounds for the following cointegration test, which will be employed to determine the impact of exchange rate interventions on manufacturing industrial production. The cointegration test enables to detect if any developments can induce permanent changes in the individual variable. Cointegration is revealed if among the individual variables a long-run equilibrium relation tying these variables together occurs, which is represented by their linear combination.

The two Johansen tests for cointegration are used to establish the rank of number of cointegrating vectors. These are represented by the "Lmax" test (also known as maximum eigenvalue test), dealing with hypotheses on individual eigenvalues, and the "trace" test for joint hypotheses. Moreover, both of these tests enable to perform the cointegration testing including a "restricted constant" or "unrestricted constant". As a default, the test including an "unrestricted constant" is applied, since it allows for the presence of a trend in the levels of the endogenous variables as well as a non-zero intercept in the cointegrating relations. Moreover, to increase the precision of the Johansen cointegration test estimate, the exogenous variables represented by interacting dummies will be included.

As the cointegration assumes the presence of the non-stationary time series, the Johansen cointegration test will work with the raw data, i.e. data in level before the first differences. Below, each of the two employed cointegration tests is described in terms of its hypotheses and rule of rejection of the null hypothesis.

- **Trace Test**

The purpose of trace test is to examine the number of linear combinations, denoted as K to be equal to a given value, denoted as K_0, and the alternative hypothesis for K to be greater than K_0.

$$H_0: K=K_0$$
$$H_1: K > K_0$$

- **Lmax test**

The Lmax test proves whether the largest eigenvalue is zero relative to the alternative that the next largest eigenvalue is zero (Dwyer, 2015). The null hypothesis assumes that number of positive eigenvalues is exactly r (row), while the alternative assumes that there are $r+1$ positive eigenvalues. The cointegration rank is then equivalent to the value at which the null hypothesis is not rejected. The Lmax hypotheses are following:

$$H_0: K= K_0$$
$$H_1: K = K_0+1$$

The rule rejection for the Lmax test is the same as for the Trace test, i.e. the null hypothesis is rejected if the p-value is larger than the critical value, i.e. level of significance. To establish the existence of cointegration in a tested set of time series, it is preferred to reject the tests null hypotheses of both tests.

The number of detected co-integrated relations will be decisive for further process of analyzing, especially the following Vector Error Correction Model. Literature suggest that in case the Johansen cointegration test will detect no cointegration relationships among tested time series, the Vector Autoregressive model (VAR) would seem as suitable instrument for subsequent analysis. In order to cover as many methods of detection as possible, both the VEC model and VAR model will be further employed.

5.2.5 Vector Error Correction Model

A VEC model belongs to a group of multiple time series models mainly applied on data where the examined variables have a long-run stochastic trend, i.e. are cointegrated. Constructing the VEC model is useful especially for estimation both short-term and long-term effects of one time series on another. The VECM is based on error-correction, which is related to the fact that the last-periods deviation from a long-run equilibrium affects its short-run dynamics. Therefore, the VECM is able to directly estimate the speed at which a dependent (endogenous) variable returns to equilibrium after a change, i.e. structural break in other variables.

The VEC model is basically a variant of VAR model with difference variables and with error correction terms. The Gretl software enables the VEC model estimation based on method of maximum likelihood. Choosing of a lag order will be realized in the

same way as in the following VAR model, i.e. based on Akaike criterion (AIC), Schwarz Bayesian criterion (BIC) and Hannan-Quinn criterion (HQC). Since the Akaike criterion is often characterized by over-evaluating the lag orders, the BIC and HQC will be rather preferred to evaluate the lag order. The constructed VEC model will operate with the number of cointegration relationships obtained from the Johansen cointegration test and will include 5 exogenous variables, i.e. dummy variables, interaction variables and time trend variable in order to reflect the structural breaks.

In the framework of VEC model, the impulse response functions (IRF) of variables to real effective exchange rate will be estimated. The IRF enables to describe the development of a variable of interest over a specified time horizon after a shock in another variable. Under the given VEC model, the IRF is based on tracing the marginal effect of a shock (i.e. structural break) in exchange rate variable through the system by setting one component of this variable to one and all other components to zero and then evaluating the response of the examined variables to such impulse as time goes by. Applying the impulse response functions will provide another method of intervention impact detection.

Even though both the VEC model and VAR model offers employing of Granger causality, it is hard to perform it within VEC model due to presence of error correction terms. Therefore, the Granger causality will be identified based on VAR model.

5.2.6 Vector Autoregression Model

Vector autoregression, especially the impulse response functions and Granger causality for industrial output in manufacturing sectors will be employed to identify how the industrial output responds to a shock in the exchange rate and what extend of industrial output can be explained by the real exchange rate. The vector autoregressive model (VAR model) is a general framework which enables to describe the dynamic interrelationship among stationary variables. The VAR model is able to capture the linear interdependencies among the stationary time series by permitting for more than one evolving variable. All variables enter the VAR model in the same way, i.e. each equation of variable explains its development or evolution as a function of its own lag, lag of other variables and error term in the system. Thus, the equations specified in a VAR model describe the evolution of each variable.

To construct the VAR model, it is necessary to have stationary time series and lag order. As the unit root tests proved, the data are stationary in their differences, i.e. I (1) and the lag order is already identified from the Vector Error Correction Model (lag order 2). Since the thesis focuses on the analysis of effect of foreign ex. intervention on the economy's output, more specifically manufacturing sector, the ordering of the exchange rate variable with respect other variables is of most importance. Even though the literature does not provide any clear guidance regarding the exchange rate order, Hahn's model (2007) proved that once the ordering of the exchange rate variable is decided, the relative order of the other variables is not relevant for the purpose of such

analysis. Therefore, the vector of endogenous variables included in the model may then be represented by:

$$x_t = (IPI_t, ex_t, y_{t,} hicp_t, s_t, i_t) \quad (1)$$

Besides the impulse response functions, the Granger causality (1969) will be estimated from the VAR model likewise. Granger causality or precedence refers to a case where one variable's time series predictably and consistently before another variable does. Distributed lag models with lagged regressor variables may prove the existence and direction of causal relationships between economic variables in time (Adamec, 2014). In the VAR framework it is therefore possible to investigate which variable cause other to move with certain delay in time by employing the Granger causality concept, which is based on fact that events in the past affect the events in the future, however not vice versa.

The Granger causality test basically consists of two-equation test examining two time series X_t and Y_t. The first regression equation tests just one direction of causal relationship between these two time series, then the F-test is used to verify the null hypothesis whether the alpha coefficients are simultaneously zero. Below are described the hypotheses for Granger causality test (Adamec, 2014):

$$H_0: \alpha_1 = \alpha_2 = \ldots = \alpha_P = 0$$
$$H_1: non\ H_0$$

The rule of rejection is that when the F-statistics is larger than p-value, the null hypothesis of Granger causality test is rejected. If the null hypothesis is rejected in first equation and not rejected in the second, then the X_t Granger causes Y_t. On the other hand, if the null hypothesis fail to be rejected in a first equation and is rejected in the second, then Y_t. Granger causes X_t. In case none of F-tests rejects the null hypothesis, Granger causal relationship does not exist, indicating so called causal independence.

6 Empirical Results

Even though the primary purpose of the foreign exchange interventions was the inflation encouragement, the CNB expected positive effect of interventions also on exporters, which are mainly formed by manufacturers. The following results of above-described econometric tests and techniques will explain and identify the extent to which the expectations of the CNB about the intervention were fulfilled.

6.1 Time Series Plot

As can be seen from the figures below, the Czech manufacturing industry (*s_sa)* shows a noticeable improvement since 2014; also the H-P filter records a growing trend. Accordingly, a similar trend occurs also within the GDP (*y*), whose the development improved since 2014 likewise. Both of these developments are consistent with the expectations of the CNB, which on the basis of unfavourable economic situation in 2013 launched the foreign exchange intervention with aim to accelerate the inflation, leading to stimulation of the economy's output. These plausible developments might be or might not be directly associated with the positive effect of the CNB's interventions; this will be proven by following econometric methods. However, looking at the figure describing the development of the industrial production index in the Eurozone countries (*IPI*), the growing trend there since 2014 may be recorded alike. This may suggest that the growing trend of the manufacturing industry performance since 2014 occurred across the European Union as a whole, which may be caused by for example higher domestic demand in the EU countries.

What is more obvious from all of these figures is that in 2008, when the financial crises hit the European economies, the IPI of Eurozone (*IPI*) as well as the IPI of Czech manufacturing branch (*s_sa*) and GDP (*y*) experienced significant declines in their performances. These unexpected shifts in time series referred to the so called "structural breaks" and their detection in the analyzed time series may explain further development of such variables. Therefore, as a next step, the ARIMA process for each variable will be constructed in order to verify whether the structural breaks, i.e. the financial crisis in 2008 and CNB's foreign exchange intervention in 2013, affected the subsequent variable's development after the shock (break).

The structural breaks, which are highlighted in following plots by lines, will be represented by the dummy variables in the following ARIMA model. More specifically, the full line pointing out the shock in a form of financial crisis will be presented by the *D_crisis* dummy covering period since I.Q 2008. The *D_intervention* dummy illustrates the break in a shape of the foreign exchange intervention covering the period since III.Q 2013, illustrated by dashed line.

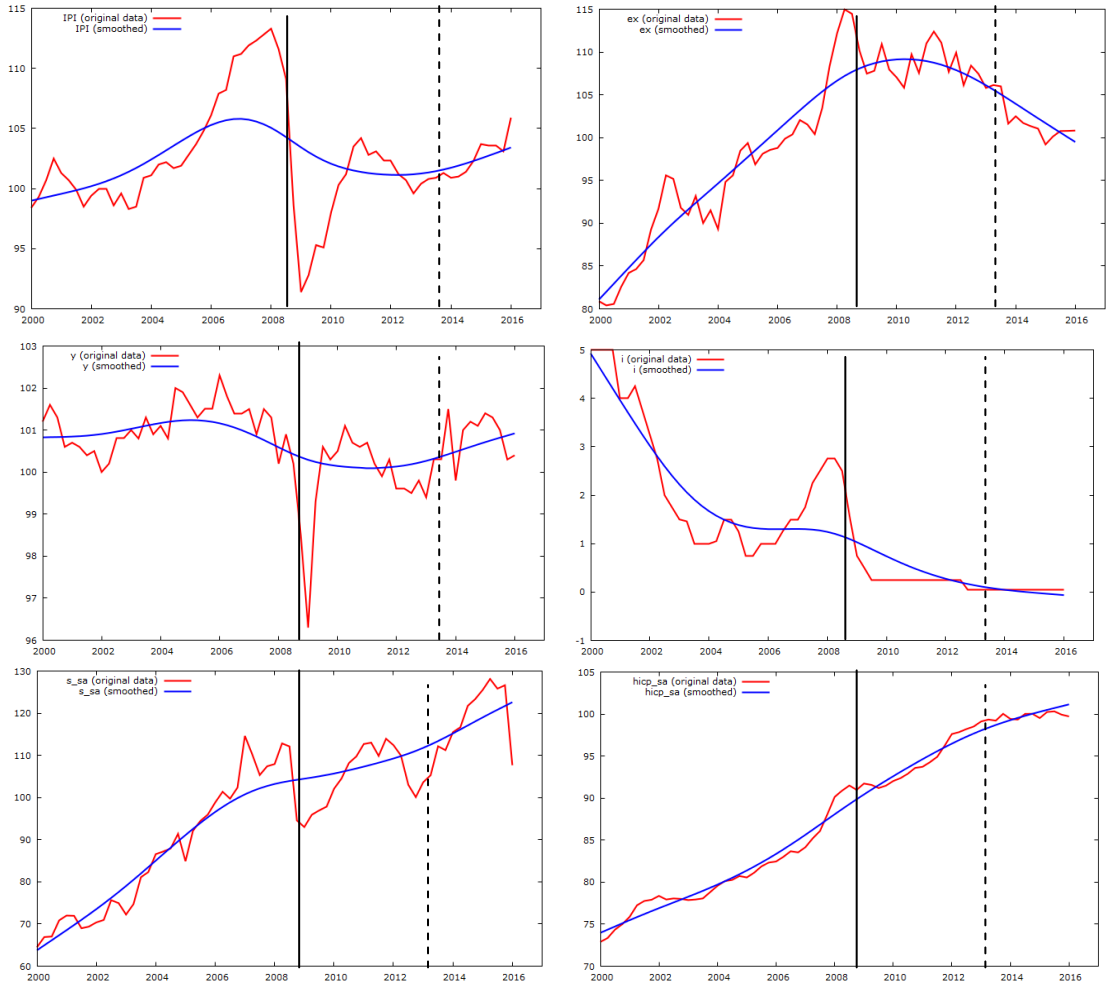


Figure 25 Time series plots of analyzed time series including H–P filter
Source: Gretl, own processing

6.2 ARIMA(*p, d, q*) Integrated Process

The table below summarizes the results of the ARIMA(*p, d, q*) integrated process for the analyzed time series. As can be seen from the p-values in the brackets below the value of coefficients, the time trend is significant for all the variables apart from the GDP (*y*). This implies that the unit root test in version including trend and constant should be employed in further examining of time series stationarity.

Both the intervention dummy (*D_intervention*) representing the period since III.Q 2013 and corresponding interaction variable *Dinttime* are significant only for IPI of Eurozone (*IPI*) and the inflation in the Czech Republic (*hicp_sa*). Most likely the industrial production index of euro area cannot be affected by the CNB's foreign intervention, so the significance of intervention dummy for this control variable can be assumed to be only weakly linked. However, for the Czech National Bank, the primary purpose of the foreign exchange interventions was the encouragement of inflation in the Czech economy. This is in accordance with obtained result – the intervention dummy and intervention interaction variable proved as significant for the *hicp_sa*, in-

dicating that the inflation is affected by structural break in a form of CNB's intervention. Generally, more crucial impact on variables compared to intervention dummies has the crisis dummy (*D_crisis*) and corresponding interaction variable *Dcristime*, representing the financial crisis in 2008. It proved significant for the IPI of Eurozone (*IPI*), correspondingly for real effective exchange rate (*ex*) and for the Czech manufacturing industry (*s_sa*).

Based on these particular results can be assumed that the Czech manufacturing industry, as the main objective of the analysis, does not react on the structural break in a form of weaker Czech crown caused by CNB's foreign exchange interventions, and thus does not meet the secondary expectations of the central bank. The Czech manufacture appears to be rather sensitive on economic events associated with financial crisis in 2008, which affected the sector's performance significantly compared to foreign exchange interventions. On the other hand, the primary purpose of the CNB's intervention was the inflation acceleration, which on the basis of ARIMA results appeared as fulfilled.

variable	*const*	*time*	*D_intervention*	*D_crisis*	*Dinttime*	*Dcristime*
IPI	97.2114	0.3144	−53.6044	18.4233	0.9993	−0.6300
	(0.0000)	(0.0009)	(0.0413)	(0.0239)	(0.0401)	(0.0059)
ex	81.1340	0.7737	22.2130	37.2364	−0.4241	−0.9938
	(0.0000)	(0.0000)	(0.1751)	(0.0000)	(0.1412)	(0.0000)
y	100.880	0.0108	−0.3543	−0.1958	0.0239	−0.0270
	(0.0000)	(0.6071)	(0.9430)	(0.9202)	(0.7867)	(0.5594)
i	3.8714	−0.0865	−3.9034	−1.0485	0.0726	0.0319
	(0.0000)	(0.0022)	(0.5741)	(0.6539)	(0.5750)	(0.6431)
s_sa	61.9937	1.3158	−21.3234	44.9522	0.4674	−1.2937
	(0.0000)	(0.0000)	(0.6639)	(0.0129)	(0.5989)	(0.0026)
hicp_sa	72.5479	0.4574	32.5392	−4.8799	−0.6036	0.1375
	(0.0000)	(0.0000)	(0.0003)	(0.0786)	(0.0003)	(0.0847)

Table 3 ARIMA model results, coefficients and p-values for each variable
Source of results: Gretl, own processing

The significance of structural breaks in analyzed time series represents an alternative option to identify the effect of CNB's intervention on manufacturing industry. The following cointegration analysis extends the possibilities of intervention effectiveness assessment and brings further empirical results in the context of the intervention effects.

6.3 Unit Root Tests

Based on the the Augmented Dickey-Fuller test (ADF, 1979) and Kwiatkowski-Phillips Schmidt-Shin (KPSS, 1992) unit root tests, all time series were tested for unit root presence with results that the data in levels were found to be non-stationary. Therefore, the first order differences were performed and data were re-tested for the unit root presence. Since the ARIMA model detected deterministic time trends in *IPI, ex, i, s_sa* and *hicp_sa*, the unit root tests accounted for the presence of constant and trend in the test specification; only *y* will be tested without the deterministic time trend component. In all cases, the data in first differences do not contain unit root and all examined series exhibit I (1) first order of integration. Bellow the results of the ADF test for unit root are summarized.

Variable	*p-value*	*Variable*	*p-value*
IPI	0.1182	*d_IPI*	0.0029
ex	0.8807	*d_ex*	0.0000
y	0.0095	*d_y*	0.0000
i	0.1890	*d_i*	0.0009
s_sa	0.4980	*d_s_sa*	0.0000
hicp_sa	0.8175	*d_hicp_sa*	0.0003

Table 4 Augmented Dickey-Fuller test results
Source of results: Gretl, own processing

For KPSS unit root tests, the deterministic time trend was included in *IPI, ex, i, s_sa* and *hicp_sa* variables and not included for *y*. The null hypothesis of no unit roots in time series was not rejected, thus the time series is stationary. Results of the KPSS test for each time series are summarized in the table below.

Variable	*Test-statistics*	*Critical value*
IPI	0.1299	0.148
ex	0.3702	0.148
y	0.3028	0.462
i	0.1582	0.148
s_sa	0.2083	0.148
hicp_sa	0.1451	0.148

Table 5 KPSS test results for time series in levels
Source of results: Gretl, own processing

Variable	*Test-statistics*	*Critical value*
d_IPI	0.0512	0.148
d_ex	0.0387	0.148
d_y	0.0406	0.462
d_i	0.0719	0.148
d_s_sa	0.0441	0.148
d_hicp_sa	0.1020	0.148

Table 6 KPSS test results for time series in differences
Source of results: Gretl, own processing

ADF and KPSS unit root tests indicated the order of integration of all time series is I (1). Verifying the same order of integration of the series in question allows proceeding further with Johansen cointegration analysis of examined data (in levels).

6.4 Johansen Cointegration Test

Johansen cointegration procedure (1990) is based on the results of Trace test and Lmax test. To increase the accuracy and precision of the cointegration test, the interaction variables *Dinttime* and *Dcristime* will be included as exogenous variables. Below are summarized results of the Johansen cointegration test for its both versions, i.e. with unrestricted constant as well as with restricted constant.

Rank	*Trace test p-value*	*Lmax test p-value*
0	0.0000	0.0000
1	0.0114	0.0955
2	0.0833	0.0945
3	0.4311	0.1462
4	0.9830	0.9875
5	0.4819	0.4819

Table 7 Johansen cointegration test with exogenous variables, case with unrestricted constant
Source of results: Gretl, own processing

Rank	*Trace test p-value*	*Lmax test p-value*
0	0.0000	0.0000
1	0.0001	0.0016
2	0.0062	0.1104
3	0.0308	0.1022
4	0.1387	0.0397
5	0.9854	0.9851

Table 8 Johansen cointegration test with exogenous variables, case with restricted constant
Source of results: Gretl, own processing

The cointegration test with two exogenous variables and including unrestricted constant predicted two cointegration relationships. On the other hand, testing the cointegration with restricted constant indicates five cointegration relationships. The indicated five cointegration relationships under restricted constant seem quite a lot considering total five possible relationships, so the further procedures should operate rather with the unrestricted constant version which assumes two cointegration relationships. Moreover, as was mentioned in chapter Methods, the literature recommends using the version with unrestricted constant likewise.

To expand the results of cointegration even more, the Johansen cointegration test with no exogenous variables included will be applied as well with both of test's versions:

Rank	*Trace test p-value*	*Lmax test p-value*
0	0.0000	0.0000
1	0.0092	0.1420
2	0.0490	0.2650
3	0.1186	0.3079
4	0.1820	0.4090
5	0.0524	0524

Table 9 Johansen cointegration test with no exogenous variables, case with unrestricted constant
Source of results: Gretl, own processing

Rank	*Trace test p-value*	*Lmax test p-value*
0	0.0000	0.0000
1	0.0009	0.0949
2	0.0063	0.3294
3	0.0086	0.0957
4	0.0371	0.0846
5	0.1500	0.1498

Table 10 Johansen cointegration test with no exogenous variables, case with restricted constant
Source of results: Gretl, own processing

Comparing the p-values of cointegration tests (including unrestricted constant) with level of significance, the null hypothesis is rejected until the rank 2, indicating that there should be three cointegration relationships between the examined variables. On the other hand, the results of Johansen cointegration test in case with restricted constant suggest five cointegration relationships.

On the basis of number of cointegration relationships, the Vector Error Correction Model may be constructed. The Johansen cointegration test with unrestricted constant indicates 2 relationships in variant incl. exogenous variables and the 3 relationships in variant without exogenous variables. Since the difference in the number of relationships between both tests including unrestricted constant is not so dramatic, the

following VECM will operate with 2 cointegration relationships and 5 exogenous variables.

6.5 Vector Error Correction Model

To construct the VECM properly, the VAR lag selection must be firstly determined. For more complicated lag structures the number of endogenous variables lacks enough observations, therefore the maximum lag order is 4. Involving stationary time series, 5 exogenous variables and constant, the Akaike criterion (AIC), Schwarz Bayesian criterion (BIC) and Hannan-Quinn criterion (HQC) are identified. Considering a fact that the Akaike criterion always overestimates, i.e. it recommends more lags then the other criterions do, the AIC is not taken into account when identifying the lag order. On the basis of values of BIC and HQC criterions, the lag order 2 is selected (see table below).

Lags	*AIC*	*BIC*	*HQC*
1	17.895318	20.297353*	18.767196
2	17.320668	20.842069	18.546833*
3	17.114966*	21.876124	18.815809
4	17.117998	23.266804	19.441410

Table 11 Lag order selection
Source of results: Gretl, own processing

To estimate both short-term and long-term effects of one time series on another, the VEC model will be employed in its version with restricted constant. The model operates with the raw data and includes 5 exogenous variables, i.e. *time, D_interventio, D_crisis, Dinttime,* and *Dcristime* in order to reflect the structural breaks in cointegration relationships and hence increase the accuracy of estimation.

Below are shown the cointegrating vectors in VEC model with restricted constant, including lag order 2 and 2 cointegration ranks.

	Cointegration matrix (normalized cointegration vectors)	
IPI	1.000 (0.0000)	0.000 (0.0000)
ex	0.000 (0.0000)	1.000 (0.0000)
y	37.9720 (4.5253)	48.1690 (6.3152)
i	10.8220 (3.9517)	29.3730 (5.5147)
s_sa	-1.3271 (0.6671)	-3.0964 (0.9310)
hicp_sa	-1.3141 (4.0472)	-13.4260 (5.6479)
const	-3805.7000 (607.9100)	-3900.3000 (848.3600)
time	3.3471 (2.16580)	12.2040 (3.0225)
D_intervention	119.8600 (130.0100)	255.0600 (181.4300)
D_crisis	-11.6150 (32.4920)	-54.5510 (45.3440)
Dinttime	-2.8706 (2.2828)	-5.9260 (3.1857)
Dcristime	0.5121 (0.9784)	1.2713 (1.3655)

Table 12 Cointegrating vectors overview, VECM with restricted constant
Source of data: Gretl, own processing

As the cointegration means equilibrium long run relationship of variables, there should be some mechanism which ensures the returning to the original variable's equilibrium in case any shock occurs. Looking on the error correction terms *EC1* and *EC2* in the following Vector Error Correction Model, the error terms appeared significant for *d_IPI*, *d_y* and *d_hicp_sa*. These error correction terms indicates whether the particular time series reacts on deviations from cointegration relationship, i.e. whether the deviation from cointegration affects the short-run adjustments.

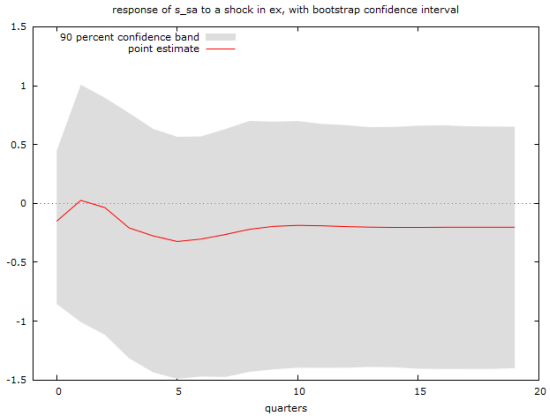
	d_IPI	*d_ex*	*d_y*	*d_i*	*d_s_sa*	*d_hicp_sa*
d_IPI_1	0.3463 (0.0357) **	0.1797 (0.4345)	0.1650 (0.0008) ***	0.0339 (0.2237)	0.8663 (0.0828) *	−0.0878 (0.0760) *
d_ex_1	−0.1366 (0.1463)	−0.0944 (0.4765)	0.0218 (0.4150)	−0.0237 (0.1417)	−0.0058 (0.9835)	0.0093 0.7392
d_y_1	0.2164 (0.5061)	0.7838 (0.0939) *	−0.0077 (0.9334)	−0.0001 (0.9978)	0.8554 (0.3897)	0.0001 0.9984
d_i_1	1.8742 (0.0412) **	1.7604 (0.1723)	1.0910 (0.0000) ***	0.4102 (0.0102) **	−0.7448 (0.7861)	−0.2055 0.4507
d_s_sa_1	0.1699 (0.0085) ***	−0.0619 (0.4862)	0.0335 (0.0654) *	0.0012 (0.9099)	−0.1290 (0.4989)	0.0317 (0.0971) *
d_hicp_sa_1	−0.0703 (0.8217)	1.3466 (0.0036) ***	−0.1006 (0.2647)	0.0308 (0.5659)	0.5822 (0.5418)	0.5738 (0.0000) ***
EC1	−0.1327 (0.0000) ***	−0.0283 (0.4625)	−0.0406 (0.0000) ***	0.0042 (0.3664)	−0.1450 (0.0831) *	−0.0254 (0.0029) ***
EC2	0.0862 (0.0000) ***	0.0098 (0.7173)	0.0100 (0.0708) *	−0.0033 (0.3072)	0.0969 (0.1015)	0.0257 (0.0000) ***

Table 13 Vector Error Correction Model with restricted constant
Note: cointegration rank 2, lag order 2
Source of data: Gretl, own processing

6.5.1 Impulse Response Functions

On the basis of VECM models, the impulse response functions of real effective exchange rate (*ex*) for individual variables including bootstrap confidence interval were estimated. Incorporating the bootstrap confidence interval will help to make the estimation more robust and prevent from heteroskedasticity.

As can be seen from the graphs of impulse response functions below, the Czech manufacturing industry activity (*s_sa*), GDP (*y*) and inflation (*hicp_sa*) as variables of the interest did not appear responsive to the change in exchange rate variable since the confidence band includes zero. These results therefore disprove the expected efficiency of the CNB's intervention and hence did not fulfill the scenario of the CNB, which expects primarily inflation acceleration and secondary output improvement.



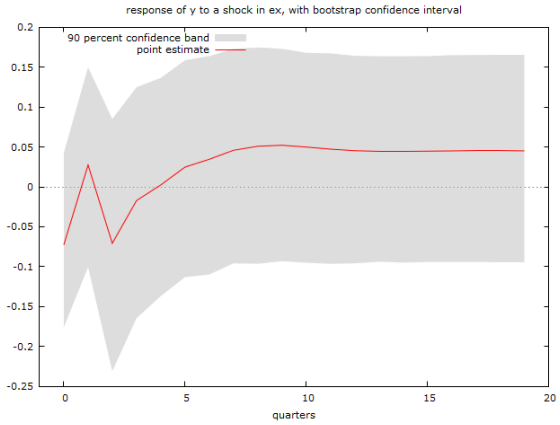


Figure 26 (left) Impulse response function of *s_sa* on *ex* with bootstrap confidence interval, based on VECM with restricted constant

Figure 27 (right) Impulse response function of *y* on *ex* with bootstrap confidence interval, based on VECM with restricted constant

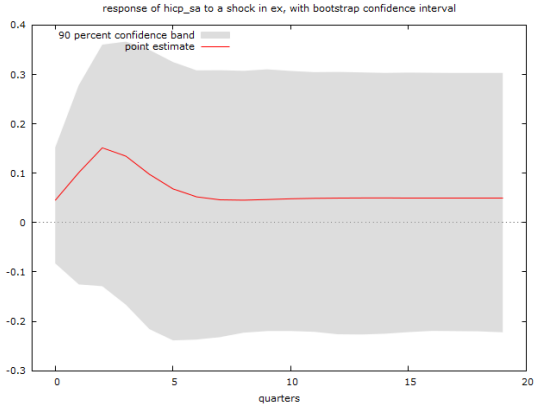


Figure 28 Impulse response function of *hicp_sa* on *ex* with bootstrap confidence interval, based on VECM with restricted constant

Sources: Gretl

6.6 Vector Autoregression Model

The constructed VAR model with lag order 2, including constant and 5 exogenous variables (i.e. *time, D_interventio, D_crisis, Dinttime,* and *Dcristime*) is shown in table below. The F-statistics and p-values in parenthesis serve as a basis for Granger causality test evaluation.

All lags of:	*d_IPI*	*d_ex*	*d_y*	*d_i*	*d_s_sa*	*d_hicp_sa*
d_IPI	2.3388	1.7298	5.5405	0.68448	6.5891	3.3990
	[0.1083]	[0.1892]	[0.0071]	[0.5096]	[0.0031]	[0.0424]
d_ex	0.074139	2.2802	2.4890	0.59300	0.14872	0.15504
	[0.9287]	[0.1142]	[0.0946]	[0.5570]	[0.8622]	[0.8568]
d_y	0.74962	3.5596	8.7289	0.28828	2.9719	1.0894
	[0.4785]	[0.0369]	[0.0006]	[0.7510]	[0.0616]	[0.3453]
d_i	0.68827	0.46139	4.2313	1.3905	0.072148	0.90827
	[0.5078]	[0.6334]	[0.0209]	[0.2597]	[0.9305]	[0.4106]
d_s_sa	2.5023	3.3312	2.5675	0.16956	4.5343	2.0906
	[0.0935]	[0.0450]	[0.0882]	[0.8446]	[0.0162]	[0.1357]
d_hicp_sa	0.89573	3.3452	−0.1006	4.9857	0.78122	2.9216
	[0.4156]	[0.0444]	(0.2647)	[0.0112]	[0.4641]	[0.0644]
All vars, lag 2	1.6911	2.5444	9.3718	0.94990	2.1665	2.2696
	[0.1458]	[0.0334]	[0.0000]	[0.4698]	[0.0645]	[0.0539]

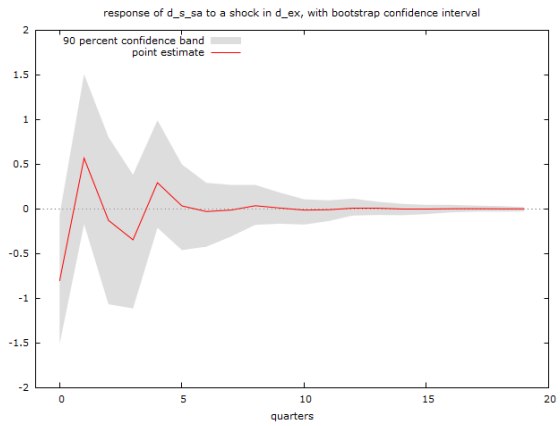
Table 14 Vector Autoregression Model, Granger Causality, lag order 2
Note: test statistics, p-value in parenthesis
Source of data: Gretl, own processing

6.6.1 Granger Causality

Based on F-statistics and p-values from the Table 14 above, the causal relationships of exchange rate (*d_ex*) with manufacturing production activity (*d_s_sa)*, GDP (*d_y*) and inflation (*d_hicp*) were estimated. Comparing the mentioned values, no Granger causality relationship was identified.

6.6.2 Impulse Response Functions

Compared to the VEC model, the impulse response functions generated from VAR model prove the same conclusions, i.e. neither the manufacturing industry (*d_s_sa*) nor output (*d_y*) and inflation (*d_hicp*) reacted on the changes in exchange rate variable (*d_ex*). These results are thus inconsistent with the expectation of CNB, and do not support its approach regarding stimulated output or inflation as an effect of intervention.



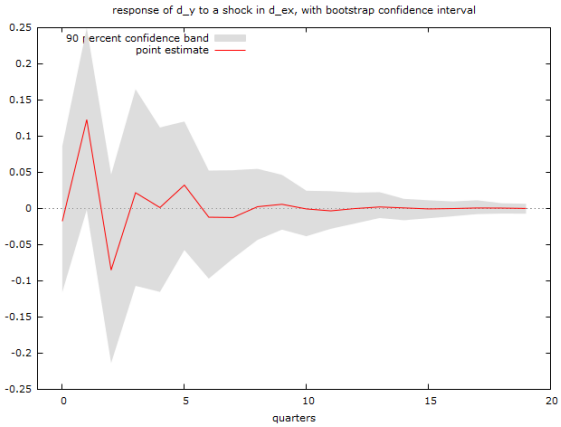


Figure 29 (left) Impulse response function of *d_s_sa* on *d_ex* with bootstrap confidence interval, based on VAR model
Figure 30 (right) Impulse response function of *d_y* on *d_ex* with bootstrap confidence interval, based on VAR model

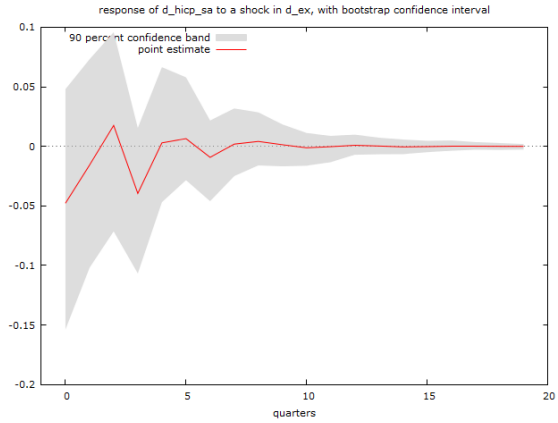


Figure 31 Impulse response function of *d_hicp_sa* on *d_ex* with bootstrap confidence interval, based on VAR model
Sources: Gretl

7 Discussion

Comparing the obtained outcomes with expected scenario of the Czech National Bank, i.e. primary inflation acceleration and secondary improvement in export and output volumes, the foreign exchange interventions did not appear as very powerful monetary instrument in the Czech economy. Neither the inflation variable nor output variables represented by GDP and industrial production index of manufacturing industry were affected by the real exchange rate. Since the results are contradictory with the CNB's expectations, the question why the foreign exchange intervention did not act as the central bank intended arises. The reasons of potential monetary intervention's failure were generally explained in the chapter 2.3.5, however these implications may be directly related to the obtained results as well. One of the several factors explaining the inefficacy of interventions might be "the exchange rate disconnect puzzle" phenomenon (Obstfeld and Rogoff, 2001) that indicates the exchange rate has very weak link with real macroeconomic essentials. The same results, i.e. no impact of exchange rate depreciation on the Czech manufacturing production were found also in Šimánková and Stavárek (2014). Partial explanation why the manufacturing industry is not sensitive to foreign exchange intervention may be that the producers who are sensitive to exchange rate fluctuations already hedge against the exchange rate oscillations, for example by forward contracts. This would imply that the Czech National Bank overestimates the role of exchange rate and should primary focus on its conventional monetary tools, such as interest rate, or adhere to stable macroeconomic rules.

Evaluating the obtained results within the framework of general macroeconomic theory, the Keynesian approach to devaluation was not met either. The examined output variable (GDP) did not respond to foreign exchange intervention and the short-run equilibrium did not shift as Keynesians expect. Regarding the monetarist approach, the inflation variable was not responsive to the foreign exchange intervention likewise. Following Johnson (1976), who stated that the inflation rises if there is no labour force available in the economy, it might be that there is still unemployment above the natural rate in the Czech economy and thus there is still space for inflation to grow.

Confronting the results with the studies investigating monetary intervention effects on economic output, the same results can be found in Wang and Rogers (1995), who estimated the impulse response function and variance decomposition for the output in Mexico. An, Kim and Ren (2014) also found no devaluation effect employing VAR model for the data of Latin America and Asian countries. Chou and Chao (2001) investigated the impact on Asian countries incorporating ARDL procedure with resulting neutral effect likewise.

Indeed, there is a space for the improvement in the analysis itself. First the data availability restricted the scope of the analysis. The estimation of the structural

change in the results would be more refined if the underlying period I.Q 2000 – I.Q 2016 was divided into two subsamples, i.e. a pre-intervention and intervention period – allowing for a potential change in all parameters. However, the number of observed quarters in the intervention period would be 10 at most, which is not sufficient amount of observations to construct a VAR model and estimate Granger causality.

Another obstacle for the structural break testing is the well-known weakness of the Augmented Dickey-Fuller unit root test, which can potentially mislead the structural breaks in the series as the evidence of non-stationarity – further influencing the cointegration tests. More specifically, the ADF test may fail to reject the unit root hypothesis if the time series have a structural break as there exists a possibility that the time series which are found to be are in fact stationary around the structural break, but are erroneously identified as I(1). Perron (1989) points out that neglecting the allowance for an existing break leads to a bias that lowers the ability to reject a false unit root null hypothesis. In order to avoid this scenario, the Perron proposes applying the unit root test which allows for the possible presence of the structural break. Such a procedure will prevent obtaining results that are probably biased towards non-rejection and hence help to analyze whether the structural break on a certain variable is associated with a particular event, i.e. monetary intervention in a framework of this thesis. To test for the unit root presents incorporating the structural breaks, the Zivot-Andrews and Perron-Vogelsang (1992) unit root tests which allow for one structural break might be applied, or the series might be manually adjusted based on auxiliary regressios (such as ARIMA employed in this thesis). Employing these procedures would hence help to analyze whether the development of examined variables is associated with structural break. Moreover, as the KPSS and ADF unit root tests revealed, the underlying time series contain one unit root, hence the appropriate method to transform the data by differencing the variables was performed. Nonetheless, such adjustment of time series may have incurred a loss of important information and thus affected the results.

Subsequent improvement in the precision of result estimation might be achieved by a different modelling approach, for instance Autoregressive Distributed Lag approach (Pesaran, Shin and Smith, 2001). The Autoregressive Distributed Lag Bounds Testing (ARDL) is especially useful when the presence of structural breaks brings uncertainty about the true order of integration of the variables as it enables to gain valid results regardless whether the examined variables are I(1) or I(0), or a combination of both. Within the ARDL framework, the underlying structural breaks which may affect the long-run stability of the estimated coefficients might be conveniently examined. Pesaran, Shin and Smith also point out that the ARDL bounds testing approach is appropriate for time series with structural breaks as it allows a flexibility regard the structure of lags of the regressors compared to the cointegration VAR models, where on the other hand, the different lags for different variables are not permitted to be set. Additionally, as the ARDL approach relies on unrestricted error correction

model, it is likely to have better statistical properties than the conventional cointegration techniques. However, due to its nature, it only allows for the presence of one cointegration relationship.

8 Conclusion

Following the thesis assignment, the objective of this thesis was to investigate the magnitude and speed of impact of the CNB's foreign exchange interventions on the manufacturing industry activity and thus to empirically verify whether the CNB's proclaimed effects can be observed on real economic data. Even though the primary purpose of foreign exchange intervention was the inflation acceleration, the CNB anticipates that weaker crown also improves the Czech export volumes. Manufactured commodities have always formed a major share of export, thus the increased activity of manufacturing branches is assumed during the intervention period. Since the literature brings ambiguous results about the effects of monetary interventions on industrial branches as well as on the economy's output, this thesis will expand the range of available empirical evidence.

The CNB approved the foreign exchange intervention in November 2013 on the basis of unfavourable development of the Czech economy and imminent risk of deflation. Therefore, the primary purpose of the intervention was the inflation acceleration. However, the CNB admitted it also anticipated export volume boost and subsequent positive output stimulation. As a transmission of such monetary intervention effect might be more complex (see Literature Review for the discussion), the development of examined variables were observed in order to detect structural breaks of the intervention. To verify the expectations of the CNB regarding the enhanced output, the industrial production index of manufacturing sector, and GDP were observed in a context of the development of real effective exchange rate and control variables, such as industrial production of Eurozone, interest rate and inflation in the Czech Republic measured by the harmonised index of consumer prices.

In order to provide the evidence on the extent and speed of the impact of foreign exchange intervention on the industrial production activity in the CZ-NACE C manufacturing sector, the structural breaks testing in ARIMA process, Augmented Dickey-Fuller and Kwiatkowski-Phillips Schmidt-Shin unit root tests as well as the Johansen cointegration analysis were employed. The main concern was a construction of a Vector Autoregression and Vector Error Correction framework, which enabled to evaluate the variables of interest based on impulse response functions and Granger causality. The extensions, modifications and further possibilities of refinement of these methods are also discussed in separate chapter.

The results of econometric tests and techniques showed that the structural breaks representing the monetary intervention are not significant in the underlying data. In both VAR and VEC models, the impulse response of incorporated variables on the exchange rate was not evident. Moreover, the Granger causality based on VAR model revealed no causal effect of exchange rate on other endogenous variables. The obtained results are therefore inconsistent with the expected scenario of the CNB and disproved the efficiency of the foreign exchange intervention regarding the stimulation

of economy's output. Comparing the results with existing empirical evidence, Wang and Rogers (1995), An, Kim and Ren (2014) as well as Chou and Chao (2001) provided similar results, i.e. no effect of monetary intervention on the economy's output. Based on the macroeconomic theory, the failure of intervention may rest on situation on labour market as well as on the phenomenon of weak exchange rate's link with macroeconomic essentials.

Finally, the results clearly confirmed the ambiguity relating the concern of monetary interventions implications and broaden the empirical evidence regarding the monetary policy efficiency. The implication is the Czech National Bank overestimates the role of exchange rate interventions and should rather utilize its conventional monetary tools while conduction the monetary policy is suggested.

9 Literature

ADAMEC, Václav. *Econometry II*. In Brno: Mendel University, 2014 [cit. 2017-04-28]. ISBN 978-80-7509-159-8.

HODRICK, Robert J.; PRESCOTT, Edward C. *Postwar US business cycles: an empirical investigation*. Journal of Money, credit, and Banking, 1997, 1-16.

JOHANSEN, S. and JUSELIUS, K. (1990). *Maximum Likelyhood Estimation and Inference on Cointegration — with Applications to the Demand for Money*. Oxford Bulletin of Economics and Statistics, 52: 169–210. doi:10.1111/j.1468-0084.1990.mp52002003.x

KRUGMAN, Paul R. a Maurice OBSTFELD. 1991. *International economics: theory and policy*. 2nd ed. New York, NY: HarperCollins, xxvi, 682, 30, 12 p. Expert (Grada) [cit. 2017-04-28]. ISBN 06-735-2151-6.

KWIATKOWSKI, D., P. C. B. PHILLIPS, P. SCHMIDT and Y. SHIN (1992). *Testing the null of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root?*, [cit. 2017-04-28] Journal of Econometrics 54: 159–178.

VERBEEK, Marno. *A guide to modern econometrics*. 2nd ed. Hoboken, NJ: John Wiley, c2004 [cit. 2017-04-28]. ISBN 04-708-5773-0.

10 Online Sources

ADLER, Gustavo and TOVAR MORA, Camilo E., *Foreign Exchange Intervention: A Shield Against Appreciation Winds?* IMF Working Papers [online] Vol. 11, p. 1-29, 2011 [cit. 2017-04-28]. Available at: https://ssrn.com/abstract=1888908

AIZENMAN, Joshua. *The Impossible Trinity – from the Policy Trilemma to the Policy Quadrilemma*. Global Journal of Economics [online]. 2013, 02(01), p. 1350001-1-1350001-17 [cit. 2017-04-19]. Available at: http://econpapers.repec.org/article/wsigjexxx/v_3a02_3ay_3a2013_3ai_3a01_3ap_3a1350001-1-1350001-17.htm

ALEXANDER, Sidney S. *Effects of Devaluation on a Trade Balance*. Staff Papers - International Monetary Fund [online]. Inter-American Development Bank, 1952, 2(2), p. 263-278 [cit. 2017-04-10]. DOI: 10.2307/3866218. ISSN 00208027 [cit. 2017-04-28]. Available at: http://www.palgrave-journals.com/doifinder/10.2307/3866218

AN, Lian, Gil KIM and Xiaomei REN. *Is devaluation expansionary or contractionary: Evidence based on vector autoregression with sign restrictions*. In: Journal of Asian Economics [online]. Elsevier Inc., 2014, p. 27–41 [cit. 2017-04-05]. Available at: http://www.sciencedirect.com/science/article/pii/S1049007814000165

ARDALAN, Kavous. *A Test of Two Open-Economy Theories: The Case of Oil Price Rise and Italy*. International Review of Business Research Papers [online]. 2013, 9.(No.1), p.105 – 115 [cit. 2017-04-18]. Available at: https://www.bizresearchpapers.com/7.%20Kavous.pdf

ARLT, Josef. Časové řady typu I(0) a I(1). In: Acta oeconomica pragensia: Vědecký sborník Vysoké školy ekonomické v Praze [online]. 6: (2). Prague: Vysoká škola ekonomická, 1998, s. 7-11 [cit. 2017-05-07]. ISSN 0572-3043. Available at: http://nb.vse.cz/~arlt/hlavni/publik/A_CRTI0I1_98.pdf

Asociace exportérů: Bez měnových intervencí ČNB by export přišel o 608 miliard korun. Asociace Exportérů [online]. 2017 [cit. 2017-05-15]. Available at: http://www.asociaceexporteru.cz/asociace-exporteru-bez-menovych-intervenci-cnb-by-export-prisel-o-608-miliard-korun/

BAHMANI-OSKOOEE, Mohsen a Ali M. KUTAN. *The J-curve in the emerging economies of Eastern Europe. Applied Economics* [online]. 2009, 41(20), 2523-2532 [cit. 2017-05-15]. DOI: 10.1080/00036840701235696. ISSN 0003-6846. Available at: https://www.cass.city.ac.uk/__data/assets/pdf_file/0010/29287/WP-EMG-01-2006.pdf

BERUMENT, Hakan and Mehmet PASAOGULLARI. 2003. *Effects of the real exchange rate on output and inflation: Evidence from Turkey*. The Developing Economies [online]. 41(4): p. 401-435 [cit. 2017-05-01]. DOI: 10.1111/j.1746-1049.2003.tb01009.x. ISSN 00121533. Available at: http://doi.wiley.com/10.1111/j.1746-1049.2003.tb01009.x

CHOU, Win Lin and Chi-Chur CHAO. *Are currency devaluations effective? A panel unit root test*. Economics Letters [online]. 2001, 72(1), 19-25 [cit. 2017-04-07]. DOI: 10.1016/S0165-1765(01)00399-8. ISSN 01651765. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0165176501003998

CHUTASRIPANICH, Nuttathum and James YETMAN. Foreign exchange intervention: strategies and effectiveness. BIS Working Papers [online]. Bank for International Settlements, 2015, (No 499) [cit. 2017-04-19]. ISSN 1682-7678. . Available at: http://www.bis.org/publ/work499.pdf

ČTK (2017), Průměrná mzda v ČR se ve 3. čtvrtletí zvýšila na 27.220 Kč [online]. [cit. 2017-05-15]. Available at: http://www.ceskenoviny.cz/zpravy/prumerna-mzda-v-cr-se-ve-3-ctvrtleti-zvysila-na-27-220-kc/1423296

Czech National Bank (2014), Czech currency intervention and forex reserves [online]. 2014 [cit. 2017-05-15]. Available at: https://www.cnb.cz/en/public/media_service/interviews/media_2014/cl_14_140821_hampl_skorepa_bis.html

Czech National Bank (2017), Globální ekonomický výhled - březen [online]. 2017(3) [cit. 2017-05-15]. Available at: https://www.cnb.cz/miranda2/export/sites/www.cnb.cz/cs/menova_politika/gev/gev_2017/gev_2017_03.pdf

Deloitte (2016), Výhled české ekonomiky na rok 2017 [online]. 2016 [cit. 2017-05-15]. Available at: https://edu.deloitte.cz/cs/Content/DownloadPublication/vyhled-ekonomika-2017

DICKEY, David A. and Wayne A. FULLER. *Distribution of the Estimators for Autoregressive Time Series With a Unit Root*. In: Journal of the American Statistical Association [online]. Volume 74, Issue 366. American Statistical Association, 1979, p. 427-431 [cit. 2017-05-09]. Available at: http://debis.deu.edu.tr/userweb/onder.hanedar/dosyalar/1979.pdf

DORNBUSCH, Rudiger. *Expectations and Exchange Rate Dynamics*. The Journal of Political Economy [online]. Volume 84, Issue 6. The University of Chicago Press, 1976, p. 1161-1176 [cit. 2017-04-04]. Available at: http://www.mit.edu/~14.54/handouts/dornbusch76.pdf

DUTTA, Jayasri and Leon HYGINUS, *Dread of Depreciation: Measuring Real Exchange Rate Interventions*. IMF Working Paper [online], Vol. , p. 1-37, 2002 [cit. 2017-04-10]. Available at: https://ssrn.com/abstract=879551

DWYER, Gerald P. *The Johansen Tests for Cointegration* [online]. In: . 2015 [cit. 2017-05-01]. Available at: http://www.jerrydwyer.com/pdf/Clemson/Cointegration.pdf

EDWARDS, Sebastian. *Are devaluations contractionary?* In: NBER WORKING PAPER SERIES: Working Paper No. 1676 [online]. Cambridge, 1985 [cit. 2017-04-05]. Available at: http://www.nber.org/papers/w1676.pdf

EKHOLM, Karolina, Andreas MOXNES and Karen Helene ULLTVEIT-MOE. 2012. *Manufacturing restructuring and the role of real exchange rate shocks*. Journal of International Economics [online]. (1): p. 101-117 [cit. 2017-04-04]. DOI: 10.1016/j.jinteco.2011.08.008. ISSN 00221996. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0022199611001048

Eurostat (2017) EU-28 Industrial production total and MIGs [online]. [cit. 2017-05-15] Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/FilEU-28_Industrial_production_total_and_MIGs_m_sa_01-2005-12-2016.png

FANG, WenShwo, YiHao LAI and Stephen M. MILLER. *Export Promotion through Exchange Rate Changes: Exchange Rate Depreciation or Stabilization?* Southern Economic Journal [online]. 2006, 72(3), 611- [cit. 2017-05-17]. DOI: 10.2307/20111836. ISSN 00384038. Available at: http://www.jstor.org/stable/10.2307/20111836?origin=crossref

GRANGER, C. W. J. *Investigating Causal Relations by Econometric Models and Cross-spectral Methods*. Econometrica [online]. 1969, 37(3), 424- [cit. 2017-05-13]. DOI: 10.2307/1912791. ISSN 00129682. Available at: http://www.jstor.org/stable/1912791?origin=crossref

HAHN, Elke. *The impact of exchange rate shocks on sectoral activity and prices in the euro area* [online]. ECB Working Paper No. 796, 2007 [cit. 2017-03-02]. ISSN 1725-2806. Available at: http://www.ecb.europa.eu/pub/scientific/wps/date/html/index.en.html

HAMPL, Mojmír. Currency Intervention and Forex Reserves – the Czech Perspective [online]. In: . ČNB, 2015 [cit. 2017-05-15]. Available at: https://www.cnb.cz/miranda2/export/sites/www.cnb.cz/en/public/media_service/conferences/speeches/download/hampl_20150807_nalm_singapore.pdf

HAUSMANN, Ricardo, Ugo PANIZZA and Ernesto STEIN. *Why Do Countries Float the Way they Float?* Working Paper [online]. Inter-American Development Bank, 2000, IV.(418) [cit. 2017-04-10]. Available at: http://www.sciencedirect.com/science/article/pii/S0304387801001687

International Monetary Fund (2014), *Annual Report on Exchange Arrangements and Exchange Restrictions 2014* [online]. Washington [cit. 2017-03-21]. ISSN 2304-0831. [cit. 2017-04-28] Available at: https://www.imf.org/external/pubs/nft/2014/areaers/ar2014.pdf

JAMIL, Muhammad, Erich W. STREISSLER and Robert M. KUNST. *Exchange Rate Volatility and its Impact on Industrial Production, Before and After the Introduction of Common Currency in Europe* [online]. Vol.2, No. 2, p. 85-109. International Journal of Economics and Financial Issues, 2012 [cit. 2017-04-04]. ISSN 2146-4138. Available at: www.econjournals.com/index.php/ijefi/article/download/93/pdf

JOHNSON, Harry G. *Elasticity, Absorption, Keynesian Multiplier, Keynesian Policy, and Monetary Approaches to Devaluation Theory: A Simple Geometric Exposition*. The American Economic Review [online]. 1976, 66(No. 3), p. 448-452 [cit. 2017-03-03]. Available at: http://www.jstor.org/stable/pdf/1828184.pdf

JUNZ, Helen B. and Rudolf R. RHOMBERG. *Price Competitiveness in Export Trade Among Industrial Countries.* The American Economic Review [online], 1973, Vol. 63, No. 2, p. 412-418 [cit. 2017-04-07] Available at: https://ideas.repec.org/p/fip/fedgif/22.html

KIM, Soyoung. *Monetary policy, foreign exchange intervention, and the exchange rate in a unifying framework.* Journal of International Economics [online]. 2003, 60(2), 355-386 [cit. 2017-04-24]. DOI: 10.1016/S0022-1996(02)00028-4. ISSN 00221996. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0022199602000284

KRÁL, Petr. *Hodnocení makroekonomické situace a její výhled, vývoj na trhu práce* [online]. In: ČNB, 2015 [cit. 2017-05-15]. Available at: https://www.cnb.cz/miranda2/export/sites/www.cnb.cz/cs/verejnost/pro_media/konference_projevy/vystoupeni_projevy/download/kral_20151207_prezentace_pro_odbory.pdf

KRUGMAN, Paul and Lance TAYLOR. *Contractionary effects of devaluation*.[online]. Journal of International Economics, 1978 [cit. 2017-04-06]. Available at: http://www.elsevierscitech.com/pdfs/np2008/contractionaryeffects.pdf

LAHIRI, Bidisha and Atef AL-RASHIDI. 2012. *Trade-Weighted Exchange Rate Indices: Explaining Industrial Production*. Journal of International and Global Economic Studies [online]. : p. 24-31 [cit. 2017-04-04]. Available at: http://www2.southeastern.edu/orgs/econjournal/index_files/JIGES%20DEC%202012%20LAHIRI%20V6%203-30-2013.pdf

LIN, Hong-Yu. *Transaction Costs, Multiple Equilibria, and Currency Devaluation*. In: Asian Economic and Financial Review [online]. 4(12). AESS Publications, 2014, p. 1705-1718 [cit. 2017-04-05]. Available at: http://www.aessweb.com/pdf-files/aefr-2014-4(12)-1705-1718.pdf

MILLS, Terence C. and Eric J. PENTECOST. *The Real Exchange Rate and the Output Response in Four EU Accession Countries* [online]. Department of Economics, 2000 [cit. 2017-04-04]. Research Paper No. 00-4. Loughborough University. Available at: https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/1128/3/bcv00-5.pdf.

Nejočekávanější ekonomický tah roku? Konec intervencí. *Česká televize* [online]. 2017 [cit. 2017-03-23]. Available at: http://www.ceskatelevize.cz/ct24/ekonomika/1999585-nejocekavanejsi-ekonomicky-tah-roku-konec-intervenci

OBSTFEL, Maurice and Kenneth ROGOFF. *The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?* [online]. Volume 15. MIT PRess, 2001 [cit. 2017-03-24]. ISBN 0-262-02503-5. Available at: http://www.nber.org/books/bern01-1

OECD (2017), Domestic demand forecast (indicator) [online]. doi: 10.1787/cf2732d3-en [cit. 2017-05-15]. Available at: https://data.oecd.org/gdp/domestic-demand-forecast.htm

OGAWA, Eiji. *Theories of Exchange Rates Determination : A Review*. Hitotsubashi Journal of Commerce and Management [online]. 1987, 22(No. 1), p. 27-54 [cit. 2017-04-24]. DOI: 10.15057/6165. Available at: http://www.jstor.org/stable/43294902?seq=1#fndtn-page_scan_tab_contents

Panorama zpracovatelského průmyslu ČR 2013 [online]. Ministerstvo průmyslu a obchodu České republiky, 2014 [cit. 2017-05-15]. Available at: https://www.mpo.cz/assets/dokumenty/51648/58724/617202/priloha001.pdf

Panorama zpracovatelského průmyslu ČR 2015. Ministerstvo průmyslu a obchodu České republiky [online]. 2016 [cit. 2017-05-15]. Available at: http://www.mpo.cz/assets/cz/prumysl/zpracovatelsky-prumysl/panorama-zpracovatelskeho-prumyslu/2016/11/Panorama_CZ_internet_komplet.pdf

PERRON, Pierre. *The Great Crash, the Oil Price Shock, and the Unit Root Hypothe*sis. Econometrica [online]. 1989, 57(6), 1361- [cit. 2017-05-16]. DOI: 10.2307/1913712. ISSN 00129682. Available at: http://www.jstor.org/stable/1913712?origin=crossref

PERRON, Pierre and Timothy J. VOGELSANG. *Nonstationarity and Level Shifts with an Application to Purchasing Power Parity.* Journal of Business [online]. 1992, 10(3), 301- [cit. 2017-05-16]. DOI: 10.2307/1391544. ISSN 07350015. Available at: http://www.jstor.org/stable/1391544?origin=crossref

PESARAN, M. Hashem, Yongcheol SHIN and Richard J. SMITH. *Bounds testing approaches to the analysis of level relationships*. Journal of Applied Econometrics [online]. 2001, 16(3), 289-326 [cit. 2017-05-16]. DOI: 10.1002/jae.616. ISSN 0883-7252. Available at: http://doi.wiley.com/10.1002/jae.616

ROGERS, John H. and Ping WANG. 1995. *Output, Inflation, and Stabilization in a Small Open Economy: Evidence from Mexico*, Journal of Development Economics [online]. 46, p. 271-293[cit. 2017-04-04]. Available at: http://mail1.dallasfed.org/assets/documents/research/papers/1993/wp9315.pdf

SAWYER, W. Charles and Richard L. SPRINKLE. *Contractionary Effects of Devaluation in Mexico*. In: Working Paper Nr. 87-01 [online]. Texas Christian University, 1987 [cit. 2017-04-05]. Available at: http://www.econ.tcu.edu/papers/wp87-01.pdf

ŠIMÁKOVÁ, Jana and Daniel STAVÁREK. *Exchange-Rate Impact on the Industry-Level Trade Flows in the Czech Republic*. Procedia Economics and Finance [online]. 2014, 12, 679-686 [cit. 2017-04-24]. DOI: 10.1016/S2212-5671(14)00393-1. ISSN 22125671. Available at: http://linkinghub.elsevier.com/retrieve/pii/S2212567114003931

ŠKODA dosáhla v roce 2016 rekordních výsledků. Škoda [online]. 2017 [cit. 2017-05-15]. Available at: http://www.skoda-auto.cz/news/pages/2017-03-22-rekordni-vysledky-2016.aspx

UPADHYAYA, Kamal P. *Currency devaluation, aggregate output, and the long run: an empirical study.* Economics Letters [online]. Elsevier Science S.A, 1999, (64), p. 197–202 [cit. 2017-04-06]. Available at: http://ac.els-cdn.com/S0165176599000889/1-s2.0-S0165176599000889-main.pdf?_tid=a1270562-19f0-11e7-80f1-00000aab0f27&acdnat=1491390874_63687ebc998e09cfa0b1b7b095b9e87e

ZIVOT, Eric and Donald W. K. ANDREWS. *Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis.* Journal of Business [online]. 1992, 10(3), 251- [cit. 2017-05-16]. DOI: 10.2307/1391541. ISSN 07350015. Available at: http://www.jstor.org/stable/1391541?origin=crossref

Wikipedia, (2017) Arbitrage [online]. [cit. 2017-05-15]. Available at: https://en.wikipedia.org/wiki/Arbitrage

Wikipedia, (2017) Impossible Trinity [online]. [cit. 2017-05-15]. Available at: https://en.wikipedia.org/wiki/Impossible_trinity

11 List of Figures

12 List of Pictures

13 List of Tables

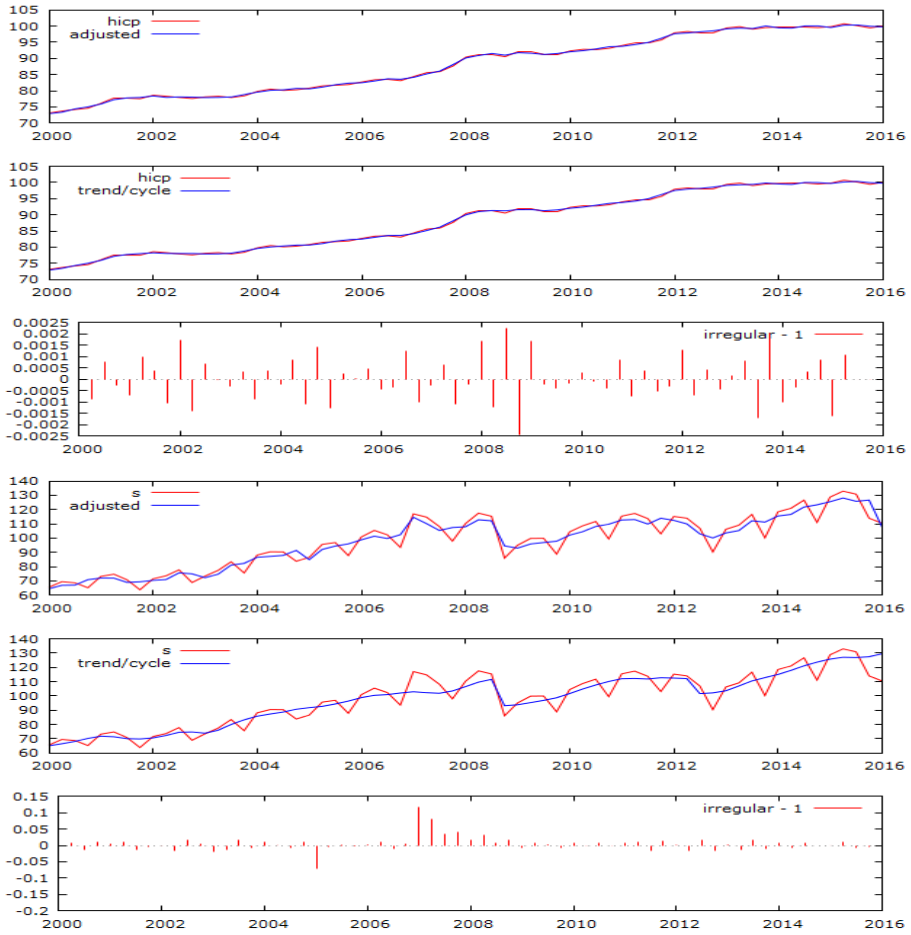
Annexes

A

Section C – Manufacturing industry	
Section	Name
10	Manufacture of food products
11	Manufacture of beverages
12	Manufacture of tobacco products
13	Manufacture of textiles
14	Manufacture of clothes
15	Manufacture of leather and related products
16	Woodworking, production of wood, cork and straw products, except furniture
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastic products
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals, metalworking, foundry industry
25	Production of metal constructions and metal products, except machinery and equipment
26	Manufacture of computers, electronic and optical devices and equipment
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment not elsewhere specified
29	Manufacture of motor vehicles (except motorcycles), trailers and semi-trailers
30	Manufacture of other transport equipment and devices
31	Manufacture of furniture
32	Other manufacturing
33	Repairs and installation of machinery and equipment

Annex 1 Manufacturing industry according to NACE-CZ classification
Source: Panorama of the manufacturing industry of the Czech Republic, Ministry of Industry and Trade (2015)

B



Annex 2 Seasonal adjustment of *hicp* and *s*
Source: Gretl