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Import Prices and the Exchange Rate

Master dissertation

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Declaration of Authorship

I, Martin Tesař, hereby declare that the thesis "Import Prices and the Exchange Rate" was written by myself, and that all presented results are my own, unless stated otherwise. The literature sources are listed in the References section.

Prague, September 30th, 2018

Signature

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Abstract

The aim of this thesis is to examine the relation between import prices and the exchange rate and to estimate the exchange rate pass-through (ERPT) to import prices in different manufacturing industries in the Czech Republic. The first chapter familiarizes the reader with theoretical foundation of ERPT – the relation between import prices and the exchange rate, what it influences, its relation to inflation and presence of asymmetries within ERPT. The second chapter introduces the econometric model and data used in this thesis. The model tests not only the level of ERPT itself, but also asymmetries with respect to the direction and size of the change in the exchange rate. The monthly dataset covers the time period from January 2000 to May 2018. The third chapter shows the results of the empirical study – ERPT, long-run ERPT, asymmetries in ERPT with respect to direction and size of the change in the exchange rate and their combinations, and the development of ERPT over time.

Key Words

Import Prices, Exchange Rate, Exchange Rate Pass-Through, Asymmetry, The Czech Republic

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INTRODUCTION

In a small open economy such as the Czech Republic, exchange rates and movements in exchange rates have strong impact on prices. Not only that, as one of the most open economies in the world, with its own national currency and independent monetary and fiscal policy, the Czech economy provides a natural laboratory where the effect of exchange rate shocks on price stability can be assessed.

The aim of this thesis is to examine the relation between import prices and the exchange rate and to estimate the exchange rate pass-through (ERPT) to import prices in different manufacturing industries in the Czech Republic. To my knowledge, no such work, with disaggregated manufacturing industry level data, has been done before.

The thesis is organized into three chapters:

The first chapter familiarizes the reader with theoretical foundation of ERPT – the relation between import prices and the exchange rate, what it influences, its relation to inflation and presence of asymmetries within ERPT.

The second chapter introduces the econometric model and data used in this thesis. The model tests not only the level of ERPT itself, but also asymmetries with respect to the direction and size of the change in the exchange rate. The monthly dataset covers the time period from January 2000 to May 2018.

The third chapter shows the results of the empirical study – ERPT, long-run ERPT, asymmetries in ERPT with respect to direction and size of the change in the exchange rate and their combinations, and the development of ERPT over time.

The core of the thesis consists of testing the following hypotheses:

1) ERPT is incomplete – change in the exchange rate is not fully transmitted into import prices.
2) ERPT is complete in the long-run.
3) ERPT is asymmetric with respect to the direction of the exchange rate change.
4) ERPT is asymmetric with respect to the size of the exchange rate change.
5) ERPT is asymmetric with respect to combinations of different directions and sizes of the exchange rate change.
6) ERPT has declined over time.

1 EXCHANGE RATE PASS-THROUGH THEORY

The degree to which a change in an exchange rate is transmitted into prices, both import prices and consequently final consumer prices, is in the economic literature referred to as the exchange rate pass-through (ERPT). As foreign currencies are heavily traded on markets and their movements are nowadays easily observable in real time, the importance of exchange rates and movements is nonnegligible. In the economic literature, the ERPT is a well-defined term:

> "*[T]he percent change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing country.*" (Campa and Goldberg, 2002).

> "*Pass-through is defined as a relationship between the nominal exchange rate and the domestic price level.*" (Devereux and Yetman, 2002).

> "*[H]ow much a given percentage movement in the exchange rate results in changes in domestic prices – is referred to as exchange rate pass-through.*" (Parker and Wong, 2014).

> "*[T]he extent to which an exchange rate change is reflected in import and consumer prices.*" (Villavicencio and Mignon, 2017).

The basic idea is that import prices change when the importing country's currency exchange rate changes towards the currency of the exporting country. If the theory proves correct, a depreciation of the importing country's currency increases import prices, whereas appreciation lowers import prices (Mumtaz et al., 2011). For the home country it means that with an appreciation of the domestic currency and reduction of import prices, domestically produced goods, which can be considered substitutes, become less competitive. Following a depreciation and increase of import prices, domestically produced goods that again can be considered substitutes, become more competitive. Exchange rates are an important factor for both exporting and importing firms, as firms' price setting policies are heavily influenced by them (Goldberg and Campa, 2010).

As discussed later, the ERPT does not depend only upon changes in exchange rates themselves, for the way the pass-through behaves, price stickiness, structure of international trade, competitiveness and other factors have their roles as well (Devereux and Yetman, 2002).

Understanding the relationship between movements in the exchange rate and movements in import and consequently domestic prices is also important for policy makers, who, through the degree of pass-through, monitor and provide forecasts about the domestic inflation, which is essential for the overall economic stability of a country (Babetskaia-Kukharchuk, 2007). Not only does the degree of pass-through helps in the field of forecasting, it is also helpful when deciding how monetary policy makers should respond to, for example, an increase in inflation that may have been caused by changes in the exchange rate (Franta et al., 2014). The ERPT ought to be part of a country's economic policy, as high levels of pass-through in any open economy are likely to cause troubles, when such an economy is hit by an exchange rate shock (Ponomarev et al., 2016).

ERPT manifests itself in two distinct ways, directly and indirectly. The difference between these two ways is that direct means that the pass-through is influenced via import prices of final goods and indirect via prices of intermediate goods that get imported and then used as inputs in the domestic production (Krugman, 1986). To get a clear idea how this ERPT mechanism works, let us consider a depreciation of the domestic currency towards a foreign currency. First, based on the literature, such a change leads to an increase in price of an imported good. The direct effect is more immediate as it is the result of pricing decisions of foreign producers who export to our home / domestic country. The indirect effect can take more time to materialize - with depreciation of domestic currency, production costs increase as imported production inputs get more expensive. During different stages of the production process towards the final good, inputs costs rise, thus putting upward pressure on the final consumer price. The opposite may be true in the case of appreciation, but not necessarily. Any change in the price, both through the direct or indirect channel, may be the result of a firm trying to keep its mark-ups and profits constant, in accordance with the change in the exchange rate, or to keep firm's prices competitive and thus lower firm's profits, regardless of the change in the exchange rate (Savoie-Chabot and Khan, 2015).

Based on empirical studies, the common observation is that changes in the exchange rate tend to have stronger effect on import prices compared to final consumer prices. The same is valid for the speed of the transmission of the change in the exchange rate, where the effect is more immediate for import prices (Campa and Goldberg, 2002). From another point of view, a change in the exchange rate has much stronger and much more immediate effect on import

prices, producer prices, and then declines along the whole pricing chain (Goldberg and Knetter, 1997). The size and speed of the transmission of the change in the exchange rate depends on the studied aggregation level of imports (in case of import prices) and product categories (in case of final consumer prices). Working with more disaggregated data provides more precise information at the product level (Villavicencio and Mignon, 2017). Final results vary across sectors (Parker and Wong, 2014), as well as across industries (Olivei, 2002). The reason for gradual and not immediate pass-through is the result of a slow process of adjusting prices. If the process was immediate, any change in the exchange rate would be transmitted immediately and also the real exchange rate would remain constant. What more, in such a perfect situation, the law of one price would hold (Devereux and Yetman, 2002).

1.1 Declining ERPT

Many recent contributions to the literature on ERPT argue that over time the degree of pass-through has declined over time. This is mostly true for advanced economies, where a low inflation environment has caused changes in composition of imports (Flodén and Wilander, 2006). For example, the study of Campa et al. (2005) shows that the degree of pass-through to import prices has declined in the euro area. The same shows the more recent study of Di Mauro et al. (2008).

What may be the cause of such results? Campa et al. (2005) suggest that the decline in the pass-through is an outcome of a change in the structure of imports, which is oriented more on manufacturing (manufactured goods) that is in general considered to be an industry with a lower degree of pass-through compared to other industries such as energy. Gust et al. (2010) propose that the decline is due to rising importance of low-price exporters whose role in the world trade has risen since the beginning of 90's tremendously. Also, globalization and its impact on the structure and behavior of markets caused the producing and importing companies to set and adjust their prices based on prices set by their competitors. Putting these two facts together, competition and lower export prices may have caused the decline in the degree of ERPT. The opposite to Gust et al. (2010) is in line with the statement of Benigno and Faia (2016) who state that greater competition results in higher degree of pass-through. According to them the degree of pass-through depends on the level of concentration in the specific market and the share of foreign goods in that market. According to Taylor (2000), a low inflation environment goes hand in hand with the lower degree of pass-through environment, resulting in reduction in the pricing power of firms. Behind such a low inflation environment there are usually capable monetary policy makers. When the inflation is low, any sudden change in the

exchange rate, in economic literature referred to as shock, is then less frequently perceived as long lasting, as the environment gets stabilized real soon again. With less persistent changes / shocks, the companies have no urge to change their prices, as such a fluctuation is just temporary and not persistent. The role of policy makers is evident and the public perception of their work and trust in their previous results helps the environment to remain stable. In his work, Taylor (2000) was the first one to point out the hypothesis that low inflation economies experience lower pass-through compared to high and unstable inflation economies.

1.2 Incomplete ERPT

Empirical evidence shows that exchange rate pass-through (ERPT) is incomplete. According to Parker and Wong (2014):

> "*The pass-through* […] *is in general neither instantaneous nor complete.*"

Compare this with complete pass-through:

> "*A one-to-one response of import prices to exchange rate changes is known as "complete" ERPT, while a less than one-to-one response of import prices to exchange rate changes is known as "partial" or "incomplete" ERPT.*" (Mumtaz et al., 2011).

Incomplete pass-through means that any change in the exchange rate results in a comparatively smaller change in the final price (Parker, 2014). It is valid for both import prices and consumer prices, where the imperfection is greater at the level of consumer prices. The reasons for incomplete pass-through are found at the micro level, how firms price their exports, in which currency they invoice, firms' competition. But macroeconomic factors as well – structure of imports, degree of openness, persistence of change of the exchange rate.

When talking about import prices, the degree of competition has an important impact on the degree of pass-through. When the home country experiences depreciation towards a foreign currency, foreign products / imports become more expensive in the home country. This phenomenon is known as producer currency pricing (PCP), which refers to a full pass-through of a change in the exchange rate to import prices. The exporting firm does not adjust its mark-up and the exporting firm's profit remains the same, even though the exchange rate has changed, (Égert and MacDonald, 2006). As an example, commodities such as coal and petroleum are typical case of PCP, as they are traded at the same international price (Savoie-Chabot and Khan, 2015). The other situation, known as local currency pricing (LCP), refers to zero pass-through

as well as partial pass-through. Byrne et al. (2010) state that any lower than complete pass-through points to LCP. The relationship between LCP and pass-through is such that the level of pass-through decreases as the share of LCP strategy increases (Égert and MacDonald, 2006). In a competitive market, where many foreign producers are active, firms using LCP may have to reduce their mark-ups, thus reducing their margins and overall profits, in order not to lose, or at least to maintain their share of the market. The lower the competition, the easier it is for a firm to adjust or not to having to adjust its prices (Gopinath et al., 2010).

The currency of invoice is important. A foreign exporting producer may charge, in its own currency, all its customers with one common price. In such a case, any change in the exchange rate is directly passed into import prices of all the customers, the pass-through is complete. But if, on the contrary, the foreign exporting producer would charge every market, to which it exports, with different price, the pass-through of the change in the exchange rate on import prices is incomplete. It primarily depends on the current situation of local competition, (Bacchetta and Van Wincoop, 2005). If all imports were to be priced in the currency of the importing country, then the import prices would not change with a change in the exchange rate (Gopinath and Itskhoki, 2010).

The movements in the exchange rate and its impact on the pass-through to import prices may be redundant, when a firm hedges itself against any such changes. It can be done in two ways. One is its financial strategy based on past and present development of the exchange rate and future expectations. The other one emerges naturally, as firms are increasingly integrated in global value chains in which the use of imported inputs from different countries is increasing. With hedging, the local currency pricing is more likely to be used (Martin and Méjean, 2012).

The degree of pass-through depends also on price rigidities and persistence of changes in the exchange rate. When a firm is about to change its prices / price list, it has to consider any applicable costs. Costs of adjusting prices are known as “menu costs”. In the case of small currency movements, neither an exporter nor an importer would change its prices. A slightly different scenario would occur, if a firm was to perceive a change in the exchange rate bigger than small but only temporary (a non-lasting shock). Then it would adjust its prices for a short period of time and only partially. This may occur more frequently in a stable, low inflation environment (Taylor, 2000).

From the previous paragraphs it may not be amiss to suggest that there is a strong relationship between the choice of the invoicing currency and the degree of ERPT.

1.3 Pricing, Pricing Power and ERPT

Setting prices of goods is a very complex and time-consuming process. The pricing power of a firm, meaning the degree to which a company can adjust its price / mark-up, as a response to a change in the exchange rate, depends on product substitutability and the number of firms present in the industry. The higher the substitutability and the higher the number of firms in the respective industry, the lower the pass-through to import prices (Dornbusch, 1987). The pricing power of a firm depends on the way how its product is differentiated from the competition's products. When substitutable products of different firms are differentiated horizontally, meaning that the quality and price are the same for substitutable products, the pricing power of these firms is low and ERPT is low. On the other hand, when the products are differentiated vertically, meaning that the quality and price are different for substitutable products, then firms that produce the higher quality products with less substitutes from the same manufacturing industry, have stronger pricing power and ERPT is high (Choudhri and Hakura, 2015).

The ability of a firm to adjust its final price as a consequence of increase in prices or costs, not just due to changes in the exchange rate, is dependent on how other firms, meaning the competition, react to such changes (Herzberg et al., 2003). If a firm does not react appropriately both to the changes in the exchange rate and to other firms' reactions to such changes, it may lose its market share and consequently profits.

The way a firm sets a price for its product now depends on a firm's expectations about the development of costs and prices that are strongly related to the movements in the exchange rate. An exchange rate fluctuation that is expected to be only short-term, for example in the case of depreciation of the domestic currency, it would result in a firm passing-through less of the depreciation into the increased price of a product (Berner, 2010).

1.4 Inflation, Inflation Targeting and ERPT

The Czech Republic is an inflation targeting country. In 1998, the Czech National Bank adopted the inflation targeting regime and currently maintains its inflation target of 2 percent (Hájek and Horváth, 2016).

> "*Understanding the behavior of import prices is a key issue for inflation targeting central banks in small open economies. Of particular importance is the responsiveness of import prices to movements in the*

nominal exchange rate – the degree of exchange rate pass-through."
(Bache, 2007)

For policy makers it is important to know how changes in the exchange rate influence the inflation level in their country. For many countries, inflation targeting has proven to be a successful monetary policy regime (Caselli and Roitman, 2016). Edwards (2006) and Gagnon and Ihrig (2004) report that countries that adopt inflation targeting regime experience a decline in their ERPT. These findings are in line with Choudhri and Hakura (2006) who tested 71 economies and found the evidence that countries who use inflation targeting regime achieve low inflation environment and their pass-through declines. Mishkin and Schmidt-Hebbel (2007) also finds that inflation targeting countries have lower pass-through compared to non-targeting countries. Results of Caselli and Roitman (2016) are also in line with previously stated findings that countries using inflation targeting regime achieve noticeably lower pass-through compared to non-targeting countries. Ramón María-Dolores (2009) find evidence for the relation between low inflation, inflation targeting regime and low degree of pass-through in the Czech Republic and other countries.

Countries with low exchange rate volatility and low and stable inflation, for example as the result of successful conduct of the inflation targeting regime policy, experience low pass-through. For countries experiencing higher exchange rate volatility and higher, not stable inflation levels, pass-through from exchange rate changes to prices is higher (Devereux and Yetman, 2002). Flodén and Wilander (2006) add based on their and other authors' research that countries with higher levels of inflation experience more evident asymmetry in their ERPT levels.

Based on the above stated findings, adoption of inflation targeting lowers the degree of ERPT. What's more, stable monetary conditions cause producers to pass-through a smaller portion of a temporary change in the exchange rate to prices (Campa and Goldberg, 2002).

It is not probably the case of the Czech Republic, but in general, national currencies of countries with high macroeconomic stability are more likely to be the choice as the invoicing currency in international transactions (Mumtaz et al., 2011).

Jašová et al. (2016) find that pass-through in emerging countries has on average decreased after the financial crisis → through decline in inflation. In advanced economies it still remains low.

1.5 ERPT and Asymmetry

It is tempting to embrace the theoretical point of view that ERPT is symmetric. However, it is not realistic. Pass-through asymmetries arise from the direction of the change in the exchange rate as well as from the size of the change in the exchange rate (Cheikh, 2012). Empirical studies show that when researching ERPT, asymmetries occur. Depreciations then may elicit a different reaction compared to appreciations and small changes in the exchange rate may prompt a different reaction compared to big changes in the exchange rate. For example, in terms of direction, Brun-Aguerre et al. (2017), Pollard and Coughlin (2004), Cheikh (2012) and Webber (2000) find that depreciations are passed-through more compared to appreciations. In terms of the size of the exchange rate, for example Pollard and Coughlin (2004) and Bussiere (2013) find that large changes in the exchange rate cause higher degree of pass-through compared to small changes in the exchange rate. Research was done on different manufacturing industries in the United States. The same is valid for European industries, Gil-Pareja (2000).

Before proceeding with asymmetries and their sources, it is important to first remember the pricing strategies, as they themselves are a possible cause of ERPT asymmetries, when not all exporters in an industry use the same strategy:

PCP – producer currency pricing

- ERPT is complete and the movement in the exchange rate is fully reflected in import price denominated in importing country's currency.

LCP – local currency pricing = pricing-to-market

- ERPT is zero or incomplete as the exporter absorbs either fully or partially the change in the exchange rate. The change is reflected in export price denominated in exporter's currency. The import price denominated in importing country's currency remains unchanged (zero pass-through) or does not reflect the change in the exchange rate completely (partial pass-through).

The economic literature (such as Krugman (1986), Menon (1996), María-Dolores (2009), Pollard and Coughlin (2004), Forero and Vega (2016), Júnior and León-Ledesma (2008)) provides a few possible explanations for why and how asymmetries may arise. Among the most important factors are:

Capacity constraints

- Appreciation of the importer's currency causes an increase in demand for imports, as imports become cheaper. In the short-run, due to the fact that production quantities are upward rigid in the short-run, an exporting firm operating at its full capacity cannot accommodate its production, increase its sales abroad, and satisfy the importing country's increased demand. In such a case, for the demand in the importing country to remain the same as before appreciation has taken place, the exporter increases its mark-up. With increased exporting price, as the result of increased mark-up, the quantity demanded in the importing country experiencing appreciation decreases. When importer's currency depreciates, the opposite happens. Exporter still wants to produce and sell at full capacity, that is why the exporting firm reduces its mark-up and the import price remains the same. ERPT is higher during times of importer's currency depreciations (Menon, 1996).

Market share

- Every firm's desire is to increase its market share or at least to avoid losing it. During times of importer's currency depreciation, in order to remain competitive and not to lose its market share, an exporter absorbs the increased costs of imports, the import price remains the same. In times of importer's currency appreciation, an exporter has three options. Either the exporting company does not take advantage of increased purchasing power in imports of the importing country, does not increase its price and the import price falls. A secondary result may be an increase in the firm's market share, as its price is more competitive and more pleasant for customers. Or the exporting company does take advantage of increased purchasing power in imports of the importing country, does increase its price, the quantity demanded does not fall and as a result, exporting firm's profits rise. Exporting firm's market share in the importing country's market does not change. Third option is combination of both. ERPT is larger during times of importer's currency appreciations (Pollard and Coughlin, 2004).

Menu costs

- Because of costs associated with changing price, an exporter may not react to small changes in the exchange rate. But as soon as a change is subjectively considered to be high enough, the exporter would change its price. Changes then occur more frequently with large changes in the exchange rate than with small changes in the exchange rate.

The threshold for distinguishing between what a small change is or what a large change is, depends solely on the exporter's perception (Krugman, 1986).

Competition

- In weakly competitive markets, exporters pass-through depreciations more than appreciations to maintain mark-ups (in case of LCP, PCP not touched). Exporters may exploit exchange rate fluctuations → they increase price with appreciation, but don't reduce it back with depreciation (Júnior and León-Ledesma, 2008).

Technology switching

- Exporters pass-through appreciations but absorb depreciations, as they can easily, almost immediately, switch from using domestic production inputs to foreign production inputs. A change in the exchange rate does not then affect the production price of the exporting good. Easier to perform in long-run compared to short-run (Forero and Vega, 2016).

Expectations about exchange rate development

- If an exporter expects the exchange rate to change, the company does not have to wait for the change and changes the export price before the change itself actually happens (María-Dolores, 2009).

In general, when the market situation is in bad shape, exporters prefer PCP to LCP, which results in a higher level of pass-through (Cheikh, 2012).

> "*When the economy faces a financial or confidence crisis, foreign firms may decide to 'pass through' a larger proportion of exchange rate changes in view of the increased likelihood of default from the importer. In this case, ERPT is higher because exporters tend to set prices in their own currency (producer currency pricing or PCP strategy). However, when macroeconomic conditions are considered good, exporting firms absorb currency fluctuations within markup by setting prices in the currency of the stable importing country (local currency pricing or LCP setting). Consequently, ERPT is expected to be higher in times of confidence crisis than during periods of macroeconomic stability*." (Cheikh and Rault, 2016).

Conversely, during times of economic growth, compared to recessions, firms' market power is stronger, exporters can increase their mark-ups without losing their market share. ERPT is larger in times of economic growth:

> "*Exporting firms would find it easier to pass-through exchange rate changes when the economy is growing fast, rather than when it is in a recession and its sales are already falling.*" (Cheikh et al., 2018).

When focusing on more disaggregated data, in this case more disaggregated levels of manufacturing industry, Yang (1997), Pollard and Coughlin (2004), Campa and Goldberg (2006) and Cheikh (2012) conclude, based on their individual empirical research, that the degree of ERPT varies throughout different disaggregated manufacturing industry sectors, with respect to the size and the direction of the change in the exchange rate.

2 EMPIRICAL INVESTIGATION

2.1 Estimation Strategy

The empirical analysis of this thesis follows the approach by Pollard and Coughlin (2004) who examine ERPT at disaggregated industry levels and explore the possibly observable asymmetries amongst them. For the purpose of the Czech Republic's case, the modified basic regression equation is as follows:

$$\Delta \ln p_{i,t}^{CZ} = \beta_{1,i} \Delta \ln e_t + \beta_{2,i} \Delta \ln p_{i,t}^{y} + \beta_{3,i} \Delta \ln w_{i,t} + \beta_{4,i} \Delta \ln I_{i,t}^{CZ} + \text{monthly dummies} + \text{error}$$

where i represents the specific manufacturing industry (list of manufacturing industries given below in Table 1), t is the time period (all observations are monthly), and the Czech Republic is the home country. The dependent variable – the import price in industry i – is expected to be influenced in the following way:

- An increase in *e* that takes place at time t, representing an appreciation of the currency [1] – the Czech koruna, is expected to lower the import price of a good produced by foreign exporter in industry i.
- An increase in the price of a domestically produced good p^y, which is a substitute to the imported good, is expected to raise the import price of the imported good.

[1] Exchange rate = units of foreign currency per unit of domestic currency.

- An increase in w (foreign marginal cost of production) should increase the import price as well.
- The impact of a change in the domestic expenditure (income) measure I^{CZ} on import price is ambiguous, as the relation between a change in the exchange rate and the resulting change in domestic expenditures is unclear.
- When the used data are seasonally unadjusted, monthly dummy variables are to be implemented to capture any seasonal effects, as recommended by Pollard and Coughlin (2004).

2.2 Data and Methodology

The dataset covers the manufacturing sector as a whole (Section), as well as 13 manufacturing industries (Divisions) based on the NACE Revision 2 classification (Statistical classification of economic activities in the European Community). The sample period runs from 01/2000 through 05/2018. In total there are 221 monthly observations. Table 1 Provides details about the structure of the Manufacturing Sector in the Czech Republic.

Table 1
List of manufacturing industries

NACE Rev. 2	description
C	Manufacturing
CA	Manufacture of food products, beverages, tobacco
CB	Textiles, clothes, leather and leather products
CC	Wood, wood product, paper, printing
CD	Coke, refined petroleum products
CE	Chemicals and chemical products
CF	Basic pharmaceutical products
CG	Rubber and plastic products, other non-metallic mineral products
CH	Basic metals, fabricated metal products
CI	Computer, electronic and optical products
CJ	Electrical equipment
CK	Machinery and equipment n.e.c
CL	Transport equipment
CM	Furniture, other manufactured products

Next, I give a short description of the data series used in the empirical analysis.

$\underline{\mathbf{p^{CZ}}}$

Data for monthly import price indices based on revised external trade structure of the year 2015 are gathered from the Czech Statistical Office (CZSO) website.

e

For the exchange rate the Nominal Effective Exchange Rate (NEER) is used, which is calculated by the Czech National Bank (CNB) on a monthly basis:

> "*The NEER calculation method applied by the European Central Bank (ECB) incorporates the shares in exports and imports of the Czech Republic's largest trading partners and comprises those groups of goods which are not so sensitive to political measures and better reflect the level of international competitiveness attained.*" (CNB, 2017).

> "*On the basis of the Czech Statistical Office statistics on the territorial and commodity structure of foreign trade for 2015, 31 countries – accounting for approximately 90% of the Czech Republic's foreign trade – were selected. For the calculations the euro area countries are identified as a single currency area (the number of euro area countries corresponds to the actual state).*" (CNB, 2017).

Weights of monetary areas displayed in Table 2 are shares of the total trade turnover of the Czech Republic by importance, calculated for the purpose of the NEER computation and reported by the CNB on their website database (CNB, 2017):

Table 2
Weights of monetary areas

Monetary area	**Corresponding weight in 2015 in %**
Eurozone	64,3
China	7,8
Poland	7,6
United Kingdom	4,3
Hungary	3,0
Russia	2,8
USA	2,6
Switzerland	1,4
Korea	1,4
Romania	1,4
Sweden	1,3
Japan	1,2
Denmark	0,9
Total	100

Source: CNB (2017)

$\underline{p^y}$

The data for Czech substitutes – domesticaly produced goods - are monthly domestic industry producer price indices (PPI) based on NACE Revision 2 obtained from the Czech Statistical Office (CZSO) website.

$\underline{w}$

The foreign marginal cost of production is calculated from individual foreign industry Producer Price Indices (PPI) (based either on NACE Rev. 2 classification or classifications in correspondence with this classification, which are stated below) and weighted according to their importance for the Czech Republic's foreign trade. The countries and areas included are identical to the list of NEER countries and areas (Table 2), as are the weights computed by the CNB. Not all the monetary areas calculate and publish their PPIs (not only industrial) available in the format of European classification of economic activities NACE Rev. 2 and some modifications must be made. The sources for PPIs differ as well:

Table 3
PPI data sources

Eurozone	Eurostat
China	National Bureau of Statistics of China
Poland	Eurostat
United Kingdom	Eurostat
Hungary	Eurostat
Russia	Russian Federation Federal State Statistics Service
USA	Bureau of Labor Statistics
Switzerland	Eurostat; OECD
Korea	Bank of Korea
Romania	Eurostat
Sweden	Eurostat
Japan	Bank of Japan
Denmark	Eurostat; Statistics Denmark

Data from Eurostat are available in NACE Rev. 2 classification format.

China - overall manufacturing PPI is used for all manufacturing industries (PPI for single sub-industries not available)

Russia – PPIs of manufacturing industries available (NACE Rev. 2 classification)

USA – PPIs of manufacturing industries available

Korea – PPIs of manufacturing industries available

Japan – PPIs of manufacturing industries available

All PPIs are shifted to the same base of monthly average of 2015 = 100. Either a time series with different base year is shifted to the desired base year [2], or as in the case of China and Russia, the shift is from chain base to fixed base [3].

Table 4 provides an overview of classification schemes used in Europe and important non-European trading partners.

Table 4
Corresponding groups of used classifications

NACE Rev. 2	USA (sub-sectors)	Korea (basic groups)	Japan (groups)
C	OMFG	Manufacturing products	Manufacturing industry products
CA	311; 312	Food products & beverages	Beverages & foods
CB	313; 314; 315; 316	Fiber products & leather products	Textile products
CC	321; 322; 323	Wood & paper products	Lumber & wood products Pulp, paper & related products
CD	324	Coal products & petroleum products	Petroleum & coal products
CE	325	Basic chemical products Chemical fibers Final chemical products	Chemicals & related products
CF	3254	Pharmaceuticals	Pharmaceutical products
CG	326; 327	Plastic products Rubber products Non-metallic mineral products	Plastic products Ceramic, stone & clay products
CH	331; 332	Basic metal products Metal products	Iron & steel Nonferrous metals Metal products
CI	334	Semiconductor & electronic display devices Other electronic components Computers and peripherals Electronic appliances for home use	Electronic components & devices Information & communications equipment
CJ	335	Electrical machinery & apparatus	Electrical machinery & equipment
CK	333	General machinery	General purpose machinery Production machinery Business oriented machinery
CL	336	Transport equipment	Transportation equipment
CM	337; 339	Other manufacture products	Other manufacturing industry products

[2] The monthly average of 2015 is computed and used as the base number equal to index number 100. For all the months observed, this average is used to compute their corresponding index number.

[3] The monthly producer price indices of Russia and China are published in such a form that a monthly index is the percent of end of previous period (month). The data gets recomputed and shifted to the base of monthly average of 2015 = 100.

As mentioned before, the weight assigned to each foreign country's or area's overall PPI or industry PPI is identical to the weight used in the NEER exchange rate - ω. Knowing this, for each industry i at time t we get:

$$w_{i,t} = \sum_{j=1}^{14} \omega_{i,j,t} \, PPI_{i,j,t}$$

In the case of division CD of NACE Rev. 2 "Coke, refined petroleum products", Denmark is excluded, as no data is available:

$$w_{CD,t} = \sum_{j=0,991}^{13} \omega_{CD,j,t} \, PPI_{CD,j,t}$$

I^{CZ}

The domestic monthly expenditures on industry level are measured as monthly gross values of output in domestic prices + imports – exports, where imports and exports are free of any tax or freight costs.

The data about the value of output for year 2015, as the base year, are from OECD and its STAN Industrial Analysis, which is based on NACE Rev. 2 classification. The whole period of 01/2000 – 05/2018 is then computed through monthly indices of "Production in industry" – again NACE Rev. 2 classification, which is available from Eurostat's short-term business statistics.

The values of imports and exports are from CZSO website and their External Trade Database. As this database does not offer NACE Rev. 2 classification, the manufactured commodities are converted from SITC classification to NACE Rev. 2 classification.

Table 5
Link between NACE Rev. 2 & SITC classification

NACE Rev. 2	**SITC codes**
C	All the below stated
CA	02; 04; 06; 07; 09; 11; 12
CB	26; 61; 65; 84; 85
CC	24; 25; 63; 64
CD	32; 33
CE	51; 52; 53; 56; 59
CF	54
CG	23; 57; 58; 62; 66
CH	67; 68; 69
CI	75; 76; 87; 88
CJ	77
CK	71; 72; 73; 74
CL	78; 79
CM	82; 89

All the used time series index data have as its base the average monthly value of the year 2015 = 100.

2.3 Taking Stock of Exchange Rate Changes

In the sample period of 01/2000 – 05/2018, the monthly changes of the nominal effective exchange rate (NEER) show that appreciations are more frequent than depreciations. The division of changes in the observed exchange rate into rises (appreciation) and falls (depreciation) is recorded in Table 6.

Table 6 **Changes in value of domestic currency**	
Appreciation	128 months
Depreciation	93 months

Appreciations account for 57,92% and depreciations for 42,08 % of all changes. To distinguish the size of the change between two months, I calculate and record in Table 7 the percentage changes, in absolute value, of each month compared to the preceding month.

Table 7 **Size of change "*x*" in NEER in % compared to previous month; in absolute value**	
$1 > x \geq 0$	136 months
$2 > x \geq 1$	59 months
$3 > x \geq 2$	13 months
$4 > x \geq 3$	7 months
$5 > x \geq 4$	1 month (11/2003)
$6 > x \geq 5$	1 month (03/2009)
$7 > x \geq 6$	2 months (04 & 05/2015)
$10 > x \geq 9$	1 month (01/2012)
$12 > x \geq 11$	1 month (02/2012)

As regards the size of observerd changes, I propose a classification scheme that distinguishes between small, medium, and large changes. Small size changes, defined to fall in the range of 0 % to 1 %, are the most frequent, accounting for 61,54 % of all changes. Medium size changes, defined to fall in the range of 1 % to 2 %, account for 26,70 % of all changes. Large size changes, which fall in the range of 2 % to 12 %, are the least frequent, accounting for 11,76 % of all changes. Not surprisingly, the larger the change, the less frequent its occurrence.

3 RESULTS

The results from estimated regression equation are given in the following Table 8.

Table 8
Regression Coefficients – Basic Model Estimated via OLS

NACE Rev. 2	β_1	β_2	β_3	β_4	R-squared	Durbin--Watson
C	-0.394 **	0.624 **	0.298	0.002	0.65	2.074
	(0.106)	(0.218)	(0.251)	(0.003)		
CA	-0.288 **	0.034	0.251	0.006	0.18	1.666
	(0.081)	(0.125)	(0.200)	(0.005)		
CB	-0.361 **	0.142	0.101	-0.001	0.53	1.693
	(0.090)	(0.156)	(0.213)	(0.002)		
CC	-0.369 **	0.301	1.330 **	-0.001	0.48	1.302
	(0.093)	(0.221)	(0.289)	(0.003)		
CD	-0.689 **	0.105 **	0.794 **	-0.017	0.72	1.919
	(0.197)	(0.036)	(0.068)	(0.015)		
CE	-0.374 **	0.054	0.550 **	-0.005	0.63	1.987
	(0.086)	(0.037)	(0.102)	(0.004)		
CF	-0.328 **	-0.088	0.328	0.001	0.37	1.484
	(0.078)	(0.079)	(0.341)	(0.003)		
CG	-0.337 **	0.274 *	1.702 **	-0.005 +	0.52	1.843
	(0.088)	(0.151)	(0.299)	(0.002)		
CH	-0.359 **	0.099	0.510 **	0.000	0.59	1.811
	(0.090)	(0.078)	(0.121)	(0.003)		
CI	-0.299 **	0.859 **	0.108	0.001	0.74	1.942
	(0.082)	(0.152)	(0.084)	(0.001)		
CJ	-0.441 **	0.185 *	-0.544 *	-0.003	0.61	1.924
	(0.104)	(0.106)	(0.316)	(0.002)		
CK	-0.445 **	0.288	-0.279	0.002	0.61	1.906
	(0.103)	(0.218)	(0.389)	(0.002)		
CL	-0.294 **	0.734 **	-0.003	-0.002	0.75	1.672
	(0.077)	(0.125)	(0.257)	(0.002)		
CM	-0.380 **	0.155	0.160	0.006 +	0.49	1.717
	(0.097)	(0.258)	(0.353)	(0.004)		

* denotes significance at the 5% level based on a one-tailed test
** denotes significance at the 1% level based on a one-tailed test
\+ denotes significance at the 5% level based on a two-tailed test
figure in ( ) below the coefficient estimate denotes its standard error[4]

Note: the estimated regression equation is as follows (as in section 2.1 Estimation Strategy):

$$\Delta \ln p_{i,t}^{CZ} = \beta_{1,i} \Delta \ln e_t + \beta_{2,i} \Delta \ln p_{i,t}^{y} + \beta_{3,i} \Delta \ln w_{i,t} + \beta_{4,i} \Delta \ln I_{i,t}^{CZ} + \text{error}$$

[4] Reported standard errors adjusted for autocorrelation and heteroscedasticity (Newey-West HAC)

As expected, β_1, the coefficient, which measures the exchange rate pass-through (ERPT) is negative in all cases. Importantly, it is always statistically significant. For all the industries, except for CD – coke, refined petroleum products, the hypothesis that $\beta_1 = -1$, can be rejected. Thus, in all but one case the hypothesis that ERPT is complete can be rejected. The only manufacturing industry, for which complete pass-through cannot be rejected, is CD. It is the only manufacturing industry where the hypothesis that $\beta_1 = -1$ falls into the confidence interval which is computed as the estimated coefficient $\beta_1 \pm 2$ times the respective standard error. In the case of CD (-0.295; -1.083). Its point estimate is above 50 percent.

The results show that pass-through is incomplete in C – manufacturing as well as in all other manufacturing industries, except for the already mentioned CD. Pass-through is zero in none of the industries.

The pass-through varies throughout manufacturing industries ranging from 29 % in CA – manufacture of food products, beverages, tobacco and CL – transport equipment to 69 % in CD - coke, refined petroleum products. Results correspond with the theory that changes in the exchange rate tend to have stronger effect on import prices compared to final consumer prices. Consumer goods market's pass-through is lower, compared to commodity market where metals, mining and petroleum products are traded. The average level of pass-through for all manufacturing industries, excluding C – manufacturing, is 38 %.

Apart from exchange rate pass-through, I find sparse evidence that other factors are statistically related to import prices. When looking at the coefficients of the other variables of the estimated regression equation, statistical significance is much less frequent. With few exceptions, the proxies for β_2 – price of domestically produced substitute good to the good imported and β_3 – foreign marginal cost of production are mostly positive, as expected, but its statistical significance varies, being present in β_2 in 5 out of 13 manufacturing industries and only in 6 out of 13 in β_3. Changes in Czech Republic's domestic expenditures - β_4 are positive in 5 and negative in 7 manufacturing industries, CH - basic metals, fabricated metal products being 0. Statistically significant are only CG – rubber and plastic products, other non-metallic mineral products and CM - furniture, other manufactured products.

3.1 Long-run Pass-through

As the transmission of a change in the exchange rate into import prices does not have to be immediate, I investigate the gradual effect of such a change in some future time.

For long-run pass-through estimation, originally three, six, nine and twelve lags were added to the exchange rate in the estimated regression equation. Results are given in the

following Table 9. Additionally, fifteen, eighteen, twenty-one and twenty-four lags were used as well, to capture delayed pass-through. These results are reported in Table 10.

Table 9
Long-run Pass-through

NACE Rev. 2	β_1 original pass-through	max. long-run pass-through	number of lags
C	-0.394 *	-0.513 *	6
CA	-0.288 *	-0.605 *	6
CB	-0.361 *	-0.412 *	3
CC	-0.369 *	-0.492 *	6
CD	-0.689 *	-0.689 *	0
CE	-0.374 *	-0.559 *	6
CF	-0.328 *	-0.369	6
CG	-0.337 *	-0.574 *	6
CH	-0.359 *	-0.543 *	6
CI	-0.299 *	-0.491	12
CJ	-0.441 *	-0.619 *	6
CK	-0.445 *	-0.661 *	6
CL	-0.294 *	-0.466 *	9
CM	-0.380 *	-0.513 *	3

* denotes significance at the 5% level based on a one-tailed test

For most manufacturing industries (8 out of 13), the hypothesis that the sum of lagged coefficients equals –1, cannot be rejected. Their pass-through is complete in the long-run, respectively in some later time / moment (within the next twelve months). Point estimates are above 50 percent.

This is valid for C - manufacturing as whole as well. For industries CB - textiles, clothes, leather and leather products, CC - wood, wood products, paper, printing, CF - basic pharmaceutical products, CI - computer, electronic and optical products and CL - transport equipment, the pass-through is not complete.

An interesting case is the case of manufacturing industry CD - coke, refined petroleum products, where the maximum (in this case complete) pass-through occurs immediately, meaning with no lags added. Possible explanation is that prices of these products are widely traded in global markets and so the prices are influenced heavily by current / immediate movements in exchange rates.

The number of lags that a specific manufacturing industry needs to achieve complete long-run pass-through, even though some manufacturing industries may never reach complete pass-through, varies from 0 to 12 lags and averages out at 6 lags. 0 lags being the shortest time

at manufacturing industry CD - coke, refined petroleum products and 12 being the longest at CI - computer, electronic and optical products.

Summary of the extent of pass-through in each manufacturing industry (during lags fifteen, eighteen, twenty-one and twenty-four) is shown in the following Table 10:

Table 10
Summary of the extent of pass-through in each manufacturing industry

NACE Rev. 2	
C	then fluctuates around 40 percent *
CA	then increases after 15 lags, but is not statistically significant
CB	never reaches complete pass-through
CC	then decreases and never reaches complete pass-through
CD	then pass-through dramatically decreases and is not statistically significant
CE	then fluctuates around 50 percent *
CF	never reaches complete pass-through
CG	then fluctuates around 55 percent *
CH	then fluctuates around 50 percent *
CI	does reach complete pass-through by 15 lags, but is not significant by that time
CJ	then fluctuates slightly below 60 percent *
CK	then fluctuates slightly above 60 percent *
CL	does reach complete pass-through by 15 lags, but is not significant by that time
CM	then fluctuates below 50 percent *
* stated number denotes % of ERPT	

3.2 Asymmetry in Pass-through: Appreciations and Depreciations

The original estimated regression equation does not distinguish between different movements in the exchange rate - appreciations and depreciations. In order to catch differences in changes in the exchange rate, in other words to determine whether the pass-through is asymmetric with respect to the direction of the change in the exchange rate, the original estimated regression equation has to be modified. Let's introduce and implement two dummy variables that make it possible to distinguish between those months in which the exchange rate appreciates and in which it depreciates. Then for each industry i we use dummy variable:

$A_t = 1$ when $\Delta \ln e_t > 0$, otherwise $A_t = 0$

and

$D_t = 1$ when $\Delta \ln e_t < 0$, otherwise $D_t = 0$

where A_t denotes a month in which appreciation takes place and D_t a month in which depreciation takes place. When letting these dummy variables interact with the exchange rate and replacing "$\beta_1 \Delta \ln e_t$" in the original estimated regression equation with "$\beta_{1A} (A_t \Delta \ln e_t) + \beta_{1D} (D_t \Delta \ln e_t)$", we get estimates for pass-through under appreciations and depreciations separately.

The results are shown in the following Table 11:

Table 11
Pass-through with Appreciation and Depreciation Dummy Variables

	Appreciation		Depreciation	
NACE Rev. 2	Estimate	Std. Error	Estimate	Std. Error
C	-0.374 **	0.040	-0.417**	0.043
CA	-0.187 **	0.065	-0.398 **	0.068
CB	-0.395 **	0.039	-0.325 **	0.040
CC	-0.406 **	0.049	-0.330 **	0.050
CD	-0.564 **	0.147	-0.830 **	0.153
CE	-0.363 **	0.037	-0.386 **	0.039
CF	-0.266 **	0.048	-0.394 **	0.049
CG	-0.291 **	0.042	-0.386 **	0.044
CH	-0.371 **	0.038	-0.346 **	0.040
CI	-0.244 **	0.037	-0.353 **	0.037
CJ	-0.416 **	0.040	-0.468 **	0.042
CK	-0.411 **	0.041	-0.842 **	0.043
CL	-0.254 **	0.035	-0.335 **	0.036
CM	-0.387 **	0.043	-0.374 **	0.045

** denotes significance at the 1% level based on a one-tailed test

Note: the estimated regression equation is as follows:

$$\Delta \ln p_{i,t}^{CZ} = \beta_{1A,i} (\Delta A_t \ln e_t) + \beta_{1D,i} (\Delta D_t \ln e_t) + \beta_{2,i} \Delta \ln p_{i,t}^{y} + \beta_{3,i} \Delta \ln w_{i,t} + \beta_{4,i} \Delta \ln I_{i,t}^{CZ} + \text{error}$$

The pass-through in all manufacturing industries, as well as in manufacturing itself, is always statistically significant, both during periods of appreciations and depreciations. In none of the industries can the restriction $\beta_{1A} = \beta_{1D}$ be rejected at the 1 percent level.

The pass-through is almost identical in both directions to original estimates β_1 (Table 8) in manufacturing industries CE - chemicals and chemical products, and CM - furniture, other manufactured products. On the other hand, industries in which the pass-through deviates largely in both directions form the original estimates β_1 are CA - manufacture of food products, beverages, tobacco and CD - coke, refined petroleum products (gasoline plus other raw material prices increase rapidly when the domestic currency depreciates).

When looking at industries, in which the deviation from original estimate β_1 are considerably larger in periods of appreciations compared to depreciations, there is no manufacturing industry to highlight. On the other hand, CK - machinery and equipment n.e.c is the one industry, in which the deviation from original estimates β_1 is considerably larger in periods of depreciations compared to appreciations.

The size of pass-through is different in periods of appreciations and periods of depreciations. The manufacturing industries, in which the pass-through estimates are larger in times of appreciation are CB - textiles, clothes, leather and leather products, CC - wood, wood products, paper, printing, CH - basic metals, fabricated metal products and CM - furniture, other manufactured products. The opposite, meaning that pass-through estimates are larger in times of depreciation, is true for CA - manufacture of food products, beverages, tobacco, CD - coke, refined petroleum products, CE - chemicals and chemical products, CF - basic pharmaceutical products, CG - rubber and plastic products, other non-metallic mineral products, CI - computer, electronic and optical products, CJ - electrical equipment, CK - machinery and equipment n.e.c and CL - transport equipment, as well as for C – manufacturing.

The average pass-through of changes in the exchange rate in appreciation periods is 35% and in depreciation periods 44% (in both cases excluding C – manufacturing with 37% and 42%). The degree of pass-through is on average larger in times of depreciation compared to times of appreciation.

3.3 Asymmetry with respect to the size of the exchange rate change

The degree of pass-through may be dependent and sensitive to the size of the change in exchange rate, meaning that the degree of pass-through may be positively correlated to the size of the exchange rate. To test this, two dummy variables are created, where one dummy variable represents a “large change” in the exchange rate in the given month and the other dummy variable represents a “small change” in the exchange rate in the given month, considering both, positive and negative changes. For each industry i, dummy variables can be written as:

$L_t = 1$ when $|\Delta \ln e_t| \geq 1$, otherwise $L_t = 0$

and

$S_t = 1$ when $|\Delta \ln e_t| < 1$, otherwise $S_t = 0$

where L_t denotes a month in which a large exchange rate change takes place and S_t a month in which a small exchange rate change takes place. The threshold value of 1 % for monthly data was chosen based on the fact that Pollard and Coughlin (2004) used a threshold of 3 % for their quarterly data. When letting these dummy variables interact with the exchange rate and replacing "$\beta_1 \Delta \ln e_t$" in the original estimated regression equation with "$\beta_{1L} (L_t \Delta \ln e_t) + \beta_{1S} (S_t \Delta \ln e_t)$", we get separate estimates for pass-through under large changes in exchange rate and small changes in exchange rate, regardless of their direction.

The results are shown in the following Table 12:

Table 12
Pass-through with Large and Small Dummy Variables

	Large Dummy		Small Dummy	
NACE Rev. 2	Estimate	Std. Error	Estimate	Std. Error
C	-0.370 **	0.026	-0.743 **	0.095
CA	-0.282 **	0.044	-0.369 *	0.164
CB	-0.347 **	0.024	-0.578 **	0.095
CC	-0.353 **	0.031	-0.594 **	0.119
CD	-0.638 **	0.094	-1.526 **	0.366
CE	-0.360 **	0.024	-0.604 **	0.090
CF	-0.307 **	0.030	-0.632 **	0.117
CG	-0.317 **	0.027	-0.671 **	0.102
CH	-0.346 **	0.025	-0.553 **	0.093
CI	-0.292 **	0.026	-0.427 **	0.084
CJ	-0.431 **	0.026	-0.613 **	0.100
CK	-0.429 **	0.027	-0.662 **	0.100
CL	-0.281 **	0.025	-0.491 **	0.080
CM	-0.370 **	0.028	-0.540 **	0.106

* denotes significance at the 5% level based on a one-tailed test
** denotes significance at the 1% level based on a one-tailed test

Note: the estimated regression equation is as follows:

$$\Delta \ln p_{i,t}^{CZ} = \beta_{1L,i} (\Delta L_t \ln e_t) + \beta_{1S,i} (\Delta S_t \ln e_t) + \beta_{2,i} \Delta \ln p_{i,t}^{y} + \beta_{3,i} \Delta \ln w_{i,t} + \beta_{4,i} \Delta \ln I_{i,t}^{CZ} + \text{error}$$

The pass-through in all manufacturing industries, as well as in manufacturing itself, is always statistically significant, both during periods of large and of small changes in the exchange rate, regardless of their direction.

In all cases, meaning in all the manufacturing industries and the C – manufacturing itself, the degree of pass-through during periods of large changes in the exchange rate, regardless of their direction, is always lower compared to the original estimates β_1 from the

original estimated regression equation, which are displayed in Table 8. Even though the estimates are a little bit lower, their values are still almost identical to the original estimates.

We cannot say the same about the pass-through during the periods of small changes in the exchange rate. When we are comparing the estimates to the original estimates β_1 from the original estimated regression equation, which are in Table 8, the values are much larger. For example, in several manufacturing industries and the C - manufacturing itself, we observe at least or more than 20 percentage points difference in the small changes in the exchange rate compared to the original estimates β_1. This is true for CC - wood, wood products, paper, printing, CD - coke, refined petroleum products, where the difference is the most visible, CE - chemicals and chemical products, CF - basic pharmaceutical products, CG - rubber and plastic products, other non-metallic mineral products and CK - machinery and equipment n.e.c.

The average pass-through in periods of large changes in the exchange rate is 37 % and in periods of small changes in the exchange rate 64 % (in both cases excluding C – manufacturing). The degree of pass-through is on average larger in periods of small changes compared to periods of large changes in the exchange rate, regardless of the direction.

3.4 Asymmetry with respect to the size and direction of the exchange rate change combined

The last step to take is to combine the two previous specifications into one regression equation – asymmetry with respect to the direction of the change in the exchange rate (appreciation and depreciation) and asymmetry with respect to the size of the exchange rate change. Four dummy variables are created, where they represent 1) appreciating large changes, 2) appreciating small changes, 3) depreciating large changes and 4) depreciating small changes. For each industry i, the dummy variables are as stated:

$LA_t = 1$ when $L_t = 1$ and $A_t = 1$, otherwise $LA_t = 0$

$SA_t = 1$ when $S_t = 1$ and $A_t = 1$, otherwise $SA_t = 0$

$LD_t = 1$ when $L_t = 1$ and $D_t = 1$, otherwise $LD_t = 0$

$SD_t = 1$ when $L_t = 1$ and $D_t = 1$, otherwise $SD_t = 0$

where LA_t denotes a month in which a combination of large exchange rate change and appreciation takes place, SA_t denotes a month in which a combination of small exchange rate

change and appreciation takes place, LD_t denotes a month in which a combination of large exchange rate change and depreciation takes place and SD_t a month in which a combination of small exchange rate change and depreciation takes place. When letting these dummy variables interact with the exchange rate and replacing "$\beta_1 \Delta \ln e_t$" in the original estimated regression equation with:

"$\beta_{1LA} (LA_t \Delta \ln e_t) + \beta_{1SA} (SA_t \Delta \ln e_t) + \beta_{1LD} (LD_t \Delta \ln e_t) + \beta_{1SD} (SD_t \Delta \ln e_t)$",

we get separate estimates for combinations of different direction and size changes in the exchange rate.

The results are shown in the following Table 13:

Table 13
Pass-through with Combination of Direction and Size Dummy Variables

	Appreciation				Depreciation			
	Large Dummy		Small Dummy		Large Dummy		Small Dummy	
NACE Rev. 2	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
C	-0.346 **	0.040	-0.601 **	0.157	-0.395 **	0.043	-0.929 **	0.192
CA	-0.192 **	0.068	-0.357	0.267	-0.385 **	0.071	-0.317	0.324
CB	-0.380 **	0.040	-0.563 **	0.157	-0.310 **	0.041	-0.623 **	0.189
CC	-0.378 **	0.050	-0.446 *	0.196	-0.322 **	0.052	-0.826 **	0.240
CD	-0.476 **	0.151	-0.837	0.602	-0.799 **	0.157	-2.391 **	0.734
CE	-0.346 **	0.038	-0.527 **	0.148	-0.373 **	0.040	-0.704 **	0.180
CF	-0.236 **	0.049	-0.405 *	0.192	-0.381 **	0.050	-0.906 **	0.234
CG	-0.278 **	0.043	-0.646 **	0.169	-0.359 **	0.044	-0.679 **	0.206
CH	-0.356 **	0.039	-0.499 **	0.155	-0.335 **	0.041	-0.637 **	0.189
CI	-0.234 **	0.038	-0.297 *	0.137	-0.349 **	0.038	-0.561 **	0.163
CJ	-0.412 **	0.042	-0.617 **	0.165	-0.453 **	0.044	-0.591 **	0.201
CK	-0.401 **	0.042	-0.666 **	0.167	-0.460 **	0.044	-0.638 **	0.201
CL	-0.241 **	0.036	-0.404 **	0.132	-0.322 **	0.036	-0.584 **	0.158
CM	-0.389 **	0.045	-0.667 **	0.177	-0.352 **	0.047	-0.375 *	0.214

* denotes significance at the 5% level based on a one-tailed test

** denotes significance at the 1% level based on a one-tailed test

Note: the estimated regression equation is as follows:

$$\Delta \ln p_{i,t}^{CZ} = \beta_{1LA} (LA_t \Delta \ln e_t) + \beta_{1SA} (SA_t \Delta \ln e_t) + \beta_{1LD} (LD_t \Delta \ln e_t) + \beta_{1SD} (SD_t \Delta \ln e_t) + \beta_{2,i} \Delta \ln p_{i,t}^{y} + \beta_{3,i} \Delta \ln w_{i,t} + \beta_{4,i} \Delta \ln I_{i,t}^{CZ} + \text{error}$$

In the vast majority of the derived results, the pass-through estimates are statistically significant, except for CA - manufacture of food products, beverages, tobacco, and CD - coke, refined petroleum products, during periods of combination of small changes in exchange rate

and appreciation and CA - manufacture of food products, beverages, tobacco, during periods of combination of small changes in exchange rate and depreciation.

The pass-through results range from 19 % to 239 %. The average value for large size appreciation changes is 33 %, for small size appreciation changes 53 %, for large size depreciation changes 40 % and for small size depreciation changes 76 %. On average, the pass-through is larger during depreciation periods compared to appreciation periods, both during small and large size changes in the exchange rate.

With one exception, depreciation in CA - manufacture of food products, beverages, tobacco, all the pass-through estimates are larger during periods of small changes in exchange rate compared to large changes, regardless of the direction of the change in the exchange rate.

The spread between large and small changes in the exchange rate during periods in which the exchange rate appreciates is sometimes large. As a significant spread one can consider a difference of at least 20 percentage points, which is present in 5 manufacturing industries during appreciations: CD - coke, refined petroleum products, CG - rubber and plastic products, other non-metallic mineral products, CJ - electrical equipment, CK - machinery and equipment n.e.c, and CM - furniture, other manufactured products. The same applies for periods in which the exchange rate depreciates. A spread of at least 20 percentage points difference is present in 9 manufacturing industries during depreciations: CB - textiles, clothes, leather and leather products, CC - wood, wood product, paper, printing, CD - coke, refined petroleum products, CE - chemicals and chemical products, CF - basic pharmaceutical products, CG - rubber and plastic products, other non-metallic mineral products, CH - basic metals, fabricated metal products, CI - computer, electronic and optical products, and CL - transport equipment. It is also true for C - manufacturing in both cases.

3.5 Pass-through before and after joining the EU

In May 2004, the Czech Republic, along with 9 other European countries, joined the European Union (EU). This part shows how this event may have influenced the degree of path-through, meaning the relationship between import prices and the exchange rate, exchange rate changes. Whether deepening of international trade and structural switch promoting exports has had an impact on the degree of path-through. The original estimated regression equation is used, without any modifications. The only difference is the two sample periods:

1) 2000M01 – 2004M04 → before joining the EU
2) 2004M05 – 2018M05 → after becoming member of the EU

The results are displayed in the following Table 14:

Table 14
Pass-through before and after joining the EU

NACE Rev. 2	whole period pass-through estimates β_1	before joining EU estimates	after becoming EU member estimates	p^y before joining EU	p^y after becoming EU member
C	-0.394 **	-0.473 **	-0.356 **	0.041	0.825 **
CA	-0.288 **	-0.294 **	-0.287 **		
CB	-0.361 **	-0.359 **	-0.359 **		
CC	-0.369 **	-0.554 **	-0.338 **	0.032	0.503 **
CD	-0.689 **	-1.229 **	-0.583 **	-0.129	0.131 **
CE	-0.374 **	-0.367 **	-0.373 **	0.200 **	0.037
CF	-0.328 **	-0.376 **	-0.315 **		
CG	-0.337 **	-0,404 **	-0.316 **	-0.188	0.457 **
CH	-0.359 **	-0.501 **	-0.333 **	0.047	0.135 *
CI	-0.299 **	-0.249 **	-0.292 **	0.489 **	0.905 **
CJ	-0.441 **	-0.313 **	-0.460 **	0.001	0.242 *
CK	-0.445 **	-0.302 **	-0.458 **	-0.518 **	0.485 **
CL	-0.294 **	-0.299 **	-0.269 **	0.098	0.834 **
CM	-0.380 **	-0.234 **	-0.408 **		

* denotes significance at the 5% level based on a one-tailed test
** denotes significance at the 1% level based on a one-tailed test

Note: the estimated regression equation is as follows (as in section 2.1 Estimation Strategy):

$$\Delta \ln p_{i,t}^{CZ} = \beta_{1,i} \Delta \ln e_t + \beta_{2,i} \Delta \ln p_{i,t}^{y} + \beta_{3,i} \Delta \ln w_{i,t} + \beta_{4,i} \Delta \ln I_{i,t}^{CZ} + error$$

As one may have already noticed, the pass-through estimates tend to be almost always statistically significant for the Czech Republic in the sample period from January 2000 until May 2018. The same applies if the sample period gets divided into two sample periods: 1) from January 2000 until April 2004, meaning before the Czech Republic becomes member of the European union, and 2) from May 2004 until May 2018 – when being part of the EU. All the pass-through estimates, for both the periods, are statistically significant.

The average estimated pass-through of manufacturing industries in the original regression equation equals 39 %. Before joining the EU, for sample period of 2000M01 to 2004M04, the average estimated pass-through equals 42 % and after becoming EU member, meaning in the sample period of 2004M05 to 2018M05, the average estimated pass-through equals 37 %. In all the cases C – manufacturing is excluded. The results of the two period samples indicate that with joining the EU, the degree of pass-through in the Czech Republic has decreased on average by 5 percentage points throughout the 13 tested manufacturing

industries. A decrease in the degree of pass-through, when comparing these two periods, is valid for the C – manufacturing industry itself as well. The manufacturing industries, in which the pass-through decreased are CA - manufacture of food products, beverages, tobacco, CC - wood, wood product, paper, printing, CD - coke, refined petroleum products, CF - basic pharmaceutical products, CG - rubber and plastic products, other non-metallic mineral products, CH - basic metals, fabricated metal products, and CL - transport equipment. On contrary, it increased in CE - chemicals and chemical products, CI - computer, electronic and optical products, CJ - electrical equipment, CK - machinery and equipment n.e.c, and CM - furniture, other manufactured products. One exception is CB - textiles, clothes, leather and leather products, where the degree of pass-through, after becoming EU member, remains exactly the same as it was before joining the EU. For one manufacturing industry, CD - coke, refined petroleum products, it is worth mentioning the numbers. The estimates of the two sample periods differ by 65 percentage points, when in the sample period before joining the EU the pass-through equals 123 % and in the sample period after becoming the EU member the pass-through equals 58 %.

A final remark about the data in Table 14. It shows that the statistical significance p^y - price of domestically produced substitute good to the good imported - has increased in the sample period "after becoming EU member" compared to the sample period "before joining the EU" in several manufacturing industries. These are CC - wood, wood product, paper, printing, CD - coke, refined petroleum products, CG - rubber and plastic products, other non-metallic mineral products, CH - basic metals, fabricated metal products, CJ - electrical equipment, and CL - transport equipment, also for C – manufacturing industry itself. A possible explanation is that the production of domestically producing firms in respective manufacturing industries have become more competitive towards foreign and abroad producing firms. The opposite is true for CE - chemicals and chemical products, where the statistical significance of p^y decreased. It has remained the same for CI - computer, electronic and optical products, and CK - machinery and equipment n.e.c.

CONCLUSION

In the case of the Czech Republic, the ERPT into import price averages at 38 % and is not complete. Firms in different manufacturing industries react differently to changes in the exchange rate. This results in asymmetric pass-through across the variety of studied manufacturing industries.

The hypothesis that ERPT is complete in the long-run cannot be rejected for 8 out of 13 manufacturing industries, as well as for manufacturing itself.

Depreciations are passed-through more compared to appreciations. The average pass-through for depreciation periods is 44 % and for appreciation periods 35 %.

Small size changes in the exchange rate are passed-through more compared to large size changes. The average pass-through for periods of small changes in the exchange rate is 64 % and for periods of large changes 37 %.

Combination of different directions with different sizes follow the above displayed facts that depreciations and small size changes in the exchange rate are passed-through more compared to appreciations and large size changes. The average value for small size depreciation changes is 76 %, for large size depreciation changes 40 %, for small size appreciation changes 53 % and for large size appreciation changes 33 %. The ERPT is larger during depreciation periods compared to appreciation periods, both during small and large size changes in the exchange rate.

When comparing two recent consecutive time periods, the period before the Czech Republic joined the EU (January 2000 – April 2004) and the period of EU membership (May 2004 – May 2018), the ERPT has declined from 42 % to 37 %. It is true that these two periods have considerably different sample sizes (40 months vs. 181 months), but the small drop may nevertheless be taken as evidence that the ERPT has declined.

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