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Institut ekonomických studií

Diplomová práce

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Fakulta sociálních věd

Institut ekonomických studií

DIPLOMOVÁ PRÁCE

Rovnovážný měnový kurz: vliv konkurence na rovnovážný reálný kurz – panelová analýza dat exportérů

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Akademický rok: **2005/2006**

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MASTER THESIS

Equilibrium exchange rate: Effect of the degree of competition on the real equilibrium exchange rate – evidence from a panel of exporting companies

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Academic year: **2005/2006**

Prohlášení

Prohlašuji, že jsem diplomovou práci vypracovala samostatně a použila pouze uvedené prameny a literaturu.

Hereby I declare that I compiled this thesis independently, using only the listed literature and resources.

V Praze dne podpis studenta

ABSTRAKT:

Diplomová práce analyzuje reálný rovnovážný kurz. Skládá se ze dvou částí. První část představuje základní teorie rovnovážného měnového kurzu a jejich empirické výsledky. Tato část se také zaměřuje na současné empirické přístupy, jimiž se testuje, zda-li měnový kurz je v rovnováze. V druhé části je analyzován vliv struktury trhu neboli stupeň konkurence na reálný rovnovážný kurz. Práce odpovídá na následující otázky: Jaké jsou příčiny vychýlení reálného měnového kurzu? Závisí toto vychýlení na struktuře trhu? A mohl by být považován za určité míry konkurence jakýkoli pohyb nominálního směnného kurzu vždy jako rovnovážný?

ABSTRACT:

This thesis analyzes the real equilibrium exchange rate. It consists of two parts. The purpose of the first part is to introduce the main equilibrium exchange rate theories and their empirical results. This part also focuses on the present empirical approaches, which are used by economists for testing the equilibrium exchange rate. The aim of the second part is to analyze the impact of market structure, expressed in degree of competition, on the equilibrium real exchange rate. Here we examine the following questions: What are the causes of misalignment of the real exchange rate? Does it depend on the market structure? And could, under certain degree of competition, be every move of nominal exchange rate assessed as equilibrium?

Acknowledgements:

I would like to thank Jiří Podpiera of the Czech National Bank for supervising my work on this thesis. I have greatly benefited from our numerous discussions and I owe him a great deal for many useful suggestions and comments regarding the thesis.
Special thanks belong to my friend Filip for his support during all the years of my studies and to my parents for their devotion.

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1. INTRODUCTION

The theme of this thesis is the equilibrium exchange rate. The exchange rate is crucial factor in economy, especially, in a small open economy. The development of exchange rate has an effect on almost every economic activity. When a country's currency depreciates, foreigners find that its exports are cheaper and domestic residents find that imports from abroad are more expensive. An appreciation has an opposite effect, foreigners pay more for the country's products and domestic consumers pay less for foreign products. Simultaneously, when domestic currency appreciates, all assets of that country are more valued in comparison with assets of other's countries. Moreover, if a country is indebted in a foreign currency, and the exchange rate appreciates, the cost of debt service gets smaller. That makes all citizens richer. That seems to indicate that appreciation of currency is only positive, however, if the currency appreciates faster than what corresponds to the equilibrium path, the country gets less competitive in a world trade, causing some domestic firms to bankrupt, consequently the unemployment rises and GDP growth slows down. Hence, policy makers are very interested in finding the equilibrium value of the exchange rate. Especially, the equilibrium exchange rate will be a top topic for the New EU member states before the Euro adoption.

The aim of this thesis is to analyze the real equilibrium exchange. The thesis consists of two parts. The purpose of the first part is to introduce the main equilibrium exchange rate theories and their empirical results. This part also focuses on the present empirical approaches which are used by economists for testing the equilibrium exchange rate. The aim of the second part is to analyze the impact of market structure, expressed in degree of competition, on the equilibrium real exchange rate. Here we examine the following questions:

- What are the causes of misalignment of the real exchange rate?
- Does it depend on the market structure?

- And could, under certain degree of competition, be every move of nominal exchange rate assessed as equilibrium?

2. EXCHANGE RATE DEFINITIONS

Commonly, when we speak about the exchange rate we mean the **nominal exchange rate**, which is the "the price of one country's currency in terms of another country's currency".[1]

Sometimes economists use **the effective exchange rate**[2] which takes into account the fact that the currency varies differently against each of the other currencies. It is calculated as a weighted average of the individual or bilateral rates, and the weights are chosen to reflect the trade with each country. The effective exchange rate is calculated as an index and it shows us how the exchange rate behaves in comparison with all the currencies, which are for the country important. The effective exchange rate may be constructed for real exchange rate, nevertheless, more often is used for nominal exchange rate.

$$r_{ei} = \sum_{j=1, j\neq i}^{n} w_j E_{ji}\,, \quad \sum_{j=1}^{n} w_j = 1\,, \tag{1}$$

where r_{ei} is (nominal) effective exchange rate of currency *i*,

E_{ji} is nominal exchange rate of currency *i* with respect to currency *j*

w_j is the weight given to currency *j* in the construction of the index; by definition, the sum of weight equal one

However, the theories of exchange rate are concerning mostly **the real exchange rate**, which takes into account the information about price levels or inflation. Thus the real exchange rate is more predicative than the nominal exchange rate, which does not say anything about prices of goods.

[1] Krugman, Obstfeld (1999), p. 331
[2] Gandolfo (2001), p.15

The real exchange rate (RER) is designed to measure the rate at which home goods are exchanged for goods from other country. The textbook definition of RER is: *"the real exchange rate between two countries' currencies is a broad summary of the prices of one country's goods and services relative to the other's".* [3]

In symbols: $$Q = \frac{E.P}{P^*} \qquad (2)$$

q is the real exchange rate

E is the exchange rate, defined as the home-currency price of foreign currency

P is the domestic-currency price of good i

P^* is the foreign currency price

The real exchange rate depends on the nominal exchange rate and on differences in national price levels. If the same basket of goods would cost 100 crowns and in Germany 5 euro, then the real exchange rate would be $Q = \frac{1/28{,}4 * 100}{5} = 0{,}7$. That also means that prices in Czech Republic are 70% of the German prices and hereby it measures the competitiveness of the domestic goods on the foreign market. We say that the home country experiences a real appreciation, when the ratio $\frac{E.P}{P^*}$ rises – domestic prices are relatively increasing.

Since the real exchange rate takes into account the information about price levels or inflation, it is is much more predicative for economists than the nominal exchange rate. Thus most of

[3] Krugman, Obstfeld (1999), p. 421

the theories and approaches are concerned with the real exchange rate. As well as, this thesis is devoted to the analysis of the real exchange rate.

3. THEORIES OF REAL EQUILIBRIUM EXCHANGE RATE

The main theories of real equilibrium exchange rate are two: purchasing power parity theory (PPP) and uncovered interest rate parity theory (UIP). The purchasing power parity theory is the fundamental theory. If PPP would hold, the real exchange rate would be a constant; hence a discussion of PPP is actually as the discussion of the real exchange rate. Contrary to PPP, the uncovered interest rate parity theory is criticized due to its substantial drawbacks; however it is very often used in approaches which are trying to find the real equilibrium exchange rate.

3.1 The purchasing power parity

The oldest and simplest theory of an equilibrium exchange rate is the purchasing power parity (PPP). In its simplest form says that goods should have the same price across countries. That was already known in the sixteenth century, when it was first articulated by the Salamanca school[4]. The theory was first properly formalized in the 1920s by the Swedish economist Gustav Cassel (1921)[5], who was the first one who singled out the problems of PPP (see chapter 3.1.2 frictions to PPP) and who proposed to use this theory practically in restoring the gold standard after World War I. The gold standard was abandoned at the beginning of the war, because countries let their currencies depreciate in order to gain seignorage to finance the war. After the war, the countries wanted to restore the gold standard again, however, the inflation during the war was different across the nations, so it was not possible to take the parities, which were used before the war. Therefore Gustav Cassel proposed to calculate cumulative CPI inflation rates from the beginning 1914 and that use for calculating the new

[4] Officer (1982)
[5] Rogoff (1996)

nominal exchange rates. In that time, he properly formalized the PPP theory and he used it as first one as a practical mean to find the equilibrium exchange rate. [6]

3.1.1 Variants of PPP[7]

The purchasing power parity has three variants: the law of one price, the absolute version and the relative version.

1) The law of one price

The law of one price indicates the intuitive idea that identical goods should sell at the same price in different countries when their prices are expressed in terms of the same currency, in absence of transactions costs. Written symbolically:

$$P_i = EP_i^*, \qquad (3)$$

where P_i is the domestic-currency price of good *i*

P_i^* is the foreign currency price

E is the exchange rate, defined as the home-currency price of foreign currency

The law of one price assumes competitive markets free of transportation costs and official barriers to trade (such as tariffs). When trade is open and costless, identical goods must trade at the same relative prices regardless of where they are sold.

The equality of prices should be forced by the international goods arbitrage. For instance, if the same good would cost in Germany 100 euro and in Czech Republic 50 euro converted to euro, then the German importers and consumers and Czech exporters would have the

[6] Rogoff (1996), p.649
[7] Rogoff (1996), p. 650

incentive to buy the good only in Czech Republic and transport it to Germany until a single price prevails on the both markets.

Nevertheless, as we analyze further, the conditions that allow the perfect arbitrage are not always fulfilled. Therefore, the law of one price holds more less only for highly traded commodities, such gold, silver or oil.

2) Absolute version of PPP

The absolute version of PPP takes the version of the law of one price more aggregately, it compares a bundle of goods, not individual goods, and it asserts that the price of the bundle of goods in one country should be equivalent to the price of the same bundle of goods in another country, when their prices are expressed in terms of the same currency. Mostly the consumer goods prices are taken, that is:

$$\sum_{i=1}^{n} P_i = E \sum_{i=1}^{n} P_i^* \,, \qquad (4)$$

where the sums are taken over consumer prices.

That means, according to the absolute PPP that domestic price level should be the same as the foreign price level.

If we take the definition of the real exchange rate $Q = \frac{E.P}{P^*}$ we see, that the real exchange rate may be viewed as a measure of the deviation from PPP. If the absolute version of PPP would hold, then the real exchange rate would be equal unity.

Unfortunately, the statistics of consumer prices across countries are not available, only different indices are published. And since the CPI or other indices are in the forms of index

relative to a base year, now mostly 2000=100, we can observe only the changes of consumer prices. Therefore, the PPP theory is empirically more used in its relative version.

3) Relative version of PPP

Relative PPP translates the absolute PPP from a statement about prices and exchange rate levels into one about prices and exchange rate changes. So it asserts that the percentage variations of the national price levels should be equal:

$$\frac{\sum_{i=1}^{n} P_{it}}{\sum_{i=1}^{n} P_{it-1}} = \frac{E_t}{E_{t-1}} \frac{\sum_{i=1}^{n} P_{it}^*}{\sum_{i=1}^{n} P_{it-1}^*}, \tag{5}$$

where t denote time.

Put simply, the relative version of PPP argues that the exchange rate will adjust by the amount of the inflation differential between two economies.

3.1.2 Frictions to PPP

The all three variants of PPP assumes that the equality (of prices of identical goods in the law of one price, aggregate prices in the absolute form of PPP or the equality of changes in aggregate levels price in the relative form) should be forced by the international goods arbitrage. However, the assumption about free mobility of goods which enables arbitrage is not always fulfilled. The arbitrage can be hindered by trade restrictions, such as quotas or tariffs or by long inspection requirements and various registrations on borders. Fortunately, since the markets in the EU and in the NAFTA are becoming more integrated, the tariff barriers are disappearing.

Nevertheless, the trade can be restricted as well as by the non-tariff barriers. The differing national standards hinder the arbitrage, for example differing national sockets – if you buy the electronic good abroad, it does not work at home, or cars from the Great Britain would not be useful in continental Europe. Or since the warranty is granted only in the country of purchase, the consumer would reconsider to buy the good abroad.

However, even if the free mobility of goods would be ensured, the arbitrage need not always be accomplished due to high transportation costs. The price of transport of some goods is in comparison with the price of such good so high, that it does not pay off to transport the good. The International Monetary Fund[8] estimated the difference between the value of world exports computed "free on board" (FOB) and the value of world imports charged in full, or "cost, insurance, freight" (CIF). This difference indicates how large the transport costs in aggregate are. They estimated this cost of 10% and they found that it is highly variable across countries.

Moreover, sometimes even the information cost are so high, that it does not pay off to try to find the information about the price differences, it is just better to buy and do not ask, how much the good costs abroad.

Other studies, stemming from the theory of investment under uncertainty, are pointing out, that the international arbitrage has some initial fixed costs. Thus the international arbitrage can turn up, only if it is profitable enough to outweigh the costs; and the exchange rate is converging to the PPP only if the exchange rate deviates from the PPP heavily. [9]

[8] IMF (1994)
[9] Dumas (1992)

Besides the free mobility of goods and no transportation and information costs, the PPP theory presupposes that the goods are highly homogenous and the markets are competitive. That means that the goods are the same wherever and however they are sold - yoghurt is always only yoghurt and there is no difference between them. However, to the real world corresponds more the model of a monopolistic competition by Robinson and Chamberlin, in which the products are differentiated. The goods are made to appear somewhat different and superior to those produced by other firms, to have a unique characteristic, such as brand or appearance, and the advertisement influence the consumer behavior. Or even the purchasing place makes the good more luxurious (the same Chinese textile is much more expensive on Paris Boulevard than on a Vietnamese market in Prague). Then "the same goods" can not be perfect substitutes and the assumption of homogeneity of goods need not always be fulfilled.

Since the markets remain segmented for whatever cause, the producers can price discriminate across different international markets. As Krugman[10] noticed, foreign firms were maintaining or even increasing their export prices to the US, when the dollar appreciated during the early 1980' (contrary to our intuition; in the appreciation period, the export prices should fall). He called the phenomenon of different price for the same good in separate economies as „pricing to market". Although the third degree price discrimination is only possible if the markets are separate, the incentive behind may be different: different demand elasticities[11], the cushion of volatility of exchange rate, relatively high "menu costs" in the currency of the destination market or varying transportation costs due to volatile price of oil denominated in dollar or as we show in our analysis, the pricing-to-market coheres with degree of competition.

[10] Krugman (1986)
[11] Marston (1994)

As the above mentioned frictions indicate, the assumptions of PPP theory do not in reality always hold. Despite these frictions, the PPP theory is still considered as an essential theory of equilibrium exchange rate and it is supposed that holds in the long run.

3.1.3 Modifications and extensions of PPP

Some studies[12] suggest that high government spending and sustained current account deficits may lead to deviations of PPP. Rise in government spending may generate appreciation of the real exchange rate, since the government is demanding more nontraded goods, which will be therefore more expensive and that will lead to higher price level. And current account deficits may lead to depreciation of currency, since the foreign currency will be more demanded as the imports are prevailing exports. That modifications may be in a shorter run useful, however, the most influential modification of PPP is the famous Balassa-Samuelson effect.

Balassa – Samuelson effect

In 1964 Balassa and Samuelson[13] [14] noticed independently that if the hypothesis of PPP would be applied to the less developed countries, their currencies would generally appear to be greatly undervalued. In other words, CPI levels tend to be relatively higher in rich countries in comparison with the CPI levels in poor countries.

Their explanation of why PPP does not hold in terms of aggregate price indices is following. The theory starts with the distinction between tradable and nontradable sector. The first

[12] Rogoff (1996), p. 663
[13] Balassa (1964), Samuelson (1964)
[14] Sometimes this effect is called Harrod-Balassa-Samuelson effect, since Roy Harrod described this phenomenon already in 1933.

assumption is that the law of one price holds for tradable goods. The second assumption is that capital is mobile across countries, but the labor only within one country.

Then, they reason that the productivity growth in the traded goods sector has been historically faster than in the nontraded goods sector. While PPP is assumed to hold for tradable goods, the prices of tradables will tend to be equal across countries. Increased productivity in the tradable sector will raise the wages in that sector and since the labor is mobile within one country, the wages in the non-tradable goods sector have to rise as well. Otherwise, all labor would work in tradable sector and nobody in the nontradable. And it is possible to pay higher wages in the nontradable sector, only if the prices of nontradable goods rise. This leads to the fact that relatively richer countries (with higher productivity in tradables than in nontradables) have higher overall price levels. [15] [16] [17]

A related prediction of the Balassa-Samuelson model is that fast-growing countries will tend to see their real exchange rates appreciate due to higher inflation in non-tradable sector. The very often cited example of the Balassa-Samuelson effect is the long appreciation of Yen, which began with postwar reconstruction. This appreciation has been contributed to rapid manufacturing productivity growth. In the 1990's, it has been said that the Balassa Samuelson effect is observed in post-communist countries, which are catching up the Euro zone countries. However, Balassa-Samuelson effect explains only the real appreciation in catching-

[15] An alternative theory explaining the lower price levels of poor countries was proposed by Jagdish Bhagwati, Irving Kravis and by Robert Lipsey. Their view relies on differences in endowments of capital and labor than on productivity differences. Rich countries have high capital-labor ratios, while poor countries have more labor relative to capital, therefore the marginal productivity of labor is greater in rich countries than in poor countries, and the former will therefore have a higher wage level than the latter. Nontradables, which consist largely of services, are naturally labor-intensive relative to tradables. And labor is cheaper in poorer countries, therefore the nontradables are cheaper than in rich, high-wage countries. That explanation has the same outcome as the Balassa-Samuelson effect, it also predicts that the relative price of nontradables increases as real per capita income increases. (Kravis, Lipsey 1983), (Bhagwati 1984)

[16] Obstfeld, Rogoff (1996), p. 210

[17] The mathematical derivation of the Balassa Samuelson model is showed in the analytical part of the thesis (chapter 5).

up countries through higher inflation, but it does not say anything about the nominal appreciation which is very often mistakenly explained by the Balassa-Samuelson effect, although the B-S model assumes constant nominal exchange rate.

Although the Balassa-Samuelson hypothesis can partly explain the behavior of the real exchange rates of countries at different stages of development, it can not explain the behavior across developed countries.

However, due to the Balassa – Samuelson effect the PPP theory is assumed to hold only on tradables, where the arbitrage is possible. Unfortunately, the distinction between tradable and nontradable good is not so obvious. The price of tradable good in retail is different from the world market price for the cost of workforce, the local transportation costs, VAT, the rent of the building, insurance, wholesale margins etc., which are different across countries.

3.1.4 Specification of PPP

The empirical measurement of PPP has many impediments. Since information on price levels of tradables is difficult to obtain for most products, mostly price indices are used. Nonetheless, the indices are not constructed for internationally standardized baskets of identical goods. Summers and Heston[18] tried to develop an international database of common baskets of goods across countries. This database is called International Comparison Programme (ICP), however, the data are available only for few countries and constructed at large time intervals, so the database is not very helpful. Therefore, in most of the research studies the price indices are used; such as consumer price index (CPI), producer price index

[18]Heston, Summers (1991)

(PPI), wholesale price index (WPI), gross domestic product deflator (GDP) or export price index. That might be misleading while we can compare incomparable, since the indices are differently constructed across countries and the difference development of these indices may not indicate the change of prices in that countries, but it can come from shift in consumption or production patterns (if the consumer start to consume different good or different quantity of the same good, the consumer index changes, although the prices do not change – the same effect with production).

In addition, the indices do not perfectly measure inflation also within one country, for instance, the CPI index does not handle the introduction of new goods, shifting consumption weights and improvement of goods.

Other problem is that CPI index includes as well as regulated prices, for example in case of Czech Republic regulated flat rents, and if these prices increase, the overall index increases, although we do not observe productivity improvement.

Moreover, since the indices are in the form of indices relative to a base year, say 2000=100, they give no indication of how large the deviation from PPP was for the base year. On that account, the models using indices are very probably biased.

To sum up, if someone wants to measure the PPP theory via indices, which are most often used, he has to think of the above mentioned drawbacks.

3.1.5 Empirical evidence of PPP

3.1.5.1 The empirical evidence on the law of one price

The empirical evidence from around the world is approving, what the frictions to assumptions of PPP suggest; the law of one price does not hold absolutely, not even for tradable goods.

The law of one price holds more less only for highly traded commodities, such as gold, silver, etc.

Interesting study did Engel and Rogers[19]. In their study of consumer prices across 23 cities in Canada and USA showed that price differentials for basic goods across countries are much bigger than across cities within the same country. The so-called „border effect“ increases the volatility of price differentials by the same magnitude as would be generated by adding anywhere between 2 500 to 23 000 miles between cities within one country, depending on the specification.

The most famous “evidence” of friction of the law of one price provides *The Economist.* The Economist publishes each year funny Big Mac index. This index compares the price of McDonald's Big Mac hamburgers in different countries converted to dollar. The last Big Mac survey[20] reports that the euro is overvalued by 17% against the dollar. The euro is worth about $1.22 on the foreign-exchange markets. A Big Mac costs €2.92, on average, in the euro zone and $3.06 in the United States. The rate that would equalize the burger's price in the two regions would be just $1.05. That means the euro is overvalued from the Big Mac perspective. According to that survey, the most undervalued currency is Yuan - Big Macs costs $1.27 in China and the most overvalued currency is Swiss franc, where the Big Mac costs $5.05. The difference in prices can be explained by the above theoretically described trade barriers, transport costs, but mostly by the Balassa – Samuelson effect (or any other effect which explains different prices for nontradables in different countries): David Parsley, of Vanderbilt University, and Shang-Jin Wei, of the International Monetary Fund, estimated that non-traded inputs, such as labor, rent and electricity, account for between 55% and 64% of the price of a Big Mac.

[19] Engel, Rogers (1996)
[20] The Economist June 9th 2005

Table 1: The Big Mac Index

The hamburger standard

	Big Mac price in dollars*	Implied PPP† of the dollar	Under (–)/ over (+) valuation against the dollar, %
United States‡	3.06	—	—
Argentina	1.64	1.55	-46
Australia	2.50	1.06	-18
Brazil	2.39	1.93	-22
Britain	3.44	1.63§	+12
Canada	2.63	1.07	-14
Chile	2.53	490	-17
China	1.27	3.43	-59
Czech Republic	2.30	18.4	-25
Denmark	4.58	9.07	+50
Egypt	1.55	2.94	-49
Euro area	3.58**	1.05††	+17
Hong Kong	1.54	3.92	-50
Hungary	2.60	173	-15
Indonesia	1.53	4,771	-50
Japan	2.34	81.7	-23
Malaysia	1.38	1.72	-55
Mexico	2.58	9.15	-16
New Zealand	3.17	1.45	+4
Peru	2.76	2.94	-10
Philippines	1.47	26.1	-52
Poland	1.96	2.12	-36
Russia	1.48	13.7	-52
Singapore	2.17	1.18	-29
South Africa	2.10	4.56	-31
South Korea	2.49	817	-19
Sweden	4.17	10.1	+36
Switzerland	5.05	2.06	+65
Taiwan	2.41	24.5	-21
Thailand	1.48	19.6	-52
Turkey	2.92	1.31	-5
Venezuela	2.13	1,830	-30

	Big Mac price in dollars*	Implied PPP† of the dollar	Under (–)/ over (+) valuation against the dollar, %
Aruba	2.77	1.62	-10
Bulgaria	1.88	0.98	-39
Colombia	2.79	2124	-9
Costa Rica	2.38	369	-22
Croatia	2.50	4.87	-18
Dominican Rep	2.12	19.6	-31
Estonia	2.31	9.64	-24
Fiji	2.50	1.39	-18
Georgia	2.00	1.19	-34
Guatemala	2.20	5.47	-28
Honduras	1.91	11.7	-38
Iceland	6.67	143	+118
Jamaica	2.70	53.9	-12
Jordan	3.66	0.85	+19
Latvia	1.92	0.36	-37
Lebanon	2.85	1405	-7
Lithuania	2.31	2.12	-24
Macau	1.40	3.66	-54
Macedonia	1.90	31.0	-38
Moldova	1.84	7.52	-40
Morocco	2.73	8.02	-11
Nicaragua	2.11	11.3	-31
Norway	6.06	12.7	+98
Pakistan	2.18	42.5	-29
Paraguay	1.44	2941	-53
Qatar	0.68	0.81	-78
Saudi Arabia	2.40	2.94	-22
Serbia & Montenegro	2.08	45.8	-32
Slovakia	2.09	21.6	-32
Slovenia	2.56	163	-16
Sri Lanka	1.75	57.2	-43
Ukraine	1.43	2.37	-53
UAE	2.45	2.94	-20
Uruguay	1.82	14.4	-40

*At current exchange rates †Purchasing-power parity
‡Average of New York, Chicago, San Francisco and Atlanta
§Dollars per pound **Weighted average of member countries
Sources: McDonald's; *The Economist* ††Dollars per euro

source: The Economist, June 9th 2005

3.1.5.2 The empirical evidence on PPP – testing mean reversion in real exchange rate[21]

The relative version of purchasing parity theory has been tested many times in many ways. However, the findings are broadly mixed. The book 'The economics of exchange rate' by L.

[21] This section draws heavily on Sarno and Taylor (2002)

Sarno and M. P. Taylor[22] provides a comprehensive overview of the empirical literature. We distinguish here just the main econometric approaches for testing PPP and the most influencing studies.

1. Regression tests of PPP

In the 1970s the PPP tests were based on equations of the simplest form:

$$s_t = \alpha + \beta p_t + \beta^* p_t^* + \varepsilon_t, \qquad \text{for absolute PPP}$$

$$s_t - s_{t-1} = \alpha + \beta(p_t - p_{t-1}) + \beta^*(p_t^* - p_{t-1}^*) + \varepsilon_t, \qquad \text{for relative PPP}$$

If $\beta = 1, \beta^* = -1$, that would be confirmation of the PPP theory.

Examples of the earliest estimation are for instance, Frenkel (1981) or Krugman (1978)[23]. The outcomes based on this estimation are rather mixed, however the rejection of PPP hypothesis prevails. That is therefore, that these equations do not introduce dynamics to distinguish between short and long run mean reversion, they estimate only the short run effect, even if it was recognized already that the PPP holds in the long run. Besides, these estimations have other drawbacks: the endogeneity of nominal exchange rate is assumed randomly and the stationarity of variables is not investigated. Therefore, other methods are rather testing only the stationarity of the real exchange rate.

2. Tests for a unit root

With the development of econometric techniques in the 1980s, the empirical literature of exchange rate concentrated on testing the stationarity of variables. If the real exchange rate would be stationary, that would imply evidence of long-run PPP or if the null hypotheses of a

[22] Sarno, Taylor (2002)
[23] Krugman (1978)

unit root alias non-stationarity cannot be rejected, then the real exchange rate contains a unit root and does not revert to its mean value, indicating consequently, that PPP does not hold in the long run. That was tested by three approaches. First approach was to employ a variant of the augmented Dickey-Fuller (ADF) test; second approach was a variance ratio test and a third approach employed the techniques developed by the literature on fractional integration. However, also these types of studies, except two[24], could not reject the unit root hypothesis for the real exchange rate; suggesting that the deviation from PPP is permanent.

3. Long-span studies

Some researchers asserted that unit root can not be rejected, since sufficiently long time series are not used. Therefore, to try to avoid the problem with nonstationarity of the real exchange rate series, some researchers employed long horizon data sets. After all, researchers using long time series were able to reject the unit root and to show that real exchange rates are mean-reverting. For example, Frankel[25] used 116 years (1869-1984) of annual data and dollar sterling exchange rate. Or Edison (1987) examined also dollar sterling exchange rate over the period 1890-1978, but using an error-correction mechanism.

Interestingly, the consensus among these studies is that the half-life of PPP deviations is three to five years. However, the relevant criticism of long-span studies is that they mix different exchange rate regimes (fixed and float)[26] and that the long period time samples are available for a few currencies. Thus the results are not much predicative.

[24] Huizinga (1987) and Chowdhury, Sdogati (1993)
[25] Frankel (1986)
[26] Rogoff (1996)

4. Cointegration studies of PPP

In 1987 Engle and Granger developed a new econometric technique – cointegration, which seemed to be a step toward better testing for PPP. "Cointegration analysis tells us that any two nonstationary series which are found to be integrated of the same order are cointegrated if a linear combination of the two exists which is itself stationary. If this is the case, then the nonstationarity of one series exactly offsets the nonstationarity of the other and a long-run relationship is established between the two variables."[27] In the case of testing for PPP, the linear combination of nominal exchange rate and the relative price ($= p_t - p_t^*$) was tested.

Although this method is progressive, the results of this type of estimations are rather mixed: the mean reversion towards PPP was reported as absent in the recent period (for example Taylor 1998), but stronger when high inflation countries were observed (for example Choudhry 1991).

5. Panel data studies

An alternative way to circumvent the low power of the previous mentioned tests is to consider a range of countries together in one panel. In this framework, Frankel and Rose[28] examined deviations from PPP using a panel data for 150 countries for the years 1948-1992 and they were able to reject the random walk hypothesis and showed strong evidence of mean-reversion.

Interestingly, also other panel data studies showed similar findings, that the deviations from PPP have a half life of approximately four years. That result is similar to the results estimated from long-run time series.

However, potential problem in panel data studies can be that this practice can lead to cross-sectional dependence in time series panel data, and then the result can be biased.

[27] Sarno (2002), p. 61
[28] Frankel and Rose (1996)

To sum up, estimation methods such as regression tests, cointegration and unit root tests mostly can not reject the unit root (or so-called random walk) hypothesis. On the other hand, the estimation using long-run time series and panel data studies can find the mean reversion to PPP and remarkably, there appears to be a consensus that the size of the half-life of deviations from PPP is about three to five years.

However, the PPP theory is fundamental theory of exchange rate. Although the empirical analyses can not agree if it holds, it is generally assumed that the PPP theory holds in the longer run.

3.2 Interest rate parities

Contrary to PPP, the interest rate parities concern the exchange rate as an asset price. The defining characteristic of an asset is that it is a form of wealth, which is transferable from the present into the future. As a consequence, the demand for a foreign currency should be influenced by the similar considerations that influences the demand of any other asset – what worth the asset will be in the future and what rate of return it offers. Similarly as the price of stock rises immediately after good news, so exchange rates respond immediately to any news concerning future currency values. And the foreign currency future value according to interest parity theory depends on two factors: on the interest rate, which the currency offers (or more precisely the interest rate differential against other currencies) and the expected change in the currency's exchange rate against other currencies.

The interest parities are two: covered and uncovered. The interest rate parity on which the other approaches are based is the uncovered interest parity. The uncovered interest parity stems from the covered interest parity. Hence we begin with the covered interest parity.

3.2.1 Covered Interest Rate Parity

The covered interest rate parity theory assumes that investor can invest his money in bonds in both countries with similar risk and maturity. If the bonds are equally risky and can be switched between them instantaneously, the only difference between them will be their currency of denomination and the interest rate attached to them. Then the investor when buying a bond will decide concerning only the relative interest rate and the forward exchange rate. That is what the covered interest parity asserts: the forward exchange rate must be equal

to the two countries' interest rate differential, otherwise there exist profitable arbitrage opportunity[29]. That is:

$$1 + i_{t+1} = (1 + i^*_{t+1})\left\{\frac{F_{t,t+1}}{S_t}\right\} \rightarrow \quad (6)$$

$$F_{t,t+1} = \frac{1 + i_{t+1}}{1 + i^*_{t+1}} S_t \quad (7)$$

where S_t is spot nominal exchange rate

F_t is the one-period forward exchange rate

i_{t+1} is the one-period the interest rate on bonds denominated in home currency at time t+1

i^*_{t+1} is the one-period interest rate on foreign-currency bonds at time t+1

The equation must hold in any time, otherwise there would be an arbitrage opportunity. As an example assume, I have 1 million Euro to invest for one year. I can either invest in Euro zone at rate $1 + i^*_{t+1}$, which is say 1,025. So in one year, the investment will be worth 1.000.000 x $1 + i^*_{t+1}$, which will be 1.025.000 Euro; or I can convert euro for Czech crown at the spot rate 28,4, invest in Czech Republic at rate $1 + i_{t+1}$ (1,02) and make a forward contract simultaneously to sell Czech crowns in one year. The future value of this investment will be equal to 1.000.000 x $(1 + i_{t+1})$ x $\frac{F_{t,t+1}}{S_t}$. Then the forward exchange rate must be 28.54, otherwise if it would be smaller than 28.54 or bigger than 28.54 there would exist an exploitable arbitrage opportunity.

[29] Wang (2005), p.46

Because this entire operation can be conducted at time t, it involves no risk (abstracting from default risk).

In any computation of CIP, it is important to consider home and foreign assets with comparable terms of maturity and characteristics such as default or political risk. Therefore empirical analyses of CIP have most often employed interest rate data on Euro deposits. Barriers which could hinder the arbitrage would be capital controls or large bid-ask spreads and transaction costs.

Empirically, the CIP can be tested by two approaches: Firstly, computing the actual deviations from interest parity to see if they differ significantly from zero and these deviations are compared with transactions costs; or secondly, estimating a regression equation: [30]

$f_t^{(k)} - s_t = \alpha + \beta(i_t - i_t^*) + u_t$, where u_t is regression error.

If the CIP holds, α should be zero and β should be one.

Since the transaction specified the CIP is covered, it does not surprise us that empirical analyses are approving that covered interest parity holds.[31] However, the uncovered interest parity has much more shortcomings.

3.2.2 Uncovered Interest Parity

The theory of uncovered interest parity assumes that foreign exchange market participants are endowed with rational expectations (they are sure of the exactness of their expectations about the future value of the spot exchange rate - world of a perfect foresight) and are risk-neutral (they cares only about the yield and not about the risk). The assumption of risk neutrality is

[30] Sarno (2002), p. 8
[31] Sarno (2002), p. 9

very often modified and the risk-premium is admitted. However, if the assumption of risk-neutrality holds, then the expected foreign exchange gain from holding one currency rather than another (the expected exchange rate change) should be just offset by the opportunity cost of holding funds in one currency rather than in the other (the interest rate differential). That is what the uncovered interest parity asserts:[32]

$$\frac{E_t\{S_{t+1}\}}{S_t} = \frac{1+i_{t+1}}{1+i^*_{t+1}} \tag{8}$$

where S_x is nominal spot exchange rate

i_{t+1} is interest rate on bonds denominated in home currency at time t+1

i^*_{t+1} is interest rate on foreign-currency bonds at time t+1

That means, if in one country are interest rates 5% and in the second country 2%, the currency with lower interest rates should, in accordance with UIP, depreciate by 3% in order to equalize the returns.

However, in a real world, the strict assumptions of the uncovered interest parity do not hold. The investors do not have perfect foresight of the behavior of the exchange rate, they are neither risk averse. Transactions costs reduce arbitrage opportunities or prevent arbitrage opportunities from materializing. These include bid-ask spreads in foreign exchange rates and in case of using borrowed funds, the difference in lending and borrowing rates. The UIP requires as well perfect capital mobility, which can be hindered by administrative obstacles such as controls on capital movements or by high transaction costs, and so on.

And when domestic and foreign assets are not perfect substitutes (they do not have equal risk), UIP cannot hold. Besides exchange risk, the factors that make domestic and foreign

[32] Obstfeld, Rogoff (1996), p. 527

bonds imperfect substitutes are, amongst other, political risk, the risk of default, the risk of the introduction of controls on capital movements, liquidity consideration, etc.[33] Therefore, the UIP is used with risk premium in an empirical analysis. However, risk premium is immeasurable, only some proxies are used.

Siegel's Paradox

The uncovered interest parity has many shortcomings due to its unrealistic assumptions; moreover it has also a substantial mathematical weakness, called Siegel's Paradox:

Siegel[34] in 1972 noted that if the UIP holds, it must hold on both sides, as well for the foreign country:

$$\frac{E_t\left\{1/S_{t+1}\right\}}{1/S_t} = \frac{1+i^*_{t+1}}{1+i_{t+1}} \tag{9}$$

And if we compare both equations, for home and foreign country, then:

$$\frac{E_t\left\{1/S_{t+1}\right\}}{1/S_t} = \frac{1+i^*_{t+1}}{1+i_{t+1}} = \frac{S_t}{E_t\{S_{t+1}\}} \quad \rightarrow \quad E_t\left\{1/S_{t+1}\right\} = \frac{1}{E_t\{S_{t+1}\}}. \tag{10}$$

On the other hand, for the convex function always holds Jensen's inequality: $E[g(x)] > g[E(x)]$, therefore it holds $E_t\left\{1/S_{t+1}\right\} > \frac{1}{E_t\{S_{t+1}\}}$ and not the equality above. That means that UIP condition is not mathematically correct.

In order to avoid the Siegel's paradox, the uncovered interest parity is for empirical purposes expressed in logarithms $i_{t+1} = i^*_{t+1} + E_t s_{t+1} - s_t$. The equation is simply multiplied by minus unity, which is a linear transformation, and in that case it is mathematically correct.

[33] Wang (2005), p. 45
[34] Siegel (1972)

Interrelationships between CIP, UIP and PPP[35]

If the covered interest parity and uncovered interest parity are applied together, then it implies that the forward rate is an unbiased predictor of the future spot rate:

$$f_t = E_t s_{t+1} \tag{11}$$

And if uncovered interest parity holds simultaneously with real purchasing power parity (PPP), then the **real interest parity** holds, that means that the differential in interest rates should be the same as the expected inflation differential between the two countries:

UIP: $$\Delta s^e_{t+1} = s^e_{t+1} - s_t = (i - i^*)_t \tag{12}$$

PPP: $$\Delta s^e_{t+1} = \Delta p^e_{t+1} - \Delta p^{*e}_{t+1} \tag{13}$$

It follows that: $$i_t - \Delta p^e_{t+1} = i^*_t - \Delta p^{*e}_{t+1} \tag{14}$$

Exactly this real interest parity is used in BEER approaches. However, the hypothesis that interest rate differentials are unbiased predictors of future exchange rate movements has been almost universally rejected in empirical studies, as it is showed in the next chapter.

3.2.3 Empirical evidence of uncovered interest rate parity[36]

The uncovered interest parity is tested by various methods. Most often is tested the hypothesis that the covered and uncovered parity holds simultaneously, that means, that the forward rate is an unbiased predictor of the future spot rate $f_t = E_t s_{t+1}$. Then the following regression is tested: $\Delta_k s_{t+k} = \alpha + \beta(f_t^{(k)} - s_t) + u_{t+k}$. If agents are risk-neutral with rational expectations, the parameter β should be equal to unity and the disturbance term u_{t+k} white noise. However,

[35] Cuthberston (1996), p.264
[36] Sarno (2002), p.12

empirical studies testing this equation are not supporting the UIP hypothesis. On the contrary, the coefficient β appears to be rather minus unity than unity (Froot, Thaler 1990). That is just opposite what the UIP theory predicts.

Even if other methods (e.g. testing orthogonality of the forward rate forecast error with respect to given information; or bivariate vector autoregression – VAR) have been developed, the uncovered interest parity has been generally rejected.

So, then the effort was shifted to explanation why the UIP does not hold. The literature mentions four reasons: the first concerning the assumption of risk neutrality and the others the assumption of perfect foresight expectations:

1) risk premium: If the foreign exchange market participants are risk-averse, the UIP may be distorted by a risk premium, because market participants demand a higher rate of return than the interest differential in return of holding foreign currency. And this risk premium is something immeasurable; however economists use some proxies. For instance Komárek and Melecký[37] used in their analysis amount of government debt as a proxy.

2) rational bubbles - failure in perfect foresight expectations: A speculative or rational bubble is characterized by an path of the exchange rate which takes the exchange rate away from its the equilibrium value. And this explanation says that speculators and investors continue to buy a currency despite the fact that it is already overvalued with respect to the fundamentals, simply because they think that continuation of the bubble will make it profitable to do so.

3) rational learning in the foreign exchange market: This explanation asserts that market participants learning about environment may be unable to fully exploit the arbitrage

[37] Komarek, Melecky (2003)

opportunities which are apparent in the data ex post. This explanation of failure of UIP was first proposed by Lewis (1989).

4) the peso problem: The peso problem concerns the evidence of uncertainty of future shift in regime. The name is derived from the fact that this consequence was first observed in the foreign exchange market for the Mexican peso. In the period from April 1954 to August 1976, the peso/US dollar spot exchange rate remained fixed at 0,080 dollars per peso. However, during all this period the forward exchange rate of the peso vis-à-vis the dollar was always smaller than the spot rate prevailing on the day of delivery. This evidence is interpreted as the existence of risk premium.

However, the above mentioned explanations can not explain the fact that exchange rate moves exactly in the opposite way than the UIP theory predicts, because the mentioned explanations are small-sample problems. In general, the conclusion that emerges from survey data studies appears to be that both risk aversion and departures from rational expectations are responsible for the rejection of the uncovered interest parity theory. Nonetheless, the uncovered interest parity theory is still used in approaches for estimating real equilibrium exchange rate.

4. APPROACHES FOR ESTIMATING REAL EQUILIBRIUM EXCHANGE RATE MISALIGNMENT

In this section we present some approaches, which are trying to estimate if the actual exchange rate is misaligned. They are famous for their funny names; however, they seem to be lack of practical use. We will show three main methods: FEER, NATREX and BEER. Other approaches (such as DEER, PEER, CHEER, ITMEER..) are more less only some variant of the three main methods.

4.1 The FEER approach

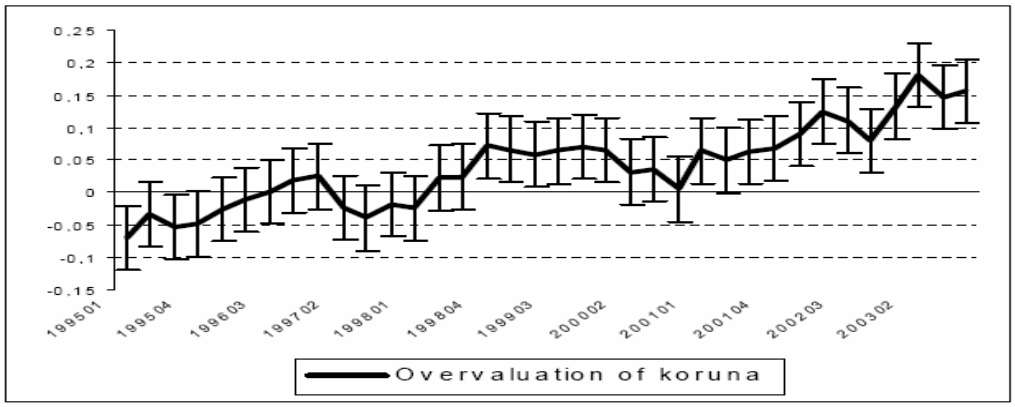
The first approach has become known as the macroeconomic balance approach. This approach appeared in 1950s and requires that the exchange rate should have the value, which achieves internal and external balance simultaneously. During the 1970s this method was refined by the International Monetary Fund, and later used by Williamson and others[38] in their work on "Fundamental Equilibrium Exchange Rates" (FEERs), where they gave the name to that approach. Williamson et al. were looking for a measure of the real exchange rate that will bring the current account, measured at potential, into line with some measure of "desirable capital flows". Since these applications have normative meaning, they tend to define external balance in terms of "balanced" or "normal" capital flows, ensuring external debt sustainability in a shorter-term horizon; and the internal balance is defined as a nonaccelerating inflation rate of unemployment (NAIRU). Williamson's desirable capital flows equal the difference between levels of investment and saving that are not distorted by public policy.

[38] Williamson, (1994)

The definition is very nice, however, if one wants to use the FEER approach empirically, he has to first determinate the potential output with low inflation. That can be done by using some filter, such as Hodrick-Prescott or Kalman etc. And secondly he needs to define what a sustainable current account is, which can be answered differently, depending on the author meaning. Since the FEER approach includes the normative assumptions, it is not an excellent tool to find the equilibrium exchange rate. Moreover, it remains unclear whether the underlying exchange rate relationship is well-founded in a statistical sense.[39]

What the Czech research concerns, the application of the FEER approach can be find in Šmídková (1998) and Šmídková et al. (2002), where they used Czech module of the NIGEM model. In 2004, Bulíř and Šmídková[40] used the foreign debt-augmented FEER termed the Fundamental Real Exchange Rate (FRER). Their result was that the Czech Koruna had been overvalued since 1998 (see figure 1). That is lack of practical use. Moreover, the estimate has very wide confidential intervals, ten percentage points. Therefore the FEER approach seems to be useless for the debate of setting central parity for ERM II entry or for any other debate of misalignment of the exchange rate.

Figure 1: Bulíř and Šmídková (2004): Misalignment of the Czech Koruna – FEER



source: Babetskii, Egert, 2005

[39] Egert (2003)
[40] Bulíř and Šmídková (2004)

4.2 The NATREX approach

Similar to the FEER approach is the NATREX (NATural Real EXchange rate) approach. It has been suggested by Stein (1995) and it is also based on internal and external balances. The definition according Stein[41] is: *"The NATREX is the equilibrium real exchange rate that clears the balance of payments in the absence of cyclical factors, speculative capital flows, and movements in international reserves."*

The difference between FEER approach and NATREX is that the NATREX is a positive behavioral concept. It is assumed, that the exchange rate is implied by real fundamental determinants and by the existing economic policies. NATREX considers, in addition to medium term, also the long-run term. NATREX also considers the stock of capital and the stock of foreign debt in the long run.

The long run equilibrium is derived so that the stock of capital and the stock of foreign debt are stabilized at their steady state levels. It is assumed that capital stock and foreign debt converge to their steady state, as the following equations determine:

$$\frac{K}{Y} = \frac{1+g}{\delta+g}.\frac{I}{Y} \qquad (15) \qquad\qquad \frac{FDEBT}{Y} = \frac{1+g}{g}.\frac{CA}{Y}, \qquad (16)$$

where K is capital stock, FDEBT is foreign debt, CA is current account, I is investment – all expressed in terms of GDP (Y)

δ is the rate of depreciation of the capital stock

g is the growth rate of GDP

[41] Stein (1995), p.6

The medium-run market-clearing equilibrium of the NATREX model can be described by the national income accounts equation,

$$I - S + CA = 0, \tag{17}$$

where I is desired national investment

S is desired national saving

CA is the desired current account

All is measured when the economy is at capacity output and expectations about inflation are met. The equilibrium is maintained by the assumption that the real exchange rate, R, appreciates in response to an excess demand for goods.

An example of application for the Czech Republic is Frait and Komarek (1999) who estimated the reduced form of NATREX. The reduced-form of NATREX is, however, very closely related to estimating BEER developed by MacDonald (1997) and Clark and MacDonald (1998).

4.3 The BEER approach

The BEER (behavioral equilibrium exchange rate) approach appeared in the literature in the 1990's and it is based on the real uncovered interest parity, through which the real exchange rate is linked to fundamentals. Real exchange rate is connected to the expected real exchange rate (which is a function of fundamentals), to the real interest rate differential and to risk premium (which depends on domestic and foreign government debt):

Written in equation: [42]

$$q_t = E_t(\bar{x}_{t+1}) - (r_t - r_t^*), \tag{18}$$

where q_t is the observed real exchange rate in period t,

$r_t = i_t - E_t(\Delta p_{t+1})$ and $r_t^* = i_t^* - E_t(\Delta p_{t+1}^*)$ represent the domestic and foreign ex ante real interest rates and

$E_t(\bar{x}_{t+1})$ denotes the expected real exchange rate, which is assumed to be determined by the outcome of the expected values of fundamentals, where $\bar{x}$ is the vector of fundamentals

Such modeling is attractive in terms of trying to assess where the actual exchange rate is in relation to its "equilibrium value". However, "the equilibrium value" is sensitive to which particular fundamentals are included in the estimated model. Different fundamentals can be used in the estimation, depending on different theoretical frameworks, on author's meaning or on ad hoc econometric analysis. Balasz Egert and then Melecký and Komárek[43] summarized the various fundamentals, which were used in various studies concerning the real exchange rate of the new EU countries (see table 2).

The consensus appears to be in labor productivity, which enters the real exchange rate equation almost every time and it is evident, that increase in labor productivity leads to an appreciation of the real exchange rate. That stems also from the Balassa – Samuelson effect. Other variables are often included based on the following arguments:

[42] Egert (2003), p. 51
[43] Komárek, Melecký (2005), p.20

Fundamentals often used in the behavioral analysis of the EER[44] [45]:

Current account: The deficit of current account should generate the depreciation of domestic currency, since the foreign currency is more demanded than the domestic currency as the imports are prevailing exports.

Terms of trade: The terms of trade are the ratio of domestic export prices and import prices. An increase in domestic export prices is assumed to result in real appreciation, since the domestic producers shift production towards tradable (exportable) goods, where the wage consequently increases and due to expected labor mobility, the overall domestic price level increases. Moreover, the improvement of the current account causes appreciation of the domestic currency.

Foreign direct investment: The inflow of FDI should cause the appreciation by the two effects. Firstly, the higher demand for domestic currency leads to nominal appreciation and secondly, it is expected that FDI inflow results in increase of average productivity, which leads to the appreciation, again due to the Balassa-Samuelson effect.

Net foreign assets (NFA): In the long term the increase of net foreign assets leads to appreciation of domestic currency due to repatriated dividends and interests, which results in higher demand for domestic currency. In the catching up countries, we should observe the depreciation due to negative net foreign assets.

Government consumption: Rise in government spending may generate appreciation of the real exchange rate, since the government is demanding more nontraded goods, which will be therefore more expensive and that will lead to higher price level. On the other hand, higher budget deficit would generate depreciation of the currency, due to larger interest payments and increase country risk.

[44] Komárek, Melecký (2005), p.7
[45] Horváth (2005)

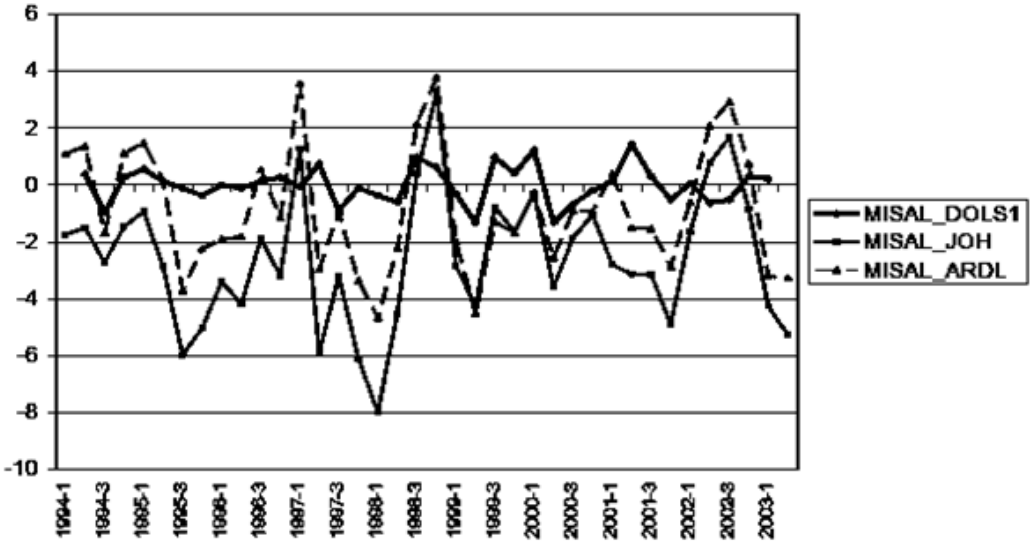
Deregulation: Deregulation is likely to generate price increases that we can observe in real exchange rate appreciation.

Real interest rate differential (UIP): The real interest rate differential is essential for the BEER approach. According to UIP, it is assumed that currency with a positive interest rate differential will depreciate in the future, because of equalization yields in domestic and foreign currency. But in the short run, the positive interest rate differential increases demand for domestic currency resulting in appreciation of the currency.

The BEER approach attempts to link the above mentioned fundamentals or any other to the real exchange rate in a single equation and it asserts that the estimated coefficients (either on the basis of observed series of fundamentals or using fundamentals' long-term values) are the equilibrium coefficients. However, these estimates represent more less merely a statistical relationship. That is the first drawback of the BEER approach. The second drawback of the BEER approach is that it draws on the real interest parity which, as we showed in the chapter 3.2, does not hold.

However, the BEER approach attracts attention and is quite often used in estimating Czech crown or other CEEC currencies, for example Babetskii and Egert (2005) or Komarek and Melecky (2005).

Figure 2: Misalignment of the Czech Koruna – BEER estimates



Source: Komárek and Melecký (2003).

Note: Misalignment = fitted – actual values. Positive values correspond to over-valuation.

4.4 Filtration techniques

Since the above mentioned analysis have substantial drawbacks, the economists often use the simplest analysis – filter. They simply take a series of the real exchange rate and estimate its trend. Various filters can be used, such as Hodrick-Prescott filter, band-pass or Kalman filter. Then the values which do not lie on the trend line are considered as misalignments. Apparently, these misalignments are difficult to interpret, since filtration does not have any underlying economic theory. In addition, these filters suffer from so—called end point bias. That means that the values at the beginning and at the end of the series have stronger influence than the values in the middle of the series, which causes biased equilibrium values at the ends. Thus the filtration techniques are not suitable for estimating the current exchange rate misalignments. However, the filtration techniques are used for estimation of the gap of the real exchange rate.

As we see, the approaches trying to find the real equilibrium exchange rate are not perfect; nonetheless they are in some measure predicative.

Nevertheless, we show in the following analysis that the amplitude of the real exchange rate misalignment derived by the BEER approaches and by various filters is determined by the degree of competition at the relevant market. That is very important and to our knowledge we are the firsts who detect it.

Table 2: An Overview of RER Determinants in BEER approaches

STUDY BY	PROD	GOV	OPEN	NFA	RIRD	TOT	INV	FD	PC	RP	FDI	No. variab.
Alberola (2003)	–			–/+								2
Alonso-Gamo et al. (2002)	–			+								2
Avallone and Lahrèche-Révil (1999)	–	–	+			–			–			5
Begg et al. (1999)	–	–	–									3
Beguna (2002)		–	–			–					–	4
Bitans (2002)	–	+	+									3
Bitans and Tillers (2003)	–			–		+						3
Burgess et al. (2003)	–			+								3
Coricelli and Jazbec (2001)	–	–							–			3
Coudert (1999)	–							+				2
Csajbók (2003)	–	–	–	–	–	–						6
Darvas (2001)	–			–	–/+							3
De Broeck and Sløk (2001)	–		+									2
Dobrinsky (2003)	–	–										2
Égert and Lahrèche-Révil (2003)	–											1
Égert and Lommatzsch (2003)	–		+		–			–/+		–		5
Filipozzi (2000)	–						–					2
Fischer (2002)	–	–			–/+	+						4
Frait and Komárek (1999, 2001)	–				+	–			(–)		–	4
Halpern and Wyplosz (1997)	–	–										2
Hinnosar et al. (2003)	–			–		–						3
IMF (1998)	–	+	–				+					4
Kazaks (2000)	–		+									2
Kim and Korhonen (2002)	–	–	+				–					4
Krajnyák and Zettelmeyer (1998)	–											1
Lommatzsch and Tober (2002b)	–			+	–							3
MacDonald and Wójcik (2002)	–			–/+	–					–		4
Maurin (2001)	–	–			–			+				4
Rahn (2003)	–			–								3
Randveer and Rell (2002)	–					–						2
Rawdanowicz (2003)	–				–	–						3
Rubaszek (2003)				–	–							2
Vetlov (2002)	–		+		+							3
Number of '–'	31	10	4	8	9	7	2	1	2	2	2	X
Number of '+'	0	2	7	5	3	2	1	3	0	0	0	X
Total number of studies	31	12	11	11	10	9	3	3	2	2	2	X

Notes: *A (–) or (+) increase in the variable leads to an appreciation or depreciation of the real exchange rate respectively. PROD = productivity proxy; GOV = share of government consumption in GDP; OPEN = exports + imports over GDP; NFA = net foreign assets; RIRD = real interest rate differential; TOT = terms of trade = export prices / import prices; INV = share of investment in GDP; FD = foreign debt to GDP; PC = share of private consumption in GDP; RP = regulated prices (or differential vis-à-vis benchmark economy), FDI = foreign direct investment over GDP; S = national savings over GDP.*

Source: Komárek and Melecký (2005)

5. RELATIONSHIP BETWEEN COMPETITION AND REAL EXCHANGE RATE – PANEL ANALYSIS OF EXPORTING COMPANIES

In the previous sections we reviewed the theories which are concerning the real exchange rate and the approaches which are trying to assess if the real exchange rate is or were on its equilibrium value. In this section we analyze our hypothesis of the relevance of degree of competition on the real exchange rate. Moreover, as we show, the degree of competition has an impact on the outcome of approaches which were showed in the previous chapter.

5.1 Exporting firm's optimum

In the model, we consider a company that produces to the domestic and foreign market. The company faces the respective demand functions in each market. A representative consumer has utility *u(Q)* from consuming domestic composite good *Q* and foreign composite good Q_f. good. The composite goods, *Q* and Q_f represent the demands at the domestic and foreign markets for distinct substitute goods with certain elasticity of substitution between products q_i (on the domestic market $\varepsilon > 1$ and on the foreign market $\varepsilon_f > 1$).

The demand for the product of a producer *i* is given by the results of the consumers' maximization problem. The standard result implies that at the local segment and at the foreign market segment the firm faces the demand:

$$q_i = f\left(\frac{p_i}{P}, Q\right) \quad \text{and} \quad q_{f,j} = f\left(\frac{p_{f,j}}{P_f}, Q_f\right), \text{ respectively.} \qquad (19)$$

P and P_f denote the aggregate price indices on the local and foreign markets, respectively. The exporting firm maximizes its profit and thus solves:

$$p_i q_i + S p_{f,i} q_{f,i} - c\left(q_i + q_{f,i}\right) \rightarrow \max_{q_i q_{f,i}} \tag{20}$$

where *c(.)* is the cost function and *S* denotes the nominal exchange rate. After substituting for prices from demands, we yield

$$q_i f\left(\frac{q_i}{Q}, P\right) + S q_{f,i} f\left(\frac{q_{f,i}}{Q_f}, P_f\right) - C\left(q_i + q_{f,i}\right) \rightarrow \max_{q_i, q_{f,i}}. \tag{21}$$

The first order conditions dictate:

$$Sf'\left(\frac{q_{f,i}}{Q_f}, P_f\right)\frac{1}{Q_f} q_{f,i} + S p_{f,i} - MC = 0 \tag{22}$$

and

$$f'\left(\frac{q_i}{Q}, P\right)\frac{1}{Q} q_i + p_i - MC = 0. \tag{23}$$

Where *f'(.)* denotes first derivatives with respect to q_i and q_{if}. After rearranging we get the optimal pricing mechanism at both markets:

$$p_{fi} = \frac{\varepsilon_f}{\varepsilon_f - 1}\frac{1}{S} MC \quad \text{and} \quad p_i = \frac{\varepsilon}{\varepsilon - 1} MC. \tag{24}$$

From the above derivations follows that the domestic prices do not respond to exchange rate changes, unlike the export prices that are directly influenced by its changes. More substantially, the changes in exchange rate are perceived by the firm as exogenous shocks into marginal costs.

Since the exchange rate changes are perceived by the firm as exogenous shocks into marginal costs, the way how the firm will react to this shock will depend on degree of competition in its market.

1) Under perfect competition:

If the firm operates under perfect competition, the elasticity ε_f goes to infinity; therefore the ratio $\frac{\varepsilon_f}{\varepsilon_f - 1}$ is equal to 1. Then the price of sold products is equal to its marginal costs: $p_{fi}=MC'$, where $MC'= 1/S_x MC$. An exchange rate appreciation leads to a rise in marginal and average costs, thus the firm has to raise the foreign price of the good by the same magnitude as the initial exchange rate impulse. Revenues and costs equalize, which has no impact on price-cost margin. Therefore under perfect competition the relative prices do not change, when the shock of nominal appreciation comes. Nevertheless, the relative change of real exchange rate does not say anything about volume of sold products at foreign market.

2) Under imperfect competition:

On the other hand, if the firm operates under imperfect competition, the ratio $\frac{\varepsilon_f}{\varepsilon_f - 1}$ is higher than 1, the price of sold products is higher than marginal costs: $p_{fi}>MC'$, where $MC'= 1/S_x MC$. Therefore, if the exchange rate appreciates, the marginal costs are rising, but the company will not increase the foreign price by the same magnitude as the exchange rate appreciated. With the rising price, the imperfect competitor is shifting along the demand curve to the more elastic region. Therefore, optimal for the imperfect competitor is to lower its margin, not to raise the p_{fi} by the same magnitude as the exchange rate shock was. The price-cost margin shrinks and relative prices change.

5.2 Measurement of relative price changes

The change of relative prices alias pricing to market (PTM) can be measured from two points of view. Firstly, from the point of view of consumer, so the question is, costs the same good in different countries the same? Then the economists mostly research the relative change of consumer prices. Or secondly, from the point of view of producer and the question is, sells the producer the same good to the domestic market and foreign market for the same price? The derivation of the producer PTM component in the exchange rate development has been presented in the paper of Cincibuch and Podpiera (2006) [46]. Their approach relates both the export and import goods $Q = \sqrt{\frac{P_{ex} P_{ppi}}{EP^*_{ppi} P_{im}}}$, thus represent more complex approach than the usual producer approach comparing merely export and domestic price indices (for instance Marston 1990).

However, these two approaches (from the point of view of producer and consumer) are identical if prices of tradable and nontrable goods perform identically and no third country exists.

In our analysis, we measure the change of relative prices from the point of view of producer. We are interested in the relative change of the real exchange rate, which we measure by means of relative change of prices of tradable goods depending on change of nominal exchange rate. In contrast to other studies which were measuring the relative change of the real exchange rate from the price indices (for example already mentioned Cincibuch and Podpiera 2006), we are using original data from the financial statements of exporting companies (in order to analyze the relevance of market structure). Since we use data only for Czech companies, we are obtaining the relative change of the real exchange rate for the Czech

[46] Cincibuch and Podpiera (2006)

side (ΔPTM_{Czech}). Properly, we should do the same analysis for the German (European) side (ΔPTM_{German}) and compute the relative change of the real exchange rate according to this relation $\Delta PTM = \sqrt{\Delta PTM_{Czech}.\Delta PTM_{German}}$. However, Cincibuch and Podpiera (2004) estimated on price indices that the German-Czech relative change of the real exchange rate ΔPTM_{German} is very similar to the Czech-German ΔPTM_{Czech}, thus we can conclude that our one-sided relative change of the real exchange rate will be comparable to the correct one.

5.3 Data description and definition of variables

To focus on firms' prices of sold products and the effect of nominal exchange rate on it, we constructed a panel data structure that is composed of individual manufacturing firms that are located in the Czech Republic and do export that is positive. The data source is database Magnus which provides financial statements for lot of Czech companies from 1993 onwards.

Since we examine the effect of the exchange rate (CZK/EUR) on exporting firms, we need the information if the firm is exporting or not. This information is not accessible for all firms; neither is showed in financial statements, however, it is sometimes published in newspapers or in magazines and the database Magnus is providing media monitoring. The media has been monitored since 2000 and the information about export percentage is available for 443 manufacturing firms.

For the firms we found the information about their share of export, we gathered the financial statements. All firms are obliged to send their financial statements to district trade registers and these financial statements are gathered in the database Magnus. By 2003 the workers of Magnus were traveling all over the district trade registers and were copying the data. Since

2004, all financial statements should be electronically on the Internet. Unfortunately, the on-line trade register does not work properly. Therefore the data set starting 2004 onwards is very restricted and we excluded limit our sample to 2003.

However, we downloaded all accessible quarterly financial statements for the period 1993-2005. We excluded the firms whose financial statements were not accessible and the observations that had not complete records on a set of these accounting variables: production, production costs and employment costs (payroll). These three variables are used for calculating price-cost margin.

We required at least 2 continuous observations, since the "*profit and loss statement*" is cumulative statement (for second, third and fourth quarter). In order to explore the effect of the exchange rate in particular quarters, we had to subtract the third quarter from the fourth quarter, the second form the third and the first from the second. For that we needed two consecutive financial statements, therefore we excluded non-consecutive observations.

In the end, we have used a sample of 94 exporting companies operating in Czech Republic, whose main activity (according to "okeč"- the Czech classification of activities) is manufacturing and for which we have information about their export share and at least 2 continuous quarterly observations during the period 1993-2003. We got the unbalanced panel data set with 1447 quarterly observations for 94 firms for the period 1993-2003. The panel is unbalanced both in the sense that we have more observations on some firms than on others and that these observations correspond to different time spans. However, as the following table 3 shows, the observation per company and year are relatively uniform.

Table 3: Descriptive statistics of data (1)

	Mean	Std. dev.	Max.	Min.
Number of observations per time period (quarter)	35	9	51	15
Number of observations per company	16	11	44	2
Revenues (thousands of czk)	536 202	2 581 855	39 000 000	7 448
Production costs (thousands of czk)	405 645	2 219 246	33 200 000	4 330
Personal costs (thousands of czk)	72 199	169 661	2 119 719	2 907
Exchange rate (CZK/EUR)	34,18	1,98	37,76	30,25

Standard deviations in table 4 suggest how the costs and revenues varied across companies and across time. The personal costs varied in observing period between 2.9 million and unbelievable 2 billion of Czech crowns, the production costs between 4.3 million and 33 billion of Czech crowns and revenues between 7.4 million and 39 billion Czech crowns. It means that both large and smaller companies are involved in our sample. Naturally, Škoda Auto is the largest company in the sample.

The within standard deviation indicates how the variables are volatile within one company over time. If it would be zero, then the personal costs, production costs and revenues would not vary. However, the within standard deviation indicates that the production costs, revenues and even personal costs are quite volatile within one firm. The negative value of "within minimum" does not mean that the variable is negative, but the within number refers to the deviation from each individual's average, and naturally, some of those deviations must be negative.

Table 4: Desriptive statistics of data (2)

		Mean	Std. dev.	Max.	Min.
Personal costs	overall	**72 199**	169 661	2 119 719	2 907
(thousands of czk)	between		232 430	1 986 702	4 105
	Within		19 754	434 125	-115625
Production costs	overall	**405 645**	2 219 246	33 200 000	4 330
(thousands of czk)	between		3 157 010	30 000 000	7 443
	Within		160 652	3 586 622	-1835458
Revenues	overall	**536 202**	2 581 855	390 000 000	7 448
(thousands of czk)	between		3 659 927	34 600 000	17 144
	Within		227 156	4 946 975	-2932990

The table 5 shows how individual industry groups' exports are explained by our firm level data. In other words, what share of all exporting firms we have in our panel data. It would seem, according the data, that our companies do not explain most of the Czech exports, however, one must bear in mind, that the figures of total export includes both sort of goods: firstly, the good that were produced in the Czech Republic and exported and secondly, the goods for which the Czech Republic is only transit country.

Table 5: Share of used data on total export of Czech Republic

Name	Okec	total export 2002 (mil. CZK)	our data export 2002 (mil. CZK)	share of our data on total export
Textiles	**17,18**	65,396	4,174	6%
Paper	**20,21,22**	62,271	4,769	8%
Chemicals	**24,25**	132,009	12,712	10%
Glass	**26**	53,447	4,368	8%
Metals	**27,28**	149,892	26,354	18%
Fitting	**29**	147,624	6,622	4%
Machines	**31,32,33**	194,307	663	0%
Cars	**34**	208,101	123,466	59%

Note: Source of data of total export is Czech statistical office, www.czso.cz

5.4 The estimation

Our regression equation is derived as following:

We define the price-cost margin (profit margin):

$$PCM \equiv \frac{(\alpha p_i + (1-\alpha) S p_{fi}) \hat{q}_i}{c_i(\hat{q}_i)}, \qquad (25)$$

where α denotes the share of production which is not exported

S denotes nominal exchange rate

p_i and p_{fi} denote the average price of produced goods at home and abroad

$\hat{q}_i$ represents the total quantity produced (for home market as well as for foreign market)

So, the numerator represents revenues and the denominator costs (payroll + material).

If we write the price-cost margin in percentage changes (log-differencing), we yield:

$$\Delta \ln PCM = \Delta \ln\left(\alpha p_i + (1-\alpha) Sp_{fi}\right) q_i - \Delta \ln c_i(\hat{q}_i) = f\left(c_i(q_i), S\right), \tag{26}$$

If we add $\Delta \ln c_i(\hat{q}_i)$ to both sides of equation, we express our regression equation:

$$\begin{aligned} &\Delta \ln\left(\alpha p_i + (1-\alpha) Sp_{fi}\right) + \Delta \ln q_i \approx \\ &\beta_i + \beta_1\left(\Delta \ln ACM_i + \Delta \ln q_i\right) + \beta_2\left(\Delta \ln AWC_i + \Delta \ln q_i\right) + \beta_3 \Delta \ln S \end{aligned} \tag{27}$$

where the dependent variable is revenues and on the right side *ACM* denotes the average costs of material and *AWC* denotes the average wage costs of the *i*-th firm.

If we theoretically subtract from both sides of regression equation $\Delta \ln q_i$, on the left side remains the relative change of prices. After the linear transformation the coefficient β_3 is unbiased (contrary to coefficients β_1 and β_2 which are biased, however, for our analysis irrelevant). So, the coefficient β_3 is expressing the relative change of prices, actually pricing to market (measured at the industry level):

$$\frac{\Delta \ln PTM_i}{\Delta \ln S} = \beta_{3,i}, \tag{28}$$

where by subscript i we denote the respective industry.

Fixed or random effects estimation?

The panel data can be analyzed by two approaches – by fixed effect estimator or by random effect estimator. The random effect estimator is more efficient estimator than the fixed effect estimator, because it is saving on degrees of freedom. However, the random effect estimator is unbiased only if its composite error is uncorrelated with the explanatory variables. Therefore, one can use the random effect estimator only if the composite error is uncorrelated with explanatory variable. Appropriate test for the independence between the error term and the explanatory variables is the Hausman test. As we can see in the table 6, we reject the null hypotheses, that the composite errors are uncorrelated with the explanatory variables. Therefore we use the fixed effect estimators.

Table 6: Results of Hausman test

Name	okec	correlation of composite error with explanatory variables
Bier	**15**	0.89
Textiles	**17,18**	-0.09
Paper	**20,21,22**	0.61
Chemicals	**24,25**	-0.70
Glass	**26**	0.25
Metals	**27,28**	0.64
Fitting	**29**	0.04
Machines	**31,32,33**	0.07
Cars	**34**	0.94

Fixed effect estimation

The regression equation that we estimate by means of fixed effect estimation is:

$$\Delta \ln revenues_{it} = \beta_j + \beta_1(\Delta \ln(material + services\_\cos ts))_{it} + \beta_2(\Delta \ln payroll)_{it} + \beta_3(\Delta \ln nom.exch.rate)_{it} + \varepsilon_{it} \quad (29)$$

where *i* stands for individual firms, and *t* for time – quarters and ε_{it} are fixed effect error terms, that $\varepsilon_{it} = u_i + v_{it}$, where u_i are individual effects constant over time and v_{it} is the "traditional" error term.

We estimate this equation for each industry (bier, textiles, paper, chemicals, glass...) separately. The firms are divided into industries groups according their main "okec". The estimated equation is with individual firm effects. The differences across firms are captured in differences in the constant term. The equations are estimated by means of econometric program Stata.

5.5 Estimation results

The results include a set of regression estimated for individual industries by the fixed effects estimator, as well as the weighted aggregate regression.

5.5.1 Sectoral PTM

The sectoral estimations of PTM are displayed in the Table 4. The table presents the results for the fixed effects model applied to each sector defined by the Okec classification. The coefficient β_3 is significant for all included industries, except beer and glass industry. Chemical industry is significant on 10% significance level, the metals industry is significant on 5% significance level and textile, paper, fitting, machines and cars industry's coefficients are significant on 1% significance level.

So the result is: if the nominal exchange rate changes by 1%, the relative prices in individual industries changes as coefficient β_3 indicates. The highest relative change of prices is indicated by the car industry (0.7%), then by machine (0.61%) and paper industry (0.55%). The smallest change of relative prices is indicated by the chemical industry (0.15%), textiles (0.16%) and metals industry (0.26%).

Table 7: Estimation results of sectoral PTM

Name	okec	β1	β2	β3=PTM	*intercept*
Bier	**15**	0.922***(0.050)	0.036(0.096)	0.241(0.159)	*-0.008(0.465)*
Textiles	**17,18**	0.822***(0.029)	0.158***(0.033)	0.216***(0.074)	*0.083(0.072)*
Paper	**20,21,22**	0.796***(0.053)	0.021(0.036)	0.550***(0.103)	*0.634***(0.215)*
Chemicals	**24,25**	0.957***(0.036)	0.045(0.042)	0.149*(0.087)	*-0.127**(0.054)*
Glass	**26**	0.702***(0.078)	0.362***(0.091)	0.087(0.146)	*-0.191*(0.103)*
Metals	**27,28**	0.913***(0.044)	0.042(0.052)	0.264**(0.116)	*0.007(0.134)*
Fitting	**29**	0.700***(0.029)	0.245***(0.046)	0.367***(0.111)	*0.046(0.106)*
Machines	**31,32,33**	0.780***(0.051)	0.073(0.054)	0.607***(0.125)	*0.102(0.115)*
Cars	**34**	0.712***(0.089)	0.144**(0.073)	0.700***(0.209)	*0.076(0.153)*

Notes: In parenthesis are given standard errors; stars denote significance as follows: 3stars 1%, 2stars 5% and 1star 10%.

The presented intercepts are not correct intercepts, since they are averages of fixed effects across individual companies.

The statistics of the estimates are presented in Table 5. As the high R square (in all dimensions cross-section, time series and the overall) indicates, the model fits well to our data. As well as, the residuals do not exhibit significant serial correlation as LBI statistics and BH-DW statistics denote.

Table 8: Estimation statistics of sectoral PTM

Name	okec	LBI	Bh.-DW	rho	s_u	s_e	exp.	obs.	firms	R2-all	Within	between	Prob >F
Bier	**15**	1.954	1.791	0.122	0.146	0.094	0.13	46	3	0.989	0.958	0.999	0.026
Textiles	**17,18**	1.741	1.522	0.261	0.089	0.076	0.72	300	15	0.967	0.984	0.981	0.000
Paper	**20,21,22**	1.799	1.473	0.273	0.199	0.111	0.43	101	6	0.982	0.956	0.994	0.006
Chemicals	**24,25**	1.691	1.384	0.347	0.158	0.097	0.51	239	18	0.989	0.992	0.994	0.000
Glass	**26**	1.785	1.209	0.413	0.094	0.096	0.68	93	7	0.987	0.985	0.995	0.001
Metals	**27,28**	1.885	1.712	0.170	0.096	0.088	0.49	145	13	0.994	0.981	0.997	0.004
Fitting	**29**	1.710	1.436	0.287	0.080	0.121	0.68	371	20	0.965	0.953	0.987	0.000
Machines	**31,32,33**	1.899	1.493	0.279	0.119	0.094	0.62	93	6	0.938	0.987	0.957	0.000
Cars	**34**	1.934	1.617	0.316	0.308	0.109	0.53	59	6	0.996	0.987	0.998	0.019

5.5.2 Aggregated PTM

The aggregated PTM indicates the size of misalignment of real exchange rate from its equilibrium. The aggregate change of relative prices can be measured in two ways. We could calculate weighted average from the industry level estimates, but the standard error of this average estimation could be high. Or we could directly apply the weights the industries

possess in the trade on the exchange rate in a single panel and estimate one regression by means of fixed effects method. We have chosen the latter approach.

The result of aggregated estimate, where we have taken into account the weights, the industries possess in the trade (table 6), is presented in table 7. The effective sensitivity of the relative prices of export companies to exchange rate changes is 0.455 and is statistically significant on 1% significance level. That means, if the nominal exchange rate changes by 1%, the relative prices change by 0.455%.

Table 9: Share of examined industries on total export (year 2003)

Name	okec	share of industry on total export 2003
Bier	**15**	2,8
Textiles	**17,18**	4,5
Paper	**20.21.22**	4,4
Chemicals	**24,25**	10,6
Glass	**26**	3,7
Metals	**27,28**	12,9
Fitting	**29**	12,7
Machines	**31,32,33**	17,1
Cars	**34**	15,7

Note: Source of data is Czech statistical office, www.czso.cz

Table 10: Estimation result of aggregated PTM

Aggregated PTM	**β1**			**β2**			**β3=PTM**			***intercept***		
	0.888***(0.014)			0.100***(0.015)			0.455***(0.052)			*0.152***(0.031)*		
Statistics of estimation	***LBI***	***Bh.-DW***	***rho***	***s_u***	***s_e***	***obs***	***firms***	***R2-all***	***within***	***betwee***	***Prob>F***	
	1,67	1,381	0,333	0,289	0,109	1447	94	0,944	0,982	0,949	0,000	

5.6 A comparison of results with estimates from price indices

Since we analyze the change of relative prices from firm level data (financial statements) and Cincibuch and Podpiera[47] analyzed the change of relative prices from disaggregated price indices, we can compare both approaches. As we can see in the table 11 and in the figure 3,

[47] Cincibuch and Podpiera (2006)

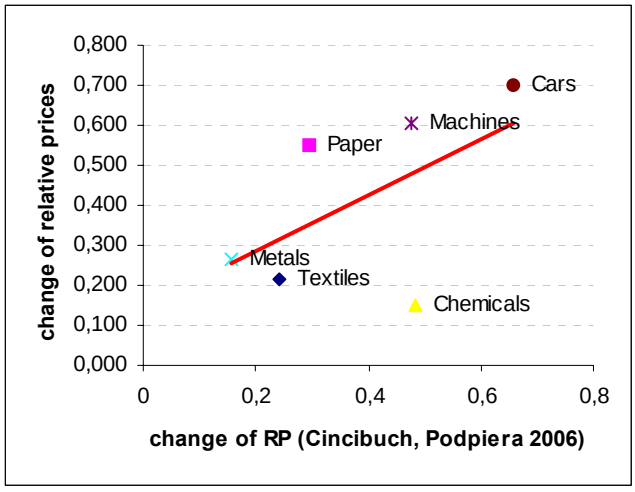
the results are very similar (except for chemical industry, where the difference is caused by broad definition of industry on the aggregate level).

Results from the company data should be more precise, as they alleviate a major drawback of the sectoral price indices – aggregation of different goods.

Table 11: Comparison of results with estimates from price indices (Cincibuch, Podpiera 2006)

Name	okec	change of RP - Cincibuch, Podpiera (2006)	change of RP -Podpiera, Rakova
Textiles	17,18	0.242 (0.074)	0.216 (0.074)
Paper	20,22	0.296 (0.119)	0.550 (0.103)
Chemicals	24,25	0.483 (0.156)	0.149 (0.084)
Metals	27,28	0.157 (0.136)	0.264 (0.116)
Machines	31,32,33	0.477 (0.102)	0.607 (0.125)
Cars	34	0.659 (0.111)	0.700 (0.209)

Figure 3: Comparison of results with estimates from price indices (Cincibuch, Podpiera, 2006)



5.7 Competition and relation to PTM

5.7.1 Competition measurement

Since our hypotheses sounds, that firms operating on more competitive markets will exhibit smaller change of relative prices with nominal appreciation, we analyze the degree of

competition for individual industries in the relevant market segment. The analysis of market competition is very difficult and controversial. In most cases is measured by market share of individual firm (for instance Herfindahl-Hirschman Index). The definition of the relevant market in important cases is decided by a court, what is for our analysis impractical. Thus, the indicators of competitiveness that do not operate with market share are suitable for our purpose; they are Lerner index and Rosse – Panzar elasticity.

The Lerner index attempts to measure market power by subtracting a firm's marginal cost from its price, and then dividing the result by the firm's price. Lerner index is in fact equal to cost-price margin (CPM). The ratios range from 0 to 1. Firms that are in perfect competition show ratios close to zero, firms that are perfect monopolists show ratio close to 1. In other words, if markets are less than perfectly competitive, firms are able to charge prices higher than marginal cost.

The computation of the cost-price margin (Lerner index) is derived as in Domowitz[48]:

$$CPM \equiv \frac{Sale + \Delta Inventories - Payroll - Material\cos t}{Sale + \Delta Inventories} \tag{30}$$

Rosse – Panzar elasticity[49] measures the market power by the extent to which changes in input prices are reflected in revenues. Under perfect competition, a proportional increase in factor prices causes a proportional change in revenues. On the other hand, under monopolistic competition, revenues will increase less than proportionally to changes in factor prices, as the demand is less than perfectly elastic.

[48] Domowitz et al. (1986)
[49] Panzar and Rosse (1987)

However, we do not hold the prices of input costs, but the average costs. Therefore we estimate the amended Rosse-Panzar ("aRP") elasticity: "aRP" elasticity close to zero indicates monopoly, "aRP" elasticity close to 1 indicates perfect competition.

Moreover, we show the price-cost margin (PCM), which indicates an extent of margins in industry (close to 1 stronger competition, bigger than 1 weaker competition).

5.7.2 Results: degree of competition and relation to PTM

We calculated the indicators of competitiveness for each industry group. The higher degree of competition according to Lerner index and amended Rosse-Panzar elasticity is indicated in metals industry, chemical industry and textiles industry. Reversely, the lower degree of competition according to Lerner index and amended Rosse-Panzar elasticity is specified in car industry, machines industry and paper industry.

And if we compare the estimated degree of competition and the size of changes in relative prices, we observe that industries with Rosse-Panzar elasticity close to 1, which indicates perfect competition, have low PCM (close to 1) and low Lerner index (close to 0) and statistically insignificant or low parameter β_3, which indicates small change in relative prices. And reversely, where the Rosse-Panzar elasticity is significantly below unity, there is high PCM and Lerner Index and high parameter β_3, that indicates perfect competition. In other words, the size of changes in relative prices is negatively correlated with the degree of competition.

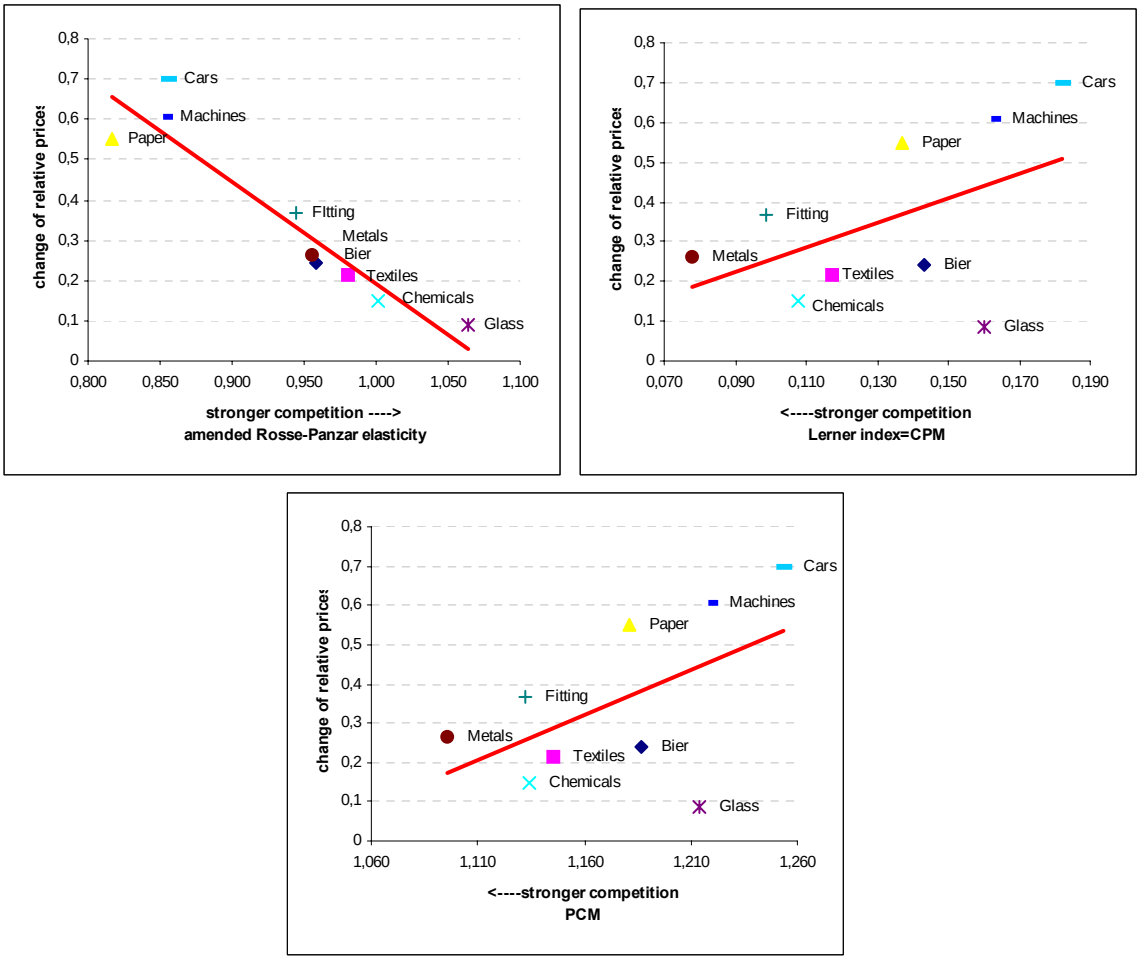
Table 12: Competition (Lerner index – Rosse-Panzar elasticity) and relation to PTM

Name	okec	PTM: β3	Lerner index=CPM	PCM	Rosse-Panzar elasticity (β1+β2)
Bier	15	0.241	0.143	1.187	0.958
Textiles	17,18	0.216	0.118	1.146	0.980
Paper	20,21,22	0.550	0.137	1.181	0.817
Chemicals	24,25	0.149	0.108	1.135	1.002
Glass	26	0.087	0.160	1.214	1.064
Metals	27,28	0.264	0.078	1.096	0.955
Fitting	29	0.367	0.099	1.132	0.945
Machines	31,32,33	0.607	0.162	1.219	0.853
Cars	34	0.700	0.182	1.253	0.856

The negative correlation can be well observed visually in figure 4. The relative change of prices is illustrated on the vertical axis and the degree of competition (measured by amended Rosse-Panzar elasticity, Lerner index and PCM) is illustrated on the horizontal axis. Especially the industries, where the high relative change of prices is estimated (car industry, machines industry and paper industry) are these industries, where both amended Rosse-Panzar elasticity and Lerner index indicate lower degree of competition. And reversely, the industries, where we estimated low or insignificant relative change of prices (metals industry, chemical industry and textiles industry) are these industries, where the lower degree of competition is indicated.

Our hypothesis of dependence of change of relative prices on degree of competition has been confirmed.

Figure 4: Competition (Lerner index – Rosse-Panzar elasticity) and relation to PTM



5.8 Relationship between degree of competition and real equilibrium exchange rate

We estimated the relative change of prices from producers' data. That analysis is similar to the analysis of PPI indices. However, can we conclude our result to the real exchange rate measured by means of CPI indices? We assert that we do, while the only difference between these two approaches is the Balassa-Samuelson effect, as the following derivation reveals, and the Balassa-Samuelson effect has been recently considered as negligible in the Czech Republic[50].

[50] Mihaljek (2003)

5.8.1 The derivation of the real exchange rate from the Balassa-Samuelson model

The definition of the real exchange rate, which relates the foreign to domestic price aggregate consumer price level, is:

$$Q = S\frac{P^*_{cpi}}{P_{cpi}} \tag{31}$$

where P^*_{cpi} represents the foreign consumer price level, P_{cpi} stands for domestic consumer price level and *S* represents the nominal exchange rate. After log-differencing, it follows that:

$$q = s + p^*_{cpi} - p_{cpi} \tag{32}$$

The CPI for each country can be expressed as follows:

$$p_{cpi} = \upsilon p + (1-\upsilon)p_n \tag{33}$$

$$p^*_{cpi} = \omega p^* + (1-\omega)p^*_n \tag{34}$$

where ω denotes the share of tradable goods in the basket of foreign consumer price index (CPI). Similarly, υ denotes the share of tradable goods in the basket of the domestic CPI. p represents prices of the domestic CPI of tradables and p_n prices of the domestic CPI of non-tradables. Similarly, p^* represents prices of the foreign CPI of tradables and p_n prices of the foreign CPI of non-tradables.

Thus the real exchange rate is:

$$q = s + \omega p^* - \upsilon p + (1-\omega)(p^*_n) - (1-\upsilon)p_n \tag{35}$$

A trend in real exchange rate based on non-tradable goods is explained by the Balassa-Samuelson model. It is assumed a perfect labor market arbitrage between tradable and non-tradable goods sectors within a country but not across countries. Capital is assumed to be perfectly mobile internationally. Technology in the domestic country is represented by a homogenous production function:

for the tradable goods sector: $Y = BLk^{1-\psi}$ (36)

and for the non-tradable goods sector: $Y_n = B_n L_n k_n^{1-\rho}$ (37)

where L and L_n denotes labor in the tradable and non-tradable sector, respectively. B and B_n represent the total factor productivity in the tradable and non-tradable sector, respectively. $k \equiv \frac{K}{L}$ is the capital labor ratio for the tradable sector and $k_n \equiv \frac{K_n}{L_n}$ for the non-tradable sector. ψ and ρ denote labor share in the domestic non-tradable sector and tradable sector, respectively.

If the capital is perfectly international mobile, the interest rate for a small open economy is determined exogenously and it is equal to the marginal product of capital. In respective sectors, we have:

$$i = (1-\psi)Bk^{-\psi} \quad (38)$$

and

$$i = \frac{p}{p_n}(1-\rho)B_n k^{-\rho} \quad (39)$$

The equations (38) and (39) determine the capital-labor ratio in the tradable sector and non-tradable sector, respectively. With respect to the wage rate, the profit maximizing behavior forces the marginal product of labor to be equal to the wage rate in the tradable sector. Hence, we have

$$\omega = B\psi k^{1-\psi} \tag{40}$$

By expressing the capital-labor ratio in terms of the international interest rate and substituting into (40) for k, we see that the wage rate is determined solely within the tradable sector. Based on the second assumption about perfect labor market arbitrage between the tradable and non-tradable sector within a country, which implies that the wage in the tradable sector determines the wage dynamics in the non-tradable sector, we write (after log-differencing):

$$p - p_n = \frac{\psi}{\rho} B - B_n \tag{41}$$

Equation (41) is the final implication of the BS model. It asserts that the differences in total factor productivity in the tradable and non-tradable sectors explain the dynamic in relative prices (internal real exchange rate).

If we put the equation (41) into the equation of the real exchange rate (35) and if we assume that temporary deviations are due to imperfections in the labor market such as sticky wages or low flexibility of labor (denoted as ε), we can express the percentage change in real exchange rate as:

$$q = s + p^* - p + (1-\upsilon)(\frac{\psi}{\rho} B - B_n) - (1-\omega)(\frac{\psi^*}{\rho^*} B^* - B_n^*) + \varepsilon, \tag{42}$$

where B denotes the total factor productivity in the domestic tradable sector and B_n stands for the total factor productivity in the domestic non-tradable sector. ψ and ρ denote labor in the domestic non-tradable sector and tradable sector, respectively. Symmetrically, B^* is the total

factor productivity in the foreign tradable sector and B_n^* in the foreign non-tradable good sector. ψ^* denotes the labor share in the foreign non-tradable and ρ^* in the tradable sector, respectively. The term $(1-\upsilon)(\frac{\psi}{\rho}B - B_n) - (1-\omega)(\frac{\psi^*}{\rho^*}B^* - B_n^*) + \varepsilon$ represents the Balassa-Samuelson effect, i.e. the cross-country inflation differentials. So, the RER can be simply expressed as:

$$q = s + p^* - p + (Balassa - Samuelson\_effect) \tag{43}$$

Since it has recently been documented that the Balassa-Samuelson effect in the Czech Republic is negligible, for instance Mihaljek (2003)[51] or Flek, Marková and Podpiera (2002), the real exchange rate is equal to:

$$q = s + p^* - p\,, \tag{44}$$

where p represents prices of the domestic CPI of tradables and p^* represents prices of the foreign CPI of tradables.

If $p_{cpi}^{tradable} = p_{ppi}$ which in two-country model holds, then:

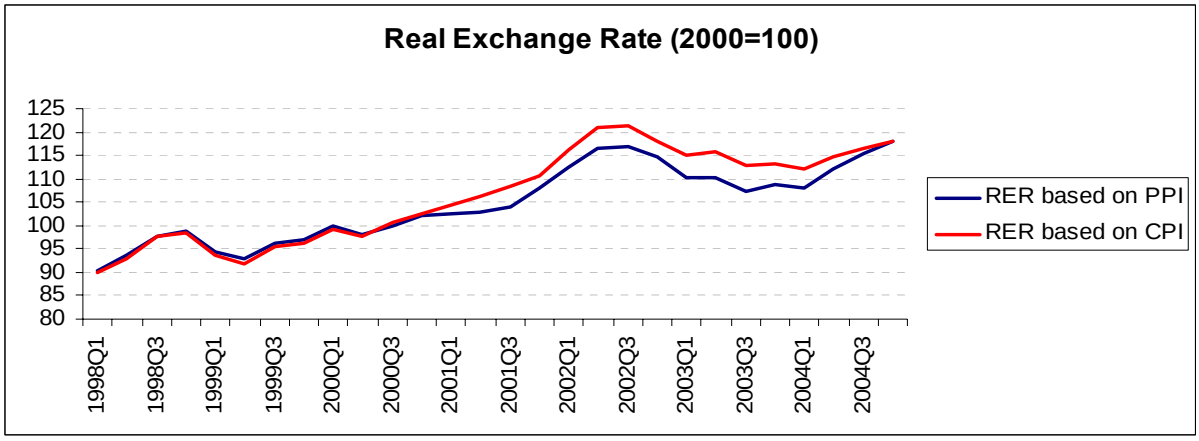
$$q = s + p_{cpi}^* - p_{cpi} = s + p_{ppi}^* - p_{ppi}\,, \tag{45}$$

i.e., the real exchange rate measured by means of CPI would have the same magnitude as the RER measured by means of PPI.

So, since the Balassa-Samuelson effect is minor and the only difference between RER based on prices of tradables (measured by PPI) and RER based on prices of nontradables and tradables together (measured by CPI) is the Balassa-Samuelson effect, we can extend our results to the real exchange rate based on CPI, too.

[51] Mihaljek (2003)

Figure 5: Real exchange rate based on PPI and CPI

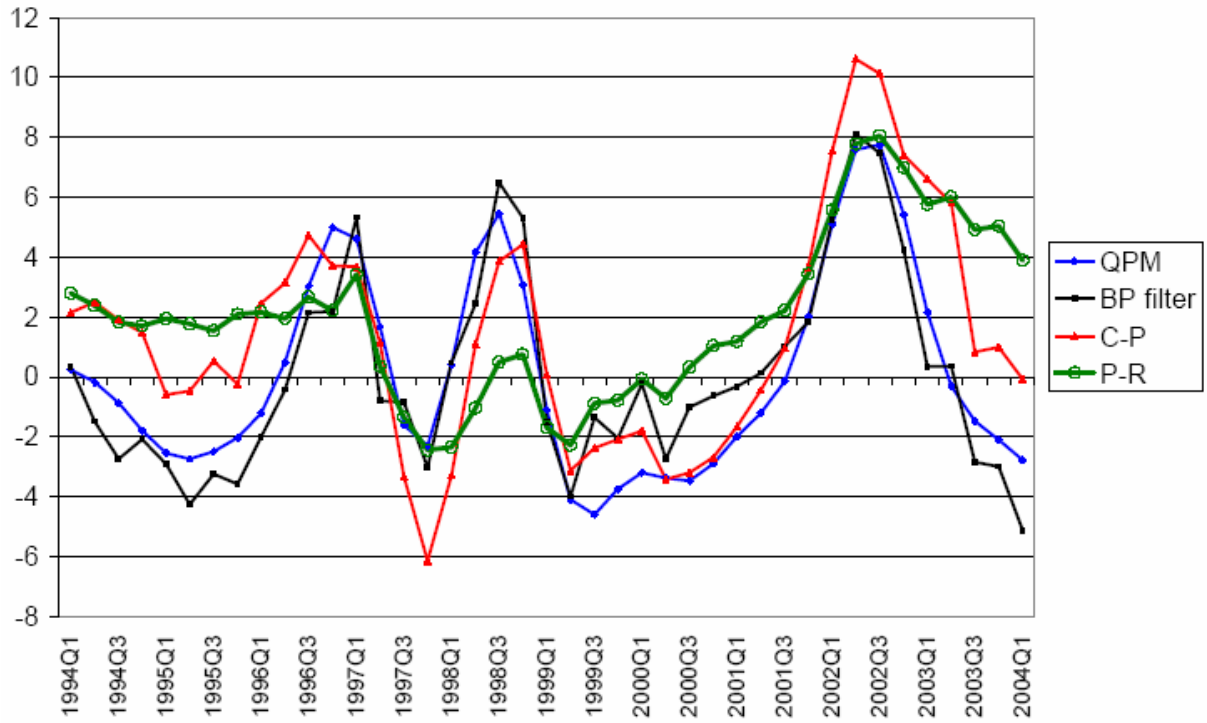


5.8.2 The effect of the degree of competition on REER estimated by various approaches

Babetskii and Egert[52] compared different approaches to real equilibrium exchange rate and as we can see in figure 6 below, all of the approaches find very similar misalignment of the real exchange rate. We added to the graph our estimation of misalignment (the green line), derived through the firms' aggregate decision on relative prices. As we can see, our disparity is highly correlated with other methods.[53]

[52] Babetskii, Egert (2005)
[53] The difference at the ends (years 1994 and 2004) between our approach and other approaches can be explained by an end-point bias. Other approaches use filtration technique, thus they suffer by an end-point bias. On the contrary, our approach does not use any filtration technique.

Figure 6: Misalignment of the Czech Koruna (%) – various approaches



source: Babetskii and Egert (2005)

Note: QPM denotes quarterly prediction model, BP filter denotes band-pass filter, the disparity C-P denotes the PTM derived by weighted sectoral disparities (derived using price indices) published in Cincibuch and Podpiera (2006). P-R denotes the disparity derived using the elasticity estimated by weighted regression in this paper.

Since our disparity is estimated from aggregate relative price changes, we assert that the gap in the real exchange rate measured by other approaches is also caused by the relative price discrepancies. And as we showed in our analysis, the relative price discrepancies depend on degree of competition.

So we conclude that the gap in real exchange rate could arise only if the companies were operating in the environment of imperfect competition. Under imperfect competition, it is optimal for firms to charge different prices at different markets (converted in a single currency), if the nominal exchange rate changes. But if all firms were operating in the environment of perfect competition (or close to perfect competition), they would optimally charge equal prices at distinct markets regardless of the development of the exchange rate.

Consequently, the real exchange rate in tradables (approximated by export/domestic production prices) remains constant under perfect competition. In other words, under perfect competition the real exchange rate is always in equilibrium and any nominal exchange rate change is an equilibrium. However, the exported quantity of firms in perfect competition would go down to zero when there is significant appreciation. On the contrary, the loss in real market shares abroad would be much less pronounced, when there will monopolistic competition or oligopoly, due to pricing to market.

This is very substantial conclusion. It implies that if market structure changes *ceteris paribus*, all the approaches (BEER, etc.) will find smaller real exchange rate misalignment under the same movement of nominal exchange rate. The smaller misalignment would be interpreted so that the real exchange rate is closer to the equilibrium. However in reality the firms will suffer more, while they will loose foreign market share. That is paradoxical and one should bear it in mind, when interpreting the gap of the real exchange rate.

Therefore, we conclude, when one wants to interpret the real equilibrium exhange rate based on price indices, he should always take into consideration the degree of competition in the relevant market. Therefore, one should not only look at price indices, when computing the real equilibrium exchange rate, but real market shares, as well.

6. CONCLUSION

Since the exchange rate is one of the most important prices in a small open economy, economists are trying to apply various approaches in order to find the right equilibrium value. However, the nominal exchange rate does not say anything about price levels and price changes, thus most of studies and theories are concerned with real exchange rate. As well as, this thesis was devoted to the analysis of the real exchange rate.

First, we presented two main theories of exchange rate – purchasing power parity and uncovered interest parity. The purchasing power parity is fundamental theory. Although the empirical analyses question it from the empirical point of view, it is overall assumed that the PPP theory holds in the long run. On the contrary, the empirical analyses of the UIP theory agree, that it does not hold in reality. Moreover, some studies show that the exchange rate behaves exactly in the opposite way than what UIP predicts. Surprisingly, the UIP theory is still very often used in empirical approaches which are assessing the relation of exchange rate in comparison to equilibrium value.

Afterwards, we presented three main empirical approaches of estimating the real equilibrium exchange rate: FEER, BEER and NATREX. The FEER approach is a normative approach; it tends to define the external balance in terms of "normal" capital flows; and then it estimates the levels of real exchange rates that would equate current account balances at positions of full employment. Its drawback is that the equilibrium value depends on an ad hoc author's definition of desirable values of fundamentals. On the other hand, the BEER approach is a positive approach; it observes the statistical relation of particular fundamentals with real exchange rate and estimates an equation, where the real exchange rate is dependant variable.

Therefore, the BEER approach measures rather statistical relationship. The NATREX approach is some mixture of the BEER and FEER approaches. Since all that approaches have substantial drawbacks, economists most often use filtration techniques. The filtration technique simply defines a trend of the real exchange rate which is then called equilibrium exchange rate.

In the last part, we analyze, to our knowledge originally, the relevance of the degree of competition on the real exchange rate and on the size of misalignment, which the above mentioned approaches find. In our analysis we use original data of almost one hundred Czech exporting companies over the period 1993-2003.

Our main finding is that size of the gap of the real exchange rate depends on degree of competition. Since the misalignment is caused by the relative price discrepancies, this misalignment will be identified only if the firms operate under imperfect competition. Under perfect competition, the price discrepancies do not appear, therefore the real exchange rate will indicate no misalignment and all methods estimating equilibrium exchange rate from the real exchange rate will find it as equilibrium. However, that is paradoxical, since the real losses in diminishing revenues under perfect competition will be higher than for firms operating under imperfect competition.

This is very essential conclusion. The real exchange rate approaches will identify, *ceteris paribus*, different size of misalignment under different degree of competition with the same nominal appreciation (or depreciation). Paradoxically, the smaller misalignment will be accompanied by huge real losses in output of firms, and reversely the bigger misalignment will indicate weaker degree of competition, thus smaller real losses.

Hence, by interpreting the gap of the real exchange rate one should always take into consideration the effect of the degree of competition on the real exchange rate.

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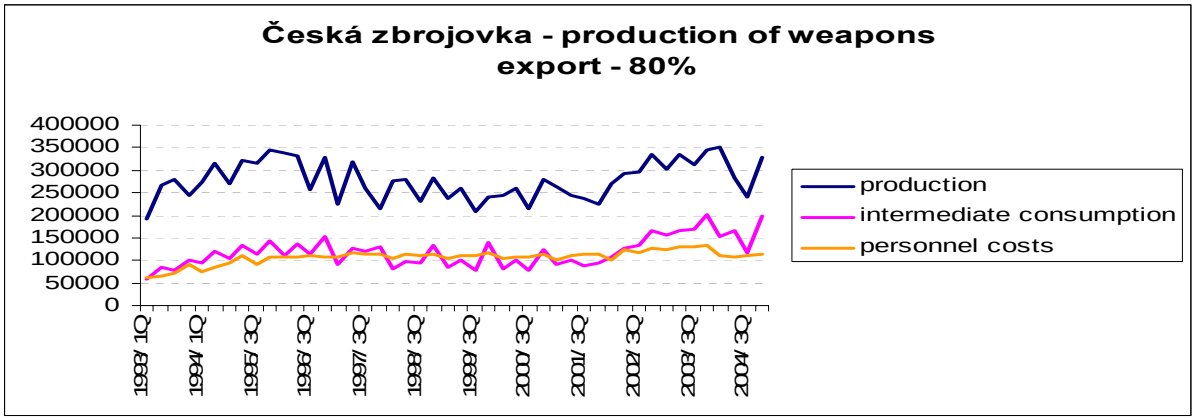
The Economist, Jun 9th 2005

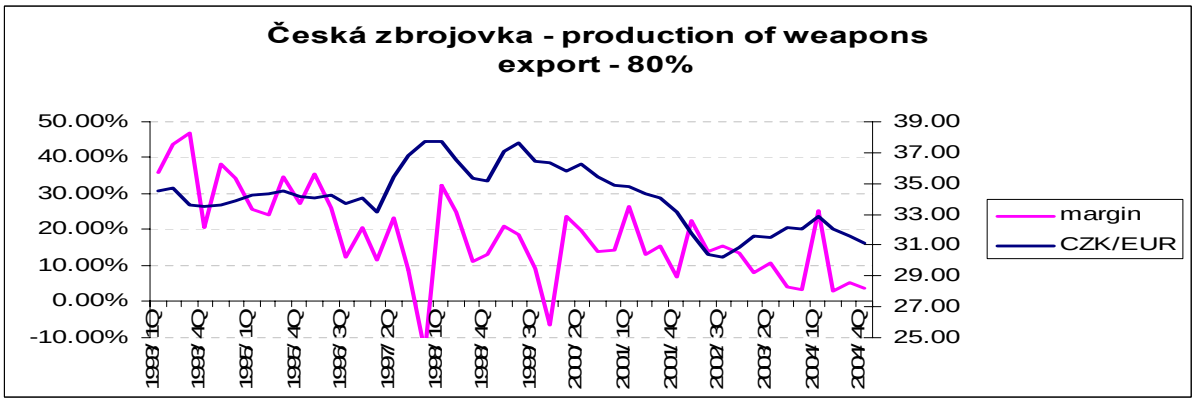
Appendix 1: List of companies

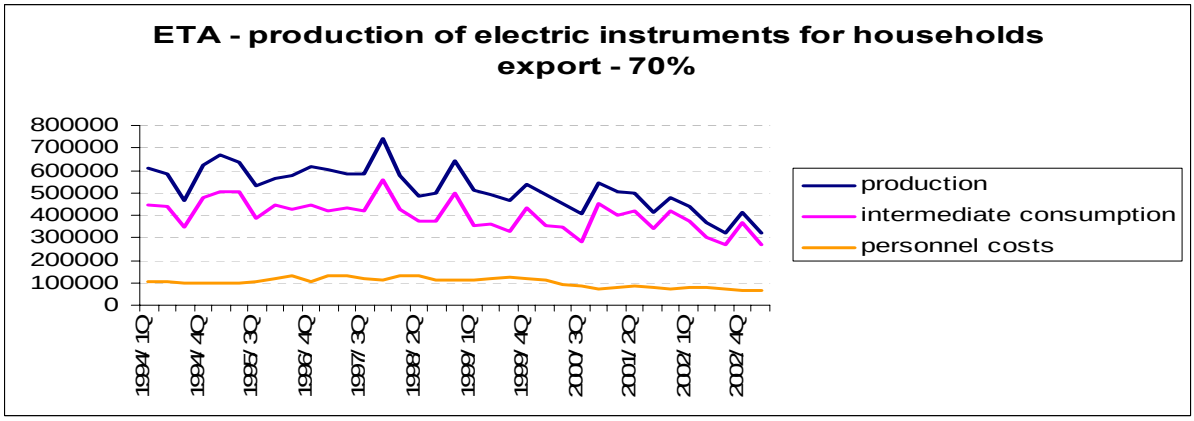
Name of the company	no.of obs.	"ico"	share of export	okec no.
RUDOLF JELÍNEK a.s.	34	49971361	14%	159100
STOCK Plzeň a.s.	6	14706563	5%	159100
Pivovar Louny, a.s.	9	46708031	10%	159600
VLNAP a.s.	17	13111	52%	171300
DEKORA-Jeníček, a.s.	4	64829359	58%	172100
Jitka, a.s.	33	13502905	70%	172100
MILETA a.s.	32	45534403	72%	172100
PERLA, bavlnářské závody,a.s.	16	60108908	73%	172100
TIBA, a.s.	7	48171468	70%	172100
VEBA, textilní závody a.s.	44	45534276	83%	172100
HEDVA, a.s.	37	48171565	52%	172400
VITKA Brněnec a.s.	14	174131	71%	172500
JUTA, a.s.	22	45534187	72%	172540
SLEZAN Frýdek-Místek a.s.	29	45193371	74%	173000
Tylex Letovice, akciová společnost	24	13366	40%	174020
LONKA Příbor, a.s.	10	18050913	70%	177100
Triola a.s.	7	60192984	70%	182300
TONAK a.s.	20	13226	79%	182410
LIRA, obrazové lišty a rámy, a.s.	16	15789772	60%	201000
OKD, PILA - SALMA, a.s.	4	47676230	23%	201000
Biocel Paskov a.s.	7	26420317	90%	211100
KRKONOŠSKÉ PAPÍRNY a.s.	15	45534284	37%	211200
Olšanské papírny a.s.	35	12351	65%	211200
Obchodní tiskárny, akciová společnost	33	13790	15%	222200
SPOLANA a.s.	26	45147787	86%	241000
Spolek pro chemickou a hutní výrobu, akciová společnost	17	11789	71%	241000
ALIACHEM a.s.	20	60108916	43%	241200
PRECHEZA a. s.	13	14617064	80%	241200
BorsodChem MCHZ, s.r.o.	6	26019388	80%	241400
Lovochemie, a.s.	20	49100262	37%	241500
COLORLAK, a.s.	24	49444964	14%	243000
BIOPHARM, Výzkumný ústav biofarmacie a veterinárních léčiv a.s.	22	46356606	59%	244200
Zentiva a.s.	18	49240030	37%	244200
Lybar, a.s.	8	49901869	55%	245200
SILON a.s.	13	14504332	62%	247010
RUBENA a.s.	7	12131	45%	251300
VULKAN akciová společnost	29	12220	60%	251300
GRANITOL, akciová společnost	15	12114	30%	252100
Alfa Plastik, a.s.	5	60793791	40%	252200
Chemoplast, a.s.	7	44015861	30%	252410
Linaset, a.s.	6	47674687	45%	252420
TANEX,PLASTY a.s.	6	13583808	70%	252420
CRYSTALEX a.s.	6	49903501	90%	261300
Sklo Bohemia, a.s.	14	48173371	85%	261320
Saint-Gobain Vertex, a.s.	33	12661	90%	261400
Staroroslký porcelán Moritz Zdekauer, a.s.	29	46886419	40%	262110
Moravské keramické závody a.s.	9	46900985	56%	262600
CIDEM Hranice, a.s.	4	14617081	22%	266500
Průmysl kamene a.s.	5	46350888	50%	267000

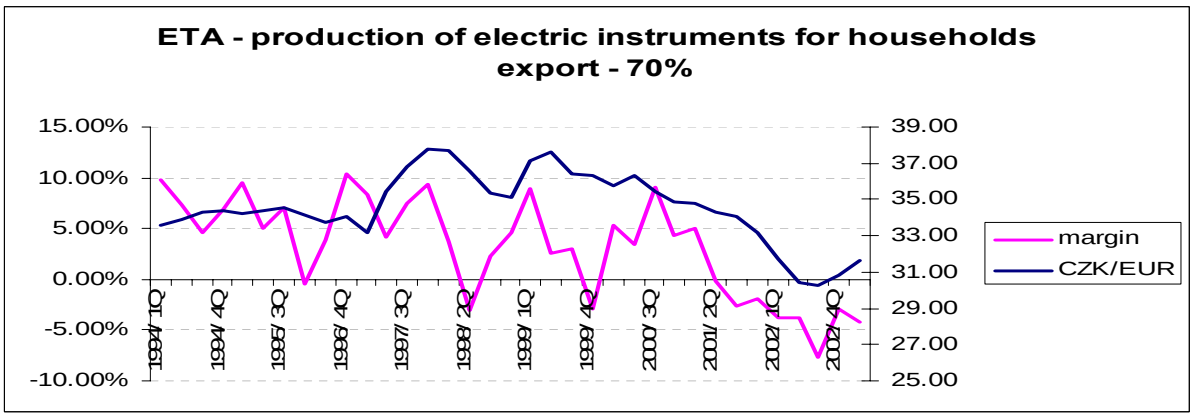
Mittal Steel Ostrava a.s.	11	45193258	34%	271000
TŘINECKÉ ŽELEZÁRNY, a. s.	4	18050646	54.50%	271000
V Á L C O V N Y P L E C H U, a.s.	5	14613581	43%	271000
ŽĎAS, a.s.	27	46347160	52%	271000
Hutní druhovýroba - reality a.s.	16	46708715	33%	273100
ŽDB a.s.	17	47672412	60%	273400
Kovohutě Mníšek a.s.	6	45148112	66%	274200
KOVOHUTĚ ROKYCANY, a.s.	4	49195719	50%	274400
Pacovské strojírny, akciová společnost, Pacov , cizojazyčné mutace : Pacovské strojírny Aktiengesselschaft,Pacovské strojírny Sociéte Anonyme	29	15821773	70%	282100
TENEZ a.s.	14	45534535	50%	282100
Impress Znojmo, a.s.	5	46347054	50%	287200
Šroubárna Turnov, a.s.	18	46504613	12%	287400
Šroubárna Žatec, a.s.	13	49903527	65%	287400
ŠKODA POWER s.r.o.	4	49193864	75%	291100
JIHLAVAN, a.s.	19	46347071	38%	291200
Poličské strojírny a.s.	32	46504851	69%	291200
MSA, a.s.	40	45192278	90%	291300
SEVEROČESKÁ ARMATURKA,a.s.	12	8885	29%	291300
STROJÍRNY POLDI, spol. s r.o.	8	46358404	74%	291400
Wikov MGI a.s.	23	529834	90%	291400
Slovácké strojírny, akciová společnost	26	8702	88.60%	292200
REMAK a.s.	8	15770397	60%	292300
ZVVZ a.s.	40	9041	54%	292300
TOS VARNSDORF a.s.	8	64651142	90%	294300
OSTROJ a.s.	24	45193681	12%	295200
STAVOSTROJ, a.s.	30	8753	90%	295200
UNEX a.s.	8	45192049	65%	295200
ADAMOVSKÉ STROJÍRNY a.s.	24	46345833	70%	295690
BUZULUK Komárov, nástupnická a.s.	4	25056301	47%	295690
KOBIT, spol. s r.o.	5	44792247	25%	295690
Česká zbrojovka a.s.	46	46345965	80%	296000
ETA a. s.	35	10341	70%	297100
Isolit-Bravo, spol. s r.o.	4	46507272	80%	297100
ATAS elektromotory Náchod a.s.	32	45534543	62%	311000
OEZ s.r.o.	7	49810146	34%	312000
KABLO ELEKTRO, a.s.	18	46504753	28%	313000
MAGNETON a.s.	4	49969862	37%	316100
ON SEMICONDUCTOR CZECH REPUBLIC, a.s.	20	45193533	70%	321000
BMT a.s.	19	46346996	68%	331000
DAEWOO AVIA, a.s.	6	45273227	50%	341000
ŠKODA AUTO a.s.	12	177041	83%	341000
TATRA, a.s.	6	45193444	78%	341000
ALMET, a. s.	26	46505156	27%	343000
MASSAG, a.s.	4	10367	30%	343000
MOTORPAL,a.s.	15	9296	80%	343000
DAKO-CZ, a.s.	5	46505091	80%	352000
LEKOV, a.s.	5	25213423	25%	352000
MTH Praha a.s.	22	45275301	90%	352000
JITONA a.s.	11	14504278	75%	361400
SPORTEN, a.s.	4	15531457	90%	364000
Knoflíkářský průmysl Žirovnice a.s.	20	60827173	40%	366310
CENTROPEN, a.s.	6	142492	78%	366330

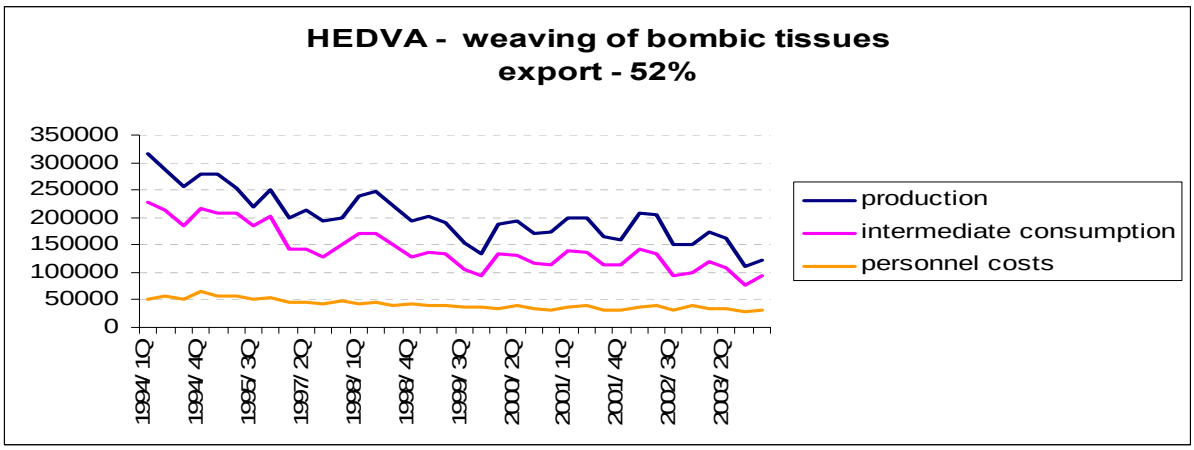
Appendix 2: The graphical evidence of 8 firms with the longest sequence of data

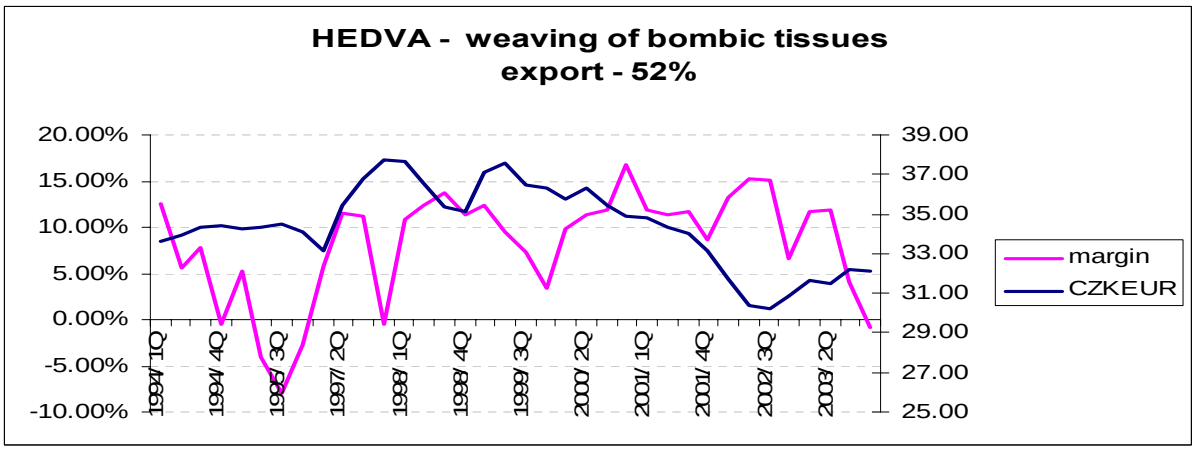


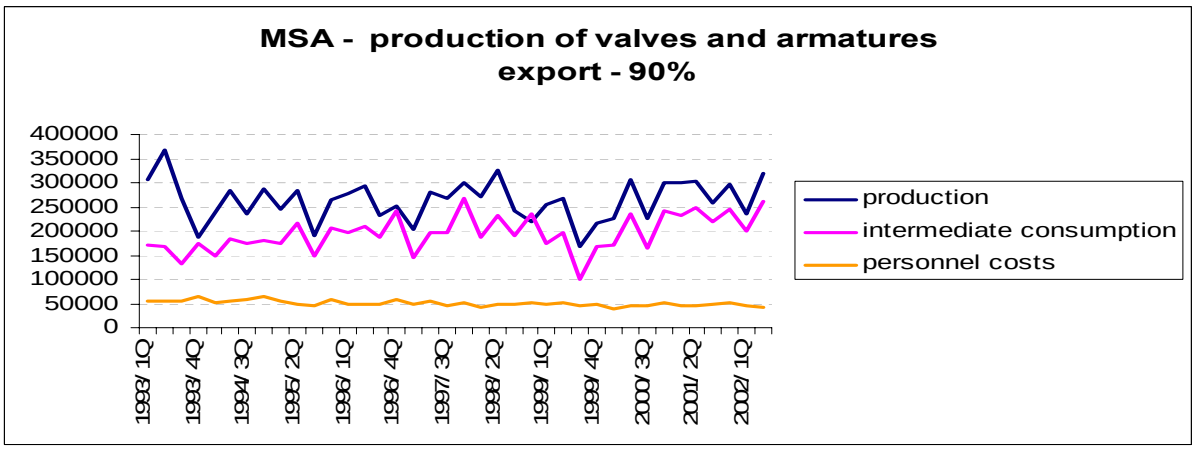


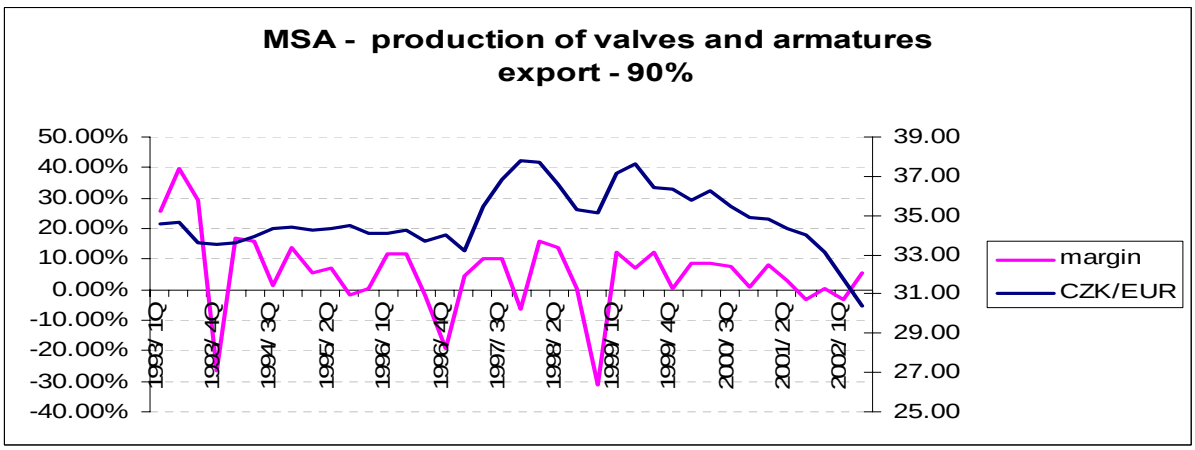


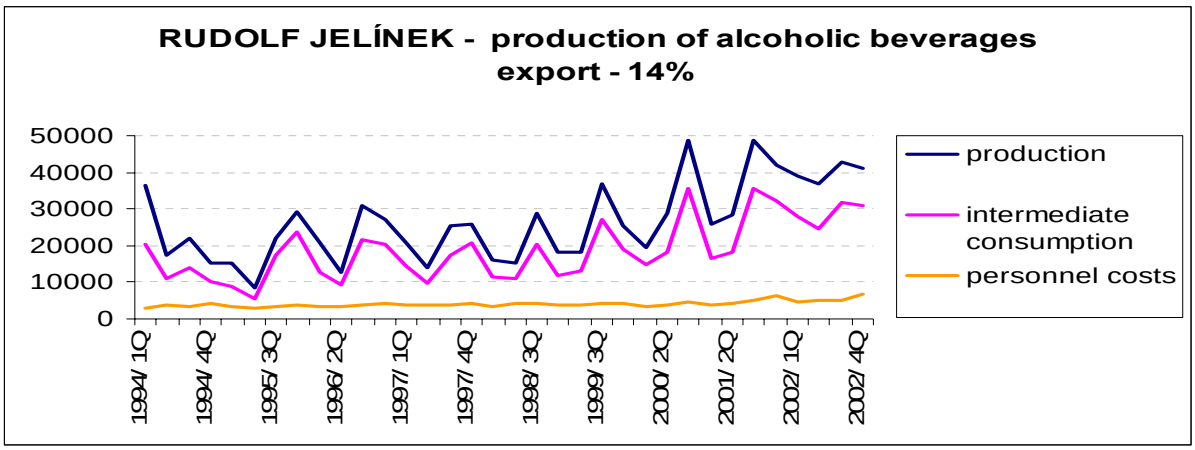


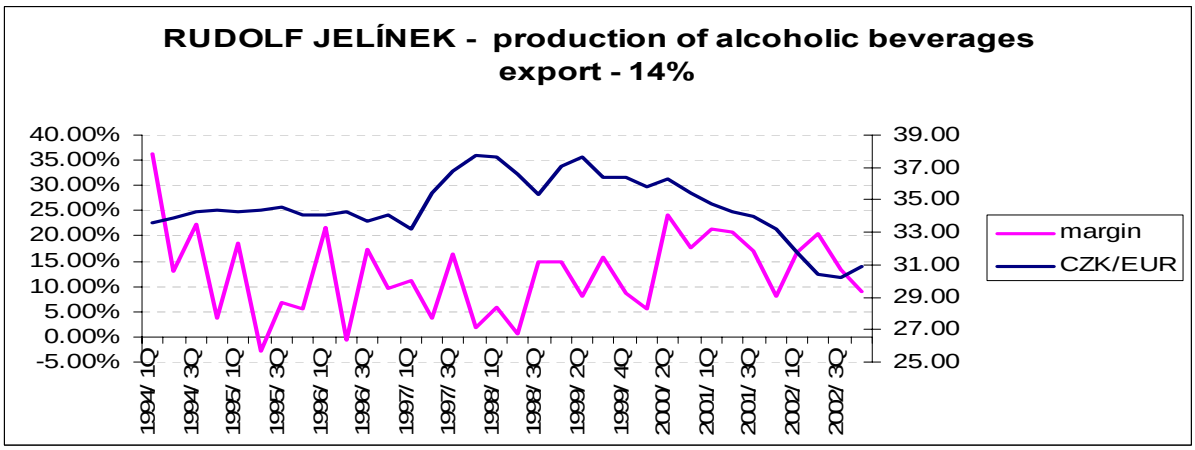

HEDVA - weaving of bombic tissues
export - 52%
350000
300000
250000
200000
150000
100000
50000
0
1994/ 1Q
1994/ 4Q
1995/ 3Q
1997/ 2Q
1998/ 1Q
1998/ 4Q
1999/ 3Q
2000/ 2Q
2001/ 1Q
2001/ 4Q
2002/ 3Q
2003/ 2Q
production
intermediate consumption
personnel costs

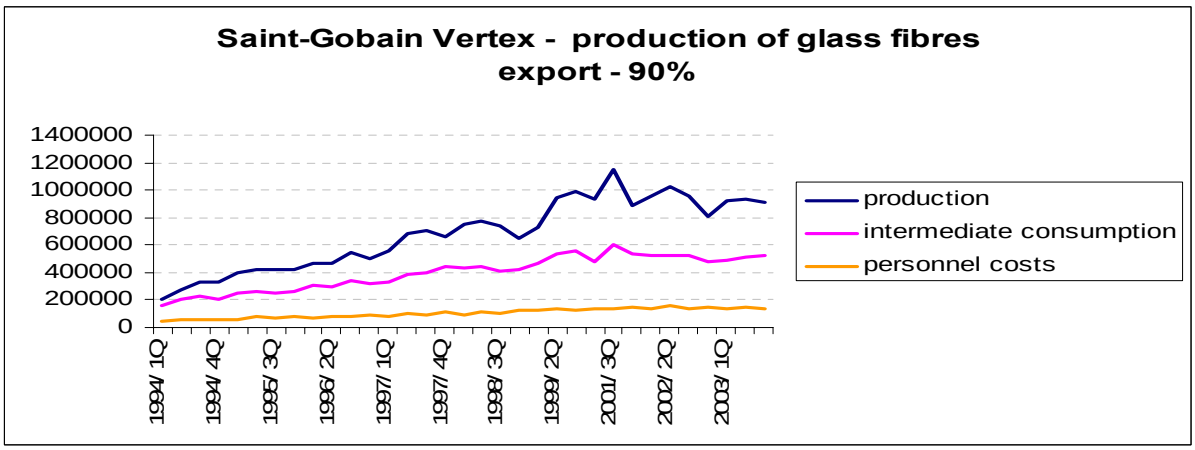

HEDVA - weaving of bombic tissues
export - 52%
20.00%
15.00%
10.00%
5.00%
0.00%
-5.00%
-10.00%
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
1994/ 1Q
1994/ 4Q
1995/ 3Q
1997/ 2Q
1998/ 1Q
1998/ 4Q
1999/ 3Q
2000/ 2Q
2001/ 1Q
2001/ 4Q
2002/ 3Q
2003/ 2Q
margin
CZKEUR

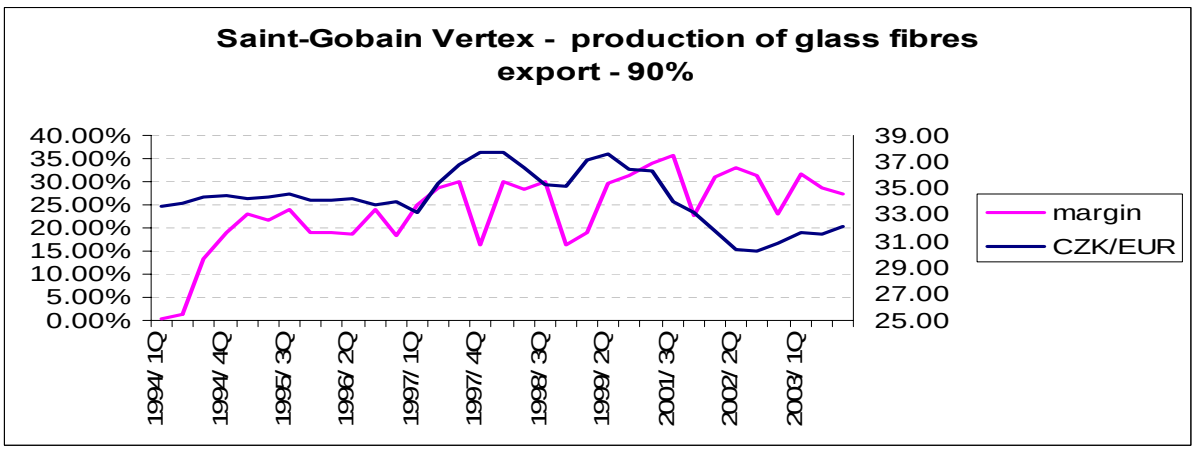

MSA - production of valves and armatures
export - 90%
400000
350000
300000
250000
200000
150000
100000
50000
0
1993/ 1Q
1993/ 4Q
1994/ 3Q
1995/ 2Q
1996/ 1Q
1996/ 4Q
1997/ 3Q
1998/ 2Q
1999/ 1Q
1999/ 4Q
2000/ 3Q
2001/ 2Q
2002/ 1Q
production
intermediate consumption
personnel costs

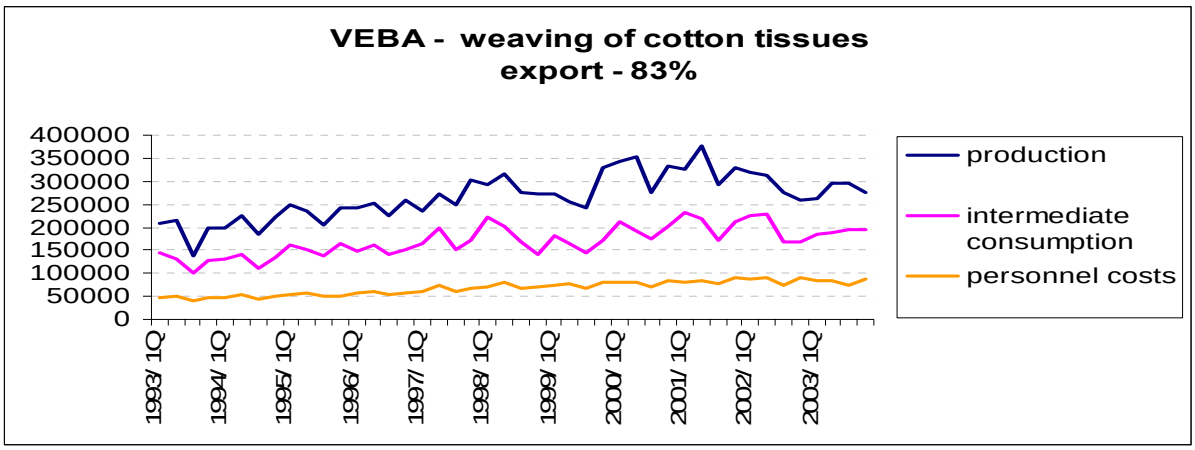

MSA - production of valves and armatures
export - 90%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
-10.00%
-20.00%
-30.00%
-40.00%
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
1993/ 1Q
1993/ 4Q
1994/ 3Q
1995/ 2Q
1996/ 1Q
1996/ 4Q
1997/ 3Q
1998/ 2Q
1999/ 1Q
1999/ 4Q
2000/ 3Q
2001/ 2Q
2002/ 1Q
margin
CZK/EUR

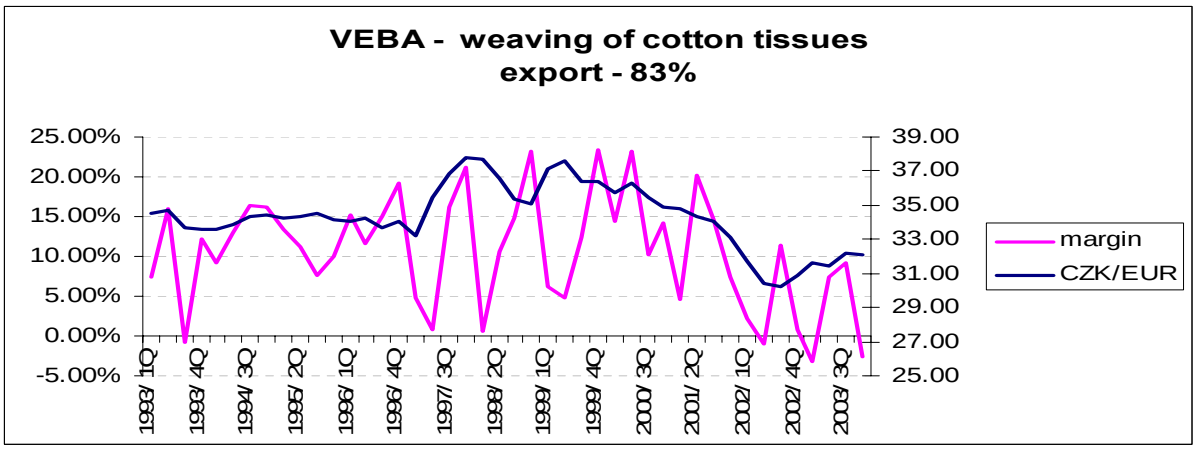

RUDOLF JELÍNEK - production of alcoholic beverages
export - 14%
50000
40000
30000
20000
10000
0
1994/ 1Q
1994/ 4Q
1995/ 3Q
1996/ 2Q
1997/ 1Q
1997/ 4Q
1998/ 3Q
1999/ 3Q
2000/ 2Q
2001/ 2Q
2002/ 1Q
2002/ 4Q
production
intermediate consumption
personnel costs

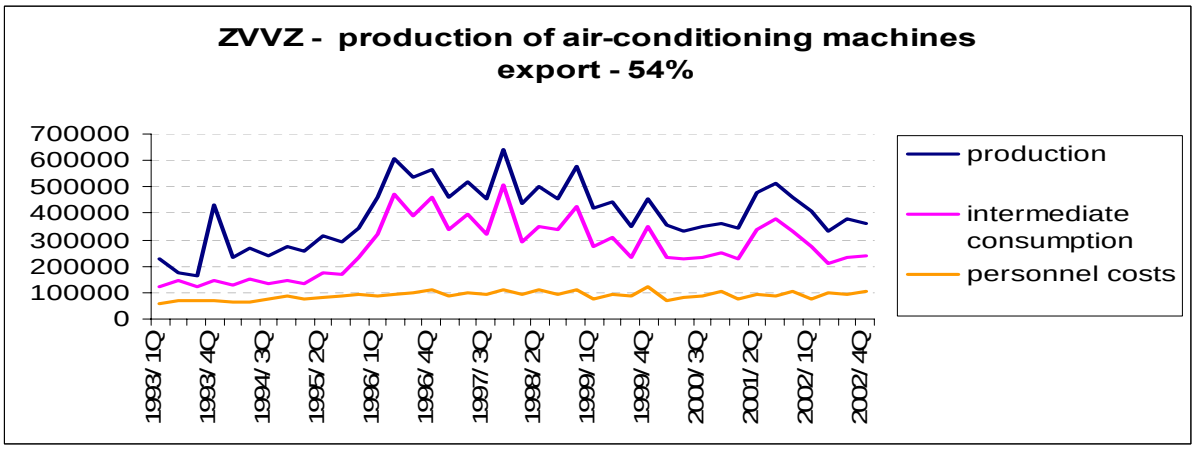

RUDOLF JELÍNEK - production of alcoholic beverages
export - 14%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
-5.00%
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
1994/ 1Q
1994/ 3Q
1995/ 1Q
1995/ 3Q
1996/ 1Q
1996/ 3Q
1997/ 1Q
1997/ 3Q
1998/ 1Q
1998/ 3Q
1999/ 2Q
1999/ 4Q
2000/ 2Q
2001/ 1Q
2001/ 3Q
2002/ 1Q
2002/ 3Q
margin
CZK/EUR

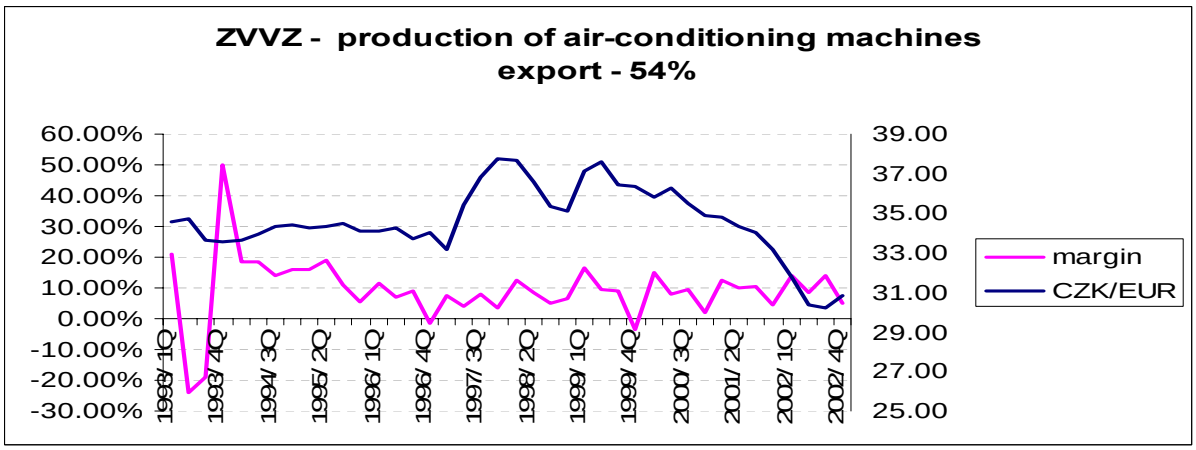

Saint-Gobain Vertex - production of glass fibres
export - 90%
1400000
1200000
1000000
800000
600000
400000
200000
0
1994/ 1Q
1994/ 4Q
1995/ 3Q
1996/ 2Q
1997/ 1Q
1997/ 4Q
1998/ 3Q
1999/ 2Q
2001/ 3Q
2002/ 2Q
2003/ 1Q
production
intermediate consumption
personnel costs


Saint-Gobain Vertex - production of glass fibres
export - 90%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
1994/ 1Q
1994/ 4Q
1995/ 3Q
1996/ 2Q
1997/ 1Q
1997/ 4Q
1998/ 3Q
1999/ 2Q
2001/ 3Q
2002/ 2Q
2003/ 1Q
margin
CZK/EUR


VEBA - weaving of cotton tissues
export - 83%
400000
350000
300000
250000
200000
150000
100000
50000
0
1993/ 1Q
1994/ 1Q
1995/ 1Q
1996/ 1Q
1997/ 1Q
1998/ 1Q
1999/ 1Q
2000/ 1Q
2001/ 1Q
2002/ 1Q
2003/ 1Q
production
intermediate consumption
personnel costs


VEBA - weaving of cotton tissues
export - 83%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
-5.00%
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
1993/ 1Q
1993/ 4Q
1994/ 3Q
1995/ 2Q
1996/ 1Q
1996/ 4Q
1997/ 3Q
1998/ 2Q
1999/ 1Q
1999/ 4Q
2000/ 3Q
2001/ 2Q
2002/ 1Q
2002/ 4Q
2003/ 3Q
margin
CZK/EUR


ZVVZ - production of air-conditioning machines
export - 54%
700000
600000
500000
400000
300000
200000
100000
0
1993/ 1Q
1993/ 4Q
1994/ 3Q
1995/ 2Q
1996/ 1Q
1996/ 4Q
1997/ 3Q
1998/ 2Q
1999/ 1Q
1999/ 4Q
2000/ 3Q
2001/ 2Q
2002/ 1Q
2002/ 4Q
production
intermediate consumption
personnel costs


ZVVZ - production of air-conditioning machines
export - 54%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
-10.00%
-20.00%
-30.00%
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
1993/ 1Q
1993/ 4Q
1994/ 3Q
1995/ 2Q
1996/ 1Q
1996/ 4Q
1997/ 3Q
1998/ 2Q
1999/ 1Q
1999/ 4Q
2000/ 3Q
2001/ 2Q
2002/ 1Q
2002/ 4Q
margin
CZK/EUR