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Degree of Competition and Export-Production Relative Prices when the Exchange Rate Changes: Evidence from a Panel of Czech Exporting Companies

Jiří Podpiera and Marie Raková [*]

Abstract

In this paper we show the relevance of the degree of competition for inferences about changes in export-production relative prices when the nominal exchange rate changes. We devise a model for tradable goods that combines the market competition and the pricing-to-market literature and we empirically document the contrast between perfectly and imperfectly competitive markets for the export-production relative price responses to exchange rate changes. When the macroeconomic view is taken, a change in the degree of competition in exports (a change in the average mark-up on exported products) alternates the reaction in relative prices and quantity exported and thus requires careful policy-related consideration.

JEL Codes: C33, D4, F31, F41.
Keywords: Degree of competition, exchange rate, pricing-to-market.

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Nontechnical Summary

Drawing on the evidence on individual Czech exporting firms, the paper aims to empirically assess how relative export-production prices respond to changes in the nominal exchange rate and how this is related to the degree of competition prevailing in the particular market segment.

The paper presents an estimation framework for testing the degree of competition and pricing-to-market simultaneously. In the model, we investigate the degree of competition by means of the elasticity of an exporting firm's revenues to costs and to the nominal exchange rate – an additional input price for export-oriented products.

In the empirical analysis we use individual firm level data. We constructed a panel structure composed of information from quarterly financial statements of manufacturing firms which are located in the Czech Republic and which export. The analysis involves revenues, production costs, and employment costs, which are collected over 1993–2003 for nearly a hundred companies grouped into distinct industries according to their predominant manufactured product.

Based on our estimates we find that firms that operate in a very competitive environment respond to nominal exchange rate changes with a smaller change in relative export-production prices (i.e., respond with quantities exported) than firms that have stronger market power. This is mainly due to the fact that firms operating in a less competitive market segment find it optimal to adjust their mark-ups when the nominal exchange rate changes. A firm that operates in a close to perfectly competitive market does not have this option and thus adjusts the quantity exported and keeps export-production prices unchanged. Empirically, close to perfect competition was found in the chemical and textile industries, for instance. On the other hand, the car and machinery industries were classified as imperfectly competitive markets.

With a change in the degree of competition in the whole economy (due to different factors, although one of them may be appreciation of the domestic currency), a nominal exchange rate change of the same magnitude would generate a different reaction of prices and export quantities. Therefore, close scrutiny of the degree of competition in the export-oriented part of the economy might bring value added as regards accurately assessing the effects of the exchange rate on the economy.

1. Introduction

The aim of the paper is to quantify the relation between the degree of competition in a particular industry and export-production relative price changes as a consequence of nominal exchange rate changes. In addition, focusing on industry level data by analyzing a panel of exporting firms allows us to establish a classification of the degree of competition, the magnitude of pricing-to-market, and the type of products prevailing (different industries).

The investigated relation is of great importance for practical policy implementation, as the degree of competition is directly influenced by persisting (trend) nominal exchange rate appreciation/depreciation. For instance, a trend appreciation of the domestic currency increases the perceived degree of competition for domestic exporting companies, since it lowers mark-ups from export markets. At the same time, the lower the size of the mark-up the higher the response as regards lowering the quantities exported, and the higher the impact on the trade balance in total. Therefore, the evidence on mark-ups and responses to the nominal exchange rate in exporting firms might contribute to more careful consideration of the exchange rate conditions represented in the overall monetary conditions of a central bank in a small open economy.

At the same time, knowledge of the prevailing competition, seen from an industry-by-industry point of view, might be beneficial as regards assessing the structural changes that affect the product (industry) structure of the economy. Thus, one can then be more certain when assessing the change in the overall effect of nominal exchange rate changes (for instance an appreciation) on the economy over time.

The literature devoted to the analysis of competition is quite extensive. The most common concept for classifying the degree of competition is the Rosse-Panzar model (Rosse and Panzar, 1987), which involves estimating the reduced form revenue function and studies the size of the elasticity of revenues to unitary changes in all prices of input factors. The second and probably most commonly used concept is that of the Lerner index. At the core of this approach is direct mark-up evaluation, which can be performed in two ways, either through evaluation of marginal costs – estimating a cost function – or via an approximation using total revenues and total costs as in Domowitz (1986). Nevertheless, as Shaffer (1983) has shown, these two concepts are interrelated: the Lerner index is a transformation of the Rosse-Panzar statistic.

The theoretical background and empirical documentation of pricing-to-market, i.e., in the Krugman (1987) sense the change in relative export-production prices when the exchange rate changes, is available. For instance Marston (1990), using the theory of the monopolistic firm (see Chamberlin, 1933), has shown exactly how pricing-to-market functions in a theoretical model and provides an application to a selected industry of machinery and electrical equipment. Many authors also document pricing-to-market behavior – see Knetter (1989, 1993), Goldberg and Knetter (1997), and Betts and Deveroux (2000). Since in these studies the authors explore pricing-to-market in a selected industry, they do not establish the empirical link between the degree of competition and pricing-to-market (and the extent of pricing-to-market in the economy), since they analyze only some typical imperfect competitive industries, the car industry being a prominent example.

Although the type of product is not a prerequisite for imperfect competition, we try to discover the regularity in product markets (industries) characterized by imperfect or perfect competition. We develop a testing procedure for jointly estimating both the degree of competition and pricing-to-market by industry, based on the lines of reasoning of Marston (1990) and the Rosse-Panzar model. In addition, we complement the analysis with an alternative method for classifying market competition (direct mark-up evaluation using total revenues and costs) and evaluating pricing-to-market, for which we use the results derived in Cincibuch and Podpiera (2006).

Our findings support the theory of pricing-to-market, although the degree varies with industry. Industries that are classified as being imperfectly competitive, such car or machinery manufacture, show a significantly lower response in export prices when the exchange rate changes than those with closer-to-perfect competition, such as the textile industry.

Despite the fact that our analysis is limited to extracting mean estimates of the response of mark-ups to exchange rate changes, it still bears an important policy implication. Since it has been shown that an imperfect competitor responds to an exchange rate appreciation by lowering its mark-up rather than losing export market share, this tendency tends to weaken as mark-ups decline under persistent (trend) nominal domestic currency appreciation (export market competition gets tougher with trend appreciation). Therefore, we suggest that a change in the exchange rate of the same size generates a different response in prices and the trade balance under a different state of market competition in exporting industries. We conclude that knowledge of market competition and its evolution over time is very important for an accordingly measured policy response.

The rest of the paper is organized as follows. Part two presents a model of a representative exporter and formulates the core tested hypothesis. Part three describes the empirical findings on pricing-to-market and competition. Part four concludes.

2. A Model of Market-Competition Dependent Cross-Border Price Setting

In the model, we consider a prototypal export company that produces one product variety and delivers to the local and foreign market. The company faces the respective (sufficiently narrowly defined – involving all close, albeit imperfect substitute products) residual demand functions in each market.

In each market (local and foreign) there is a representative consumer having utility from consuming, $u(.)$, the composite goods Q and Q_f respectively. The composite goods Q and Q_f represent the aggregate demand in the local and foreign markets for distinct substitute goods with a certain elasticity of substitution between products (on the domestic market $\varepsilon > 1$ and on the foreign market $\varepsilon_f > 1$, and both can vary with time and some other relevant variables).

The residual demand for the product of a producer i is given by the results of the consumers' maximization problem. The standard result implies that in the local market segment and in the foreign market segment the firm i (subscript i classifies the variable pertaining to a particular firm as well as to its product variety) faces:

$$Q_i = f\left(\frac{P_i}{P}, Q\right) \quad \text{and} \quad Q_{f,i} = f\left(\frac{P_{f,i}}{P_f}, Q_f\right), \text{ respectively.} \tag{2.1}$$

The aggregate price indices on the local and foreign market in the respective currency are denoted by P and P_f, respectively. Thus the optimal quantities of goods supplied to the local and foreign markets by an exporting firm i are denoted by Q_i and $Q_{f,i}$, respectively. The prices P_i and $P_{f,i}$ refer to the prices of products sold in the domestic and foreign markets invoiced in the currency of the respective market. In the next subsection we describe the optimal decision of an exporting firm i, in which we follow to some extent the reasoning of Marston (1990).

2.1 Exporting Firm's Optimum

The exporting firm maximizes its profit and thus solves:

$$P_i Q_i + S P_{f,i} Q_{f,i} - C\left(Q_i + Q_{f,i}\right) \rightarrow \max_{Q_i, Q_{f,i}} \tag{2.2}$$

where $C(.)$ is the cost function and S denotes the nominal exchange rate. After substituting for prices from demands, we get:

$$Q_i f\left(\frac{Q_i}{Q}, P\right) + S Q_{f,i} f\left(\frac{Q_{f,i}}{Q_f}, P_f\right) - C_i\left(Q_i + Q_{f,i}\right) \rightarrow \max_{Q_i, Q_{f,i}}. \tag{2.3}$$

The first-order conditions dictate:

$$S f_f'\left(\frac{Q_{f,i}}{Q_f}, P_f\right)\frac{1}{Q_f} Q_{f,i} + S P_{f,i} - MC_i = 0 \tag{2.4}$$

and

$$f'\left(\frac{Q_i}{Q}, P\right)\frac{1}{Q} Q_i + P_i - MC_i = 0. \tag{2.5}$$

where $f_f'(.)$ and $f'(.)$ denote the first derivatives with respect to $Q_{f,i}$ and Q_i, respectively. After rearranging we obtain the optimal pricing mechanism in both the foreign and local markets:

$$P_{f,i} = \frac{\varepsilon_f}{\varepsilon_f - 1}\frac{1}{S} MC_i \quad \text{and} \quad P_i = \frac{\varepsilon}{\varepsilon - 1} MC_i. \tag{2.6}$$

And the sizes of the mark-ups on the respective markets are as follows:

$$\frac{\varepsilon_f}{\varepsilon_f - 1} = \frac{SP_{f,i}}{MC_{i\ i}} \quad \text{and} \quad \frac{\varepsilon}{\varepsilon - 1} = \frac{P_i}{MC_i}. \tag{2.7}$$

The above derivations imply that the price in the local market does not respond to nominal exchange rate changes directly. The response is intermediated through changes in demand for companies' products in their market segment (elasticity of substitution) and changes in marginal cost. In contrast, export prices are, in addition to the intermediated effect through changes in demand and usual marginal costs, influenced directly by changes in the nominal exchange rate. Even more substantially, changes in the exchange rate are perceived by the firm as exogenous shocks to the marginal costs of exported products.

Thus, similarly to Marston (1990), we see that relative prices on the two markets are linked by a common factor, i.e., the marginal cost. Therefore it is intuitive that as long as the mark-ups in both markets remain constant, the relative prices in the local and foreign markets expressed in a single currency do not change with any movement of the nominal exchange rate. It follows that changes in cross-border relative prices are facilitated by changes in mark-ups, although only in relation to nominal exchange rate changes and autonomous changes in the elasticity of demand in the respective country.

2.2 Degree of Competition and Export-Production Relative Prices

The size of the mark-ups as derived in (2.7) is, however, one of the measures of the degree of market competition; it is used, for instance, for the evaluation of the Lerner index. Thus, if the mark-up has changed as a result of a change in the nominal exchange rate, then the degree of competition has also changed in that market. Therefore, if the exchange rate changes, the exporting firm adjusts its mark-ups (because the elasticity of residual demand changes, which in fact changes the degree of competition). In this way the nominal exchange rate can be interpreted as an additional and specific marginal cost for products delivered to the foreign market.

If we take the interpretation of nominal exchange rate changes as an additional marginal cost determining factor for products delivered to the foreign market, we can design an estimation procedure testing for the relation between the degree of competition and export-production relative prices, which is similar to the underlying idea of the competition classification of Rosse and Panzar (1987).

The underlying idea is to estimate the elasticity of the reduced revenue function to changes in marginal costs. If there is unitary total sensitivity (the sum of the partial sensitivities) of revenues to changes in marginal costs, then the competition is nearly perfect. If the total sensitivity is, however, lower than unity (or negative), then we classify the prevailing competition as imperfect (or a monopoly).

In our setup including the exchange rate as an additional input price, the focus is on both the sum of the elasticities to marginal costs except the nominal exchange rate, and the nominal exchange rate elasticity separately. In particular, if the sensitivity of revenues to changes in the nominal exchange rate is nil, then the competition is perfect in that market segment, since every change in the nominal exchange rate is translated into changes in price regardless of the changes in the quantity sold. This should be reflected in a unitary sum of the partial marginal cost elasticities. If the elasticity of revenues to the exchange rate is, however, greater than zero, then the quantity

sold enters into consideration, which is typical for the price-setting behavior of an imperfect competitor.

Let us define the total production of firm *i* as $\hat{Q}_i = Q_i + Q_{f,i}$. Based on the optimal pricing rules in the respective markets, i.e. (2.6), the total price-marginal-cost margin is equal to the ratio of the price to the marginal cost:[1]

$$PCM_i \equiv \frac{P_{c,i}}{MC_i}, \tag{2.8}$$

where $P_{c,i} = \left(\alpha_i P_i + (1-\alpha_i) SP_{f,i}\right)$ and α_i denotes the share of the total production of firm *i* which is supplied to the local market, i.e., $\alpha_i = \frac{Q_i}{\hat{Q}_i}$. In terms of average costs AC_i – a common shortcut in the empirical literature (see, for instance, Domowitz, 1986) – we can write the price-cost margin as:

$$PCM_i \equiv \frac{P_{c,i}}{AC_i} \tag{2.9}$$

We henceforth use equation (2.9), since these concepts – in (2.8) and (2.9) – are interrelated and since the marginal cost estimation would require more subtle information about production, especially the quantities produced, which we do not have at our disposal.

Nevertheless, controlling for the effect of costs on revenues, the exchange rate is an additional factor in an exporting firm which determines revenues and thus the price-cost margin. Writing the price-cost margin in percentage changes (log-differencing) and rearranging, we obtain:

$$p_{c,i} = f\left(\beta_i, ac_i, s, \eta\right), \tag{2.10}$$

where η denotes the i.i.d. disturbance term and β_i denotes product (firm) specific autonomous changes in residual demand (autonomous change in mark-ups, i.e., the price to average cost margin). The relation (2.10) states that given average costs and an autonomous shift in residual demands (autonomous change in the elasticity of demands), the exchange rate is potentially a direct determinant of the cross-border relative prices of the same product.

2.3 Estimated Equations

Expressing equation (2.10) in linear form and in terms of revenues, which involves a linear transformation, i.e., adding the percentage changes in quantity $q_{i,t}$ to both sides of the equation and assuming perfect competition in the limit for now ($\beta_3 = 0$), and grouping companies according to the industry classification, we get the estimation equation for companies in each of the analyzed industries:

[1] Alternatively, we can express profit as a share of revenue as follows (cost-price margin): $CPM \equiv 1 - \frac{1}{PCM}$, which is also known as the Lerner index.

$$p_{c,i,t} + q_{i,t} = \beta_i + \beta_1\left(acm_{i,t} + q_{i,t}\right) + \beta_2\left(awc_{i,t} + q_{i,t}\right) + \beta_3 s_t + \eta_t \tag{2.11}$$

where $acm_{i,t}$ denotes the log-differenced *average costs of material*, and $awc_{i,t}$ denotes the log-differenced *average wage costs* of the *i*-th firm at time *t*.

By estimating equation (2.11) we obtain both the classification of the type of competition in a particular industry and the export-production relative price changes in the given industry when the nominal exchange rate changes. The former is determined by the sum of coefficients $\beta_1 + \beta_2$, while the second is given by the coefficient β_3, which is the measure of the change in the cross-border relative prices of identical products when the exchange rate changes, thus corresponding to the notion of pricing-to-market (PTM) in the sense of Krugman (1986).

Since the total average cost is homogenous in input prices of degree one, an increase of one percentage point in input prices results in a upward shift of the cost curves by the same percentage point. Consequently, the optimal quantity produced decreases, but by less than one percentage point (the extent depends on the shape of the curves). This implies an increase in revenues, as the optimal pricing rule dictates an increase in price in both markets. However, under lower quantities revenues increase by less than the initial percentage rise in total costs. This situation will reveal itself through the sum of the estimated coefficients: $\beta_1 + \beta_2 \leq 1$.

In fact, the sum of the coefficients resembles the Rosse-Panzar statistic (Panzar and Rosse, 1987), but it is not quite identical, since the independent variables are not prices of inputs but volumes of input costs. However, especially in the case of perfect competition, i.e. $\beta_1 + \beta_2 = 1$, our specification offers a similar testing hypothesis as the Rosse-Panzar model, thus we call the summation $\beta_1 + \beta_2$ the *approximate R-P statistic*.

Under imperfect competition, the sum of the estimated coefficients $\beta_1 + \beta_2$ will not represent the correct sensitivity of relative prices to percentage changes in *ACM* and *AWC* ($\beta_{1*}+\beta_{2*}$). This follows from the imposed restriction due to data limitation – only wage and material cost volumes are available. If we reject the restriction that $\beta_1 + \beta_2 = 1$, then we identify imperfect competition and the bias in the coefficient has the following structure, i.e. the true coefficient $\beta_{1*}+\beta_{2*}$ *(which is actually the correct Rosse-Panzar statistic)* is determined as follows:

$$\beta_{1*} + \beta_{2*} = \frac{\beta_1 + \beta_2 - \theta}{1 - \theta}. \tag{2.12}$$

The higher the market power (operating on the more elastic part of the demand curve), the lower the parameter θ, which represents the proportion of the change in revenues due to changes in quantity.

However, when considering the optimal behavior, the summation of the coefficients β_1, β_2 and β_3 is likely to be close to unity, since even in the foreign market it must hold that a marginal increase in costs cannot generate a greater response in revenues than unity. Thus, exporting companies face nearly perfect competition due to the exchange rate (additional marginal cost) on the foreign market, unlike on the domestic market, where their market power remains preserved. Thus, we can derive the parameter that pertains only to *acm* and *awc* as follows:

$$\beta_{1*} + \beta_{2*} = 1 - \beta_3 . \tag{2.13}$$

Similarly, if the coefficient $\beta_1+\beta_2=1$, then an increase in input prices translates directly into a rise in prices in both markets, as there is no space for price-cost margin alternation. The firm operates under perfect competition and thus the influence of the exchange rate is nil. There is already perfect competition on both markets and thus exchange rate changes are immediately translated into foreign price adjustment in the same proportion, i.e., there is no space for pricing-to-market. Therefore, the value of the parameter θ can in fact be inferred from the optimum, i.e., directly from the coefficients β_1, β_2 and β_3 as follows:

$$\theta = 1 + \frac{\beta_1 + \beta_2 - 1}{\beta_3} . \tag{2.14}$$

On the contrary, the estimate of the parameter β_3 should always be unbiased and consistent with respect to the impact on relative prices. Since the coefficient directly relates the change in the exchange rate and the change in the composite price (the weighted export and domestic price of a product), and the domestic price changes with marginal costs as well as the foreign price, the parameter β_3 represents the change in relative prices across markets expressed in one currency (provided the export share is constant or hovers near one half).

In order to obtain the weighted aggregate effect of the nominal exchange rate on relative export-production prices (see Table A-3 in the Appendix), we define an industry-specific nominal exchange rate, which is constructed as the export share of the industry multiplied by the change in the nominal exchange rate. It follows that:

$$p_{c,i,t} + q_{i,t} = \beta_i + \beta_1\left(acm_{i,t} + q_{i,t}\right) + \beta_2\left(awc_{i,t} + q_{i,t}\right) + \overline{\beta}_3 s_{i,t} + \eta_t , \tag{2.15}$$

where $s_{i,t} = \phi_i s_t$ and ϕ_i is the export share of the industry i in the total exports of the economy. $\overline{\beta}_3$ is the weighted total response of the relative prices to the change in the nominal exchange rate. Equation (2.15) is estimated on a panel of all the companies in our sample.

We neglected here the role of the change in the share of exported goods in produced goods in identifying the response of relative prices to exchange rate changes, as the empirical evidence on the share of exports across industries suggests slight fluctuations around fifty percent on average in our sample of companies. However, for the industry-specific estimations, where the shares occasionally differ from a half and fluctuate more substantially, the coefficient β_3 (if different from zero) not only measures relative prices, but also includes the quantity adjustment.

2.4 Alternative Measures of the Degree of Competition and Pricing-to-Market

In our empirical investigation we chose to base the testing of the pricing-to-market hypothesis on a Rosse-Panzar type of model. This choice was determined by the fact that we lacked the physical quantity produced by each firm. Nevertheless, the Rosse-Panzar statistic has been shown in the literature to be related to the concept of the Lerner index, where the Lerner index is actually a

transformation of the Rosse-Panzar statistic (see Shaffer, 1983). Therefore, a compelling way to verify that our estimations of the approximate Rosse-Panzar statistic are correct is direct computation of the Lerner index (for a firm *i*) using total costs and revenues, i.e., the cost-price margin, as in Domowitz (1986):

$$CPM_i \equiv \frac{Sale + \Delta Inventories - Payroll - Material\cos t}{Sale + \Delta Inventories} \tag{2.16}$$

The ratio ranges from 0 to 1. Firms that are in perfect competition show ratios close to zero, while firms that are perfect monopolists show ratios close to 1.

Thus, our prediction would be that perfectly competitive markets should show no changes in relative prices when the nominal exchange rate changes. On the other hand, imperfectly competitive markets should exhibit pricing-to-market behavior.

Therefore, we should observe contemporaneously a high *PCM*, *a high CPM* (*Lerner Index*), the sum of parameters $\beta_1 + \beta_2$ significantly below unity, and a high parameter β_3 in the case of monopolistic competition, and, conversely, contemporaneously a low *PCM*, *a* low *CPM* (*Lerner Index*), the sum of parameters $\beta_1 + \beta_2$ equal to unity, and a statistically insignificant parameter β_3 in the case of perfect competition.

In addition, an alternative measure of pricing-to-market would be based on disaggregated price indices as available in Cincibuch and Podpiera (2006), where changes in relative export and production prices are regressed on changes in the exchange rate. Therefore, as far as possible we provide a comparison with the statistics derived from price index data as well.

3. Empirical Application to the Czech Republic

In this section we present a case study on a panel of Czech exporting companies and test the hypothesis formulated in the preceding section. The conclusions are, however, probably extendable to other converging, transition countries in Central and Eastern Europe.

3.1 Data Description

Focusing on the effects of the nominal exchange rate on the prices of the sold products of a firm in different markets, we constructed a panel data structure that is composed of individual manufacturing firms which are located in the Czech Republic and which export. The data source was the Magnus database, which continuously provides quarterly financial statements for Czech companies from 1993 onwards.

Information on the share of exports, which is the selection criterion for our sample of companies, is, however, not available for all the firms listed in the database. Nevertheless, it is occasionally published in the press, and the Magnus database provides media monitoring. The media has been monitored since 2000 and information about export percentages is available for 443 manufacturing firms. Nevertheless, we could not use all of these firms, for the reasons described below. Data on the financial indicators of companies selected in this way are sometimes gathered

by the Magnus database in a difficult way. Unfortunately the data set from 2004 onwards is very scarce, so we were forced to restrict our sample to 2003.

Thus, we downloaded all accessible quarterly financial statements for the period 1993–2003. We excluded those firms whose financial statements were not accessible as well as observations that did not have complete records on a set of accounting variables such as production (revenues), production costs, and employment costs (payroll), since we use these variables in the regressions. Since the "*profit and loss statement*" is a cumulative statement (for the second, third, and fourth quarters), we had to subtract the third quarter from the fourth, the second quarter from the third, and the first quarter from the second, in order to explore the effect of the exchange rate in particular quarters. For that we needed two consecutive financial statements, hence we excluded non-consecutive observations.

We ended up with a sample of 94 exporting companies operating in the Czech Republic whose main activities involve manufacturing (according to the *Czech classification of activities "OKEČ";* see Table A-2 in the Appendix) and for which we obtained information about their share of exports and for which at least two continuous quarterly observations during the period 1993–2003 were available (for the list of companies, see Table A-1 in the Appendix). We obtained an unbalanced panel data set with 1 447 quarterly observations for 94 firms for the period 1993–2003. The panel is unbalanced in the sense that we have more observations for some firms than for others and that these observations correspond to different time spans. However, as the statistics in the following Table 1 show, the observations per company and year are quite uniform.

Table 1: Data Descriptive Statistics

		Mean	Std. dev.	Max.	Min.
Number of observations per quarter		35	9	51	15
Number of obs. per company		16	11	44	2
Exchange rate (CZK/EUR)		34.18	1.98	37.76	30.25
Personnel costs	overall	72.2	169.7	2 119.7	2.9
(CZK millions)	between		232.4	1 986.7	4.1
	within		19.8	434.1	-115.6
Production costs	overall	405.6	2 219.2	33 200	4.3
(CZK millions)	between		3 157	30 000	7.4
	within		160.7	3 586.6	-1 835.5
Revenues	overall	536.2	2 581.9	390 000	7.4
(CZK millions)	between		3 659.9	34 600	17.1
	within		227.2	4 947	-2 933

Note: The statistics encompass the entire period 1993–2003. The minimum and maximum statistics represent the extreme deviations from the firm's mean. The CZK/EUR exchange rate prior to 1999 was based on CZK/DEM.

As we can also see from Table 1, the average revenues across companies are CZK 536 million (Czech koruna) and production costs have the highest share of total costs (around 76%).

As the standard deviations suggest, the costs and revenues varied substantially across companies and across time. The differences between the minima and maxima are very high – in the observation period personnel costs varied between CZK 2.9 million and CZK 2 billion, production costs between CZK 4.3 million and CZK 33 billion, and revenues between

CZK 7.4 million and CZK 39 billion. Naturally, the car producer Škoda Auto is behind the largest numbers.

The "within" standard deviations indicate how volatile the variables are within one company over time. They suggest that production costs, revenues and even personnel costs were reasonably volatile within firms. Intuitively, the variation within companies is only a fraction of the variation across companies.

3.2 Estimation Results on Pricing-to-Market

The results of the estimated relations comprise a set of industry-by-industry regressions as well as a "weighted" regression, where the weights are on the exchange rate and reflect the share of exports of the industry in total exports by the entire manufacturing sector.

The industry estimations of PTM (in the sense of changes in relative export-production prices) are displayed in Table 2. Table 2 presents the results for the fixed effects model applied to each industry defined by the *OKEČ classification*; hence the intercept β_0 represents the average over the company-specific fixed effects in the particular industry.

Table 2: Fixed Effects Estimation Results – Industry eq. (2.10) and Weighted eq. (2.14)

Industry	**Beer**	**Textiles**	**Paper**	**Chemicals**	**Glass**	**Metals**	**Fitting**	**Machines**	**Cars**	**Weighted**
OKEČ	**15**	**17,18**	**20,21,22**	**24,25**	**26**	**27,28**	**29**	**31,32,33**	**34**	**PTM**
β_1	**0.922*****	**0.822*****	**0.796*****	**0.957*****	**0.702*****	**0.913*****	**0.700*****	**0.780*****	**0.712*****	**0.888*****
	(0.050)	(0.029)	(0.053)	(0.036)	(0.078)	(0.044)	(0.029)	(0.051)	(0.089)	(0.014)
β_2	**0.036**	**0.158*****	**0.021**	**0.045**	**0.362*****	**0.042**	**0.245*****	**0.073**	**0.144****	**0.100*****
	(0.096)	(0.033)	(0.036)	(0.042)	(0.091)	(0.052)	(0.046)	(0.054)	(0.073)	(0.015)
β_3	**0.241**	**0.216*****	**0.550*****	**0.149***	**0.087**	**0.264****	**0.367*****	**0.607*****	**0.700*****	**0.455*****
	(0.159)	(0.074)	(0.103)	(0.087)	(0.146)	(0.116)	(0.111)	(0.125)	(0.209)	(0.052)
β_0	***-0.008***	***0.083***	***0.634******	***-0.127*****	***-0.191****	***0.007***	***0.046***	***0.102***	***0.076***	***0.152******
	(0.465)	*(0.072)*	*(0.215)*	*(0.054)*	*(0.103)*	*(0.134)*	*(0.106)*	*(0.115)*	*(0.153)*	*(0.031)*
LBI	1.954	1.741	1.799	1.691	1.785	1.885	1.710	1.899	1.934	1.670
BH.-DW	1.791	1.522	1.473	1.384	1.209	1.712	1.436	1.493	1.617	1.381
ρ	0.122	0.261	0.273	0.347	0.413	0.170	0.287	0.279	0.316	0.333
s_u	0.146	0.089	0.199	0.158	0.094	0.096	0.080	0.119	0.308	0.289
s_e	0.094	0.076	0.111	0.097	0.096	0.088	0.121	0.094	0.109	0.109
export	0.13	0.72	0.43	0.51	0.68	0.49	0.68	0.62	0.53	0.53
obs.	46	300	101	239	93	145	371	93	59	1447
firms	3	15	6	18	7	13	20	6	6	94
R2-all	0.989	0.967	0.982	0.989	0.987	0.994	0.965	0.938	0.996	0.944
R2-within	0.958	0.984	0.956	0.992	0.985	0.981	0.953	0.987	0.987	0.982
R2-between	0.999	0.981	0.994	0.994	0.995	0.997	0.987	0.957	0.998	0.949
P-value[a)]	0.0260	0.0000	0.0062	0.0000	0.0012	0.0044	0.0000	0.0001	0.0191	0.000

Note: Standard errors are given in parenthesis; asterisks denote significance as follows: *** 1%, ** 5%, and * 10%.

[a)] Probability of rejecting the existence of a regression relation (F-test).

As we can see from Table 2, the majority of the estimated elasticities of relative prices to exchange rate changes β_3 (measuring pricing-to-market) are significant and lower than unity. The size of the elasticity is negatively correlated with the degree of competition (measured by the summation of the coefficients on material and personnel costs, i.e., the *approximate Rosse-Panzar*

statistic), thus confirming the hypothesis that pricing-to-market appears in the market of imperfect competition.

Turning to the diagnostic statistics of the estimates, the residuals do not exhibit significant serial correlation (based on LBI statistics and BH-DW statistics) and the share of the explained variance is relatively high in all dimensions (cross-section, time series as well as overall). Since the estimation is in fact based on variations in the mark-ups, which are stationary over time, panel cointegration methods do not need to be used. Some complementary statistics are given as well, for instance the *number of firms* in our sample per industry, and *export*, denoting the share of exports of production in the industry.

The 'weighted' PTM measure has been estimated as a weighted regression, where weights (the share of exports in the industry in total manufacturing exports – see Table A-3 in the Appendix) have been applied to the exchange rate for different industries. The results can be found in the column *Weighted PTM* in Table 2. Although the pricing-to-market measured in the different industries may be affected to some extent by the variable average export share of the industry in our sample, the aggregated PTM should remain unaffected due to the stable export share at the level of the manufacturing sector, which basically fluctuated moderately around fifty per cent over our sample period. The size of the weighted PTM of 0.455 suggests that each percentage change in the nominal exchange rate (say, an appreciation of the local currency, i.e. CZK/EUR, by 1 percent) would transmit into price differences of Czech production across markets of roughly half a percentage point.

The interpretation of the *approximate Rosse-Panzar statistic* in the aggregate PTM regression is somewhat more complicated. In the regression, the weights were applied only to the exchange rate. Therefore, the labor cost and production cost elasticity cannot be directly interpreted. With the use of (2.13) we derive the Rosse-Panzar statistic to be equal to 0.545. This statistic classifies the internal market overall as monopolistic competition. Nevertheless, there appear to be quite large differences in the degree of competition at the level of particular industries. Some markets were identified as close to perfect competition, such as Chemicals, whereas some were classified as monopolistic competition, for instance Cars and Machines.

3.3 Degree of Competition and Pricing-to-Market: A Comparison

Our results, presented in Table 3, confirm that industries with approximate Rosse-Panzar elasticity close to 1, which indicates conditions close to perfect competition, have a low price-cost margin and individual industry Lerner index, and a statistically insignificant or very low parameter β_3. This implies that, in these highly competitive industries, cross-border relative prices do respond less to nominal exchange rate changes than in less competitive industries.

Conversely, though, where the approximate Rosse-Panzar elasticity is significantly below unity, we observe a high price-cost margin and individual industry Lerner index, and a high parameter β_3. Thus, these industries exhibit imperfect competition and significant pricing-to-market. Thus our findings from the regression (2.11 and 2.15) are confirmed by the direct market competition evaluation via the Lerner index, computed according to (2.16).

Table 3: Market Competition and Pricing-to-Market Measures

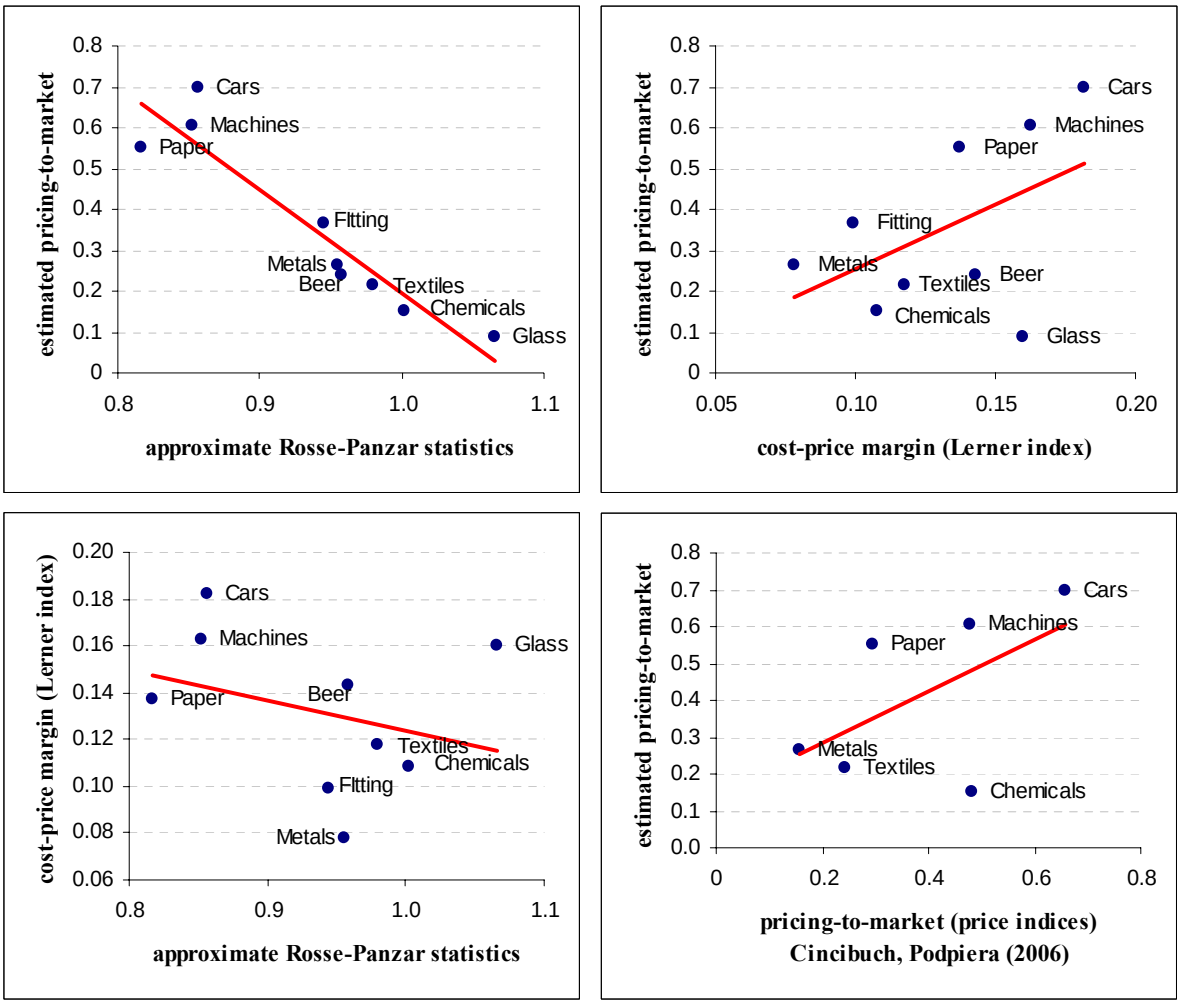
Industry	OKEČ	PTM, i.e. β_3		PTM (C&P 2006)		Lerner index	Price-cost margin	Approximate Rosse-Panzar statistic
Beer	15	0.241	(0.159)	-		0.143	1.187	0.958 [0.759]
Textiles	17,18	0.216***	(0.074)	0.242	(0.074)	0.118	1.146	0.980 [0.784***]
Paper	20,21,22	0.550***	(0.103)	0.296	(0.119)	0.137	1.181	0.817 [0.450***]
Chemicals	24,25	0.149*	(0.087)	0.483	(0.156)	0.108	1.135	1.002 [0.851*]
Glass	26	0.087	(0.146)	-		0.160	1.214	1.064 [0.913]
Metals	27,28	0.264**	(0.116)	0.157	(0.136)	0.078	1.096	0.955 [0.736**]
Fitting	29	0.367***	(0.111)	-		0.099	1.132	0.945 [0.633***]
Machines	31,32,33	0.607***	(0.125)	0.477	(0.102)	0.162	1.219	0.853 [0.393***]
Cars	34	0.700***	(0.209)	0.659	(0.111)	0.182	1.253	0.856 [0.300***]

Note: Standard deviations in parenthesis. The change in relative prices (export vs. production prices) PTM C&P (2006) was derived using price indices published in Cincibuch and Podpiera (2006), Table 3. The computation of the *cost-price margin* (profit margin) is derived as in Domowitz *et al*. (1989), which is an approximation of the Lerner index: $CPM \equiv \frac{Sale + \Delta Inventories - Payroll - Material\cos t}{Sale + \Delta Inventories}$, and similarly, the price-cost margin we obtained as: $PCM \equiv \frac{1}{1 - CPM}$. The approximate Rosse-Panzar statistic is computed as $\beta_1 + \beta_2$, and $\beta_{1*} + \beta_{2*}$ is given in brackets; the asterisks denote the statistically significant difference of the statistic from unity.

The relations between pricing-to-market and the different measures of market structure are represented visually in Figure 1. The data show an apparent relation between the measures of competition and pricing-to-market, telling a consistent story about the impact of exchange rate changes on relative prices under different prevailing market competition.

The relation between the approximate Rosse-Panzar statistics and the estimated pricing-to-market across industries is apparently linear and negative, which means that high pricing-to-market is connected with imperfectly competitive markets. The evidence from the cost-price margin and the price-cost margin (the one being an affine transformation of the other) is such that imperfect competition (high values of both) positively correlates with a high parameter estimate of pricing-to-market. And finally, comparing the estimated pricing-to-market from company data with the pricing-to-market estimates from price index data (export price index over domestic production price index) as derived by Cincibuch and Podpiera (2006), we can conclude that the two measures correlate very well (data points are featured in Table 3). An apparent relation is also seen between the estimate of the approximate Rosse-Panzar statistics and the directly evaluated cost-price margin (Lerner index), which confirms the reliability of the estimated values classifying market competition.

Figure 1: Degree of Competition and Pricing-to-Market



Note: The marked trend is the linear trend.

4. Concluding Remarks

In this paper, we study the role of market competition in the strength of the response of relative export-production prices to changes in the nominal exchange rate, i.e., pricing-to-market. We devise a theoretical base for empirical testing of the relation between the degree of competition and the response in relative prices across markets to exchange rate changes, which we apply to exporting companies in manufacturing industries in the Czech Republic during 1993–2003.

We document a strong link between the degree of competition and pricing-to-market. Namely, in those industries classified as having close to perfect competition, we find virtually no pricing-to-market behavior, i.e., no changes in export-production relative prices when the nominal exchange rate changes. On the contrary, in industries which distinguishably exhibit imperfect competition, we observed strong responses in relative prices to exchange rate changes. We verified our findings by means of alternative measurement of pricing-to-market and the degree of competition, such as evidence on pricing-to-market from export and production price indices and direct cost-price margin evaluation.

Our finding might possibly have an important policy implication. Namely, in the case of a tendency of increasing export market competition (for instance due to a trend nominal domestic currency appreciation), the prevailing market competition in an economy would approach perfect competition and thus the scope for accommodating nominal exchange rate changes in mark-ups would diminish. Consequently, a stronger response in quantities exported to exchange rate changes would take place, which would have an implication for the assessment of exchange rate conditions: the same change in the nominal exchange rate (domestic currency appreciation) would lead to a stronger impact (restriction) on quantities exported under a more competitive external market than under a less competitive one.

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Appendix 1
Data Description

Table A-1: List of Companies in the Sample

Name of company	No. of obs.	Identification number	Export share	OKEČ -CPA2
RUDOLF JELÍNEK a.s.	34	49971361	14%	15
STOCK Plzeň a.s.	6	14706563	5%	15
Pivovar Louny, a.s.	9	46708031	10%	15
VLNAP a.s.	17	13111	52%	17
DEKORA-Jeníček, a.s.	4	64829359	58%	17
Jitka, a.s.	33	13502905	70%	17
MILETA a.s.	32	45534403	72%	17
PERLA, bavlnářské závody,a.s.	16	60108908	73%	17
TIBA, a.s.	7	48171468	70%	17
VEBA, textilní závody a.s.	44	45534276	83%	17
HEDVA, a.s.	37	48171565	52%	17
VITKA Brněnec a.s.	14	174131	71%	17
JUTA, a.s.	22	45534187	72%	17
SLEZAN Frýdek-Místek a.s.	29	45193371	74%	17
Tylex Letovice, akciová společnost	24	13366	40%	17
LONKA Příbor, a.s.	10	18050913	70%	17
Triola a.s.	7	60192984	70%	18
TONAK a.s.	20	13226	79%	18
LIRA, obrazové lišty a rámy, a.s.	16	15789772	60%	20
OKD, PILA - SALMA, a.s.	4	47676230	23%	20
Biocel Paskov a.s.	7	26420317	90%	21
KRKONOŠSKÉ PAPÍRNY a.s.	15	45534284	37%	21
Olšanské papírny a.s.	35	12351	65%	21
Obchodní tiskárny, akciová společnost	33	13790	15%	22
SPOLANA a.s.	26	45147787	86%	24
Spolek pro chemickou a hutní výrobu, akciová společnost	17	11789	71%	24
ALIACHEM a.s.	20	60108916	43%	24
PRECHEZA a. s.	13	14617064	80%	24
BorsodChem MCHZ, s.r.o.	6	26019388	80%	24
Lovochemie, a.s.	20	49100262	37%	24
COLORLAK, a.s.	24	49444964	14%	24
BIOPHARM, Výzkumný ústav biofarmacie a veterinárních léčiv a.s.	22	46356606	59%	24
Zentiva a.s.	18	49240030	37%	24
Lybar, a.s.	8	49901869	55%	24
SILON a.s.	13	14504332	62%	24
RUBENA a.s.	7	12131	45%	25
VULKAN akciová společnost	29	12220	60%	25
GRANITOL, akciová společnost	15	12114	30%	25
Alfa Plastik, a.s.	5	60793791	40%	25
Chemoplast, a.s.	7	44015861	30%	25
Linaset, a.s.	6	47674687	45%	25
TANEX,PLASTY a.s.	6	13583808	70%	25
CRYSTALEX a.s.	6	49903501	90%	26
Sklo Bohemia, a.s.	14	48173371	85%	26

Saint-Gobain Vertex, a.s.	33	12661	90%	26
Staroroslký porcelán Moritz Zdekauer, a.s.	29	46886419	40%	26
Moravské keramické závody a.s.	9	46900985	56%	26
CIDEM Hranice, a.s.	4	14617081	22%	26
Průmysl kamene a.s.	5	46350888	50%	26
Mittal Steel Ostrava a.s.	11	45193258	34%	27
TŘINECKÉ ŽELEZÁRNY, a. s.	4	18050646	54.50%	27
V Á L C O V N Y P L E C H U, a.s.	5	14613581	43%	27
ŽĎAS, a.s.	27	46347160	52%	27
Hutní druhovýroba - reality a.s.	16	46708715	33%	27
ŽDB a.s.	17	47672412	60%	27
Kovohutě Mníšek a.s.	6	45148112	66%	27
KOVOHUTĚ ROKYCANY, a.s.	4	49195719	50%	27
Pacovské strojírny, akciová společnost, Pacov , cizojazyčné mutace : Pacovské strojírny Aktiengesselschaft,Pacovské strojírny Sociéte Anonyme	29	15821773	70%	28
TENEZ a.s.	14	45534535	50%	28
Impress Znojmo, a.s.	5	46347054	50%	28
Šroubárna Turnov, a.s.	18	46504613	12%	28
Šroubárna Žatec, a.s.	13	49903527	65%	28
ŠKODA POWER s.r.o.	4	49193864	75%	29
JIHLAVAN, a.s.	19	46347071	38%	29
Poličské strojírny a.s.	32	46504851	69%	29
MSA, a.s.	40	45192278	90%	29
SEVEROČESKÁ ARMATURKA,a.s.	12	8885	29%	29
STROJÍRNY POLDI, spol. s r.o.	8	46358404	74%	29
Wikov MGI a.s.	23	529834	90%	29
Slovácké strojírny, akciová společnost	26	8702	88.60%	29
REMAK a.s.	8	15770397	60%	29
ZVVZ a.s.	40	9041	54%	29
TOS VARNSDORF a.s.	8	64651142	90%	29
OSTROJ a.s.	24	45193681	12%	29
STAVOSTROJ, a.s.	30	8753	90%	29
UNEX a.s.	8	45192049	65%	29
ADAMOVSKÉ STROJÍRNY a.s.	24	46345833	70%	29
BUZULUK Komárov, nástupnická a.s.	4	25056301	47%	29
KOBIT, spol. s r.o.	5	44792247	25%	29
Česká zbrojovka a.s.	46	46345965	80%	29
ETA a. s.	35	10341	70%	29
Isolit-Bravo, spol. s r.o.	4	46507272	80%	29
ATAS elektromotory Náchod a.s.	32	45534543	62%	31
OEZ s.r.o.	7	49810146	34%	31
KABLO ELEKTRO, a.s.	18	46504753	28%	31
MAGNETON a.s.	4	49969862	37%	31
ON SEMICONDUCTOR CZECH REPUBLIC, a.s.	20	45193533	70%	32
BMT a.s.	19	46346996	68%	33
DAEWOO AVIA, a.s.	6	45273227	50%	34
ŠKODA AUTO a.s.	12	177041	83%	34
TATRA, a.s.	6	45193444	78%	34
ALMET, a. s.	26	46505156	27%	34
MASSAG, a.s.	4	10367	30%	34
MOTORPAL,a.s.	15	9296	80%	34

Table A-2: Description of "OKEČ" – CPA2

Classification	Description
15	Food products and beverages
17	Textiles
18	Wearing apparel; furs
19	Leather and leather products
20	Wood and products of wood and cork (except furniture)
21	Pulp, paper and paper products
22	Printed matter and recorded media
23	Coke, refined petroleum products and nuclear fuel
24	Chemicals, chemical products and man-made fibers
25	Rubber and plastic products
26	Other non metallic mineral products
27	Basic metals
28	Fabricated metal products, except for machinery and equipment
29	Machinery and equipment n.e.c.
30	Office machinery and computers
31	Electrical machinery and apparatus n.e.c.
32	Radio, television, communication equipment and apparatus
33	Medical, precision and optical instruments; watches, clocks
34	Motor vehicles, trailers and semi-trailers
35	Other transport equipment
36	Furniture; other manufactured goods n.e.c.

Table A-3: Share of industry in total exports of manufactured goods – 2004

Industry	OKEČ	Share in manufacturing exports (%)
Beer (food and beverages)	15	3.3
Textiles	17;18	5.3
Paper	20;21;22	5.2
Chemicals	24;25	12.6
Glass	26	4.4
Metals	27;28	15.3
Fitting	29	15.0
Machines	31;32;33	20.3
Cars	34	18.6

Source: Czech Statistical Office and authors' computations.

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