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Has the export pricing behaviour of German enterprises changed? Empirical evidence from German sectoral export prices

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Abstract

The question as to whether the globalisation-related increase in competitive pressure may have caused the importance of exchange rate pass-through and pricing-to-market for export pricing in Germany to shift since the 1990s is addressed by testing the long-run export pricing behaviour of German enterprises for changes in the impact of its determinants. As globalisation may have affected competitive pressure in individual product markets differently, export pricing is analysed for 11 product categories. Analytically, this problem is solved by applying the Saikkonen (1991) approach to estimate the individual export price categories in single equations. Moreover, error correction models are used to test exporters' short-run price-setting behaviour for asymmetry, ie whether short-run increases in the export price determinants are passed through to a different extent than decreases.

Keywords: export pricing, exchange rate pass-through, pricing-to-market, Germany.

JEL classification: C22, F41.

Non-Technical Summary

Increasing competitive pressure since the 1990s owing to more rapid globalisation has raised the question as to whether this might have induced exporters to gear price-setting more strongly to foreign competitors' prices and less to their own costs. Thus, for German export prices, this paper estimates changes in exchange rate pass-through (ERPT), ie in the impact of the exporters' cost situation - represented by the domestic producer prices - and commodity prices, and changes in pricing-to-market (PTM), ie in the impact of foreign competitors' prices and exchange rates, in the period 1991-2004 compared to the 1976-1989 sample. As globalisation may have intensified competitive pressure in the individual product markets to a varying extent, the export pricing behaviour of German enterprises is analysed for 11 product categories (food, textiles, paper products, petroleum products, chemicals, plastic products, metals, machinery, computers, electrical equipment, motor vehicles).

From exporters' profit calculations one can derive theoretically that, the stiffer the competition, the weaker ERPT is and the stronger PTM is for export pricing. Two hypotheses are therefore developed and examined. The first states that long-term ERPT is stronger, and PTM weaker, for heterogeneous products than for homogeneous products. With machinery being the reference group for heterogeneous products, the hypothesis holds more for ERPT than for PTM.

The second hypothesis presumes that long-term ERPT has weakened and PTM has strengthened since the 1990s. The estimation results show that this holds for exports of machinery and motor vehicles. However, for several sectors the empirical evidence conflicts with the hypothesis. Nevertheless, identifying the overall outcome by weighting the results of the individual sectors with export shares enables the second hypothesis to be confirmed. From this hypothesis it may be concluded that measured changes in relative prices are reflected to a lesser extent in export prices. This shift in the importance of ERPT and PTM for export pricing may have contributed to the downward trend in the relative price sensitivity of German exports since the 1990s.

Moreover, this paper examines empirically whether the short-term pricing behaviour of German exporters is asymmetric, ie whether increases in the export price determinants are passed through to a greater or lesser extent than decreases. The tests are conducted across all 11 product categories for both ERPT effects and both PTM effects. Evidence is provided that the hypothesis of symmetric export price-setting is seldom rejected in the short run. Furthermore, symmetric

pricing is more pronounced for exchange rate fluctuations than for changes in domestic producer prices or commodity prices.

Nicht technische Zusammenfassung

Zunehmender Wettbewerbsdruck im Zuge der fortschreitenden Globalisierung hat die Frage aufgeworfen, ob dadurch Exporteure veranlasst werden könnten, ihre Preise stärker an den ausländischen Konkurrenzpreisen und weniger an den eigenen Kosten zu orientieren. Aus diesem Grund werden in diesem Diskussionspapier für deutsche Exportpreise Veränderungen des *Exchange rate pass-through*-Effekts (ERPT), d. h. des Einflusses der Kostensituation der Exporteure - abgebildet durch die heimischen Produzentenpreise - und der Rohstoffpreise, sowie Veränderungen des *Pricing-to-market*-Effekts (PTM), d. h. des Einflusses der ausländischen Konkurrenzpreise und der Wechselkurse, im Zeitraum 1991-2004 verglichen mit der Periode 1976-1989 geschätzt. Da die Globalisierung den Wettbewerbsdruck auf den einzelnen Gütermärkten in unterschiedlichem Ausmaß verschärft haben könnte, wird das Exportpreissetzungsverhalten deutscher Unternehmen für 11 Gütergruppen (Nahrungsmittel, Textilien, Papierprodukte, Mineralölerzeugnisse, chemische Erzeugnisse, Kunststoffprodukte, Metalle, Maschinen, Computer, elektrische Ausrüstung, Fahrzeuge) analysiert.

Aus dem Gewinnmaximierungskalkül der Exporteure wird theoretisch abgeleitet, dass bei der Exportpreisgestaltung die ERPT-Effekte umso schwächer und die PTM-Effekte umso kräftiger ausfallen, je stärker der Wettbewerbsdruck ist. Daraus werden zwei Hypothesen entwickelt und untersucht. Die erste Hypothese nimmt an, dass in der langen Frist ERPT für heterogene Güter stärker und PTM schwächer ist als für homogene Produkte. Werden Maschinenbauerzeugnisse als Referenzgruppe für heterogene Güter herangezogen, zeigt sich, dass diese Hypothese häufiger für ERPT als für PTM zutrifft.

Die zweite Hypothese unterstellt, dass sich seit den neunziger Jahren ERPT langfristig abgeschwächt und PTM verstärkt hat. Die Schätzergebnisse bestätigen dies für Maschinen- und Fahrzeugexporte. Für mehrere Sektoren steht der empirische Befund allerdings im Widerspruch zur Hypothese. Dennoch lässt sich die zweite Hypothese bestätigen, wenn das Gesamtergebnis dadurch bestimmt wird, dass man die Ergebnisse der einzelnen Sektoren zusammen gewichtet, wobei die Exportanteile als Gewichte verwendet werden. Aus der Hypothese lässt sich die Schlussfolgerung ziehen, dass sich die gemessenen Fluktuationen der relativen Preise in geringerem Ausmaß in den Exportpreisen niederschlagen. Diese Verschiebung der Bedeutung von ERPT und PTM für das Exportpreissetzungsverhalten könnte dazu beigetragen haben, dass die deutschen Exporte seit den neunziger Jahren tendenziell schwächer auf Veränderungen der relativen Preise reagieren.

Darüber hinaus wird empirisch analysiert, ob das kurzfristige Preissetzungsverhalten der deutschen Exporteure asymmetrisch ist, d. h. ob ein Anstieg der Exportpreisdeterminanten stärker oder schwächer weitergegeben wird als ein Rückgang. Die Tests werden für alle 11 Gütergruppen sowohl für beide ERPT- als auch für beide PTM-Effekte durchgeführt. Es zeigt sich, dass die Hypothese einer symmetrischen Exportpreisbildung in der kurzen Frist selten verworfen wird. Außerdem ist symmetrisches Preissetzungsverhalten bei Wechselkursfluktuationen stärker ausgeprägt als bei Veränderungen der heimischen Produzentenpreise oder der Rohstoffpreise.

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1 Introduction

Estimation equations of German exports to euro-area partners and to non-euro-area countries provide evidence that the long-run relative price sensitivity of German exports has been on a downward trend since the 1990s.[1] As export pricing is determined by the exporter's own cost situation and the pricing behaviour of foreign competitors, one reason for these empirical findings could be that measured changes in relative prices are reflected to a lesser degree in export prices. Increasing competition owing to globalisation might have induced exporters to gear their price-setting more strongly to foreign competitors' prices and less to their own costs. This paper thus investigates whether the importance of domestic costs (exchange rate pass-through - ERPT) and foreign competitors' prices (pricing-to-market - PTM) for German export pricing has shifted since the 1990s.

As globalisation is alleged to have affected competitive pressure in the individual product markets to a varying extent, German enterprises' export pricing behaviour is analysed for 11 product categories. In addition, this paper examines whether exporting enterprises exhibit asymmetrical pricing behaviour, ie whether increases in the export price determinants are passed through to a greater or lesser extent than decreases.

This paper begins with an overview of empirical studies analysing shifts in pricing behaviour. Subsequently, the paper investigates, for 11 product categories, whether long-term exporter pricing behaviour has changed. Therefore, price-setting will be derived theoretically from an exporter's profit calculation. Then the underlying data set and the long-term estimation approach are outlined. Next, the estimation results are presented and interpreted. The paper concludes with a test of exporters' short-term pricing behaviour for asymmetry using error correction models.

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[1] See Stahn (2006), pp 15 et seq.

2 Overview of the literature

Studies examining changes in pricing behaviour are still scarce. Moreover, most analyses focus on ERPT to import prices. One strand of research investigates whether the establishment of EMU may have influenced import price-setting due, for instance, to stronger price harmonisation. These studies mostly cover the period after the 1990s. However, empirical evidence is still mixed. Campa et al (2005) do not find much evidence, whereas Brissimis and Kosma (2005) observe such a shift. Anderton (2003) observes that EU countries which are not members of the EMU show lower ERPT for exports to the euro area than exporters from non-EU countries. As this result could, at least in part, be attributed to increasing price convergence within the EU, it may indicate that the establishment of a unified economic area might have influenced the pricing behaviour of enterprises.[2]

The second strand of research focuses on shifts in import pricing since the 1990s. However, for Germany empirical evidence of a decrease is not firm. Campa and Goldberg (2002) find a fall in long-run ERPT of 0.12 for the 1977-1999 sample compared with the 1977-1989 period, although the decrease is statistically insignificant. However, the decline in pass-through differs noticeably for the individual product categories under review.[3] By contrast, in a more recent paper Campa and Goldberg (2004) observe that ERPT has hardly changed for the 1988-1999 period compared with the 1975-1987 period.[4] The BIS (2005) derives a rather small decline in ERPT of 0.09 since the 1990s, although it is not tested for statistical significance.[5]

International estimation results do not provide clear evidence of a decline in ERPT to import prices, either. For the euro area, Hahn (2003) and Warmedinger (2004) - who additionally analyses the five largest euro-area countries separately - conduct the estimates across a sample covering both the pre- and the post-1990 periods.[6] As their results correspond largely to the findings of Anderton et al (2004), whose sample is restricted to the period after 1990, this comparison may indicate that shifts in price-setting have hardly taken place. However, comparing the post-1990 estimation results with an earlier sample is the appropriate way to detect changes in import pricing. Campa and Goldberg (2005) indeed observe a fall in ERPT since the 1990s for

[2] See Anderton (2003), pp 15 et seq. However, the fact that smaller non-EU countries are more apt to be price takers than larger non-EU countries may also play a role. Moreover, the higher ERPT from non-EU countries could also be driven by the strong ERPT for imports from the United States. That US exporters are most likely to invoice their exports in US dollars may also have contributed to this.

[3] See Campa and Goldberg (2002), p 11 and p 33.

[4] See Campa and Goldberg (2004), p 9.

[5] See BIS (2005), p 17.

[6] See Hahn (2003), p 18, and Warmedinger (2004), pp 12 and 18.

15 out of the 21 countries under review, although in many cases the decreases are not statistically significant.[7] By contrast, Bailliu and Fujii (2004) find a decrease for 11 industrialised countries in the early 1990s. Further empirical evidence of a decline in ERPT to import prices across a wide range of countries is offered by studies examining changes in ERPT to consumer prices, as the impact of exchange rates on import prices usually works through to consumer prices.[8]

Research on changes in *exporters'* pricing behaviour is even scarcer than for import prices. As export prices are the mirror images of import prices, shifts in import pricing can be expected to be detected in export price-setting, too. Marazzi et al (2005) examine German exporters' price-setting behaviour in order to explain the decline in ERPT to US import prices. They find that German export prices denominated in domestic currency move almost one-to-one with changes in German exporters' costs over time and thus cannot account for the fall in ERPT to US import prices.[9]

Therefore, to shed further light on this topic, estimations are performed in this paper to assess whether the importance of ERPT and PTM for the *export* pricing behaviour of *German* enterprises has shifted *since the 1990s*. The focus here is on *German* enterprises' price-setting for two reasons. First, German enterprises are strongly export-oriented and not supposed to be price-takers. Hence, incomplete PTM is likely to be found for both the pre-1990 and the post-1990 period. This is the premise to actually detect the impact of increasing competition on export pricing. Second, Germany experienced low inflation rates in both periods. Thus, the impact of high or volatile inflation rates on exporters' cost situation and thus their price-setting should be negligible.[10] If shifts in export pricing are found, they can then be attributed more easily to increasing competition.

Examining shifts in price-setting *since the 1990s* makes sense, as changes in the external environment, eg the economic catching-up process of Asian emerging markets and of central and east European transition countries, have altered German foreign trade and foreign direct investment flows and have increasingly led to mounting competition in the past fifteen years. By contrast, testing the establishment of EMU as a cause for changes in export pricing may be fraught with problems. First, this may be due to the fact that the time period since EMU is still rather short for time series analysis. Second, as the establishment of EMU coincided with the

[7] See Campa and Goldberg (2005), p 684.

[8] See Baillu and Fujii (2004), p 28, Gagnon and Ihrig (2004), p 325, and Frankel et al (2005).

[9] See Marazzi et al (2005), pp 28 et seq. They attribute the decrease in ERPT to exporters from Canada and Asian emerging markets.

[10] See section 3.4 for evidence.

burst of the hi-tech bubble, which was followed by a global downturn in economic activity, and with the reversal in the development of the external value of the domestic currency against non-euro-area countries, its impact on exporters' price-setting is probably difficult to separate from the impact of the other two shocks.

As globalisation is alleged to have affected competitive pressure in the individual product markets to a varying extent, exporters' pricing behaviour is analysed for 11 product categories separately. This approach has the advantage that changes in price-setting owing to shifts in the structural composition of highly aggregated price variables are reduced.[11] By contrast, various studies investigate price-setting for individual goods or for more deeply disaggregated price indices. However, as *long-term* export pricing, ie price-setting over the past thirty years, is examined in this paper, the use of more deeply disaggregated price indices would be problematic, since the composition of sectoral German price indices has shifted considerably during that period. Moreover, data on foreign prices and on domestic enterprises' cost situation for this long time period and in a sectoral breakdown similar to German export prices would be necessary, but is not available. The same holds for individual goods' prices, where even firm-level data would be necessary for adequate research.

3 Has long-term German export pricing behaviour changed?

3.1 Theoretical approach

The theoretical approach is the extended Dixit-Stiglitz model of export pricing, which assumes imperfect monopolistic competition according to the Chamberlin model and strategic behaviour on the part of the exporters. The starting point is a mark-up model, where the suppliers of the product category i - pricing in domestic currency units - set the export price (P_i^x) by adding a profit margin (π_i) to their unit costs (K_i).[12]

$$P_{it}^x = (1 + \pi_{it}) \cdot K_{it}. \tag{1}$$

[11] See section 3.4 for this line of argument.

[12] See Dornbusch (1987), pp 99 et seq, and Clostermann (1996), pp 9-10, for the theoretical derivation.

The mark-up depends on the competitive pressure on the market for product category i. Competitive pressure is captured by the ratio between foreign competitors' prices for product category i in foreign currency units (P_i^f) and the export prices for product category i, which are converted to foreign currency units. This is done using the nominal external value of the domestic currency against the most important trading partners for product category i (W_i), where an appreciation of the domestic currency is formulated as a rise in the variable:

$$(1 + \pi_{it}) = \left(\frac{P_{it}^f}{P_{it}^x \cdot W_{it}} \right)^{\theta_i}, \quad \theta_i \geq 0. \tag{2}$$

θ_i is a parameter denoting the intensity of competitive pressure in the market for product category i. After taking logarithms (lower-case letters represent logarithmic variables), equations (1) and (2) give:

$$p_{it}^x = (1 - \phi_i) \cdot k_{it} + \phi_i \cdot (p_{it}^f - w_{it}), \quad \phi_i = \frac{\theta_i}{1 + \theta_i}. \tag{3}$$

The first term denotes the exchange rate pass-through (ERPT) effect. It shows the extent to which exporters gear export prices to their own cost situation. If the parameter ϕ_i is zero, export prices are set exclusively with respect to the exporter's unit costs. Foreign buyers would therefore bear the full brunt of exchange rate movements, ie ERPT is complete. The second term denotes the pricing-to-market (PTM) effect. It represents the extent to which export prices are adjusted to the prices of foreign competitors, denominated in domestic currency units. If ϕ_i is one, then the domestic exporters' prices are based solely on foreign competitors' prices, ie PTM is complete. In this case, exchange rate fluctuations are fully absorbed by variations in the exporters' profit margins. If the value of ϕ_i is between zero and one, then export prices are geared to both domestic unit costs and foreign competitors' prices, converted to domestic currency units.[13] The larger the competitive pressure θ_i is, ie the higher the substitutability between export goods and foreign products, the larger ϕ_i is, and consequently the weaker ERPT is and the stronger PTM is. The aim of this paper is to determine the behavioural parameter ϕ_i empirically.

For the estimation, the theoretical approach (3) is broadened by relaxing two homogeneity restrictions. First, the assumption that the impact of the individual determinants adds up to one is abandoned. Second, export prices may adjust differently to changes in foreign competitors'

[13] Incomplete long-run pass-through is mainly ascribed to imperfect competition, arising in segmented markets and through market power by enterprises. See Goldberg and Knetter (1997) for a review of this literature.

prices and to changes in the nominal external value. For instance, exporters might conceivably react more strongly to changes in foreign competitors' prices than to changes in the external value because exchange rate movements are unpredictable.[14]

Furthermore, exporters may react more strongly to changes in prices of commodities or intermediate goods than to changes in other cost components. This could be particularly relevant if commodities play an important role in the manufacturing process. This impact is captured by including commodity prices in domestic currency units (p_q^r) as an additional determinant. This provides the following equation for export price-setting:

$$p_{it}^x = \beta_{i1} k_{it} + \beta_{i2} p_{qt}^r + \beta_{i3} p_{it}^f - \beta_{i4} w_{it}, \tag{4}$$

with $\beta_{i1},\ \beta_{i2}, \beta_{i3}, \beta_{i4} \geq 0$ being economically plausible values.

According with equation (3), increasing competitive pressure would reduce both ERPT effects $(\beta_{i1},\ \beta_{i2})$ and raise both PTM effects $(\beta_{i3},\ \beta_{i4})$. From these theoretical findings two hypotheses are derived and analysed in the following:

1. Supposing that competitive pressure is lower for heterogeneous products than for homogeneous products, ERPT will be stronger, and PTM weaker, for heterogeneous products than for homogeneous products.

2. Supposing that competitive pressure has increased since the 1990s, ERPT will have weakened and PTM will have strengthened.

The first hypothesis is examined to check the long-term estimation results for plausibility, while the second hypothesis states the precise motivation of the paper.

[14] See Hung et al (1993), p 5. Moreover, menu costs could also prevent exporters from adjusting their prices to temporary exchange rate changes. See Delgado (1991). Mahdavi (2000), p 72, argues that this restriction may not hold for relatively aggregated indices in particular. Athukorala and Menon (1995), pp 535-536, also state that the restrictions may be rejected because the indices are compiled differently. Clostermann (1996), p 15, captures this problem by including a trend variable. By contrast, Warmedinger (2004) conducts the estimations under these two homogeneity restrictions.

3.2 Data and estimation approach

3.2.1 Data set

The prices of export goods in 11 categories are estimated for the 1976-2004 period. The categories' codes have 2 or 3 digits according to the structure of the German Product Classification for Production Statistics (*Güterverzeichnis für Produktionsstatistiken*, GP). The modifications to the GP structure in 1995 are taken into account by linking group indices which contain sub-indices of very similar product categories for 1995 (see the table on the following page). The sub-indices are consolidated according to their weighting in the overall export price index for the relevant base years. The second column contains the simplified notation for the respective category that is used throughout the paper. The final column lists the individual product categories' percentage share in the overall volume of German exports in 2004.

German sectoral unit costs are not available and therefore are approximated by domestic producer prices for 11 product categories in the same sectoral breakdown as export prices. The modifications to the GP structure in 1995 are likewise taken into account by combining the sub-indices in a group index according to their weights in the overall producer price index for the respective base year and then linking the group indices for 1995.

Time series for disaggregated foreign competitors' prices are not available in a sectoral breakdown that corresponds to the GP for a sufficient number of trading partners for the envisaged long estimation period. As such, the total sales deflators of the 19 most important trading partners are aggregated and used for each product category as an approximation of the foreign competitors' prices. This aggregate is composed of Germany's 11 current euro-area partner countries plus Canada, Denmark, Japan, Norway, Sweden, Switzerland, the United Kingdom and the United States. The weighting takes account not only of bilateral trade relations between the German economy and each of its trading partners but also of competition in non-euro-area markets.

As an exception, a sectoral foreign competitors' price is used for group IX (computers). The reason is the downward trend in export and producer prices for this group, which contrasts with the other 10 categories.[15] As it is reasonable to suppose that foreign competitors' prices have followed a similar course, the foreign total sales deflator - the trend of which is upward - is not a suitable regressor. A suitable time series is generated by linking US producer prices for computer

[15] This might be due to the use of hedonic price measurement, which influences the prices of IT goods in particular, as these are characterised by major technological progress.

Table 1: Consolidated product categories according to the GP

Group		Code	GP 1989	Code	GP 1995/2002	Share
I	Food	68	Food products	15	Food products and beverages	3.7
II	Textiles	63	Textiles	17	Textiles	
		64	Clothing, made-up textiles	18	Clothing	2.7
III	Paper products	56	Paper and pulp products	21	Pulp, paper and paper products	
		57	Publishing, printing and reproduction	22	Publishing, printing and reproduction of recorded media	2.8
IV	Petroleum products	22	Refined petroleum products	232	Refined petroleum products	1.0[16]
V	Chemicals	40	Chemical products	24	Chemicals and chemical products	13.6
VI	Plastic products	58	Plastic products	25	Rubber and plastic products	
		59	Rubber products			3.3
VII	Metals	27	Iron and steel	27	Basic metals	
		28	Non-ferrous metals, non-ferrous metal ores	28	Fabricated metal products	
		29	Cast metal products			
		30	Fabricated steel products, rail vehicles			
		31	Products from wire drawing plants, cold rolling mills, steel forming			
		38	Iron, sheet metal and metal products			7.2
VIII	Machinery	32	Machinery (including tractors)	29	Machinery	14.0
IX	Computers	50	Office machinery and computers	30	Office machinery and computers	3.7
X	Electrical equipment	36	Electrical equipment	31	Electrical machinery and apparatus	
		37	Precision and optical instruments, watches, clocks	32	Radio, TV and communication equipment and apparatus	
				33	Medical, precision and optical instruments, watches, clocks	14.1
XI	Motor vehicles	33	Road vehicles (excluding tractors)	34	Motor vehicles and parts	17.6

[16]Including coke and nuclear fuel.

manufacturers (available from 1991) with US producer prices for calculating and accounting machines and parts (1976 Q1-1990 Q4) and typewriters (1976 Q1-1983 Q4) or typewriters, word processors and parts (1985 Q3-1990 Q4). This implies that, for computers, the prices of the most important competing trading partners (denominated in foreign currency) have followed the same trend as US producer prices.

Instead of a sector-specific nominal external value, the nominal external value against Germany's 19 most important trading partners is used for each product category, the countries weighted in accordance with the foreign total sales deflators. Once again, product group IX is the exception, where the nominal US dollar/domestic currency exchange rate is used. This appears to be plausible in the context of this product category, as important foreign competitors are based in Asian countries, whose currencies are aligned to the US dollar.

For individual product categories, this paper uses the following HWWA commodity price indices in US dollars (which are then converted to domestic currency): food, crude oil, iron and steel, non-ferrous metals, cellulose and spun yarn. Prices for the latter two commodities are only available from 1978 Q4. Consequently, these indices will be assumed to take the value of 1978 Q4 (in US dollars) for the period before this point in time. This means that changes to the indices converted to domestic currency during this period are solely the result of exchange rate fluctuations against the US dollar.

3.2.2 Estimation approach

As, for each product category, the trace test rejects the hypothesis that no cointegrating relationship exists between the export price and its determinants, it is appropriate to estimate long-term export pricing in levels.[17] This approach has advantages over studies where cointegration is rejected,[18] making it necessary to estimate in first differences, which means that long-run effects of the determinants can only be captured by summing up the estimated coefficents of the current and the lagged first differences. Consequently, the results may depend heavily on the number of lags included.

[17] Tests for cointegration are presented in the appendix.

[18] This might be due to the use of export unit values which comprise period-by-period changes in the composition of exports as a proxy for export prices. However, trade prices are often not available in an internationally consistent sectoral breakdown.

The long-run relationship for each of the 11 export price categories is estimated using a single equation following the asymptotically efficient approach of Saikkonen.[19] Including the leads and lags of the regressors' first differences solves the endogeneity problem. This aspect is important as, at least for some product categories, exchange rates or the foreign total sales deflator may be influenced by export price trends.[20] To keep the degrees of freedom as high as possible, the number of leads and lags is restricted to one. Using the Newey-West covariance estimator, the regressions are adjusted for autocorrelation and heteroscedasticity. The regressions are conducted on a quarterly basis using non-seasonally adjusted data.[21] The estimation approach is:

$$\begin{aligned} p_{it}^{x} &= \beta_i' x_{it} + \sum_{j=-1}^{1} \gamma_{ij}' \Delta x_{it+j} + c_i + \sum_{l=0}^{2} \delta_{il} s_{t-l} + u_{it} \\ &\text{with} \quad x_{it}' = \left(p_{it}^{h}, p_{qt}^{r}, p_t^{f}, w_t \right). \end{aligned} \tag{5}$$

p_i^x denotes the German export prices for goods belonging to product category i in domestic currency units, p_i^h the German producer prices for domestic sales of product category i, p_q^r is the HWWA price index for commodity q in domestic currency units, p^f the foreign deflator of total sales in foreign currency units (for group IX: US producer prices for computers in US dollar), w Germany's nominal external value against the 19 most important trading partners (for group IX: the US dollar exchange rate), c_i a constant, s seasonal variables, Δ the first difference of the logarithmic system variables and u_i the residual.

The effects of globalisation have presumably gathered pace since the 1990s. Therefore, the estimations for each product category i are conducted for the period before (1976-1989) and after German unification (1991-2004). As export prices for individual product groups were affected substantially by the introduction of the D-Mark in eastern Germany in 1990, this year is excluded from the regressions. If the changes to the external framework have indeed influenced German exporters' pricing, then the estimations for the two sub-samples should differ.

[19] See Saikkonen (1991).

[20] This problem is mentioned by Hung et al (1993), p 6.

[21] In addition, estimates were carried out across all 11 product groups using a Seemingly Unrelated Regression (SUR) model. The elasticities were very similar to those of the single equation estimations. Moreover, the SUR estimations were performed for two further indicators of foreign competitors' prices. With respect to the plausibility of the elasticities, the foreign total sales deflator proved indeed to be superior to both aggregate indices of foreign consumer prices and foreign unit labour costs (this estimate started at 1977 Q1), as the number of elasticities with an economically plausible - ie positive - sign was the largest. However, for many product categories the elasticities of the three indicators were quite similar.

To assess whether changes in long-term pricing behaviour have occurred since the 1990s, the case that the impact of the constant and each regressor in the sub-samples 1976-1989 and 1991-2004 may have changed will be examined. The estimation is therefore conducted across the entire 1976-2004 period, and a dummy variable is included for each regressor and the constant. Expressed in this way, the elasticities for the West German sub-sample (1976-1989) are estimated directly. In addition, the elasticities of the dummy variables illustrate how the influence of the respective regressor has changed in the sub-sample for unified Germany (1991-2004) compared with the earlier sub-sample (1976-1989).[22] This method has the advantage that the *changes* in the long-run impact of the export price determinants are tested for *statistical significance* to provide firm empirical evidence. Moreover, shifts in ERPT and PTM are tested *simultaneously*, whereas many studies concentrate only on one impact. The estimation approach is:

$$\begin{aligned} p_{it}^{x} &= \hat{\beta}_i' x_{it} + \sum_{j=-1}^{1} \hat{\gamma}_{ij}' \Delta x_{it+j} + c_i + \sum_{l=0}^{2} \hat{\delta}_{il} s_{t-l} \\ &\quad + \left(\tilde{\beta}_i' x_{it} + \sum_{j=-1}^{1} \tilde{\gamma}_{ij}' \Delta x_{it+j} + 1 + \sum_{l=0}^{2} \tilde{\delta}_{il} s_{t-l} \right) \cdot d_{91} \\ &\quad + \sum_{n=0}^{3} \eta_n \Delta d_{90-n} + v_{it}, \end{aligned} \tag{6}$$

where d_{90} and d_{91} are dummy variables which are zero prior to 1990 Q1 or 1991 Q1 and one from that point in time on and v_i the residual. The year 1990 was excluded from the estimation using the impulse dummies Δd_{90-n}.

It holds that

$$\beta_{i1} = \hat{\beta}_{i1} + \tilde{\beta}_{i1},\ \beta_{i2} = \hat{\beta}_{i2} + \tilde{\beta}_{i2},\ \beta_{i3} = \hat{\beta}_{i3} + \tilde{\beta}_{i3},\ \beta_{i4} = \hat{\beta}_{i4} + \tilde{\beta}_{i4},$$

with $\beta_{i1},\ \beta_{i2},\ \beta_{i3},\ \beta_{i4}$ from equation (5) for the sample 1991-2004.

[22] See Judge et al (1988), pp 428-429.

3.3 Estimation results

The following Table 2 lists the individual estimation results. The numbers in square brackets denote the t-values. Equation (6) yields the results for the west German sample (1976-1989), termed "WG" in the table, and the changes in pricing behaviour. The results for the unified Germany (1991-2004), notated "G" in the table, stem from equation (5), thereby yielding the significance level of the regressors for this sample. The asterisks (*) appended to the estimated elasticities indicate a significance level of 1% (***) /5% (**) /10% (*). A positive (negative) sign for the change in the impact of the determinants signifies that ERPT or PTM has increased (decreased). To simplify the following presentation, the PTM effects of the nominal external value of the domestic currency are also captured by the term "exchange rate" effects.

3.3.1 Export pricing of heterogeneous and homogeneous products

Prior to examining the first hypothesis, a short overview of the estimated elasticities will be presented below.

Overview of long-run ERPT and PTM effects

The estimations show that ERPT via the domestic producer prices is rather strong and, for most categories, statistically significant: positive elasticities range from 0.48 to 1.00 for the west German sample and from 0.44 to 1.04 for unified Germany.[23] By constrast, ERPT via commodity prices, which plays a role for the food, textiles, paper, petroleum and plastic products and metals sectors, is small, with values of 0.1 for the pre-unification period and a maximum of 0.2 for the pan-German sample. However, this could be due to the fact that commodity prices are already captured by the domestic producer prices. By contrast, for petroleum products large elasticities of 0.3 and 0.8 are observed. This finding may be explained by the importance of crude oil, as the commodity that is being processed, to this sector.

In contrast to ERPT, only 60% of both PTM impacts are statistically significant. PTM via foreign prices does not exceed values of 0.21 - except for computer exports, where the elasticity

[23]For the euro area as a whole, Anderton et al (2004), pp 22-23, find a somewhat lower ERPT for the post-unification period as enterprises pass through changes in domestic costs and foreign competitors' prices, denominated in euro, in equal part (50% each) to export prices for non-euro-area customers.

Table 2: Long-run impact of export price determinants

Group		Sample	p^h	[t-value]	p^r	[t-value]	p^f	[t-value]	w	[t-value]
I	Food	WG	0.80^{***}	[5.24]	0.10^{***}[24]	[3.57]	0.21^{***}	[4.11]	0.19^{**}	[2.07]
		G	0.59^{***}	[8.24]	0.05^{***}	[7.76]	-0.02	$[-0.51]$	0.24^{***}	[7.54]
		Change	$\mathbf{-0.21}$	$[\mathbf{-1.24}]$	$\mathbf{-0.05}$	$[\mathbf{-1.58}]$	$\mathbf{-0.23}^{***}$	$[\mathbf{-3.83}]$	$\mathbf{0.05}$	$[\mathbf{0.47}]$
II	Textiles	WG	0.76^{***}	[11.49]	-0.01^{*}[25]	$[-1.70]$	0.07^{**}	[2.18]	0.06	[1.56]
		G	0.44^{***}	[4.52]	0.03^{***}	[4.30]	0.22^{***}	[12.56]	-0.07^{***}	$[-3.61]$
		Change	$\mathbf{-0.33}^{***}$	$[\mathbf{-2.81}]$	$\mathbf{0.04}^{***}$	$[\mathbf{4.32}]$	$\mathbf{0.14}^{***}$	$[\mathbf{3.83}]$	$\mathbf{-0.13}^{***}$	$[\mathbf{-3.13}]$
III	Paper	WG	0.51^{***}	[2.86]	0.05^{*}[26]	[1.85]	0.18^{***}	[2.96]	0.08	[1.16]
	products	G	0.59	[1.67]	0.02	[0.45]	-0.01	$[-0.10]$	0.08	[0.96]
		Change	$\mathbf{0.08}$	$[\mathbf{0.20}]$	$\mathbf{-0.03}$	$[\mathbf{-0.58}]$	$\mathbf{-0.20}$	$[\mathbf{-1.27}]$	$\mathbf{0.00}$	$[\mathbf{-0.04}]$
IV	Petroleum	WG	0.84^{***}	[4.93]	0.31^{***}[27]	[4.14]	-0.25^{**}	$[-2.16]$	0.03	[0.18]
	products	G	-0.20	$[-1.01]$	0.77^{***}	[9.18]	0.45	[1.52]	0.07	[0.40]
		Change	$\mathbf{-1.05}^{***}$	$[\mathbf{-4.16}]$	$\mathbf{0.45}^{***}$	$[\mathbf{4.15}]$	$\mathbf{0.70}^{**}$	$[\mathbf{2.33}]$	$\mathbf{0.05}$	$[\mathbf{0.20}]$
V	Chemicals	WG	1.00^{***}	[7.11]	–	–	-0.05	$[-0.59]$	-0.15	$[-1.45]$
		G	0.95^{***}	[6.79]	–	–	0.07	[1.99]	0.04	[1.36]
		Change	$\mathbf{-0.05}$	$[\mathbf{-0.59}]$	–	–	$\mathbf{0.13}$	$[\mathbf{1.29}]$	$\mathbf{0.19}$	$[\mathbf{1.78}]$
VI	Plastic	WG	0.67^{***}	[14.55]	0.01^{***}[28]	[4.38]	0.05^{*}	[1.73]	0.12^{***}	[4.05]
	products	G	0.46^{***}	[4.91]	0.02^{***}	[4.26]	-0.15^{***}	$[-5.44]$	-0.05	$[-1.59]$
		Change	$\mathbf{-0.22}^{**}$	$[\mathbf{-2.04}]$	$\mathbf{0.02}^{**}$	$[\mathbf{2.62}]$	$\mathbf{-0.21}^{***}$	$[\mathbf{-4.86}]$	$\mathbf{-0.17}^{***}$	$[\mathbf{-3.80}]$
VII	Metals	WG	0.82^{***}	[2.93]	0.08^{**}[29]	[2.46]	0.13	[1.21]	0.09	[0.76]
					0.04[30]	[1.48]				
		G	0.57^{***}	[8.39]	0.16^{***}	[6.62]	-0.01	$[-0.23]$	-0.15^{***}	$[-3.51]$
					0.10^{***}	[9.03]				
		Change	$\mathbf{-0.25}$	$[\mathbf{-0.86}]$	$\mathbf{0.07}^{*}$	$[\mathbf{1.82}]$	$\mathbf{-0.14}$	$[\mathbf{-1.22}]$	$\mathbf{-0.24}^{*}$	$[\mathbf{-1.90}]$
					$\mathbf{0.06}^{*}$	$[\mathbf{1.87}]$				
VIII	Machinery	WG	0.96^{***}	[66.35]	–	–	0.00	[0.08]	0.02^{***}	[2.76]
		G	0.80^{***}	[24.83]	–	–	0.14^{***}	[5.84]	0.04^{***}	[6.94]
		Change	$\mathbf{-0.16}^{***}$	$[\mathbf{-4.53}]$	–	–	$\mathbf{0.14}^{***}$	$[\mathbf{5.40}]$	$\mathbf{0.02}^{*}$	$[\mathbf{1.69}]$
IX	Computers	WG	0.48^{***}	[5.63]	–	–	2.25^{***}	[10.89]	0.25^{***}	[8.37]
		G	-0.51^{*}	$[-1.95]$	–	–	0.42^{***}	[6.19]	0.35^{***}	[4.36]
		Change	$\mathbf{-0.99}^{***}$	$[\mathbf{-3.46}]$	–	–	$\mathbf{-1.83}^{***}$	$[\mathbf{-8.36}]$	$\mathbf{0.09}$	$[\mathbf{1.04}]$
X	Electrical	WG	0.64^{***}	[10.66]	–	–	0.11^{***}	[4.77]	0.03^{**}	[1.97]
	equipment	G	1.04^{***}	[9.79]	–	–	0.15^{***}	[8.12]	0.09^{***}	[3.98]
		Change	$\mathbf{0.40}^{***}$	$[\mathbf{3.31}]$	–	–	$\mathbf{0.04}$	$[\mathbf{1.37}]$	$\mathbf{0.06}^{**}$	$[\mathbf{2.36}]$
XI	Motor	WG	0.70^{***}	[13.09]	–	–	0.18^{***}	[7.63]	0.06^{**}	[2.61]
	vehicles	G	0.57^{***}	[7.16]	–	–	0.26^{***}	[5.45]	0.24^{***}	[12.45]
		Change	$\mathbf{-0.13}$	$[\mathbf{-1.41}]$	–	–	$\mathbf{0.08}$	$[\mathbf{1.62}]$	$\mathbf{0.18}^{***}$	$[\mathbf{6.03}]$

[24] Food.
[25] Spun yarn.
[26] Cellulose.
[27] Crude oil.
[28] Crude oil.
[29] Iron and steel.
[30] Non-ferrous metals.

is 2.25 - for the first sub-sample and 0.45 for the second sub-sample. The impact of the exchange rates assumes values of 0.25 for the pre-1990 period and, at most, of 0.35 for the post-1990 sample.

Apparently, for all sectors except computers, ERPT via domestic producer prices is noticeably stronger than both PTM effects.

An examination of the estimation results for economic plausibility shows that, for the west German sample, 4 out of 40 elasticities (in the sectors textiles, chemicals, and, statistically significant at the 5% level, for petroleum products) show a negative sign, while for the pan-German period this is the case for 9 elasticities (in the sectors food, paper and petroleum products, computers, textiles, plastic products, metals, the sign being statistically significant for the three last named categories). Nevertheless, all in all the findings are plausible, for the pre-1990 somewhat more than for the post-1990 period, though.

Examination of the first hypothesis

Here, the hypothesis that ERPT is stronger and PTM is weaker for heterogeneous products than for homogeneous products is examined.[31]

Machinery exports are chosen as the reference group for heterogeneous products, as these goods are most often custom-manufactured. The other 10 product categories are assumed to contain more homogeneous goods.

In the case of machinery, strong ERPT with values close to one is found for both sub-samples (the elasticities are 0.96 and 0.80). Only for chemicals and electrical equipment ERPT is as large as for machinery or even larger. The sizable elasticities for chemicals (values of 1.00 and 0.95) may be explained by high concentration of suppliers in a strongly segmented market.[32] Moreover, the importance of intermediate goods and commodities, in particular crude oil, for this sector could have induced the substantial ERPT effect. For electrical equipment, a strong ERPT

[31]The corresponding hypothesis for import prices is that ERPT is weaker for heterogeneous goods than for homogeneous products. This is confirmed by Engel (1993), p 48, for US and Canadian data. Feinberg (1989), p 510, shows for the United States that increased substitutability increases ERPT to domestic prices.

[32]For the theoretical background on the import side, see Dornbusch (1987). Feinberg (1986), p 67, shows, for Germany, a stronger ERPT to domestic prices in more highly concentrated industrial sectors, though the effect of concentration is rather small. Goldberg and Knetter (1997) note that numerous studies find a stronger ERPT to import prices in more heavily segmented sectors. Moreover, the degree of ERPT may be dependent on the relative market shares of domestic and foreign firms. See, again, Dornbusch (1987) for the theory.

(elasticity of 1.04 for the pan-German sample) may be explained by the fact that this category contains many hi-tech products such as medical, precision and optical instruments, which opens up scope for price-setting.

By contrast, PTM for machinery is weak, the impact of the foreign prices and the exchange rates taking values of 0.00 and 0.02 for the pre-unification sample and values of 0.14 and 0.04 for the post-unification period. The minor impact of the exchange rates may be explained by the fact that manufacturers of machinery in particular have long delivery times, above all, for customised plants and therefore attempt to hedge against exchange rate risks.

For homogeneous product categories, positive PTM effects for the west German sample range from 0.05 to 0.21 (foreign prices) and from 0.03 to 0.19 (exchange rates), while they take values from 0.07 to 0.45 (foreign prices) and from 0.04 to 0.24 (exchange rates) for unified Germany.[33] Thus, at the upper bound of the range, the elasticities are noticeably larger than for machinery and, in most cases, statistically significant. However, PTM effects at the lower bound of the range are not much stronger than for machinery and, in some cases, insignificant.

To summarise, with respect to ERPT the hypothesis holds for most product categories. By contrast, for PTM via foreign prices it is confirmed for only 3 categories (textiles, electrical equipment, motor vehicles), while with regard to the exchange rates it holds for 6 categories (food, paper and petroleum products, chemicals, electrical equipment, motor vehicles). All in all, the first hypothesis holds more for ERPT than for PTM.

Table 3 on the next page presents the estimation results of other studies, with the coefficients given in absolute values. For the export side, Hung (1993) observes surprisingly low long-run ERPT and high PTM. Döhrn (1993) and Knetter (1994) likewise find the impact of the (real) exchange rate to be larger than in the results of this paper.[34] Moreover, estimations of ERPT to foreign import prices are presented, as they are part of the mirror image of German exporters' pricing behaviour on foreign markets. Overall, the empirical findings are apparently very sensitive with respect to the applied data and method.[35]

[33]Computers, where the strongest PTM effects are found, are excluded from the comparison as this result may have been induced by using sectoral foreign prices and the bilateral US dollar exchange rate as determinants. Nevertheless, this approach turns out to be empirically appropriate, as the US dollar exchange rate explains export prices of computers better than the nominal external value of the domestic currency.

[34]Using the real effective exchange rate implies the restriction $\beta_{i1} = \beta_{i3} = \beta_{i4}$ in equation (4) of section 3.1.

[35]Menon (1995), who presents an overview of 43 empirical studies that predominantly cover the period before 1990, reaches the same conclusion.

Table 3: Overview of empirical studies

Author	Sample	Endogenous variable	Determinants	Elasticities
Hung et al (1993), p 10	1971-1989	Aggregate German export unit value	ERPT foreign prices exchange rates	0.11 0.71 0.52
Döhrn (1991), p 107	1978-1991	German export unit values machinery road vehicles chemicals electrical equipment	real effective sector-specific exchange rate	 0.53 0.58 0.51 0.48
Knetter (1994), p 61	1975-1987	German export prices small cars	bilateral exchange rate	 0.36; 0.54
Marquez (1991), p 128	1973-1984	Overall US import prices	D-Mark/US dollar exchange rate	 0.83
Kasa (1992), p 23	1978-1987	US import price cars suits	real D-Mark/US dollar exchange rate	 1.74 5.20
Gross/Schmitt (2000), p 103 et seq	1977-1994	Swiss import prices small cars medium-sized cars	D-Mark/Swiss Franc exchange rate	 0.75 (long-run) 0.23 (short-run) 4.05 (long-run) 0.51 (short-run)
Bernhofen/Xu (2000), p 292 et seq	1982-1993	US import prices 29 petrochemicals	D-Mark/US dollar exchange rate	 1.06-1.08

Some studies estimate coefficients larger than one, in most cases for single product prices or a very tight product category; that could be because the exchange rate may incorporate the impact exerted by other determinants which are not included in the regression. By contrast, Bernhofen and Xu (2000), who conduct pooled estimations, find impacts of the exchange rate on US import prices which are very close to this paper's results for the chemicals sector.

3.3.2 Changes in export pricing behaviour since the 1990s

Next, this paper will turn to the second hypothesis, that ERPT has weakened and PTM has strengthened since the 1990s. First, the hypothesis will be analysed with regard to the individual product categories. Subsequently, the overall outcome will be derived.

Second hypothesis with respect to the individual product categories

The estimation results show that the second hypothesis holds for exports of motor vehicles and machinery. However, for machinery the increase in PTM via the exchange rates is minor. This may indicate that the importance of machinery exporters' motive of hedging against exchange rate risks is nearly unchanged.

By contrast, ERPT via the commodity prices has strengthened for textiles, petroleum and plastic products and metals. Apparently it is increasingly easier for exporters to pass through commodity costs to customers abroad than other cost components.[36] However, except for petroleum products, the rise is small. Consequently, the increasing impact of commodity prices offsets the declining impact of the domestic producer prices only in part. Therefore, for these product categories the decreasing impact of domestic producer prices should be regarded as the dominant shift in ERPT.

However, for several sectors the estimation results conflict with the second hypothesis. For instance, stronger ERPT via domestic producer prices is shown for electrical equipment. This finding may be explained by German manufacturers benefitting from the global increase in demand for hi-tech products, opening up scope for price-setting.

Furthermore, a decline in PTM via the exchange rates is observed for textiles, plastic products and metals. This may reflect the fact that the nominal external value against the 19 most important trading partners no longer captures the regional structure of the foreign competitors adequately, as emerging market economies have increasingly entered the markets for these goods. For instance, many Asian competitors peg their currencies *de facto* to the US dollar. Thus, the US dollar's weight within the nominal external value might be too small.

Moreover, weaker PTM via foreign competitors' prices is shown for metals and computers. For metals, this could be explained by the findings for ERPT, which indicate that export pricing is geared more strongly to commodity prices. Therefore, foreign prices may not be reflected appropriately by the foreign total sales deflator. For computers, the decline in the impact of the foreign prices could be due to the construction of this time series, which, in 1991, changes from product-specific prices to industry-specific prices and thus to a more broadly defined index.[37]

[36] Marazzi et al (2005), p 39, find that the impact of the exchange rates on US import prices is somewhat larger and more stable if commodity prices are excluded, but still declines relative to estimations including commodity prices. In their view, this result indicates that an increased share of the exchange rate's impact on import prices is now working through the commodity price channel, which is in line with the findings of this paper.

[37] See section 3.2.1.

In addition, for chemicals the changes in ERPT and PTM are all insignificant. These results might be consistent with the picture of a sector where concentration and market segmentation influence export pricing substantially in both sub-samples. Moreover, intermediate goods and commodities, being of nearly unchanged importance in the manufacturing process and thus in price-setting in this sector, could have contributed to these findings.

Second hypothesis with respect to the overall outcome

The overall outcome is identified by comparing the export shares of sectors in which the impact of the respective determinant is increasing with the export shares of sectors for which the impact is decreasing. The basis of the export shares is Germany's total export volume in 2004. The comparison is drawn first for all sectors exhibiting a change in ERPT or PTM and then for only those sectors in which the change is statistically significant.

Table 4: Export shares of product categories with shifts in ERPT or PTM

Determinant	p^h		p^f		w	
Direction of shift	$\Uparrow$	$\Downarrow$	$\Uparrow$	$\Downarrow$	$\Uparrow$	$\Downarrow$
All shifts	17%	67%	63%	21%	68%	13%
Significant shifts (5% level)	14%	25%	18%	11%	32%	6%
Sectors	X	II, IV, VI, VIII, IX	II, IV, VIII	I, VI, IX	X, XI	II, VI
Insignificant shifts	3%	42%	45%	10%	36%	7%
Sectors	III	I, V, VII, XI	V, X, XI	III, VII	I, IV, V, VIII, IX	VII

The comparison of export shares indicates that the weakening in ERPT via the domestic producer prices and the strengthening in PTM via the exchange rates is clearly the prevailing behaviour for both significant and insignificant shifts. The increase in PTM via foreign prices is only slightly predominant for significant changes, though. Nevertheless, on the whole the second hypothesis is confirmed. Consequently, since the 1990s measured changes in relative prices have been reflected to a lesser extent in export prices.

3.4 Further reasons for the decline in ERPT

The downward trend in ERPT may not only be explained by growing competition in goods markets, though.[38] A further reason could be that the composition of export goods has shifted from goods with a high pass-through to goods with a low pass-through.[39] However, this argument may hold more for higher aggregated price indices than for the disaggregated indices which are analysed in this paper. Moreover, research for the United States and Japan indicates that sectoral shifts in trade cannot account for all of the fall in ERPT to import prices.[40] Furthermore, even these sectoral shifts still need explanation. One reason may be outsourcing to low-cost countries, as this is held to affect low-tech products in particular, ie, products with a weak ERPT with respect to exports.

Another attempt to explain the decline in ERPT is that monetary policy in many countries is more strongly oriented to keeping inflation low, thus leading to reduced inflation expectations. Domestic supply-side factors such as technological progress and its impact on productivity or the deregulation of product and labour markets could have also contributed to this.[41] Exchange rate shocks may then be regarded as temporary, which causes enterprises to seek to absorb exchange rate fluctuations by adjusting their profit margins. Several empirical studies confirm that countries with lower or less volatile inflation rates have a lower pass-through of exchange rate changes to import or consumer prices.[42]

In addition, several studies attribute the size of pass-through to the choice of the invoicing currency.[43] Increasing export pricing in foreign currency is expected to lower ERPT via domestic enterprises' cost situation.[44] The following table shows the shares of German exports invoiced in domestic currency units, ie D-Mark and/or euro, and the US dollar in German total exports.[45] The arrows indicate the trend in shares during the respective period.

[38] The contrasting view is that increasing competition might lead to higher ERPT as enterprises become price takers. Empirical research is still scant, though. Hellerstein (2005) provides some evidence for the US beer market.

[39] Campa and Goldberg (2002), pp 19 et seq, see changes in the composition of import bundles as the most important determinant for changes in ERPT to import prices over time. By contrast, the role of macro determinants such as inflation or money growth rates, exchange rate volatility or real GDP is negligible.

[40] See Marazzi et al (2005), pp 38-39, Otani et al (2003), pp 14 et seq, and Otani et al (2005), p 11.

[41] See also BIS (2005), pp 18-19, for reasons for the decline in global inflation.

[42] See Gagnon and Ihrig (2004), pp 323 et seq, Baillu and Fujii (2004), p 20, Frankel et al (2005), Choudhri and Hakura (2001), pp 15 et seq, or the simulations by Taylor (2000), pp 1400 et seq.

[43] See Engel (2002).

[44] Spencer (1984), pp 473-474, argues that export suppliers from large countries have a higher degree of monopoly power in the world market and therefore gear their export prices primarily to their cost situation.

[45] See semi-annual surveys by the Ifo Institute after 1989, otherwise the source is the Deutsche Bundesbank (once per year). The domestic currency before 2001 is the D-Mark, for the 1991-2000 period D-Mark and euro and from

Table 5: Shares of invoicing currencies in German exports

Time period	Share of invoicing currency	
	Domestic currency	US dollar
1976-1989	87% → 79%	5% → 10%
1991-2000	71% — 80%	8% — 12%
2002-2005	73% → 78%	18% → 14%

On the whole, for unified Germany export pricing in foreign currency units was higher than during the pre-unification period. This confirms the above hypothesis.

Finally, intra-firm trade may have impacted on changes in exporters' pricing behaviour. However, empirical evidence for Germany is not available[46] and evidence for the USA is mixed.[47]

4 Is short-term German export pricing asymmetric?

Peltzman (2000) documented that prices in the United States increase faster than they decrease. This raises the question of whether German export pricing is asymmetric, ie whether increases in the export price determinants are passed through to a greater or lesser extent than decreases. In this chapter, two theories that explain why export pricing may be asymmetric are presented first.[48] Then the estimation approach for the asymmetry tests is given. Subsequently, the empirical results are interpreted.

According to the *bottleneck* theory, capacity constraints in the distribution networks or quantitative trade restrictions may induce exporting enterprises to pass through a reduction of their unit costs to export prices to a lesser extent than an increase. This is because allowing export prices to fall would result in rising demand for export goods. As both capacity constraints and

2002 on exclusively euro. The year 2001 is excluded due to uncertainties while the euro was being introduced. However, period-on-period changes in the shares may also owe something to changes in the composition of the responding enterprises.

[46] According to a survey by the Federal Statistical Office of Germany for the year 2001, the share of German intra-trade is sizeable, at roughly 25% of goods exports to and 38% of imports from EU countries. However, this result should be treated with caution, as only trade with EU countries is captured and respondent exporters/importers make up only 2% of total German exports/imports. See Ebert (2002), p 382.

[47] See Eden and Rodriguez (2004) and Clausing (2000), pp 24-25.

[48] See Knetter (1994), p 56, and Mahdavi (2000), p 71.

quantitative trade restrictions limit (potential) sales in the event that sales are already at their upper bound, enterprises deter the lowering of the export price that the reduction in costs would usually have induced. The arguments for a fall in foreign competitors' prices or an appreciation of the domestic currency are the same, as both changes normally prompt the exporting enterprise to reduce export prices. By contrast, a rise in unit costs or foreign prices or a depreciation of the domestic currency, which would cause export prices to rise and demand for the export good thus to decline, would not be delayed. Therefore, an increase in unit costs or foreign competitors' prices or a depreciation in the domestic currency are expected to be passed through to export prices more strongly than a decline in unit costs or foreign prices or an appreciation of the domestic currency.

According to the *market share* theory, enterprises attempt to hold or raise their market share. Thus, an increase in unit costs and thus in export prices may be offset in part by a reduction in their profit margins. The same motive induces enterprises to push up export prices to a lesser extent in the event the foreign competitors' prices rise or the domestic currency depreciates. By contrast, enterprises maintain their profit margins and allow export prices to fall when unit costs or foreign prices decrease or the domestic currency appreciates. Therefore, export prices are supposed to react more strongly to a decline in unit costs or foreign competitors' prices or an appreciation of the domestic currency than if unit costs or foreign prices increase or the domestic currency depreciates.

Both theories give reasons for asymmetric export pricing. However, they differ in the issue of whether changes in the determinants that lower export prices are passed through more strongly than the changes that push up prices.

4.1 Estimation approach

To examine German export pricing for asymmetry, error-correction models are used. The tests are applied to the short-run determinants in the error correction model, ie the first differences of the regressors ($\Delta(\bullet)$), alone. For that purpose, two dummy variables are created for each short-run determinant that separate quarters with positive ($\Delta^+(\bullet)$) and negative ($\Delta^-(\bullet)$) changes:

$$\Delta^+(\bullet) = \begin{cases} \Delta(\bullet), & \text{if} \quad \Delta(\bullet) > 0, \\ 0, & \text{otherwise.} \end{cases} \qquad \Delta^-(\bullet) = \begin{cases} \Delta(\bullet), & \text{if} \quad \Delta(\bullet) < 0, \\ 0, & \text{otherwise.} \end{cases}$$

The starting point for the asymmetry tests for each product category i is the error correction model (7) below. As enterprises may delay adjustments of their export prices when changes of the determinants occur, eg due to menu costs, first differences up to the fourth lag are included.

$$\begin{aligned}\Delta p_{it}^{x} &= \alpha_i \cdot ect_{it-1} + g_i + \sum_{l=0}^{2} \delta_{il} s_{t-l} + \sum_{y=1}^{4} \epsilon_{iy} \Delta p_{it-y}^{x} \\ &\quad + \sum_{a=0}^{4} \lambda_{ia}' \Delta^{+} x_{it-a} + \sum_{b=0}^{4} \mu_{ib}' \Delta^{-} x_{it-b} + z_{it} \qquad (7)\end{aligned}$$

$$\text{with} \quad ect_{it} = p_{it}^{x} - \beta_i' x_{it} - c_i,$$

$$x_{it}' = \left(p_{it}^{h}, p_{qt}^{r}, p_{t}^{f}, w_t \right),$$

where g_i denotes a constant and z_i the residual. The elasticities of the long-run equilibrium relationship $\beta_{i\tau},\ \tau = 1, \ldots, 4$ stem from equation (6) for the west German sample and from equation (5) for the unified Germany.

A Wald test is performed to test the null hypothesis that the impact via the direction of change in the respective short-run determinant is symmetric, ie that changes in the determinant that push up export prices $(\Delta^{+}(\bullet))$ are passed through to the same extent as changes that lower prices $(\Delta^{-}(\bullet))$.

The following hypotheses may be tested:

1. Increases and decreases in domestic producer prices - approximating enterprises' unit costs - induce the same absolute change in export prices.
2. Rising and falling commodity prices are passed through to export prices to the same extent in terms of value.
3. Increasing and declining foreign competitors' prices lead to the same change in export prices in terms of value.
4. Depreciations and appreciations of the domestic currency result in the same absolute change in export prices.

If the null hypothesis is rejected at a given significance level, then export pricing is termed "asymmetric". The test is conducted lag-wise for one short-run determinant at a time, with all lags up to the fourth tested simultaneously, irrespective of the marginal level of significance of the correspondent dummy variables.[49]

Thus, for each product category i the null hypotheses to be tested successively for the short-run determinants $\tau = 1, \ldots, 4$ are:

$$\lambda_{i0\tau} - \mu_{i0\tau} = 0 \ \wedge \ \lambda_{i1\tau} - \mu_{i1\tau} = 0 \ \wedge \ \lambda_{i2\tau} - \mu_{i2\tau} = 0 \ \wedge \ \lambda_{i3\tau} - \mu_{i3\tau} = 0 \ \wedge \ \lambda_{i4\tau} - \mu_{i4\tau} = 0.$$

At the same time, in the error correction model (to keep the degrees of freedom as high as possible) all those lagged endogenous variables and dummy variables which are not tested are eliminated if statistically insignificant at the 5% level. The tests are carried out separately for the pre-unification period 1976 Q1-1989 Q4 ("WG") and the post-unification sample 1991 Q1-2005 Q1 ("G").

4.2 Empirical results of asymmetry tests

Table 6 on the next page lists the test results. The residuals of the 51 error correction models are normally distributed at a significance level of 5%[50] and not autocorrelated up to the fourth order according to the Breusch-Godfrey LM test. If the White test (without cross terms) revealed heteroscedasticity, estimations would be conducted using White's heteroscedasticity-consistent procedure. Tests for asymmetry are not carried out if the number of data points for one direction of change in the respective regressor is too small. These cases are labelled by "./." in the table. If commodity prices have no long-run impact on export prices, asymmetry tests on their short-run impact are not conducted, either (marked by "−"). The figure "1" indicates that the respective null hypothesis is not rejected - ie symmetric export pricing holds - whereas the figure "0" denotes that the null hypothesis is rejected at a significance level of 5%.

[49] Prior to these tests, the error correction term is also tested for asymmetry, ie whether the speed of adjustment is larger for positive deviations than for negative deviations from the long-run equilibrium relationship. At the same time, the lagged endogenous variables and the dummy variables are eliminated if statistically insignificant. However, symmetric adjustment speed is rejected at the 5% significance level only for 4 out of 22 cases, namely for food, textiles and motor vehicles for the west German sample and for plastic products for the pan-German period. As symmetric adjustment speed is by far the dominant result for both samples, especially for the post-1990 period, the asymmetry tests on short-run impacts are performed under this assumption for all sectors.

[50] With two exceptions.

Table 6: Asymmetry tests on short-run export pricing

Group		Sample	Δp^h	Δp^r	Δp^f	Δw
I	Food	WG	1	1[51]	./.	0
		G	**1**	**1**	**./.**	**1**
II	Textiles	WG	./.	1[52]	./.	1
		G	**1**	**1**	**./.**	**1**
III	Paper products	WG	./.	1[53]	./.	1
		G	**1**	**0**	**./.**	**1**
IV	Petroleum products	WG	1	0[54]	./.	1
		G	**0**	**0**	**./.**	**1**
V	Chemicals	WG	0	–	./.	1
		G	**1**	–	**./.**	**1**
VI	Plastic products	WG	1	0[55]	./.	1
		G	**1**	**1**	**./.**	**1**
VII	Metals	WG	./.	1[56] 1[57]	./.	1
		G	**0**	**0** **1**	**./.**	**1**
VIII	Machinery	WG	./.	–	./.	0
		G	**./.**	–	**./.**	**1**
IX	Computers	WG	1	–	1	0
		G	**1**	–	**./.**	**1**
X	Electrical equipment	WG	./.	–	./.	0
		G	**0**	–	**./.**	**1**
XI	Motor vehicles	WG	./.	–	./.	1
		G	**./.**	–	**./.**	**1**

The results indicate that, on the whole, symmetric short-run export pricing is by far the prevailing behaviour, as the null hypothesis is not rejected for three quarters of the examined cases. Moreover, price-setting is even slightly more frequently symmetric for the post-1990 than for the pre-1990 period (see the following Table 7). If both samples are taken together, symmetric pricing is more pronounced for PTM via exchange rates than for ERPT via domestic producer prices or commodity prices. Only in one case can changes in foreign competitors' prices be

[51] Food.
[52] Spun yarn.
[53] Cellulose.
[54] Crude oil.
[55] Crude oil.
[56] Iron and steel.
[57] Non-ferrous metals.

tested reasonably for symmetry, which is not rejected. Moreover, asymmetry is found in either ERPT or PTM, but not both together.

Table 7: Shares of symmetric short-run export pricing

	all	WG	G	Δp^h	Δp^r	Δp^f	Δw
Shares	75%	71%	78%	71%	64%	100%	82%

Asymmetric short-run ERPT via commodity prices is observed for petroleum products and metals (iron and steel) for unified Germany. This might be due to the fact that for these sectors commodities play an important role in the manufacturing process. For the pan-German period, asymmetric ERPT is also found for electrical equipment. For chemicals and plastic products, short-run ERPT switched from asymmetry to symmetry in the 1990s, whereas for paper products, petroleum products and metals the reverse switch is observed. With respect to PTM via exchange rates, asymmetric impacts are only found for the west German sample (food, machinery, computers, electrical equipment), ie for these sectors short-run price-setting switched from asymmetry to symmetry in the 1990s.

Other studies on German export prices which focus mostly on asymmetric PTM via exchange rates do not provide clear empirical evidence for asymmetry, though. Knetter (1994), for the 1975-1987 period, and Gil-Pareja (2000), for the 1988-1996 sample, perform asymmetry tests using highly disaggregated industry-level data. Knetter (1994) cannot reject symmetric responses to exchange rate fluctuations for any of the disaggregated industries or any of the more aggregated groups of industries, eg cars and chemical products, or for the aggregate of all industries under review.[58] Gil-Pareja (2000) observes asymmetric PTM only for polypropylene, whereas tests across chemical and automobile industry products likewise do not reject symmetric price-setting.[59] Thus, both studies are in line with this paper's findings for the chemicals and motor vehicles sectors. By contrast, Mahdavi (2000) examines the German overall export price index for responses to the sum of lagged exchange rate fluctuations and observes both symmetric and asymmetric pricing, depending on which lags of the exchange rate changes are being tested.[60] Therefore, on the whole, the data, estimation approach and formulation of the asymmetry test appear to be crucial for the empirical results. Nevertheless, symmetric export pricing is apparently hard to reject.

[58] See Knetter (1994), pp 63-64.
[59] See Gil-Pareja (2000), pp 11 et seq.
[60] See Mahdavi (2000), p 79.

5 Conclusion

From exporters' profit calculations, one can derive that, the greater competition is, the weaker ERPT is and the stronger PTM is for export pricing. This paper therefore develops and examines two hypotheses empirically for 11 German export price categories. The first hypothesis states that long-term ERPT is stronger, and PTM weaker, for heterogeneous products than for homogeneous products. Estimations show that this holds more for ERPT than for PTM. The second hypothesis presumes that long-term ERPT has weakened and PTM has strengthened since the 1990s. With respect to the overall outcome, this is confirmed empirically. Consequently, measured changes in relative prices are reflected to a lesser extent in export prices. This shift in export pricing may have contributed to the downward trend in the relative price sensitivity of German exports since the 1990s.

However, three aspects should be borne in mind. First, symmetric export pricing is by far the dominant behaviour in the short run, ie increases in the export price determinants are passed through to the same extent as decreases. Moreover, empirical evidence for several export sectors conflicts with the second hypothesis. It may be worth investigating whether the findings for sectoral export pricing correspond to export estimations in a sectoral breakdown. Third, increasing competition may not be the only reason for a decline in ERPT.

6 Appendix

Tests for the integrated order of the variables

To test the time series used in equation (5) and (6) for their integrated order, the ADF test is performed.[61] It is shown that the null hypothesis - the levels of the time series are I(1) - is not rejected at a significance level of 5% except for non-ferrous metals.

Table 8: Tests for the integrated order of the variables

Variables	Test statistic	Model[62]	Lags	Variables	Test statistic	Model	Lags
Export prices				**Producer prices**			
I Food	-3.16^{*}	*c, tr*	1	I Food	-3.27^{*}	*c, tr, s*	1
II Textiles	-1.23	*c, tr, s*	1	II Textiles	-1.04	*c, tr, s*	1; 5; 8
III Paper prod.	-0.77	*c, tr, s*	1; 4	III Paper prod.	-1.55	*c, tr, s*	1
IV Petrol. prod.	-2.50	*c, s*	1; 3	IV Petrol. prod.	-1.69	*c*	1-3
V Chemicals	-2.37	*c, tr, s*	1	V Chemicals	-2.44	*c, tr*	1
VI Plastic prod.	-2.04	*c, tr, s*	1	VI Plastic prod.	-1.31	*c, tr*	1-2; 5
VII Metals	-2.69	*c, tr, s*	1; 3-4	VII Metals	-2.78	*c, tr, s*	1; 8
VIII Machinery	-0.52	*c, tr, s*	1; 4	VIII Machinery	-1.23	*c, tr, s*	1-2; 4-5
IX Computers	-0.70	*c, tr*	1-2	IX Computers	1.50	*c, tr*	1
X Electr. equip.	1.20	*c, tr, s*	1; 4	X Electr. equip.	0.36	*c, tr, s*	1; 4
XI Motor veh.	-1.19	*c, tr, s*	4	XI Motor veh.	-0.51	*c, tr, s*	0
Foreign competitors' prices				**Commodity prices**			
Foreign deflator of total sales	-3.01	*c, tr*	1	Food	-3.06	*c, tr*	1
				Spun yarn	-2.58	*c, tr, s*	0
US producer prices computer	-0.91	*c, tr, s*	1; 4	Cellulose	-3.20^{*}	*c, tr, s*	1
				Crude oil	-2.11	*c*	1
Exchange rates				Iron and steel	-0.98	*c, tr, s*	1
External value of domestic currency	-2.76	*c, tr*	1	Non-ferrous metals	-4.71^{***}	*c, s*	1; 3
US dollar/ domestic currency	-1.90	*c*	1				

[61] The MacKinnon critical values generated by Eviews across the sample 1976 Q1-2005 Q1 are -3.49^{***} /-2.89^{**} /-2.58^{*} for the model with a constant and -4.04^{***} /-3.45^{**} /-3.15^{*} taking into account a constant and a trend at the 1% (***) /5% (**) /10% (*) levels of significance.

[62] Here, *c* denotes a constant, *tr* a trend and *s* seasonal dummies.

Tests for cointegration

To test the long-run relationship between the time series used in equation (5) and (6) for cointegration, the Johansen procedure is conducted on the VECMs for the 11 product categories across both the west German sample and the pan-German period. The system variables included in the individual VECMs are identical with the specification in Table 2. In addition, centered seasonal dummies are factored in. It is shown that the null hypothesis that the system's rank is zero is rejected in each model at a significance level of 5%.[63]

Table 9: Tests for cointegration

Group		Sample	Number of system variables	Number of lags (first differences)	Trace test statistic (rank = 0)
I	Food	WG	5	1	91.86
		G	**5**	**0**	**85.46**
II	Textiles	WG	5	0	233.34
		G	**5**	**0**	**96.92**
III	Paper products	WG	5	0	189.87
		G	**5**	**0**	**101.17**
IV	Petroleum products	WG	5	0	217.76
		G	**5**	**0**	**149.93**
V	Chemicals	WG	4	1	63.28
		G	**4**	**1**	**66.57**
VI	Plastic products	WG	5	0	201.21
		G	**5**	**0**	**126.82**
VII	Metals	WG	6	0	194.17
		G	**6**	**0**	**147.79**
VIII	Machinery	WG	4	1	59.01
		G	**4**	**0**	**104.55**
IX	Computers	WG	4	0	51.04
		G	**4**	**0**	**67.73**
X	Electrical equipment	WG	4	0	181.57
		G	**4**	**0**	**94.67**
XI	Motor vehicles	WG	4	1	52.95
		G	**4**	**0**	**51.52**

[63] The critical values for rank $= 0$ generated by Eviews are 47.86 /69.82 /95.75 for the model with 4/5/6 system variables.

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