Pricing to Market of German Exporters: Evidence from Panel data *

Martin Falk* und Rahel Falk**

*Centre for European Economic Research, Mannheim

**Heidelberg University

published in: Empirica 2000, 27, 1, 21-46

Abstract: This paper investigates price discrimination of German exporters across different foreign markets. We examine the degree of pass-through of exchange rate fluctuations in the pricing of 70 export items. The model is estimated using panel data on export unit values. Parameter estimation relies on GMM first difference, fixed effects, LAD, OLS first difference, and the random coefficients model. The main results for 70 manufactured goods and 15 destination countries between 1990-1994 are: The degree of pricing to market differs among destinations and products. Highest pricing to market is observed for the U.S., Japan, Italy and Spain. Pricing to market is more prevalent in exports of chemicals and fertilisers than in machinery products.

Keywords: Pricing to market, law of one price, panel data
JEL Classification: F12, F14, L13, L60

Corresponding author:
Martin Falk
Centre for European Economic Research
L7,1 D-68161 Mannheim
Tel.: (0621) 1235-153
Fax: (0621) 1235-225
E-Mail: falk@zew.de

* The first author thanks the German Science Foundation (DFG) for financial support within the programme 'Industrial Economics and Input Markets', the second author appreciated financial help from the BMW AG. We benefited from lively discussions with participants of the 1997 annual meeting of the European Economic Association in Toulouse, France, and participants of the 1997 meeting of the 'Verein für Socialpolitik' held in Bern, Switzerland. We are indebted to Florian Heiss for excellent research assistance. Furthermore, we thank Herbert Buscher for excellent comments and suggestions on an earlier draft. Finnally, we thank Nancy Carollo and Sandra Kneile for proof-reading.

1 Introduction

The recent swing in the DM/Pound exchange rate has revitalised the old debate on potential impacts of exchange rate movements on traded good prices and trade volume. As this relationship is of particular interest to the public, several economists have dedicated their research effort to theoretical and empirical analyses of the underlying mechanisms that link exchange rate changes to the pricing behaviour of exporters and importers.[1] Despite the interest of policymakers, only few disaggregated studies on German exporters' pricing behaviour in the nineties exist, a rare exception being the recent study of the Deutsche Bundesbank (1997). This paper aims to fill this gap.

As is it well-known, on perfectly competitive markets the relative change of exchange rates as well as changes of marginal costs are completely transmitted to output prices. To put it the other way round: incomplete competition may lead to incomplete price adjustments. In the literature this incomplete pass-through is called 'pricing to market' or PTM in short. More precisely, PTM describes the phenomenon of mark-up adjustments in response to exchange rate changes (Knetter, 1989, 1993).[2] The exporter then typically aims to protect market share during currency appreciation by cutting off profit margins. In this sense PTM may be interpreted as some strategic pricing behaviour.

There are two ways to examine the impact of exchange rates on prices.[3] One branch of the literature models a price-discriminating monopolist selling on both domestic and export markets (see for example Branson and Marston, 1989). Using this approach and exploiting data from aggregate time series, the Deutsche Bundesbank (1997) studied PTM-behaviour for the 1975-1997 period and found a long-run PTM coefficient of –0.10. Non-EU and EU countries were distinguished in a second step. For the latter they found a higher short run exchange rate pass-through and concluded that pricing to market behaviour is different for different destination markets.

A second approach uses panel data rather than time series data. The typical panel data approach includes multiple products exported to several destinations. Using fixed effects models, Knetter (1989, 1993) found that German exporters adjust their profit margins to stabilise $-prices on goods exported to the United States. For Italian exports, Arcangelis and Pensa (1997) found PTM to be higher for exports shipped to the U.S. as compared to Germany or France. For the 1988-1996 period they estimated a PTM-elasticity of -0.53 for the United States, for Germany and France the respective elasticities are –0.42 and -0.15,

[1] Theoretical studies include Dornbusch (1987), Baldwin (1988) and Krugman (1987), and a major reference for empirical studies is Knetter (1989, 1993).

[2] Incomplete pass-through also arises, of course, whenever appreciation of some currency is correlated with increases in world demand and whenever industry marginal costs are increasing. Though the pass-through remains incomplete, this has nothing to do with PTM-behaviour as long as the exporter does refrain from price-discrimination across destinations.

[3] For a recent survey see Knetter and Goldberg (1996).

respectively. Some studies include the exchange rate volatility as an additional regressor, its impact on export prices proves to be weak, however (Clark and Faruquee, 1997). Arcangelis and Pensa (1997) found that exchange rate volatility is in general not significant.

A major advantage of the panel data approach consists in the possibility of testing deviations from the law of one price (LOP henceforth) which states that in the absence of trade distortions prices for identical goods should be equal across destinations. Knetter (1997) analysed the LOP for 37 German seven-digit export categories in the 1973-1987 period. He found that exports to Japan are systematically more expensive than exports to the U.S. market. The magnitude of that premium ranges from 10-45 percent. Ceglowski (1994) tested absolute and relative versions of the LOP for eighteen German and U.S. export products for the 1974-1990 period and also reported considerable deviations from the above rule.

In this paper we will test violations of the LOP for the 1988-1994 period. The main purpose of this paper, however, is to analyse the price adjustment behaviour to exchange rate changes on various export markets. Since it is more likely that the identical good assumption holds for exports than for imports, we concentrate on exports, not on imports. This paper updates Knetter’s microeconomic evidence of German pricing behaviour by providing a much broader cross-country look where products enter the sample at an extremely detailed level (8 digit level). Whereas previous research basically focused on industry specific PTM behaviour for large export markets, we include small destination countries as well (for example the Nordic countries and Switzerland). Moreover, the inclusion of Spain and Italy, where bilateral exchange rates became volatile after 1992, allows us to study the impact of the ERM crisis.

Second, this paper makes several contributions concerning estimation techniques. Measurement errors in unit values which are very likely to come up will be addressed by median regression methods. Also non-parametric methods are used to analyse non-linearities between exchange rate changes and price changes. Furthermore, GMM first difference methods are used to study dynamic relationships and simple fixed effects, while OLS first difference estimates are applied for the sake of comparison. Eventually Random coefficients models enable us to answer the question whether PTM is rather an industry-specific or a country-specific phenomenon.

In sections two and three we formulate a simple theoretical model of the relationship between exchange rates and export prices, the standard empirical framework as well as some extensions. Section four describes the data, results are discussed in section five. The last chapter summarises our basic findings.

2 Theoretical background

The theoretical concept of PTM is based on a simple model of a profit maximising domestic firm which acts on different export markets i=1,2,...,N. We assume that this firm sells a homogenous product and that demand in each destination market follows normal demand schedules. Destination markets are separated which means that price transmissions are exclusively related to the transactions of a single supplier. Furthermore we assume marginal costs to be constant over destination and quantity, thereby ruling out that incomplete exchange rate pass-through on local prices is *not* explained by PTM-behaviour (compare footnote 2). Under these circumstances price differences in the exporter's currency are a function of the price elasticities on the export market only. Assuming finally that the exporter is a major supplier of some good, import demand will be negatively sloped. In such a situation the quantity supplied determines the price level and vice versa. More formally, profit earned on a specific market i = 1,2,...,N at time t = 1,2,...,T can be expressed as follows:

(1) $\pi_{it} = p_{it} q_{it}(e_{it} p_{it}) - C_t(q_{it}(e_{it} p_{it}))$ with

π_{it} profit on market i at time t
p_{it} price on market i in exporter's currency
q_{it} quantity demanded by destination market i
e_{it} exchange rate measured in buyer's currency per unit of seller's currency
$C_t(\cdot)$ cost function.

In this notation a depreciation of the foreign currency (domestic currency) is indicated by a relative increase (decrease) in e_{it}.
The exporter's profits are maximised if marginal revenue on each market i is equal to the common marginal costs (MC). Rearranging this condition, we find:

(2) $p_{it} = MC_t \left| \frac{\eta_{it}(e_{it} p_{it})}{\eta_{it}(e_{it} p_{it}) - 1} \right|,$

where η_{it} denotes the demand elasticity with respect to prices on market i at time t measured in buyer's currency and expressed in absolute terms.[4] That is, the profit-maximising local export price is a mark-up over marginal cost. This mark-up again is determined by the elasticity of demand in the corresponding export market.
For illustrating purposes let us assume that the currency of some importing country depreciates against the exporter's currency, namely against the DM. Ceteris paribus the FOC for profit-maximisation (eq. 2) no longer hold. The

[4] Demand elasticity is transformed to its absolute value simply to ease the interpretation of equation (2).

exporter's reaction now crucially depends on whether and if so how the demand elasticity changes when a relative price change takes place on the destination market (column 2 Table 2-1).[5]

Table 2-1: Exchange rate transmission on local prices

	$\frac{\delta\eta_{it} / \eta_{it}}{\delta(e_{it}p_{it}) / e_{it}p_{it}}$	$\frac{\delta p_{it} / p_{it}}{\delta e_{it} / e_{it}}$	relative local price-change as compared to exchange rate changes	
case a)	0	0	$\frac{\delta(e_{it}p_{it})}{e_{it}p_{it}} = \frac{\delta e_{it}}{e_{it}}$	→ Complete Pass-Through
case b)	> 0	[-1, 0][6]	$\frac{\delta(e_{it}p_{it})}{e_{it}p_{it}} < \frac{\delta e_{it}}{e_{it}}$	→ Pricing-to-Market
case c)	< 0	> 0	$\frac{\delta(e_{it}p_{it})}{e_{it}p_{it}} > \frac{\delta e_{it}}{e_{it}}$	→ Negative PTM

The German exporter will leave DM-prices unchanged (case a) whenever the demand elasticity on export market i does not respond to local price changes. In this case local price increases on the destination market are proportional to the exchange rate increase, i.e. exchange rate movements do completely pass through. As by assumption marginal costs are set constant, the change of the DM price equals the change of the mark-up. In this scenario profit margins do not alter. The same exporter will hesitate, however, to let exchange rate changes completely pass through to local prices whenever export demand becomes more price-elastic with increasing local prices (case b). Consumers in the export market might still face a price increase but if so its extent will be less than proportional to the relative exchange rate change. Evaluated at domestic DM-prices we then observe a price fall; in order to protect market share during currency appreciation the exporter cuts off profit margins. As an extreme case local price stability implies $\frac{\delta p_{it} / p_{it}}{\delta e_{it} / e_{it}} = -1$, that is DM export prices fall by the same extent as the exchange rate rises. By the same line of argumentation mark-ups may finally increase if the elasticity of demand for the German product becomes smaller with an increase in price (case c).

Before the empirical implementation is investigated, we discuss some important criticisms of the model. Some of these may be captured by empirical

[5] In fact, matters are even more complicated: the exporter's reaction depends on his *assumption* regarding possible changes of demand elasticity in the export market.

[6] In case b) the transmission elasticity must not be less than minus one because this would imply an absolute value of the demand elasticity of less than one which in turn is not compatible with profit-maximising behaviour.

implementation, others have to be kept in mind when interpreting the results. For one, export firms may have contracts with traders in the importing country in which case prices and quantities of the product in concern are fixed. The question of market power then becomes immaterial: exporters are simply not able to react to exchange rate changes immediately. For second, possible reaction lags have to be kept in mind. Estimating a static model might give evidence for incomplete transmission which is not necessarily due to market power but to adjustment costs. In the empirical part of the paper we therefore apply a partial adjustment model which allows a distinction between long-run and short run pricing to market behaviour. Thirdly, marginal transaction costs may vary over time and across destinations. In this case mark-ups over marginal costs are straightforward. This consideration will be picked up in section 3 where destination- and time dummies are modelled.

3 Empirical model[7]

A straightforward empirical specification of equation (2) is given by

(3) $\ln p_{it} = \alpha_0 + \alpha_1 \ln MC_t + ß \ln e_{it} + u_{it}$.

This log-transformed model is particularly useful as the coefficients of interest, viz. $\beta = \frac{\partial p_{it}}{\partial e_{it}} \frac{e_{it}}{p_{it}}$ and $\alpha = \frac{\partial p_{it}}{\partial MC} \frac{MC}{p_{it}}$ are directly estimated.

PTM thus occurs whenever $\hat{\beta}$ is significantly different from zero and negative. More specifically, the PTM coefficient $\hat{\beta}$ exhibits the degree to which exchange rate induced price changes are offset by mark-up adjustment.

As we mentioned in the introduction, one of our aims is to explore whether PTM is rather a product-specific or a destination-specific phenomenon. We therefore employ two different elementary panel data models. The first panel data model groups commodities by type, i.e. we pool across export markets and analyse how German producers of different commodities react to exchange rate fluctuations (see section 3.1). From the fixed effects model we obtain a single PTM coefficient per product. This restrictive assumption will then be relaxed and tested by means of the random coefficient model which allows the PTM-coefficients to vary across destinations.

The second panel data model groups commodities by destination countries, i.e. we pool across products and analyse in how far German exporters price discriminate between export markets depending on which country experiences currency fluctuations (section 3.2). From the fixed effect model we obtain a

[7] This section is based on Knetter (1989, 1991) and Knetter and Goldberg (1995).

single PTM coefficient per destination. Again this simplifying assumption will be relaxed and tested later by means of the random coefficient model.

3.1 PTM using data grouped by commodities

An empirical specification such as equation (3) contains marginal costs on which data are generally not available. Taken in consideration that marginal costs accrue in the producing country we introduce time-dummies w_t which capture effects of factors altering prices to all destinations in a common manner. The corresponding time effects (γ_t) are therefore identical across destinations. Besides the inclusion of time effects our specification contains time-invariant group dummies d_i. For the approach that groups by commodities group dummies vary across countries. The corresponding country effects λ_i pick up differences in product quality across destination markets and/or reflect different *levels* of mark-up over marginal costs. The resulting equation (4) is a two-factor fixed effect model where the problem of multicollinearity - time and group dummies both sum to one - is avoided by imposing the restriction $\sum_{t=1}^{T} \gamma_t = \sum_{i=1}^{N} \lambda_i = 0$ on each of the total 70 product price equations to be estimated:

$$(4)\quad \ln(P_{it}^{ex}) = \alpha_0 + \lambda_i d_i + \gamma_t w_t + ß \cdot \ln(e_{it} / PPI_{it}) + u_{it},$$

where i=1,...,N and t=1990,...,1994 indicate destination of exports and time, respectively; $u_{it} \sim N[0, \sigma_u^2]$.

P_{it}^{ex}	DM export price to destination i in period t.
PPI_{it}	Manufacturing producer price level on destination market i in period t[8]
e_{it}	Bilateral exchange rate measured in buyer's currency per unit of seller's currency
w_t	Time dummies $= \left(\begin{Bmatrix} 1 \text{ for } 90 \\ 0 \text{ for } 91-94 \end{Bmatrix}, \ldots, \begin{Bmatrix} 0 \text{ for } 90-93 \\ 1 \text{ for } 94 \end{Bmatrix} \right)$
d_i	Destination dummies $\lambda_i = \left(\begin{Bmatrix} 1 \text{ for country } 1 \\ 0 \text{ for country } 2-15 \end{Bmatrix}, \ldots, \begin{Bmatrix} 0 \text{ for country } 1-14 \\ 1 \text{ for country } 15 \end{Bmatrix} \right)$

The parameters to be estimated are the overall constant (α_0), destination-specific constants (λ_i), time effects (γ_t) and the common PTM-coefficient for all

[8] Adjustment of DM-export prices should be neutral to changes in the nominal exchange rate induced by inflation in the destination market (Knetter, 1993). Exchange rates are therefore divided by producer price indices in the destination market.

destinations (ß). $\hat{\beta} < 0$ catches classical PTM. For $\hat{\beta}$= -1, exchange rates will be fully absorbed in profit margins which leaves prices in foreign currency unchanged. At the other extreme, if the null hypothesis H_0: $\hat{\beta}$=0 cannot be rejected, complete pass-through is observed. When the overall constant captures the average export price for some arbitrary commodity (averaged across destination markets), λ_i indicates to what extent the export price to destination i deviates from α_0. Differences in the intercept (λ_i) might result from quality differences across different destination markets, product differentiation or differing demand elasticities.

Next, we apply the random coefficients model and estimate N pricing to market coefficient $\hat{\beta}$. The underlying assumption is that each country's parameter vector $ß_i$ varies from mean vector ß by a vector of random errors v_i that is,

$$(5)\ ß_i = \beta + v_i,\ v_i \sim N[0, \sigma_v^2].$$

To eliminate time effects and destination-specific fixed effects, we subtract destination means and year means, respectively, so that equation (4) reduces to

$$(6)\ \ln(\tilde{P}_{it}^{ex}) = ß_i \cdot \ln\left(\frac{\tilde{e}_{it}}{PPI_{it}}\right) + \tilde{u}_{it},$$

where $\tilde{u}_{it} \sim N[0, \sigma_u^2]$, $\ln(\tilde{P}_{it}^{ex}) = \ln(P_{it}^{ex}) - \frac{1}{T}\sum_{t=1}^{T} \ln(P_{it}^{ex}) - \frac{1}{N}\sum_{i=1}^{N} \ln(P_{it}^{ex})$, and

$$\ln\left(\frac{\tilde{e}_{it}}{PPI_{it}}\right) = \ln\left(\frac{e_{it}}{PPI_{it}}\right) - \frac{1}{T}\sum_{t=1}^{T} \ln\left(\frac{e_{it}}{PPI_{it}}\right) - \frac{1}{N}\sum_{i=1}^{N} \ln\left(\frac{e_{it}}{PPI_{it}}\right).$$

Equations (5) and (6) are estimated by applying Aitken generalised least squares. Furthermore, homogeneity tests will be conducted in order to test the appropriateness of this alternative specification.

3.2 PTM using data grouped by destinations

According to the previous section we estimate one equation per product. The second panel data set groups commodities by destination countries, so the number of "individuals" j (=products) now amounts to 70. Since marginal cost are product specific and identical for all export markets, we cannot approximate them by time effects anymore. Instead, we subtract mean German export prices at time t (where the mean is taken across destinations):

$$\ln(\overline{P}_{jt}^{ex}) = \ln(P_{jt}^{ex}) - \frac{1}{N}\sum_{i=1}^{N} \ln(P_{ijt}^{ex})$$

In this specification, time-invariant group dummies d_j are defined as

$$d_j = \left(\begin{cases} 1 \text{ for product } 1 \\ 0 \text{ for product } 2-70 \end{cases}, \ldots, \begin{cases} 0 \text{ for product } 1-69 \\ 1 \text{ for product } 70 \end{cases} \right).$$

The corresponding product effects λ_j measure to what extent the export price of product j deviates from the average export price (α_0) of the aggregate commodity bundle shipped to a specific destination country. Group effects λ_j thus reflect product heterogeneity.

For the 1990-1994 period we applied the following fixed effects model to each of our 15 destinations markets:

$$(7)\ \ln(\overline{P}^{ex}_{jt}) = \alpha_0 + \lambda_j d_j + \beta \cdot \ln(e_t / PPI_t) + u_{jt},$$

where perfect collinearity is ruled out by imposing the restriction $\sum_{j=1}^{J} \lambda_j = 0$.

Besides α_0 and λ_j we estimated the PTM coefficient ß. $\hat{\beta}<0$ means that exchange rate movements induce German exporters (across all industries) to adjust profit margins for a particular destination, while an insignificant coefficient $\hat{\beta}$ indicates pass-through pricing strategy with respect to some export market i.

Secondly, we estimated the above equation in first differences applying the least absolute deviations estimator (LAD henceforth) for a median regression model. Here estimates are obtained by minimising the sum of the absolute rather than the sum of the squared residuals. This approach aims to correct for possible measurement errors which are likely to arise when export unit values are taken as a proxy for export prices.[9] LAD is also robust to non-normality of the error term. By equation (7') we aim to run an outlier-robust regression:

$$(7')\ \ln(\overline{P}^{ex}_{jt}) - \ln(\overline{P}^{ex}_{jt-1}) = \alpha + \beta \cdot [\ln(e_t / PPI_t) - \ln(e_{t-1} / PPI_{t-1})] + (u_{jt} - u_{jt-1})$$

For third one could argue that short-term effects of exchange rates on prices are distinct from their long-run effects and set up a partial adjustment model:

$$(8)\ \ln(\overline{P}^{ex}_{jt}) - \ln(\overline{P}^{ex}_{jt-1}) = \alpha + \varphi[\ln(\overline{P}^{ex}_{jt-1}) - \ln(\overline{P}^{ex}_{jt-2})] +$$

$$+ \xi \cdot [\ln(e_t / PPI_t) - \ln(e_{t-1} / PPI_{t-1})] + (u_{jt} - u_{jt-1}),$$

where φ captures the adjustment parameter and ξ the short-run PTM coefficient.[10] As the error term is correlated with the lagged dependent variable,

[9] In our sample nine percent of the observations show year-to-year growth rates of export unit values that exceed +/- 30%. Especially small countries exhibit high fluctuations.

[10] Note that in (7') and (8) a constant term α is re-introduced after lagged values have been subtracted.

estimation of equation (8) has to rely on instrumental variable techniques. We applied the one-step Arellano/Bond estimator, tested for the absence of (second order) serial correlation and the validity of the over-identifying restrictions.
Finally, the random coefficient model allows PTM coefficients to vary across products j. To eliminate product-specific fixed effects we subtract year means from equation (7) which leaves us with

$$(9)\ \ln(\overline{P}^{ex}_{jt}) - \frac{1}{T}\sum_{t=1}^{T}\ln(\overline{P}^{ex}_{jt}) = ß_j\left[\ln(e_t/PPI_t) - \frac{1}{T}\sum_{t=1}^{T}\ln(e_t/PPI_t)\right] + \tilde{u}_{jt},$$

where $ß_j$ is the outcome of some random process with mean vector $ß$.

3.3 PTM using data grouped by commodities and destinations

As we mentioned earlier, the fixed effects from equation (4) measure to what extent a product's export price to some destination deviates from its average export price across all destinations. In this sense the null H_0: $\lambda_i=0\ \forall i$ implies the validity of the law of one price (LOP). The respective sample period covers only five years, however, so the estimated country effects will not be very precise. Another approach to test deviations from the LOP is a simple cross country regression of relative export prices against a set of (N-2) destination dummy variables λ_i[11]:

$$(10)\ \left(P^{ex}_{ij}/P^{ex}_{numeraire,j}\right) = \alpha_0 + \sum_{i=1}^{N-2}\lambda_i d_i + u_{ij}.$$

For $\hat{\lambda}_i = 0$ the respective price differential will be zero and thus deviations from the LOP must be rejected.

4 Data description and stylised facts

In order to construct export prices we select German export values and quantities to several major destinations from the EUROSTAT COMEXT CD-ROM 'Trade by Commodities'. Export values are measured net of transportation, insurance and tariffs (f.o.b.) and are expressed in units of 1000 ECU. Dividing export values by quantities, we constructed export *unit* values. These export unit values, however, reflect only biased measures of true prices since the composition of some aggregate commodity bundle will change with

[11] One observation is lost for the numeraire and one for the reference group.

changing relative prices. We aim to minimise this bias by using highly disaggregated data on the eight-digit level.

Finally, to gain export unit values in the exporter's currency (DM), we multiplied export unit values with the DM/ECU rate. Manufacturing producer price indices and exchange rates are taken from the International Financial Statistics and OECD main economic indicators.

Product categories were chosen according to the following criteria: For one, total export values of selected products had to amount to at least 50 million ECU. Secondly, product categories had to be relatively homogenous (such as vitamin C, organic chemical products, fertilisers and aluminium foils and plates). For third, some products entered the sample because they are important export items in German manufacturing such as offset-printing machinery, packing or wrapping machinery or machinery for filling, closing, sealing or labelling bottles and last but not least cars.[12] For fourth, a significant amount of the product in concern had to be shipped to industrialised countries, as developing countries generally follow quite protectionist trade policies and resulting prices are highly distorted.

When PTM is addressed the sample period covers 1990-1994. For destinations to qualify the respective currency had to fluctuate in its value against the DM. For the Netherlands, France, Belgium, Denmark and Austria, for example, exchange rate variations against the DM are negligible, so we dropped these countries from the exchange rate regressions. Furthermore, destinations had to import German products equivalent to 500,000 ECU. This leaves us with relatively large destinations which is of some help to improve the accuracy of unit values. In total the data set contains 3730 product-destination-year observations and up to 15 destinations. The general structure of the data set is balanced panel. However, for four out of 70 products either 1988 or 1994 values are not available, so the panel become unbalanced.

When the LOP is addressed the period extends to 1988-1994 and those ERM countries excluded above enter the sample. This data contains 7017 destination-year observations, approximately 1,000 for each cross-section.

To obtain first evidence for the validity of the LOP we calculated for each product and year export unit values across destinations relative to the French export price and then calculated the median over products.[13] Table 4-1 reports these medians for the years 1988, 1990, 1992 and 1994. The basic message from this table is that there is some degree of price discrimination across destinations thereby violating the LOP. In 1994 exports to Italy and Spain are charged 8 and 9% lower as compared to the French export price. In contrast, German export prices in Japan and Korea exceed benchmark export prices by 14 to 33%. For large European markets such as Italy, Great Britain and Spain

[12] Offset printing machines are important to such a degree that they entered the sample despite there is no 1994 data available on this item.

[13] Alternatively, one could choose the average export unit value as the numeraire.

monopsonistic market power might be an important factor explaining departures from the above rule as exports to large destinations are expected to be cheaper than exports to small markets.

Table 4-1: Relative Export Unit Values (Medians), 1988-1994[a]

country	1988	1990	1992	1994	Numb. of items
Australia	1.07	1.12	1.08	0.99	40-41
Austria	0.98	1.03	0.99	1.04	63-64
Belgium	1.00	1.01	1.00	1.04	64-65
Canada	0.99	1.00	1.06	1.03	35
Denmark	1.01	1.03	0.98	1.02	57-58
Finland	1.07	1.06	0.98	1.00	47
France	1.00	1.00	1.00	1.00	69-70
Great Britain	1.00	0.99	1.01	0.98	65-66
Greece	1.02	1.02	0.94	0.96	39
Italy	1.00	1.02	0.99	0.92	68-69
Japan	1.15	1.20	1.21	1.33	46-47
Korea	1.16	1.23	1.12	1.14	29
Netherlands	0.97	0.97	1.00	1.03	66-68
Norway	1.05	1.05	1.10	1.02	45-46
Portugal	0.96	1.01	1.00	0.99	41
Singapore	1.03	1.06	0.99	1.02	26
Spain	0.98	1.00	0.95	0.91	64-66
Sweden	1.04	1.03	1.02	1.01	63-64
Switzerland	1.08	1.08	1.10	1.15	67-68
U.S.	0.95	1.01	1.06	1.08	62-64

[a]Export unit value to destination i relative to the French export unit value.

Source: Eurostat , own calculations.

It is difficult, however, to separate price discrimination among different export markets from product differentiation or differences in quality. Finally, differing demand elasticities may also explain observed price differentials across markets. It should not be surprising, for instance, to find relatively high export prices in Japan and Switzerland.

Table 4-2 presents changes of destination specific export prices, exchange rates and producer indices.

Table 4-2: Changes of destination specific export prices[a], exchange rates and manufacturing producer price index' (selected destinations)

country	growth rates of	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94
Finland	export price (49)	2.3	-0.3	-1.8	-3.2	1.2	-0.3
	ex. rate Markka/DM	-4.3	3.6	2.9	16.3	18.6	-7.1
	producer price	5.9	2.1	-0.1	2.5	3.8	1.5
Great Br.	export price (66)	3.4	-0.3	3.6	-0.7	-3.0	1.3
	exch. rate Pound/DM	1.5	7.0	-2.0	6.6	10.0	-0.2
	producer price	4.8	5.9	5.6	2.3	3.7	2.9
Italy	export price (69)	6.0	0.5	0.2	1.0	-7.8	-2.8
	exch. rate Lira/DM	-1.5	1.6	0.8	5.4	18.7	4.3
	producer price	6.4	7.4	3.3	1.9	3.7	3.8
Japan	export price (47)	4.1	6.0	2.0	1.5	3.4	6.0
	exch. rate Yen/DM	0.6	20.0	-9.9	-0.1	-18.7	-6.6
	producer price	2.6	2.1	0.2	-0.9	-1.7	-1.7
Norway	export price (46)	2.4	0.8	1.4	1.8	-5.0	-0.5
	exch. rate Kronor/DM	-1.0	5.3	0.8	1.9	7.5	1.3
	producer price[b]	5.5	3.7	2.6	0.0	0.0	1.4
Spain	export price (66)	7.2	2.9	-0.6	-1.8	-2.8	-5.1
	exch. rate Pesetas/DM	-5.2	0.2	-0.8	4.6	16.1	7.0
	producer price	4.2	2.1	1.5	1.3	4.8	4.3
Sweden	export price (64)	3.0	-0.5	2.7	0.6	-2.9	-0.2
	exch. Rate Kronor/DM	-1.7	6.6	-0.5	2.3	23.3	1.0
	producer price	7.7	4.4	2.0	-0.5	5.5	4.6
U.S.	export price (64)	7.9	-2.0	5.3	-2.9	3.2	-1.3
	exch. Rate US-$/DM	-6.8	15.2	-2.7	6.1	-5.7	1.9
	producer price	5.0	2.1	1.2	1.2	1.3	0.6

[a] median of year-to-year growth rates. Maximum number of products in parentheses. [b] For Norway (and Greece) general wholesale price index.

Source: IMF, OCED main indicators, EUTOSTAT COMEX CD-ROM.

The most striking feature is that changes in export unit values (expressed in DM) are related to changes in nominal and real bilateral exchange rates.[14] Apart from some exceptions, growth rates of DM export prices and of nominal exchange rates are of opposite sign. This indicates that exporting firms partially adjust export prices to the exchange rate shift and accept decreasing profit rates. Secondly, the figures do not seem to support the hypothesis of lagged adjustment, except perhaps for Spain. At the product level, extreme PTM

[14] Real exchange rates are not explicitly listed. However, they can easily be calculated as the difference between changes in nominal exchange rates and producer prices.

adjustment is observable for household dishing washing machines exported to Italy: in 1992, a household dishing washing machine produced in Germany cost Lira 0.54 million (or 690 DM).[15]
In 1994, the same dishwasher cost 0.522 million Lira (or 530 DM), suggesting local price stability, whereas DM prices decreased by 30 percent. Since German exporters maintained their Lira prices in Italy DM prices decreased by the same amount as the real exchange rate did.
To conclude this chapter we present some non-parametric evidence for the impact of exchange rate changes on export price changes (compare Figure A-1 in the Appendix). Non-parametric methods are used to analyse non-linearities between exchange rate and price changes. A Gaussian kernel is used and the bandwidth is 0.05. The results are fairly robust if other than Gaussian kernels are used (e.g. Epanechinikov). The kernel fits imply that adjustment of prices accelerates with increasing exchange rate changes and that - apart from Spain - export prices in DM actually fall once the nominal exchange rate divided by the destination-specific PPI exceeds some lower critical level of about 5 percent. As German exporters cannot afford to decrease prices ad infinitum and profit margins are limited, the burden of rising exchange rates is passed over to foreign consumers once an upper critical level is reached. However, this upper critical level varies from country to country suggesting that pricing behaviour is submitted to long-term strategic considerations. We pick up this issue in section 5.4.

5 Estimation results

As mentioned above two panel data models and one cross section analysis are applied. The first panel data model groups commodities by type. The number of ”individuals” (=destinations) is rather small (up to 15). Using fixed effects and random coefficients models, we investigate how German producers of different commodities react to exchange rate fluctuations. The second panel data model groups commodities by destination countries. For this panel the number of ”individuals” (=products) ranges between 26 for Korea and 69 for Italy. Estimating static as well as dynamic panel data models, we analyse to what extent German exporters price discriminate between different export markets. Before we present the PTM results, tests of deviations from the LOP are presented from the third data set that groups by commodities and destinations. Here we consider 18 countries.

[15] Individual product specific export unit values are not reported.

5.1 Law of one price

Table 5-1 presents the results for the hypothesis that the LOP price holds across destinations. We simply regressed the product specific export unit value relative to the French export unit value against a set of dummy variables (e.g. destinations), the omitted regional dummy variable being Belgium. To correct for measurement error, the LAD estimator for a median regression model has been applied. From Table 5-1 we find that the coefficients of the destination dummies within the EU are not significant except for Italy and Spain in 1994 (when DM export prices in Italy and Spain were about 13 percent lower as compared to other EU-destinations). One explanation for the stable relative prices within Europe is much closer real economic integration. For Italy and Spain the widening price gap in 1994 compared with previous years indicates pricing to market behavior. Outside the EU there is some evidence for deviations from the LOP. This is especially true for Japan where coefficient are quite large, ranging from 0.14 in 1988 to 0.39 in 1993. This equals to an elasticity of 14 % for 1988 and 29 % for 1994.[16] The significantly positive coefficients for the Japan dummy are consistent with the descriptive statistics in Table 4-1 and confirm previous empirical evidence (Knetter, 1997). German export prices are most expensive in Japan, followed by Korea and Switzerland where the coefficient proves to be positive in six out of seven years.[17] On average German export prices in Switzerland are charged 10 percent higher as compared to EU-destinations.

[16] Since the dependent variable is not in logarithm and all right hand side variables are dummies, for large coefficients the percentage effect is given by [EXP(0.34/1.33)] - 1. The enumerator is the coefficient from Table 5-1 and the denominator is the median relative export unit value from Table 4-1.

[17] Since for Korea only 26 products are available, we need to be cautious about the interpretation.

Table 5-1: Testing the law of one price; dependent variable: relative export unit value (median regression)

	1988		1989		1990		1991		1992		1993		1994	
Country	coef.	t-st.	coef.	t-st.	coef.	t-st.	coef.	t-st.	coef.	t-st.	coef.	t-st.	coef.	t-st.
Australia	0.06	1.4	0.02	0.5	0.11**	2.6	0.02	0.6	0.08**	2.0	0.06	1.2	-0.02	-0.3
Austria	-0.02	-0.4	0.05	1.4	0.02	0.7	-0.02	-0.6	-0.01	-0.2	0.10**	2.4	0.00	-0.1
Canada	-0.01	-0.3	0.04	0.8	-0.01	-0.2	0.00	-0.1	0.09**	2.0	0.04	0.8	-0.01	-0.2
Denmark	0.00	0.0	-0.01	-0.3	0.02	0.5	0.00	0.0	-0.02	-0.6	0.00	-0.1	-0.02	-0.4
Finland	0.07	1.6	0.06	1.3	0.05	1.3	-0.01	-0.2	-0.02	-0.6	-0.02	-0.5	-0.04	-0.7
Great Br.	-0.01	-0.3	0.01	0.2	-0.02	-0.5	-0.03	-1.1	0.00	0.1	-0.02	-0.4	-0.06	-1.0
Greece	0.02	0.4	0.05	1.0	0.01	0.3	-0.01	-0.4	-0.06	-1.3	0.00	0.0	-0.08	-1.3
Italy	0.00	0.0	0.04	1.0	0.01	0.3	0.01	0.3	-0.01	-0.2	-0.06	-1.4	-0.13**	-2.4
Japan	0.14**	3.4	0.25**	5.6	0.19**	4.9	0.16**	5.0	0.21**	5.2	0.39**	8.3	0.34**	5.8
Korea	0.17**	3.6	0.19**	3.7	0.22**	4.9	0.15**	4.3	0.12**	2.5	0.18**	3.5	0.10	1.4
Netherl.	-0.03	-0.9	-0.04	-1.0	-0.04	-1.2	-0.05*	-1.7	0.00	0.1	0.04	0.9	-0.01	-0.1
Norway	0.05	1.1	0.01	0.3	0.05	1.3	0.04	1.1	0.10**	2.6	0.06	1.2	-0.01	-0.2
Portug.	-0.04	-1.0	0.02	0.3	0.00	0.0	-0.03	-1.0	0.02	0.4	0.02	0.5	-0.05	-0.9
Singap.	0.03	0.6	-0.02	-0.4	0.05	1.1	0.03	0.7	-0.01	-0.2	0.08	1.4	0.00	0.0
Spain	-0.03	-0.7	0.01	0.3	-0.01	-0.3	-0.04	-1.4	-0.05	-1.4	-0.05	-1.2	-0.13**	-2.4
Sweden	0.04	0.9	0.02	0.6	0.04	1.1	0.05	1.6	0.02	0.7	0.04	0.8	-0.03	-0.6
Switzerl.	0.08**	2.0	0.07*	1.7	0.08**	2.1	0.02	0.8	0.10**	2.8	0.11**	2.7	0.12**	2.2
U.S.	-0.06	-1.4	0.02	0.6	0.00	0.0	0.08**	2.7	0.06	1.5	0.15**	3.4	0.03	0.6
constant	1.00**	37	1.00**	35	1.01**	39	1.03**	50	1.00**	38	1.00**	33	1.04**	28
Obs.	979		1012		1012		1012		1012		1012		978	
Pseudo R^2	0.024		0.025		0.020		0.025		0.027		0.026		0.036	

** (*) indicates significance at the 5 percent (10 percent) level. Dependent variable: Export unit value relative to the French export unit value. N-1 destination dummies are included. The reference group is Belgium. A positive coefficient means that export price are on average cheaper than the reference group.

Source: Eurostat, own calculations.

5.2 PTM-results using data grouped by commodities

Table A-1 in the Appendix reports estimation results of price equation (4) for all 70 products. This table lists PTM coefficients $\hat{\beta}$ (column 6) with corresponding heteroscedasticity consistent t-statistics (column 7) and the results of a likelihood-ratio test (LRT in column 9) on the appropriateness of the two-factor fixed effects model as opposed to the one-factor fixed effects model, where the latter states the absence of time-effects across destinations

($H_0: \gamma_t = 0 \ \forall t$). For the vast majority of products (44 products) we find that time effects should indeed be included in the model. Furthermore, the null hypothesis that there are no deviations from the LOP (equal prices across destinations implies H_0: $\lambda_1=\lambda_2=...=\lambda_N$) is rejected for all but three products, namely packing and wrapping machines, transmission belts and dioctyl orthophalats (compare column 8 in Table A-1). For 55 export items PTM-coefficient show the expected negative sign, although standard errors are often very high. For 25 products the PTM-coefficient $\hat{\beta}$ is significantly negative at the five percent level and for another three products at least the ten percent level holds. This means that only for 28 products German exporters are indeed willing either to cut off profit margins when the DM appreciates or to accept windfall profits when the DM depreciates.[18] Producers of titanoxyde, compounds with nitrogen function, electric magnets, contact lenses and small cars seem to have fulfilled (or even over-fulfilled) the objective of local prices stabilisation, because the PTM-coefficient for these products is close to one. Last but not least we have four products with positive coefficients which means that depreciation on the destination market induces exporters to even increase their mark-ups.[19] For these products Germany must either have a great deal of market power or alternatively: before appreciation of the DM market power has not been exploited to full extent and after currencies are re-evaluated this is corrected for.

The last three columns in Table A-1 exhibit the results for the random coefficient model as written down in equations (5) and (6). In total we get 751 PTM-coefficients (between 5 and 15 coefficients for each of our 70 sample products). It is an incredibly troublesome and laborious task to interpret all coefficients. To give a general picture instead, we found that within an industry mark-up adjustment differs highly across destinations. If one was to interpret only the overall mean of the individual predictions listed in column 10 (i.e. β in equation (5)) one would obtain twelve significant and negative PTM coefficients - all but one are also significant and negative in the FEM. Furthermore, motor cycles and diesel cars exhibit significant and positive coefficients as in the fixed effects specification. At last a likelihood ratio test is performed to test whether the assumption of identical slope-coefficients across destinations is indeed true. The null hypothesis demands all PTM-coefficients to be equal, viz. H_0: $\beta_1=\beta_2=...\beta_{15}=\beta$. In our sample LR-tests for equal coefficients are mostly rejected (compare column 12) which makes the random

[18] Specifically, PTM is observed for the following products: silicon dioxyde, titanoxyde, dioctyl orthophalat, compounds with nitrogen function, VAT dyes, pigments, pigments based on titanoxyde, paints, photographic plates, fungicides, weed killers, polymers, aluminium foils, dishing-washing machines, self-propelled work trucks, harvest threshers, DC motors, electric magnets, electric shavers, agricultural tractors, cars, trucks, crane lorries, contact lenses, microscopes and cardiographs.

[19] This result holds for piston pumps, motor cycles, diesel cars and spectrophotometers.

coefficient model indeed a more favourable specification as compared to the fixed effect model.

5.3 PTM-results using data grouped by destinations

For the panel data set that pools across products, the results from the fixed effects specification are presented in Table 5-2. The most evident finding is that there are large differences of pricing to market behaviour across destinations and that this is true regardless of the estimation technique applied (i.e. least square dummy estimator from equation (7), LAD first difference estimator for the median regression model of equation (7') or one-step GMM estimator for the model in first differences (equation (8)). For the latter, Sargan tests for the validity of the overidentifying restrictions are reported. Moreover, the instrumentation with lagged values is only valid if there is no second order correlation. Fortunately, LM tests indicates the absence of second-order serial correlation. Finally, simple OLS first difference estimates are employed for comparison.

For the estimation period 1990-94, the exchange rate coefficient is significantly negative for the United States, Italy, Spain, Finland, Norway, and Japan. Hence, pricing to market is prevailing for exports going to these countries. PTM coefficients from the fixed effect model range between -.17 for Finland and -1.14 for the United States.[20] For German products sold in Spain and Italy, a one percent real appreciation of the DM against local currency induces German exporters to reduce mark-ups by 0.31 and 0.4 percent. For the remaining countries PTM does not take place.

For Greece, Sweden, Canada and Australia this is no surprising result if one considers the low import share of these countries. Great Britain and Portugal, however, show zero pricing to market coefficient although real exchange rate changes are similar to Italy and Spain. The second finding from table 5-2 is that measurement errors in unit values seem to play only a minor role. There are slight differences in the PTM coefficients when we compare results from fixed effects or GMM estimators to those obtained from the LAD first difference estimator. For the latter PTM coefficients are mostly decreasing in absolute magnitude, the only exception being Norway. The differences ranges from -0.05 for Spain to -0.74 for the U.S. Consequently, whereas the magnitude of the deviations is of considerable extent, qualitative results are unambiguous.

[20] This PTM coefficient is sensitive concerning the starting point of the estimation, however. The inclusion of the 88/89 values raises the PTM coefficient ß to -0.20 for GMM first differences and to -.28 for the fixed effects model.

Table 5-2: PTM-Estimates, GMM first difference (equation (8)), FEM (equation (7)) and LAD first difference (equation (7’)), 1990-1994

	GMM first difference one step estimator[b]						FE model		LAD (OLS first diff.)		OBS
	φ	t-st.	ξ	t-st.	Sarg.[c]	α(LM)[d]	$\hat{\beta}$	t-st.	$\hat{\beta}$	t-stat	
Australia	.39**	2.4	-.01	-0.1	19.4	.16	-.21	-0.7	.18 (.06)	1.1 (0.2)	204
Canada	.06	0.3	-.11	-0.6	24.9	.05	.02	0.1	-.23 (.05)	-1.2 (0.2)	179
Finland	-.18	-1.3	-.25**	-2.0	18.7	.15	-.17**	-2.4	-.02 (-.06)	-0.3 (-0.5)	243
Great Brit.	.82**	2.3	.03	0.2	12.0	.74	.10	0.5	-.06 (.02)	-0.5 (0.1)	328
Greece	.08	0.6	.31	0.7	21.5	.11	.48	0.7	.84* (.65)	1.9 (0.7)	203
Italy	.32*	1.8	-.32**	-2.9	26.4	.31	-.40**	-5.4	-.22**(-.17)	-2.5 (-1.4)	343
Japan	.13	0.7	-.32**	-2.3	17.4	.82	-.38**	-4.1	-.23**(-.24**)	-2.5 (-2.3)	233
Korea	.12	0.4	.05	0.2	13.1	.39	-.20	-0.5	.00 (.14)	0.0 (0.6)	128
Norway	.51**	5.7	-.40*	-1.9	20.7	.02	-.37**	-2.0	-.62** (-.64*)	-2.2 (-1.8)	228
Portugal	-.15	-0.6	.03	0.3	17.1	.94	-.04	-0.4	.11 (.08)	1.3 (0.6)	209
Singapore	.00	-0.1	-.20	-0.4	21.8	.35	-.59	-0.7	-.54 (.03)	-1.3 (0.1)	135
Spain	.30**	2.0	-.28**	-3.0	22.1	.75	-.31**	-4.0	-.26 (.08)	-1.4 (0.6)	323
Sweden	.53*	1.8	.07	0.6	16.2	.23	.04	0.5	.08 (.07)	1.1 (0.6)	318
Switzerl.	.70**	2.1	.20	0.7	25.5	.99	-.05	-0.2	.14 (.18)	0.4 (0.7)	338
U.S.	.41**	3.6	-1.00**	-3.7	23.0	.95	-1.14**	-5.1	-.40**(-.46**)	-3.5 (-3.8)	318
dest-15	.34**	6.2	-.12**	-2.6	21.0	.27	-.22**	-2.1	-.11**(-.10**)	-3.7 (-2.0)	3730

** (*) indicates significance at the five (ten) percent level. t-values are based on heteroskedasticity consistent standard errors (for GMM, FEM and OLS first differences).[a] OLS first differences estimates in parentheses.

[b] Instruments used are p_{i88}, w_{88} for the 1989/90-equation p_{i88}, p_{i89}, w_{89} for the 1990/91-equation; p_{i88}, p_{i89}, p_{i90}, w_{90} for the 1991/92-equation; p_{i88}, p_{i89}, p_{i90}, p_{i91}, w_{91} for the 1992/93-equation and p_{i88}, p_{i89}, p_{i90}, p_{i91}, p_{i92}, w_{92} for the 1993/94-equation and a constant. For the U.S., the starting point is 1990/91.

[c] The test statistic is asymptotic chi-squared distributed with degrees of freedom equal to the number of overidentifying restrictions (in our case this equals the number of instruments minus the number of parameters= 18). The 5 percent critical value is 26.29.

[d] Lagrange multiplier test for second order serial correlation; α gives the marginal significance level of the test statistic.

For the 1990-94 period the overall PTM coefficient for 15 destinations ranges from –0.22 for the fixed effects estimator to –0.11 for the LAD estimator. The PTM-coefficient obtained from the GMM first difference estimator is falling between these two values with a coefficient of –0.12 which translates into a long-run coefficient of -0.18 (= -0.12/(1-0.34)). These results are fairly comparable to those reported by the Deutsche Bundesbank (1997) who obtained a PTM coefficient of –0.10 for the 1977-97 period. The third result from table 5.2 is that adjustment costs do in fact matter, as adjustment parameters are significant in 8 out of 15 cases.

Table 5-3: PTM-Estimates of the RCM (equation (9)), 1990-94 (selected destinations)

Destination	$\hat{\beta}$ [a]	t-stat	Homogeneity-test [b] Chi-squar.	DF.	chemicals rubber (28-40) [c]	metal (72-83)	mach-inery (84-85)	vehicles (86-89)	optical, precision (90-92)
Finland	-0.13**	-2.8	539.8**	49	-0.02	-0.11	-0.17	-0.25	0.47
Great Britain	-0.06	-0.3	288.6**	66	-0.01	-0.14	0.41	-0.07	-0.35
Italy	-0.38**	-5.4	684.4**	69	-0.49	-0.42	-0.35	0.08	-0.51
Japan	-0.36**	-2.7	409.7**	47	-0.39		-0.34	0.00	-0.80
Norway	-0.33	-1.2	621.6**	46	-0.57	-0.30	-0.16	-0.30	-0.87
Spain	-0.30**	-4.3	728.1**	66	-0.59	-0.23	-0.02	-0.04	-0.71
Sweden	-0.02	-0.2	415.8**	64	-0.26	0.04	-0.08	-0.14	0.12
Switzerland	0.14	0.5	193.3**	68	0.10	-0.27	0.11	0.45	0.73
U.S.	-0.83**	-4.9	431.2**	64	-0.88	-0.93	-1.02	-0.71	-0.84
mean(dest-9) [d]	-0.25				-0.35	-0.30	-0.18	-0.11	-0.31

** (*) indicates significance at the five (ten) percent level.

[a] Weighted average of individual predictions. [b] LR-test of the random coefficient model against the alternative of no randomness of the PTM-coefficient. [c] Industry classifications in parentheses. [d] Includes the nine countries listed in the above table.

Table 5-3 lists the results for the random coefficient model as written down in equation (9). Except for Norway whose coefficient is not significant anymore, results from this alternative specification are quite robust. In particular, the overall mean $\hat{\beta}$ from the RCM comes closest to the estimates of the fixed effects model. The LR-test (χ^2) on homogeneity is rejected for all countries. PTM-coefficients are therefore not equal across products and hence price responsiveness to exchange rates can be expected to differ across industries. The columns of Table 5-2 show that PTM is highest in the chemical industry and lowest for vehicles.

5.4 Import share, market share and pricing to market

From the preceding sections the existence of both product-specific as well as destination-specific price discrimination can clearly be affirmed. Our final question then refers to possible causes of the observed price-discrimination. An intuitive approach is to tie pricing behaviour to import shares where the latter is defined as the value of imports from Germany divided by a country's total import value. In this sense Pick and Park (1991) claim the mark-up to be lower for large destinations than for small ones.

Table 5-4: Crosstable PTM and import share[a] for machinery products and precision instruments[b]

		PTM ($\hat{\beta}$ <-0.3)	No PTM ($\hat{\beta}$ >-0.3)
Italy	number of cases	14	10
	PTM coeff. ß (means)	-0.59	-0.23
	import share in 1990	0.51	0.51
	import share in 1994	0.55	0.49
	change 1990-94	0.04	-0.02
Spain	number of cases	9	15
	PTM coeff. ß (means)	-0.81	0.17
	import share in 1990	0.38	0.36
	import share in 1994	0.45	0.32
	change 1990-94	0.07	-0.04
Great	number of cases	7	17
Britain	PTM coeff. ß (means)	-0.86	0.40
	import share in 1990	0.44	0.38
	import share in 1994	0.43	0.38
	change 1990-94	-0.01	0.00

[a] Import shares are defined as the ratio of imports from Germany and total imports.
[b] Detailed results are listed in Table A-2 in the Appendix.

This would be especially true whenever strategic aims such as constant market shares induce firms to deviate from the short-sighted maxim of profit-maximisation. Hence, export firms accept shrinking profits in order to defend market shares. When import share is high, exporting firms face little competition from other foreign suppliers. Feenstra et al. (1996) showed that the pass-through depends positively on the exporter's share in the respective destination market. This finding is supported by Lee (1995), who found that PTM effects become larger with an increasing number of firms. By comparing our PTM estimates with import shares (changes and levels), we find more pricing to market in destinations where German exporters hold a significant share of the import volume (see Table 5-4). In 1994 (1990), the average German share in the Italian import market for 14 products priced to market comprises 55% (51%) as opposed to 49% (51%) where no PTM is observed. A similar pattern is observable for Spain where the value of imports from Germany rose by 7 percentage points in PTM-industries as opposed to a decrease of 4 percentage points in 'pass-through' industries. A counter-example, of course, is Great Britain with fairly constant import shares. For those products which are priced to market there even is a slight decline is observable.

6 Conclusion

This paper uses data on bilateral export unit values to examine the degree of German exporters' mark-up adjustment associated with exchange rate changes. We found that German exporters of manufactured goods follow a midway pricing strategy, i.e. we observed a moderate degree of mark-up adjustment mitigating the effects of exchange rate changes on single export items. Second, mark-up levels proved to be identical across export markets. This result was confirmed in a somewhat more sophisticated approach which revealed that the LOP generally holds for EU countries. Outside the EU significant price differentials are observed for Japan and Switzerland. Third, within an industry mark-up adjustment differs highly across destinations. When data is rather grouped by destinations, we found that mark-up adjustment is especially important in huge export markets such as the United States, Italy, Spain and Japan. This result proved to be robust against alternative estimation approaches. Allowing for varying slope coefficients PTM behaviour was detected mainly for exports of chemical products and to some extent for exports of the machinery sector.

References

Arcangelis G. and De, C. Pensa, 1997, 'Exchange Rate Volatility, Exchange Rate Pass-Through and International Trade: Some New Evidence from Italian Export Data', *CIDEI Working Paper* 43, Rome.

Arellano, M. and S. Bond, 1991, 'Some Tests of Specification for Panel data: Monte Carlo Evidence and an Application to Employment Equations', *Review of Economic Studies*, 58, pp. 277-297.

Baldwin, R., 1988, 'Hysteresis in Import Prices: The Beachhead Effect', *American Economic Review*, 78, pp. 773-85.

Branson, W.H. and R.C. Marston, 1989, 'Price and Output Adjustment in Japanese Manufacturing', *NBER Working Paper Series*, 2878, Cambridge, MA.

Clark, P.B., and H. Faruquee, 1997, 'Exchange Rate Volatility, Pricing to Market and Trade Smoothing', *IMF Working Paper* 126, International Monetary Fund, Washington, DC.

Ceglowski, J., 1994, 'The Law of One Price Revisited: New Evidence on the Behaviour of International Prices', *Economic Inquiry*, 32, 3, pp. 401-418.

Deutsche Bundesbank, 1997, 'Exchange Rate and Foreign Trade', *Monthly Report*, 1 (January), pp. 41-59.

Dornbusch, R., 1987, 'Exchange Rates and Prices', *American Economic Review*, 77, pp. 93-106.

European Commission, 1998, 'Nineth Report on Car Prices', *http://europa.eu.int /en/comm/dg04/ aid/en/ip97640.html.*

Eurostat, 1998, 'Trade by Commodities', Comext CD-ROM.

Feenstra R. C, J. E. Gagnon and M. Knetter, 1996, 'Market Share and Exchange Rate Pass-Through in World Automobile Trade' *Journal of International Economics*, 40, 187-207.

Greene, W., 1993, *Econometric Analysis*, Prentice-Hall, Englewood Cliffs, NJ.

Hsiao, C., 1986, *Analysis of Panel Data*, Cambridge.

Hsiao, C., 1992, ‘Random Coefficients Models’, in L. Matyas and Patrick Sevestre, eds., *The Econometrics of Panel Data*, pp. 72-94, Kluwer Academic Publishers, Dordrecht.

International Financial Statistics, CD-ROM.

Knetter, M., 1989, ‘Price Discrimination by U.S. and German Exporters’, *American Economic Review*, 79, pp. 198-210.

Knetter, M., 1991, ‘Pricing to Market in Response to Unobservable and observable Shocks’, *Dartmouth College Working Paper*.

Knetter, M., 1993, ‘International Comparisons of Pricing-to-Market Behaviour’, *American Economic Review*, 83, pp. 473-486.

Knetter, M., 1997, ‘Why are Retail Prices in Japan so High: Evidence from German Export Prices’, *International Journal of Industrial Organization*, 15, 5, pp. 549–572.

Knetter, M. and J. E. Gagnon, 1992, ‘Mark-up Adjustment and Exchange Rate Fluctuations: Evidence from Panel Data on Automobile Exports’*, NBER Working Paper* 4123.

Knetter, M. and P. K. Goldberg, 1995, ‘Measuring the Intensity of Competition in Export Markets’, *NBER Working Paper* 5226.

Knetter, M. and P. K. Goldberg, 1996, ‘Exchange Rates and Good Prices’, *NBER Working Paper* 5862.

Krugman, P. R., 1987, ‘Pricing to Market when the Exchange Rate Changes’, in S.W. Arndt and J.D. Richardson, (eds.), *Real Financial Linkages Among Open Economies,* Cambridge, MA. MIT Press, 1987, pp. 49-70.

Lee, J., 1995, ‘Pricing to Market in Korean Manufacturing Exports’, *International Economic Journal*, 9, 4, pp. 1-12.

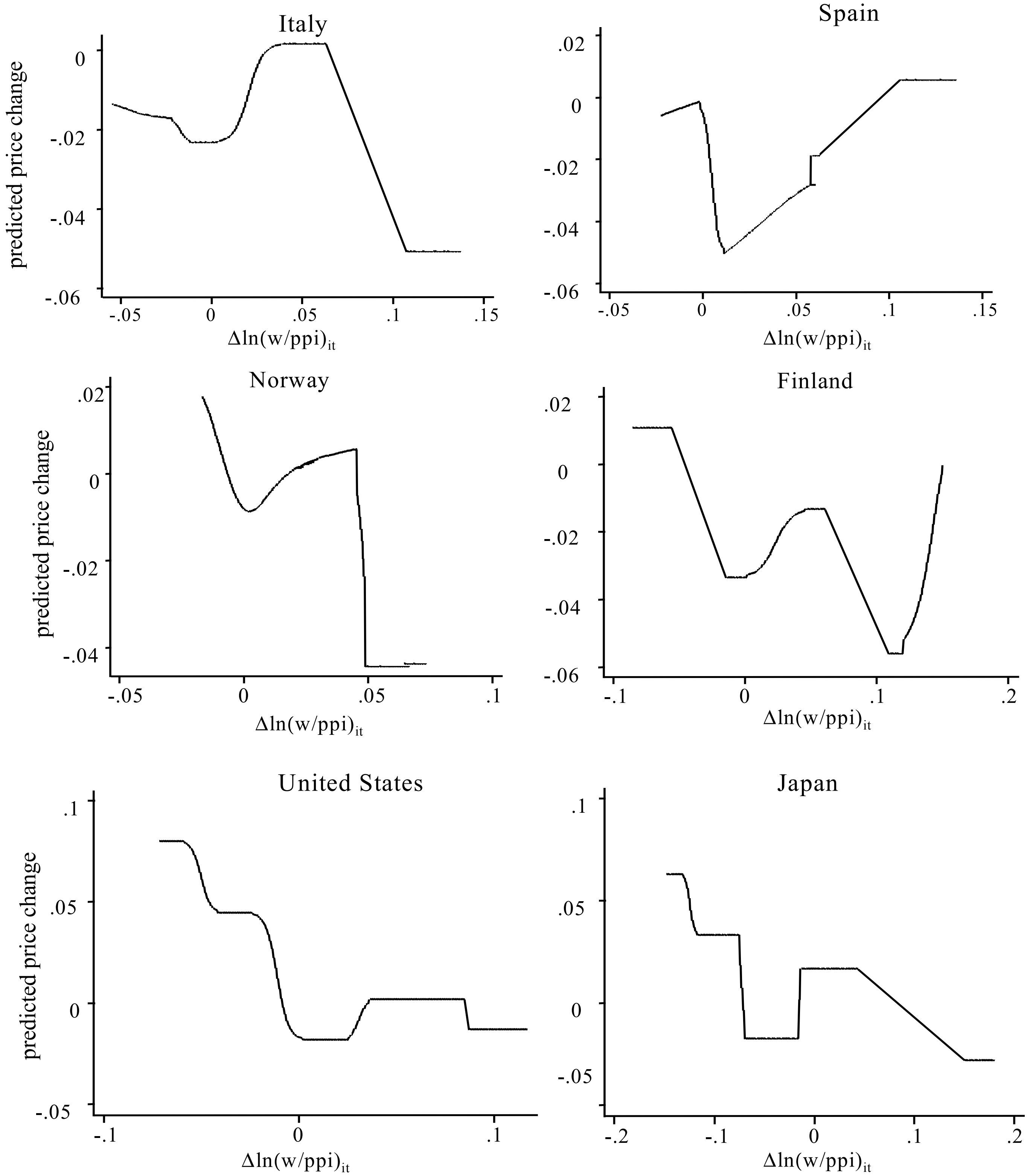
OECD, various issues, ‘Main Economic Indicators’, Paris.

Pick, D., and T. A. Park, 1991, ‘The Competitive Structure of U.S. Agricultural Exports’, *American Journal of Agricultural Economics*, pp. 133-140.

Sachverständigenrat (SVR, Council of economic advisors), 1995, ‘Im Standort-wettbewerb’, Jahresgutachten 1995/96, Stuttgart.

Appendix

Figure A-1: Nonparametric evidence: Impact of exchange rate changes on export price changes (selected destination countries)[a]



[a] Nonparametric estimation of equation (7'). The bandwidth is 0.05 and a Gaussian Kernel is used. Number of grid points is 100.

Table A-1: Product list and results for equation (4) and (6)

	Nomen-clatura	Units	Exports mill DM	Obs	Fixed Effects model				RCM		
					coeff	t-st	LRD	LRT	coeff	t-st.	LRH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
beer in containers	22030010	100 l	327	30	-.16	-1.4	79.0**	29.8**	-.24**	-2.3	8.9
beer in bottles	22030090	100 l	586	65	-.04	-1.1	116.7**	9.1	-.01	-0.1	7.3
White wine,<2L,<13%	22042121	100 l	264	35	-.26	-1.6	54.2**	24.7**	-.33	-1.0	44.1
Silicon Dioxyde	28112200	tons	361	50	-.44*	-1.9	83.3**	17.2**	-.85	-1.5	27.1
Aluminium hydrox.	28183000	tons	184	35	-.47	-0.9	102.2**	11.4**	-.42	-1.3	49.2
Titanoxyde	28230000	tons	117	20	-1.07**	-2.7	15.7**	7.6	-.08	-0.1	3.9
Dioctyl orthophalat.	29173200	tons	178	25	-.49**	-3.4	9.4	48.8**	-.48	-0.6	9.2
Amino alcohol	29221900	tons	184	20	.43	0.7	48.6**	8.1**	1.06	1.4	19.6
Compounds w. nitrog.	29291000	tons	562	44	-1.16**	-2.8	90.1**	7.4	-.92	-1.5	59.7
Vitamin B6	29362500	tons	100	45	-.14	-0.6	76.2**	15.7**	-.05	-0.1	7.0
Vitamin C	29362700	tons	233	50	-.12	-0.9	92.7**	12.1**	.04	0.1	7.8
VAT dyes	32041500	tons	283	75	-.40**	-2.7	82.6**	13.4**	-.42*	-1.9	58.3
Pigments	32041700	tons	1079	55	-.50**	-2.0	13.2**	89.2**	-.44	-1.0	56.4
Pig. bas on titanoxid.	32061010	tons	481	70	-.33**	-2.3	34.2**	24.0**	-.16	-0.3	62.5
Paints	32089910	tons	422	60	-.70**	-2.4	54.3**	34.8**	-.35	-1.0	63.1
Photographic plates	37013000	qm^2	531	65	-.80**	-2.4	153.3**	1.0	-.72**	-2.5	20.5
Fungicides	38082000	tons	781	50	-.80**	-2.4	46.1**	10.3**	-.84	-1.2	41.2
weed killers	38083000	tons	681	70	-.46**	-4.0	55.5**	73.1**	-.40**	-3.3	41.4
Polystyrene	39030000	tons	1115	65	-.26	-1.4	90.9**	31.1**	-.17	-0.9	29.7
Polyethylengykole	390720-11-19	tons	536	55	-.14	-1.1	72.4**	2.2	-.13	-0.3	104.4
epoxid resins	39073000	tons	327	75	-.06	-0.7	161.2**	8.9	-.23**	-2.2	224.2
Polyurethanes	39095000	tons	721	50	.09	0.5	84.7**	7.3	.09	0.3	13.4
Polymers	39162000	tons	631	50	-.46**	-2.1	85.7**	22.6**	-.38	-0.8	56.8
Plates of ethylane	39201090	tons	314	50	-.11	-0.5	41.6**	30.3**	-.11	-0.2	5.0
Transmission belts	40101000	tons	189	35	.18	1.2	11.0	48.0**	.03	0.0	6.0
Flat-rolled iron/steel	72092390	tons	689	40	-.26	-1.6	15.6**	59.0**	-.27*	-1.7	36.8
iron/non-alloy steel	72104910	tons	636	45	.09	0.3	38.1**	8.7	.25	0.4	16.0
Alumin. plats >0.2mm	76061191	tons	486	55	.17	1.2	74.9**	18.5**	.23	0.5	10.9
Alumin. plats <3mm	76061291	tons	744	50	-.32	-0.7	30.5**	6.1	-.62	-0.5	23.4
Alu. foil >0.2mm	76071110	tons	406	65	-.41**	-3.5	68.7**	44.8**	-.09	-0.1	26.5
Alu. foil 0.021-.02mm	76071191	tons	304	25	-.42*	-1.9	35.0**	21.5**	-.52	-1.2	11.0
Diesel engines	84081080	numb	239	25	.60	1.6	26.9**	11.1**	.54	0.8	10.5
Fluid pow. piston pumps	84135071	tons	391	70	.38**	3.3	70.6**	15.1**	.31	0.8	36.1
Centrifugal fans	84145950	tons	179	70	.29	1.1	42.8**	4.6	.43	0.7	45.4

Table A-1 continued	Nomen-clatura	Units	Exports mill DM	Obs	Fixed Effects Model coeff	t-st	LRD	LRT	RCM coeff	t-st.	LRH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Ma. f. filling/closing	84223000	tons	1342	75	-.17	-0.6	44.7**	14.9**	-.28	-0.3	44.1
Packing/wrapping ma.	84224000	tons	1551	75	-.02	-0.1	20.9	12.8**	.29	0.6	41.4
Self pro. works trucks	84271010	tons	429	65	-.40**	-2.5	84.4**	9.1	-1.46	-1.4	58.7
Combine harv-thresh.	84335100	tons	411	50	-.55**	-3.8	28.9**	51.9**	-1.03**	-2.7	40.3
Mach. f. food/bever.	84385000	tons	344	70	-.16	-0.6	28.9**	17.3**	-.08	-0.2	19.3
M. f. type found. Sett.	84421000	numb	122	45	-.22	-1.2	60.6**	23.4**	-.29	-0.5	6.3
Offset printing mach.	84431100	tons	1025	35	-.01	0.0	31.9**	8.9	1.16	0.9	34.0
Off. Print Size >29x42	84431919	tons	2386	60	-.12	-1.0	26.7**	5.5	-.10	-0.2	34.5
Inject.-mould. mach.	84771000	tons	914	75	-.27	-0.7	42.0**	8.0	.51	0.4	32.2
Ball bearings	84821090	tons	667	75	-.10	-0.3	88.9**	4.5	-.88	-0.9	91.0
Gears and Gearing	84834091	tons	656	75	.04	0.2	78.8**	4.2	.69	1.0	31.2
DC motors,=<37.5kw	85011099	numb	424	60	-.69**	-2.4	95.3**	3.4	-.83	-1.2	26.6
Ac motors >0.75kw	85015291	numb	332	75	-.41	-1.6	119.3**	14.9**	-.31	-0.5	41.9
Electric magnets	85059010	tons	222	55	-1.06**	-2.3	33.7**	49.7**	-.72	-0.8	26.7
vacuum cleaners	85091010	tons	351	65	-.17	-1.0	137.0**	2.6	-.01	-0.1	29.0
Shavers electric	85101000	numb	379	55	-.40**	-2.3	111.5**	32.9**	-.67*	-1.7	29.1
Filament lamps	85392130	numb	245	50	-.02	-0.2	72.3**	9.4**	.03	0.1	41.0
Agric. Tract.37-59kw	87019025	tons	368	60	-.48**	-3.8	86.8**	13.8**	-.29	-1.4	43.1
Agric. Tract.59-75kw	87019031	tons	795	65	-.12	-1.4	118.6**	20.4**	-.11	-0.4	85.6
motor cycle>800cm^3	87115000	tons	211	45	.51**	8.4	41.4**	21.1**	.52**	2.3	4.9
Cars 1500-3000cm^3	87032319	numb	33927	75	-.92**	-5.0	160.8**	42.4**	-.77**	-3.3	77.2
Cars >3000cm^3	87032410	numb	8937	75	-.83	-1.3	31.4**	11.5**	-.11	-0.2	22.1
Cars >2500cm^3 (diesel)	87033319	numb	651	50	.49**	4.4	70.3**	20.2**	.62*	1.8	28.7
Trucks >2500cm^3	87042131	numb	395	35	-.19**	-3.2	31.2**	24.3**	-.04	-0.2	76.2
Trucks <2500cm^3	87042191	numb	1004	45	.01	0.1	16.2**	7.0	.17	0.3	21.9
Trucks 5-20 tons	87042291	numb	1624	45	.03	0.2	132.8**	8.4	.02	0.1	26.3
Trucks < 5 tons	87042391	numb	1129	50	.23	0.5	28.9**	6.1	.65	0.4	22.6
Crane lorries	87051000	tons	493	35	-.58*	-1.9	26.5**	5.8	-.28	-0.8	13.0
Contact lenses	90013000	numb	69	50	-1.82**	-3.0	47.4**	21.1**	-1.51	-1.2	30.9
Stereros. Microscopes	90111000	tons	129	40	-.60**	-2.0	79.9**	30.9**	-.57	-0.9	8.1
Electric cardiographs	90181100	tons	302	40	-.69**	-2.6	26.3**	8.1	-.36	-0.6	33.1
Spectrophotometer	90273000	tons	296	75	.71**	2.5	66.9**	7.6	.58	1.0	36.8
infra-red instruments	90275000	tons	354	65	-.20	-0.7	35.9**	14.3**	-.63*	-1.7	57.3
Meas./check. Instr.	90318031	tons	491	75	-.15	-0.4	43.8**	8.3	.51	0.8	25.8

** (*) indicates significance at the 5 percent (10 percent) level. LRD: Likelihood-ratio test - FEM vs X's and overall constant term only. LRT: Likelihood-ratio test - Full two factor FEM vs. one factor FEM. LRH: Homogeneity test.

Source: Eurostat, IMF own calculations.

Table A-2: Import shares and PTM-coefficient for selected products[a]

		Italy			Spain			Great Britain		
		import share		$\hat{\beta}$	import share		$\hat{\beta}$	import share		$\hat{\beta}$
		1990	1994		1990	1994		1990	1994	
84135071	Hydraulic fluid power piston pumps	0.93	0.94	0.37	0.23	0.25	0.46	0.44	0.41	1.26
84145950	centrifugal fans	0.88	0.85	0.53	0.50	0.41	0.47	0.54	0.36	1.48
84221100	Dishing-washing machines	0.89	0.88	-0.72	0.22	0.57	-1.06	0.55	0.48	-0.89
84223000	Machinery f. fill.-/clos.-/seal.-/capsul.-/laballing bottles	0.53	0.28	-0.11	0.23	0.20	-0.02	0.68	0.68	0.22
84224000	Packing or wrapp. Mach.	0.33	0.31	0.20	0.64	0.39	0.26	0.41	0.41	0.42
84271010	Self propelled works trucks powered by an elect. motor.	0.30	0.67	-1.01	0.46	0.90	-1.10	0.36	0.48	-1.13
84335100	combine harvester	0.49	0.55	-0.39	0.40	0.23	-0.26	0.34	0.42	0.00
84431919	Offset printing machinery. Sheets of a size > 29.7 X 42	0.65	0.80	0.71	0.30	0.86	1.11	0.30	0.24	1.50
84771000	Injection-moulding machines	0.39	0.39	-0.05	0.79	0.65	0.08	0.45	0.58	0.27
84834091	Gears and Gearing	0.41	0.42	0.05	0.42	0.19	0.18	0.54	0.70	0.41
85011099	DC motors =<37.5 kw	0.43	0.28	-0.33	0.30	0.37	-0.04	0.12	0.38	0.00
85015291	Ac motors>750w but<7.5kw	0.48	0.64	-0.43	0.21	0.48	-0.47	0.37	0.49	0.00
85059010	Electric magnets	0.57	0.39	-0.52	0.68	0.58	-0.51	0.21	0.16	-0.13
85101000	Electric shavers	0.25	0.38	-0.31	0.35	0.22	-0.04	0.33	0.32	0.00
85392130	Wolfram halogen	0.79	0.53	-0.71	0.69	0.59	-0.94	0.53	0.90	-0.52
87019025	agricultural tractors	0.43	0.49	-0.64	0.57	0.34	-0.61	0.21	0.18	-0.35
87019031	agricultural tractors	0.64	0.43	-0.36	0.12	0.24	-0.06	0.14	0.16	0.00
87115000	motor cycle	0.29	0.15	0.35	0.28	0.04	0.27	0.58	0.26	0.46
90013000	contact lenses	0.33	0.16	-0.09	0.36	0.39	0.03	0.41	0.50	0.26
90111000	Stereomicroscope	0.80	0.55	-0.64	0.29	0.35	-0.53	0.54	0.27	-0.34
90189020	Endoscope	0.93	0.95	-1.10	0.08	0.15	-1.18	0.61	0.48	-2.38
90273000	spectrometer	0.21	0.32	-0.38	0.20	0.27	-0.14	0.26	0.29	0.00
90275000	infra-red instruments	0.17	0.60	-0.67	0.20	0.12	-0.91	0.25	0.21	-0.44
90318031	electric measuring instruments	0.41	0.65	0.37	0.32	0.14	0.30	0.34	0.17	0.71

[a] Import shares are defined as the export value shipped to destination i divided by the total destination import value. PTM coefficients are obtained from the random coefficient model (see equation 9). Half of PTM coefficients are significant at the 5 percent level. Standard errors are available upon request.

Source: Comext CD-ROM.