PRICE DISCRIMINATION AND MARKET POWER IN EXPORT MARKETS: THE CASE OF THE CERAMIC TILE INDUSTRY

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This paper combines the pricing-to-market equation and the residual demand elasticity equation to measure the extent of competition in the export markets of ceramic tiles, which has been dominated by Italian and Spanish producers since the late eighties. The findings show that the tile exporters enjoyed substantial market power over the period 1988-1998, and limited evidence that the export market has become more competitive over time.

I. Introduction

Since the late 1980s the global production of exported ceramic tiles has been concentrated in two small and well-defined industrial districts, one in Emilia-Romagna (Italy) and another in Castellon de la Plana (Spain). In 1996 these two areas constituted above 60 percent of the world export value of glazed ceramic tiles, and in several countries these exports represented over 50 percent of national consumption. Furthermore, Italian and Spanish manufacturers exported more than 50 percent of their production while other major producers, such as China, Brazil and Indonesia, exported less than 10 percent.

Although it is widely accepted that local competition is aggressive in the Italian and Spanish domestic markets, it is not clear how much competition there is between Italian and Spanish exporter groups in international markets. On one hand, market segmentation may have prevented the strong domestic competition apparent in domestic markets from occurring in export destinations. In addition, a leadership position of some producers might have allowed them to act as monopolists in some destinations. On the other hand, the increasing presence of both exporter groups in all exports markets may have eroded the market power of established exporters over time. As far as I know, this study is the first to estimate international mark-ups with data for two exporter groups that clearly dominate all the major import markets (a case of two-source-countries with multiple destinations).

To measure the extent of competition in the export markets of the tile industry, I propose a simple two-step approach. In the first step, I use the pricing-to-market equation (Knetter 1989) to estimate the marginal cost functions of both Italian and Spanish exporters. Indeed, this is a methodological contribution of the paper since previous research measuring market power in foreign markets has relied on crude proxies to measure the supply costs of the industry (such as wholesale price index or some input price indices).[1] In the case of this study, since Italian and Spanish producers are concentrated in the same area within each country, I can reasonably assume that firms in each exporter group face the same marginal cost function. In the second step, I identify which markets each exporter group had market power in, and the extent to which that market power was affected by the presence of other competitors, using the residual demand elasticity equation and the marginal cost estimates obtained in the first step.

My findings show that the tile exporters enjoyed substantial market power over the period 1988-1998, with weak evidence that the export market has become more competitive over time. There is strong evidence of market segmentation and pricing-to-market effects in the export markets of tiles. In particular, exporters adjust mark-ups to stabilise import prices in the European destinations, while they apply a "constant" mark-up export price policy in non-European markets. This finding may be explained by greater price transparency of the European destinations, in line with what Gil-Pareja (2002) finds for other manufacturing sectors. The results using the residual demand elasticity equation show positive price-above-marginal

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[1] See Aw (1993), Bernstein and Mohen (1994), Yerger (1996), Bughin (1996), Steen and Salvanes (1999), Goldberg and Knetter (1999), among others. In some papers cost proxies are derived at national rather than industrial level of aggregation.

costs occur in half of the largest destination markets. Accounting data of both source countries provide support for this outcome (Assopiastrelle 2001). Following Goldberg and Knetter (1999), I relate the extent of each exporter group's mark-up to the existence of "outside" competition in each destination market, finding that only Spanish mark-ups are sensitive to Italians' market share. Moreover, both Spanish and Italian mark-ups are insensitive to the market quota of domestic rivals, suggesting that these two exporters group have capacity to differentiate successfully their product in the international markets.

The remainder of the paper is structured as follows. Section II briefly describes the ceramic tile industry. Section III introduces the theoretical framework and its empirical implementation. Section IV examines the data, specification issues and the results, and Section V provides conclusions.

II. The ceramic tile market

Ceramic tiles are an end product that is produced by burning a mixture of certain non-metal minerals (mainly clay, kaolin, feldspars and quartz sand) at very high temperatures. Tiles have standardised sizes and shapes but have different physical qualities, especially in terms of surface hardness. Tiles are used as a building material for residential and non-residential construction with the non-residential property being the primary source of demand.

Italy, the world leader, produced 572 million square metres in 1997, compared with only 200 million square metres in 1973. Over the same period exports rose from 30% to 70% of total production. Overall, Italy's tile industry accounts for 20% of global output and 50% of the world export market. The sources of comparative advantage in Italy in the seventies and eighties comes from a pool of specialised labour force, access to high quality materials and a superior technological capacity to develop specific machinery for the tile industry.[2]

Tile makers elsewhere are catching up with the Italians.[3] In 1987 Italy was clearly the largest producer and exporter of ceramic tiles in the world. Spanish

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[2] Porter (1990) attributes the success of Italian tile producers in the international markets to fierce domestic competition coupled with the high innovation capacity of machinery engineers to reduce production costs. Porter's analysis covers the period 1977-1987 in order to explain the success of Italian producers abroad. Our study starts in 1988, year in which Spain and other large producers start gaining market quota to Italy in most export markets.

[3] The documentation of the facts in this section relies heavily on ASCER, *Annual Report 2000*, and *The Economist*, article "On the tiles", December 31st, 1998.

production started competing against Italian producers in the late 1970s, although the technological and marketing superiority of Italian producers was very clear. In 1977 Spanish production was equivalent to one-third that of Italy. In 1987 Spain's production was only one half that of Italy, but by 1997 Spanish production was equivalent to 85% of Italian output. In the same year, exports represented 52% of total Spanish production. The success of Spanish producers may be attributed to the use of high quality clay and pigments to create a new market niche in large floor tiles, and to the control of marketing subsidiaries by manufacturing companies.

The abundant supply of basic materials, low labour costs and the sheer size of population are amongst the most important factors that led to the expansion of the ceramic tile industry in China, Brazil, Turkey and Indonesia. However, the expansion in production by developing countries is strongly orientated to their respective domestic markets. In 1996 China's production was slightly below that of Italy, but its exports were only 5% of total production, while Brazil, Indonesia and Turkey exported 14%, 12% and 11% of their output, respectively. Moreover the destination markets of developing countries are mainly neighbour countries, showing the difficulties of these countries to penetrate other destination markets.

There are two reasons why Italians and Spanish tile makers maintain their leadership position in the export markets. On the one hand, because of a superior own-developed engineering technology that allows Italian and Spanish producers to elaborate high-quality tiles compared to competitors in developing countries. The best example is the high-quality porcelain ceramic tile, a product in which Italian and Spanish exporters are the absolute world leaders. On the other hand, because of the innovative designs that differentiate the product from other competitors. High quality ceramic tiles with the logos "Made in Italy" and "Made in Spain" add value to what is basically cooked mud.

Table 1 displays the distribution of the ceramic tile exports among the 19 largest destinations (accounting for 77% of world import market). Three features about these export markets are worth mentioning since they have important implications in the later empirical analysis. First, in almost all countries, imports represent more than 60% of total domestic consumption, and the import/consumption ratio is above 75% in the majority of cases. Second, in all but one market (Hong Kong), either Italy or Spain is the largest exporter, and in fourteen of the nineteen markets one of the two dominant exporting nations is also the second largest exporter. Furthermore, in all the destinations, the sum of Italian and Spanish products is above 50% of total imports and, in some cases, the ratio is above 95% (Greece, Israel and Portugal). Third, in almost every market, Italian and Spanish exporters

Table 1. Import shares and main exporters in the largest destination markets in 1996

Country	Imports (thous. m2)	Imports/ Consump. (%)	1st exporter	(%)	2nd exporter	(%)	3rd exporter	(%)	4th exporter	(%)
Germany	145,159	78	**Italy**	68	**Spain**	9	France	7	Turkey	7
USA	87,743	60	**Italy**	32	Mexico	24	**Spain**	18	Brazil	10
France	75,674	63	**Italy**	61	**Spain**	15	Germany	6	Netherlands	5
Poland	32,262	64	**Italy**	55	**Spain**	28	Czech Rep.	9	Germany	4
UK	29,382	78	**Spain**	38	**Italy**	21	Turkey	12	Brazil	7
Greece	27,577	91	**Italy**	62	**Spain**	33	Turkey	2	Others	3
Hong Kong	27,008	93	China	33	**Spain**	29	**Italy**	20	Japan	10
Belgium	22,518	98	**Italy**	53	**Spain**	14	Netherland	10	France	8
Netherlands	20,453	78	**Italy**	39	**Spain**	18	Germany	16	Portugal	4
Singapure	19,422	100	**Italy**	34	**Spain**	31	Malaysia	17	Indonesia	7
Saudi Arabia	19,276	78	**Spain**	61	Turkey	11	**Italy**	10	Libanon	6
Australia	17,703	84	**Italy**	54	**Spain**	11	Brazil	7	Indonesia	5
Israel	17,009	74	**Spain**	55	**Italy**	34	Turkey	4	Others	7
Austria	16,963	99	**Italy**	79	Germany	9	**Spain**	4	Czech Rep.	3
Portugal	15,083	28	**Spain**	97	**Italy**	2	Others	1		
Russia	14,044	21	**Spain**	27	**Italy**	24	Turkey	14	Germany	5
Canada	13,450	88	Italy	43	Turkey	14	Brazil	12	**Spain**	11
South Africa	12,418	57	**Italy**	43	**Spain**	17	Taiwan	13	Brazil	10
Switzerland	10,485	87	**Italy**	69	Germany	10	**Spain**	6	France	5

Source: Own elaboration using data from ASCER, *Informe Anual 2000*.

face competition from a neighbouring exporter group. Germany has a notable market share in the Netherlands, Austria and Switzerland while Turkey has a significant presence in Greece and Saudi Arabia.

III. The theoretical framework

For a "normal" demand curve on an international market k in a particular period t, $X_{kt} = X_{kt}(P_{kt}, Z_t)$, the supply of tiles by a profit-maximising monopolistic exporter selling to market k is given by the equilibrium output condition, where marginal revenue equals marginal cost,

$$P_{kt} = \left(\frac{\varepsilon_{kt}}{\varepsilon_{kt} - 1} \right) \lambda_t,$$

(1)

where P_k is the product price FOB in source country's currency, ε_k is the price elasticity of demand facing all firms in market k, and λ is the marginal cost of production (all at time t). As written, it states that price in source country's currency is a mark-up over marginal cost determined by the elasticity of demand in the destination market.

A. The pricing-to-market equation

Knetter (1989, 1993) showed that equation (1) can be approximated for cross-section time series data by

$$\ln P_{kt}^J = \beta_k^J \ln e_{kt}^J + \theta_k^J + \lambda_t^J + u_{kt}^J, \quad J = I, S,$$

(2)

where J refers to source country (here, Italy or Spain), k refers to each of the destination markets and t refers to time. The export price to a specific market becomes a function of the bilateral exchange rate expressed as foreign currency units per domestic currency, e_{kt}; a destination-specific dummy variables, θ_k, capturing time-invariant institutional features; and, a set of time dummies, λ_t, that primarily reflects the variations in marginal costs of each exporter group. A random disturbance term, u_{kt}, is added to account for unobservable factors by the researcher, or for measurement error in the dependent variable.[4]

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[4] Sullivan (1985) defined the conditions under which the use of industry-level data can be used to make inferences about the extent of market segmentation using equation (1): (i) the industry

The advantage of the pricing-to-market (PTM) equation as an indicator of imperfect competition is its simplicity and clear interpretation. First, if $\theta_k \neq 0$ the null hypothesis of perfect competition in the export industry is rejected since the exporter firm is able to fix different FOB prices for each destination; and, if $\beta_k \neq 0$ firms may adjust their mark-ups as demand elasticities vary with respect to its local currency price.[5]

A second advantage of the PTM equation is that it allows me to test for similarities in pricing behaviour between exporter groups in different source-countries by comparing the β coefficients across destinations.

A third advantage of using the PTM equation is that I can incorporate a variable that proxies time varying marginal costs for each exporter group, under the assumptions that it is common to all destination markets. This measure is precise when the elasticity of demand is constant so the mark-up is fixed over marginal cost. When the mark-up is sensitive to exchange rate changes and there is a correlation between shocks to the cost function and the exchange rates, changes in marginal costs will affect all prices equally so there is no idiosyncratic effect on prices, and the time effects will account for the impact of such shocks. In that case, even when the time effects obtained from the PTM equation are not the marginal costs exactly, "… there is no reason to think that they are biased measures of marginal cost, only noise ones" (Knetter 1989, p. 207).

has no influence over at least one factor that changes the supply price; (ii) there is little variation in the perceived elasticity of demand and in the marginal costs across firms selling in the same destination market, and that (iii) no arbitrage opportunity exists across destinations. The three conditions are satisfied in the export markets of tiles. First, exchange rate variation is exogenous to the tile industry. Second, the cost of production differences across exporters are likely to be small since ceramic tiles are produced with a standard technology in a single region of each of the dominant exporting countries. Third, the physical characteristics of tiles make arbitrage highly unlikely.

[5] The parameter β_k has also an economic interpretation as the exchange rate pass-through effect. On the one hand, a zero value for β_k implies that the mark-up to a particular destination is unresponsive to fluctuations in the value of the exporter's currency against the buyer's. On the other hand, the response of export prices to exchange rate variations in a setting of imperfect competition depends on the curvature of the demand schedule faced by firms. As a general rule, when the demand becomes more elastic as local currency prices rise, the optimal mark-up charged by the exporter will fall as the importer's currency depreciates. Negative values of β_k imply that exporters are capable of price discrimination and will try to offset relative changes in the local currency induced by exchange rate fluctuations. Thus, mark-ups adjust to stabilise local currency prices. Positive values of β_k suggest that exporters amplify the effect of exchange rate fluctuations on the local currency price.

Once the cost structure of the competitors is ascertained, we are able to measure the extent of competition in the export markets using the residual demand elasticity approach.

B. The residual demand elasticity equation

How exchange rate shocks are passed through to prices in itself reveals little about the nature of competition in product markets. Indeed, the interpretation of the PTM coefficients depends critically on the structure of the product market examined (Goldberg and Knetter 1997). To assess the importance of market power in the export industry, I directly measure the elasticity of the residual demand curve of each exporter group.

The residual demand elasticity methodology was first developed by Baker and Bresnahan (1988) to avoid the complexity of estimating multiple cross-price and own-price demand elasticities in product differentiated markets. The residual demand elasticity approach has the advantage of summarising the degree of market power of one producer in a particular market in a single statistic. Recently, Goldberg and Knetter (1999) successfully applied a residual demand elasticity technique to measure the extent of competition of the German beer and U.S. kraft paper industries in international markets.

Consider two groups of exporters, Italians and Spaniards, selling in a particular foreign market (therefore we omit the subindex k). The inverse demand curve includes the export price of the other competitor and a vector of demand shifters,

$$P^J = D(X^J, P^R, Z), \;\; J = I,\, S \,; R = \text{rival}\,, \tag{3}$$

where X^J stands for the total quantity exported by the J exporter group (note that I use the letter J to refer to Italy or Spain and the letter R to refer to rival), P is the price expressed in destination country's currency terms, and Z is a vector of exogenous variables affecting demand for tile exports. The supply relations for each exporter group are

$$P^J = e^J \lambda^J + X^J D'_J v^J, \;\; J = I, S, \tag{4}$$

where λ^J reflects the variations in marginal costs of each exporter group, D'_J is the partial derivative of the demand function with respect to X^J and v^J is a conduct parameter.

The estimation of the market power of each exporter group requires the estimation

of the system of equations (3) and (4). A way to avoid estimating these equations simultaneously is to estimate the so-called residual demand equation. The approach does not estimate the individual cost, demand and conduct parameters, but it captures their joint impact on market power through the elasticity of the residual demand curve.

The first step in deriving the residual demand curve is to solve (3) and (4) simultaneously for the price and quantities of the rival exporter group,

$$P^{R*} = P^{R*}\left(X^J, e^R \lambda^R, Z, v^R\right), \; J = I, S; R = \text{rival}. \tag{5}$$

P^{R*} is a partial reduced form; the only endogenous variable on the right-hand side is X^J. The dependence of P^{R*} and X^J arises because only the rivals' product has been solved out. By substituting P^{R*} into (3), the residual demand for each exporter group ($J = I$ or S) is obtained:

$$P^J = D(X^J, P^{R*}, Z) = R\left(X^J, e^R \lambda^R, Z, v^R\right) J = I, S; R = \text{rival}. \tag{6}$$

The residual demand curve has three observable arguments: the quantity produced by the exporter group, the rival exporter group cost shifters and demand shifters and one unobservable argument (the rivals' conduct parameters).

For each destination k, we can estimate a reduced form equation of the following general form:

$$\ln P^J_{kt} = \alpha^J_k + \eta^J_k \ln X^J_{kt} + \beta^R_k \ln e^R_{kt} + \gamma^R_k \ln \lambda^R_{kt} + \delta_k \ln Z_{kt} + v_{kt},$$
$$J = I, S; \; R = \text{rival}. \tag{7}$$

Equation (7) is econometrically identified for each exporter group since cost shifters for each exporter group are excluded arguments in their own residual demand function. In each expression the only endogenous variable is the exported quantity X^J. I can use both e^J and λ^J as instruments since both variables affect the exported supply of the exporter group in a particular destination independently of other exporter groups competing in the same destination market. Exchange rate shocks rotate the supply relation of the exporting group relative to other firms in the market, helping us to identify the residual demand elasticity.

Baker and Breshanan (1988) review the cases in which the residual demand elasticity correctly measures the mark-up over marginal cost: Stackelberg leader case, dominant firm model with competitive fringe, perfect competition, and markets with extensive product differentiation. In other oligopoly models the equality

between the relative mark-up and the estimated residual demand elasticity breaks down. However, even in these cases, a steep residual demand curve is likely to be a valid indicator of high degree of market power. In the ceramic tile industry, the estimated residual demand elasticity may be a good approximation to the mark-ups, since the industry is characterised by substantial product differentiation, and both source countries (especially Italy) have enjoyed a dominant position in the world market.

IV. Data, estimation and results

A. The data

The data consist of quarterly observations from 1988:I to 1998:I on the values and quantities of ceramic tiles exports (Combined Nomenclature Code 690890) from Spain and Italy to the largest market destinations. The prices of exports are measured using FOB unit values. As far as I am aware, no country produces bilateral export price series, which is probably the main justification for the use of unit value to measure bilateral export prices. The drawbacks of using unit values as an approximation for actual transaction prices are well known. The most serious problems are the excessive volatility of the series and the effect on prices of changes in product quality over time (Aw and Roberts 1988). However, any purely random measurement error introduced by the use of unit values as a dependent variable will only serve to reduce the statistical significance of the estimates.

The analysis includes sixteen export destinations (60 percent of world import market): Germany, USA, France, United Kingdom, Greece, Hong-Kong, Belgium, Netherlands, Singapore, Australia, Israel, Austria, Portugal, Canada, South Africa and Switzerland. Spanish and Italian exports represented between 48 and 99 percent of total imports in each of these markets in 1996.[6]

The destination-specific exchange rate data refer to the end-of-quarter and is expressed as units of the buyer's currency per unit of the seller's (unit of destination market currency per home currency).

As explained above, the exporter's marginal cost function for ceramic tiles is obtained directly from the estimation of the PTM equation. Demand for ceramic tiles in each destination market is captured by two variables: building construction

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[6] Three large destination markets (Poland, Saudi Arabia and Russia) were excluded from our analysis due to data limitations.

and real private consumption expenditure. All the series in the empirical analysis are seasonally adjusted. An Appendix contains more details about the sources and construction of the variables for the interested reader.

B. Evidence of pricing-to-market effects

In order to assess the potential for price discriminating behaviour on the part of Italian and Spanish exporters, I start by comparing the response of export prices to exchange rate variations in each of the major destination markets. For a comparable export product, differences in prices across export markets can be attributable to market segmentation. If the null of perfect competition is rejected, price discrimination is possible so exporters may enjoy market power in those destinations.

Equation (2) is estimated by Zellner's Seemingly Unrelated Regression technique (Zellner 1962) to improve on efficiency by taking explicit account of the expected correlation between disturbance terms associated with separate cross-section equations. The model is estimated with two different exchange rate measures, the nominal exchange rate in foreign currency units per home currency, and the nominal exchange rate adjusted by the wholesale/producer price index in the destination market. The exchange rate adjustment is made, because the optimal export price should be neutral to changes in the nominal exchange rate that correspond to inflation in the destination markets. Estimated coefficients of the destination-specific dummy variables, θ_k, reveal the average percentage difference in prices across markets during the sample period, conditional on other controls for destination-specific variation in those prices. In practice, only (N-1) separate values of θ_k can be estimated in the presence of a full set of time effects. Consequently, I will normalise the model around West Germany, the world largest import market, and test whether the fixed effects for the other countries are significantly different from zero. Results for the two source-countries, Italy and Spain, are reported in Table 2. For each destination the Table reports the estimates of the country effects θ_k and the coefficient on the exchange rate β_k.

Using either exchange rate measures, the destination specific effects are significantly different from zero in almost all the cases.[7] These results provide evidence against the hypothesis of perfect competition. Looking at the estimated

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[7] F-tests for the exclusion of the country effects are overwhelmingly significant: 3486 for Italy and 4970 for Spain.

Table 2. Estimation of price discrimination across export markets

	Nominal exchange rate		Foreign price adjusted nominal exchange rate	
	θ_k^J	β_k^J	θ_k^J	β_k^J
Destination k - source country J = Italy				
Germany		-0.59 (0.127)***		-0.53 (0.117)***
United States	-0.34 (0.037)***	0.15 (0.150)	-0.32 (0.031)***	0.12 (0.127)
France	-0.09 (0.032)***	-0.90 (0.132)***	-0.14 (0.028)***	-0.71 (0.104)***
UK	-0.04 (0.032)	-0.25 (0.230)	-0.05 (0.029)*	-0.26 (0.123)**
Greece	-0.41 (0.030)***	-0.54 (0.161)***	-0.35 (0.048)***	0.08 (0.110)
Hong-Kong	-0.45 (0.037)***	-0.07 (0.148)	-0.45 (0.030)***	-0.03 (0.132)
Belgium	-0.12 (0.032)***	-0.23 (0.125)*	-0.11 (0.030)***	-0.23 (0.124)*
Netherland	-0.08 (0.032)**	-0.57 (0.126)***	-0.09 (0.030)***	-0.58 (0.131)***
Singapore	-0.33 (0.037)***	-0.07 (0.180)	-0.34 (0.046)***	0.03 (0.163)
Australia	-0.16 (0.033)***	0.00 (0.168)	-0.14 (0.029)***	-0.10 (0.131)
Israel	-0.51 (0.030)***	-0.40 (0.121)***	-0.62 (0.044)***	-0.37 (0.095)***
Austria	-0.05 (0.032)	-0.57 (0.127)***	-0.09 (0.050)***	-0.56 (0.127)***
Portugal	-0.37 (0.030)***	-0.35 (0.246)	-0.39 (0.032)***	-0.18 (0.081)**
Canada	-0.29 (0.040)***	1.03 (0.261)***	-0.21 (0.028)***	0.69 (0.161)***
South Africa	-0.34 (0.033)***	-0.03 (0.137)	-0.29 (0.036)***	-0.35 (0.134)***
Switzerland	-0.02 (0.032)	-0.22 (0.114)*	-0.03 (0.030)	-0.24 (0.122)*
Destination k - source country J = Spain.				
Germany		-0.69 (0.130)***		-0.68 (0.111)***
United States	-0.29 (0.034)***	0.21 (0.137)	-0.28 (0.027)***	0.08 (0.112)
France	-0.04 (0.030)	-0.84 (0.134)***	-0.10 (0.024)***	-0.80 (0.095)***
UK	-0.01 (0.029)	-0.70 (0.183)***	-0.07 (0.025)***	-0.60 (0.107)***
Greece	-0.45 (0.028)***	-0.12 (0.117)	-0.44 (0.043)***	0.03 (0.101)
Hong-Kong	-0.42 (0.034)***	0.04 (0.136)	-0.41 (0.026)***	-0.03 (0.116)
Belgium	0.03 (0.030)	-0.24 (0.128)*	0.04 (0.026)*	-0.43 (0.118)***
Netherland	0.11 (0.030)***	-0.56 (0.128)***	0.12 (0.026)***	-0.72 (0.124)***
Singapore	-0.25 (0.033)***	0.20 (0.158)	-0.29 (0.039)***	0.30 (0.136)**
Australia	-0.14 (0.030)***	0.34 (0.148)**	-0.11 (0.025)***	0.03 (0.116)
Israel	-0.13 (0.027)***	0.61 (0.091)***	-0.27 (0.038)***	0.73 (0.083)***
Austria	0.19 (0.030)***	-0.56 (0.129)***	0.20 (0.026)***	-0.72 (0.121)***
Portugal	-0.11 (0.028)***	-0.10 (0.293)	-0.16 (0.028)***	-0.29 (0.073)***

Table 2. (Continued) Estimation of price discrimination across export markets

	Nominal exchange rate		Foreign price adjusted nominal exchange rate	
	θ_k^J	β_k^J	θ_k^J	β_k^J
Canada	-0.14 (0.036)***	-0.39 (0.222)*	-0.17 (0.025)***	-0.37 (0.141)***
South Africa	-0.24 (0.029)***	0.92 (0.109)***	-0.22 (0.032)***	0.81 (0.127)***
Switzerland	0.03 (0.029)	0.06 (0.112)	0.04 (0.027)	0.09 (0.115)

Note: SUR Estimation, N=41. ***, ** and * indicate significance at the 1%, 5% and 10% level Heteroskedasticity robust standard errors in parenthesis. Exchange rate series are expressed as destination market currency per source country currency and normalised to 1 in 1994:1. Wholesale price are used to adjust exchange rates.

β_k, the regression with nominal exchange rates indicates that 9 export markets for Italy and 10 export markets for Spain violate the invariance of export prices to exchange rates implied by the constant-elasticity model (at 10 % significance level). The regression with adjusted exchange rates increases the number of export markets to 11 for Italy and 11 for Spain for the same significance level. There is evidence of imperfect competition with constant elasticity of demand ($\theta_k \neq 0$ and $\beta_k = 0$) for most non-European markets (see USA, Hong Kong, Singapore, Australia) in one or another source-country. In most European destinations, tile exporters perceive demand schedules to be more concave than a constant elasticity of demand ($\theta_k \neq 0$ and $\beta_k < 0$) revealing that exporters are able to price discriminate by offsetting the relative price changes in the local currency price induced by exchange rate fluctuations. A plausible explanation is that tile exporters have an incentive for price stabilization in the local currency in the European markets while there is a lack of significant stabilisation across non-European markets. In other words, European destinations are more competitive than non-European ones in the export tile industry. Theories explaining PTM behaviour such as large fixed adjustment cost differences across destinations (Kasa 1992) or concerns for market share varying with the size of the market (Froot and Klemperer 1989) seem unlikely to explain this dichotomy in price behaviour. An alternative explanation could be the greater price transparency in the European markets over the period 1988-1998, together with the fact that the number of firms selling in the European markets is larger than in the non-European markets. This interpretation coincides with the predictions of the Cournot oligopoly model (Dornbusch 1987).

A surprising feature of our results is that destination-specific mark-up adjustment is very similar across source countries for each destination country. In order to examine in more detail the pattern of price discrimination across destinations we re-estimate Equation (2) under the assumption that $\beta_k = \beta$ across destination markets (Knetter 1993). The t-statistics of the first row in Table 3 indicate that the PTM coefficients are significantly different from zero for each exporter group. The reported F-statistic reveals that the null hypothesis of identical PTM behaviour across destination markets is rejected at the 5 percent level. The second row in Table 3 offers a test of whether the identical PTM behaviour is supported across only European destinations, leaving the non-European market coefficients unconstrained. The last column of Table 3 offers pooled regression results. In it, the constrained coefficients across destination markets for each source country are additionally constrained to be the same for both source countries. The reported F-statistic reveals that the null hypothesis of identical PTM behaviour across source countries cannot be rejected at the 5 percent level. Therefore export price-adjustment behaviour is different across the range of destination countries for each source country but on aggregate both source countries have similar export price-adjustment behaviour.

The results allow me to conclude that the export price-adjustment in response to exchange rate variations is on average 30 percent, implying that more than half of the exporter's currency appreciation or depreciation are passed through to import prices (after controlling for country-specific effects and time effects). The low sensitivity of domestic currency prices to changes in exchange rates provides

Table 3. Testing for identical pricing-to-market behaviour across destination

	Italy	Spain	Pooled
Constrained β_k (all destinations)	-0.256 (0.063)***	-0.304 (0.067)***	-0.292 (0.045)***
F-test	F(15,584) = 21.52***	F(15,584) = 11.57***	F(1,599) = 0.46
Constrained β_k (Europe only)	-0.281 (0.072)***	-0.401 (0.064)***	-0.337 (0.038)***
F-test	F(8,584) = 8.41***	F(8,584) = 11.94***	F(1,592) = 2.14

Note: F-statistic tests the null hypothesis that PTM coefficient is the same across export destinations. For the pooled regression, F-statistics test the null that PTM coefficient is the same for both source countries. *** indicates significance at the 1% level. Heteroskedasticity robust standard errors in parenthesis.

indirect evidence of the existence of positive mark-ups in the export markets of tiles. The next questions to be addressed are how much market power each tile producers has. To do that first I need an estimate of the marginal costs of each exporter group.

C. Estimating marginal costs

In this section, I present the estimates of the coefficients on the time dummy variables, λ_t, which capture variations in marginal costs of exporters. Figure 1 plots the indexes of the estimated time effects from the regression with price-level adjusted exchange rates for Italy and Spain.[8] The estimated marginal costs of both exporter groups are relatively flat over the sample and exhibit less volatility than producer price indices, used in past studies to control for marginal cost changes.[9] Therefore, if the time effects estimated in the PTM equation are better measures of the true marginal cost changes, using producer price indices as a proxy probably underestimate the role of mark-up adjustments in explaining the response of local currency prices of exports in relation to exchange rates changes (Knetter 1989).
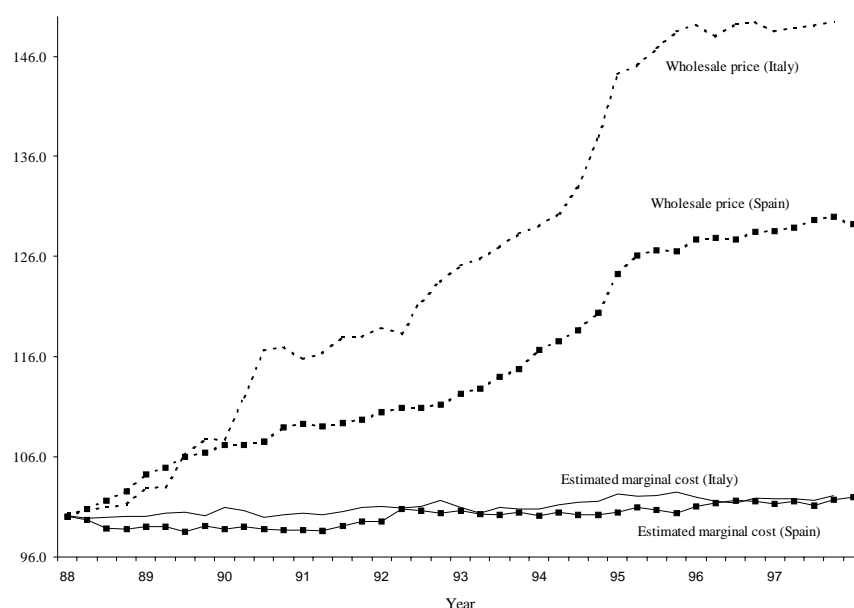
D. Estimating the residual demand elasticities

Equation (7) is estimated for each of the destinations, $k = 1,\ldots16$. Each equation is in double log form so that the coefficients are elasticities. The cost shifter λ_t^J is the estimated time effect of each exporter group J derived from the pricing-to-market equations in the previous section. The demand shifters Z_{kt} consist of a combination of the construction index, real private consumption, the nominal exchange rate of a third competitor and a time trend.

If the exported quantity $\ln X_{kt}^J$ and its price are endogenously determined through the residual demand function, then OLS provides biased and inconsistent estimates. Three-stage least squares (3SLS) is employed to estimate separately each of the 16 systems of two equations. The exogeneity assumption of the exported quantity is testable by comparing the 3SLS and seemingly unrelated regression (SUR) estimates using the Hausman-Wu test statistic (Hausman 1978). The choice

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[8] Although the estimated time effects have been normalised in Figure 1, the residual demand elasticity equation uses the actual estimated coefficients. The mean and standard deviation statistics of the estimated time effects are (9.49, 0.070) for Italy and (6.97, 0.071) for Spain.

[9] It is interesting to point out that our results are opposite to those of Knetter (1989) who found that the estimated time effects trend upwards over the sample and exhibit higher volatility.

Figure 1. Estimated marginal costs for Italian and Spanish producers

of an appropriate instrument in the 3SLS is a crucial step. It is necessary to obtain a set of instrumental variables that are correlated with the exported quantity but not with the error term of the residual demand function in each equation. The ideal candidates are the cost shifters and exchange rate of the source-country, as they have been excluded from each equation as regressors. It is easy to check that the system is identified due to exclusion of the cost shifter and exchange rate of the source-country in its own equation and the possible combination of four exogenous demand shifters in each equation.

Results of my preferred specifications by 3SLS appear in Table 4. The last column reports the p-value of the Hausman-Wu test for the null hypothesis of exogeneity of log quantity after estimating the model with (3SLS) and without instrumental variables (SUR). The null hypothesis is rejected in about half of the specifications at 10 percent significant level, suggesting that IV techniques are necessary to control for endogeneity in the equation system. The R^2 and Durbin-Watson statistics vary substantially across destinations and source countries.

The coefficient on the log quantity directly estimates the residual demand elasticity. If I interpret the η_k^J parameters as estimates of the exporter's group mark-up of price over marginal cost, Italy and Spain had a significant market power

Table 4. Measuring the residual elasticity of demand in export markets of ceramic tiles

	η_k^J	β_k^R	γ_k^R	R^2	D-W	H-W
Destination k - source country J = Italy						
Germany	-0.362 (0.105)***	0.518 (0.319)	-6.496 (2.177)***	0.37	1.75	0.1
United States	-0.460 (0.196)**	0.533 (0.280)*	5.686 (4.194)	0.49	2.31	0.00°
France	-0.363 (0.132)***	0.582 (0.251)**	9.408 (3.027)***	0.63	1.71	0.40
UK	-0.885 (1.833)	1.632 (1.011)	26.706 (19.763)	0.05	1.63	0.0°
Greece	-0.417 (0.077)***	0.655 (0.402)	4.342 (3.736)	0.91	1.93	0.08°
Hong-Kong	-0.718 (0.379)*	-0.309 (0.271)	7.960 (7.921)	0.73	1.90	0.00°
Belgium	-0.428 (0.423)	1.792 (0.999)*	0.895 (2.600)	0.12	2.05	0.20
Netherland	-0.317 (0.130)**	0.981 (0.285)***	11.235 (3.980)***	0.45	2.22	0.01°
Singapore	-0.472 (0.355)	0.830 (0.318)**	1.154 (6.955)	0.21	2.03	0.12
Australia	-0.042 (0.111)	1.190 (0.235)***	4.995 (1.822)***	0.71	2.30	0.06°
Israel	-0.231 (0.179)	0.455 (0.620)	11.391 (7.923)	0.68	1.44	0.18
Austria	-0.409 (0.237)*	-0.014 (0.221)	-1.602 (4.948)	0.12	1.67	0.38
Portugal	-0.099 (0.073)	0.753 (0.395)*	-0.839 (2.167)	0.45	1.87	0.54
Canada	-0.782 (0.338)***	-1.352 (0.354)***	3.017 (2.321)	0.45	1.87	0.05°
South Africa	-0.662 (1.835)	0.120 (1.923)	-14.298 (18.207)	0.02	1.71	0.17
Switzerland	-1.139 (0.615)*	2.510 (0.861)***	11.404 (5.365)**	0.49	1.72	0.16
Destination k - source country J = Spain						
Germany	0.412 (0.723)	0.854 (0.972)	8.848 (11.480)	0.04	1.25	0.12
United States	-0.372 (0.134)***	0.483 (0.250)*	8.180 (2.927)***	0.69	1.73	0.00°
France	-0.135 (0.066)**	0.718 (0.161)***	11.432 (2.799)***	0.73	2.26	0.40
UK	0.019 (0.081)	0.720 (0.282)**	12.44 (2.771)***	0.67	1.24	0.01°
Greece	-0.060 (0.278)	0.518 (0.884)	-1.615 (4.179)	0.58	1.64	0.08°
Hong-Kong	-0.259 (0.124)**	-0.704 (0.175)***	3.914 (3.143)	0.74	2.18	0.00°
Belgium	0.111 (0.377)	0.883 (0.677)	11.172 (5.929)*	0.29	1.40	0.20
Netherland	-0.466 (0.430)	0.478 (0.682)	4.410 (4.087)	0.25	1.61	0.0°
Singapore	-0.713 (0.447)*	0.597 (0.338)*	3.044 (9.333)	0.61	2.15	0.12
Australia	0.068 (0.056)	1.530 (0.139)***	7.262 (2.539)***	0.84	1.41	0.06°
Israel	-0.136 (0.078)*	0.399 (0.533)	6.890 (10.93)	0.74	2.10	0.18
Austria	0.106 (0.286)	0.369 (0.328)	2.124 (2.053)	0.00	2.28	0.38
Portugal	-0.192 (0.073)**	-0.079 (0.156)	-1.353 (2.511)	0.75	2.20	0.55
Canada	-0.063 (0.063)	-0.341 (0.419)	2.259 (7.084)	0.05	1.57	0.05°

Table 4. (Continued) Measuring the residual elasticity of demand in export markets of ceramic tiles

	η_k^J	β_k^R	γ_k^R	R^2	D-W	H-W
South Africa	-0.145　(0.092)	0.678　(0.251)***	3.032　(5.763)	0.60	1.57	0.17
Switzerland	-0.009　(0.132)	1.174　(0.243)***	14.265　(5.144)***	0.65	1.52	0.16

Notes: Each destination is estimated jointly for Italy and Spain using 3SLS estimator. Dependent variable: log-price of exports in local currency. Reported independent variables are log-quantity of exports, log-exchange rate between destination country and the direct rival country, and marginal cost of direct rival country. Additional omitted exogenous variables may include the construction index, log-real private consumption, time trend and log-neighbour rival exchange rate in the destination market. ***, ** and * indicate significance at the 1%, 5% and 10% level. Standard errors are reported in parentheses. P-values reported for the Hausman-Wu test (H-W) test the endogeneity of log sales $(\ln X^J, J=I, S)$. ° indicates p-value < 0.10.

over nine and six destinations respectively. For example, the residual demand elasticity for Italy in the three largest markets is 0.362 (Germany), 0.460 (US) and 0.363 (France) corresponding to a mark-up over marginal cost between 36 and 46 percent. Although Spain shows no market power in Germany, its residual demand elasticity for US and France are 0.372 and 0.135, respectively. Looking at the rest of the destinations, Italy's mark-up over marginal cost was on average 40 percent while Spain's were about 10 percent. This finding is consistent with Italy having a leadership role in the industry.

The interpretation of the rest of the coefficients in each equation is unclear since they may reflect both direct effects on demand and indirect effects through the adjustments of a rival exporter's group; therefore I do not report them. Columns 3 and 4 in Table 4 display the estimated coefficients of the rival's adjusted exchange rate and marginal costs. The positive sign of the coefficients reflects the significant role of "outside" competition in constraining the market power of a particular exporter group. In general, the coefficients of the other exporter group's exchange rate and marginal costs are positive (and for some destinations significant), indicating that the market power of one or another exporter group in most destination markets is constrained by the presence of the other exporter group.[10]

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[10] When I estimated the residual demand elasticity equation using the wholesale price index instead of the estimated marginal cost obtained from the PTM equation, the sign of the significant coefficients for log-exchange rate and marginal cost of direct rival country did not change. However, the magnitude of the estimated coefficient of the log-quantity of exports

Table 5. Relationship between residual demand elasticity and rivals' market share

Source country: Italy	Residual demand	Spain market share	Domestic share	Source country: Spain	Residual demand	Italy market share	Domestic share
Switzerland	**-1.139**	6.2	13.0	Singapore	**-0.713**	34.4	0.3
UK	-0.885	38.3	21.5	Netherland	-0.466	38.8	22.4
Canada	**-0.782**	10.7	12.2	USA	**-0.372**	31.8	39.9
Hong-Kong	**-0.718**	29.3	7.4	Hong-Kong	**-0.259**	20.0	7.4
South Africa	-0.662	17.4	42.5	Portugal	**-0.192**	1.9	72.4
Singapore	-0.472	30.5	0.3	South Africa	-0.145	43.1	42.5
USA	**-0.460**	17.6	39.9	Israel	**-0.136**	34.2	26.1
Belgium	-0.428	14.1	2.1	France	**-0.135**	61.2	36.8
Greece	**-0.417**	32.8	9.4	Canada	-0.063	43.1	12.2
Austria	**-0.409**	3.8	1.5	Greece	-0.060	62.1	9.4
France	**-0.363**	15.3	36.8	Switzerland	-0.009	69.2	13.0
Germany	**-0.362**	8.5	22.3	UK	0.019	20.5	21.5
Netherland	**-0.317**	18.1	22.4	Australia	0.068	54.4	16.2
Israel	-0.231	54.8	26.1	Austria	0.106	79.3	1.5
Portugal	-0.099	97.3	72.4	Belgium	0.111	52.8	2.1
Australia	-0.042	10.9	16.2	Germany	0.412	67.7	22.3
Spearman correlation		-0.15	-0.33	Spearman correlation		-0.64	0.26
Pearson correlation		-0.34	-0.30	Pearson correlation		-0.51	0.09
Regression analysis		b_Spain	b_home	Regression analysis		b_Italy	b_home
Rsq=0.13		-0.003	-0.002	Rsq=0.30		-0.007	-0.003
		(0.004)	(0.004)			(0.003)	(0.003)

Notes: Figures are obtained from Table 1 and Table 4. Market shares are for the year 1996. Figures in bold means p-value<0.10. In the regression analysis, standard errors are in parenthesis.

Table 5 contains the final results of the two-step procedure used to estimate the extent of competition in the destination markets of Italian and Spanish ceramic tile exporters. Destination countries are ranked from the highest to the lowest residual demand elasticities for each source country. If the market demand elasticities are not very different across destinations, the residual demand elasticities measure

increased in many equations, suggesting on average greater mark-ups for both Italian and Spanish exporter groups across destination markets than the ones reported in Table 5.

the degree of "outside" competition in each destination. To interpret the elasticities, note that the lower (in absolute value) the elasticity, the stronger the competition that each exporter group faces from the other competitor. In the previous section the PTM analysis showed that demand elasticities were constant for non-European destinations and convex across European destinations. The rank correlations between the market power of one exporter group and the market share of the other exporter group are clearly negative with values of -0.34 for Italy and -0.51 for Spain, suggesting that the presence of competitors reduces the market power of the other export group. A weaker correlation was also found between the market power of one exporter group and the local producers' domestic market share. In my regression analysis, reported in Table 5 (last rows), the coefficient of Italian market share in the Spanish market power regression is negative and significant, while the coefficient of Spanish market share in the Italian market power regression is negative but not significant. The coefficient of domestic market share is negative but not significant in both samples. Hence, Italian exports are strong substitutes of Spanish tiles while the evidence is weaker in the opposite direction. Finally, domestic tiles seem to be poor substitutes for both Italian and Spanish tiles. A plausible explanation behind these findings is the combined technological superiority and design innovation that allow Italian and Spaniard tile makers to differentiate successfully their products in the international markets.

V. Conclusions

Prior to 1987 Italian firms were the absolute world leaders in the production and export of ceramic tiles. After 1988 the international market structure of the export industry changed as some developing countries attained large levels of domestically orientated production, and Spanish producers gradually gained market quota in the international export market.

In order to characterise the market structure and conduct of Spanish and Italian tile makers in each export market, I combine two different techniques borrowed from the New Industrial Organisation (Bresnahan 1989). First, I measure the sensitivity of local currency prices of exported tiles to different countries with respect to exchange rate changes. The so-called pricing-to-market equation permits me to identify the existence of price discrimination and the similarity in the price behaviour of Italian and Spanish exporter groups across destination markets. Second, I measure the response of one exporter group's price to changes in the quantity supplied, taking into account the supply response of the other rival

exporter group. The so-called residual demand elasticity equation allows me to identify the extent of competition in the international tile market by quantifying the sensitivity of the positive mark-ups of an exporter group across destinations with respect to the market share of its rivals.

Using the pricing-to-market equation I found that the export price-adjustment in response to exchange rate variations was on average about 30%. I also observe that both Spanish and Italian exporters set different prices in domestic currency to different destination markets. The evidence of market segmentation is weaker for European destinations compared to non-European destinations, which could be explained by the greater price transparency associated with economic integration within Europe.

The estimation of the residual demand elasticity for each exporters' group revealed that, across destinations, both Italian and Spanish exporters have enjoyed positive market power during the period examined (1988-1998). On average Italian producers obtained mark-ups of 30 percent while Spanish mark-ups were 10 percent. The results also reveal that Italian mark-ups are less sensitive to Spanish competition, while the historical leadership of Italian exporters has a depressive effect on Spanish mark-ups in many destinations.

While the findings of this paper are most relevant to researchers studying ceramic tile industry, the methodology developed contributes more generally to the literature testing market power in export markets. Obtaining information on the determinants of the marginal costs such as input quantities or prices presents a major problem for researchers interested in estimating market power in an industry. I propose a simple solution to this problem by estimating the marginal cost for each exporter group directly from the pricing-to-market equation. I also show that techniques developed in one-source-country/multiple-destination can be implemented to multiple-source-countries/multiple-destinations. My current agenda of research includes explicitly modelling the strategic behaviour between exporter groups for a better understanding of export pricing policies in different periods of time, in a similar way as Kadayali (1997) did for the US photographic film industry or Gross and Schmitt (2000) did for the Swiss automobile market.

Appendix

A. Export quantities and prices

Price and quantity of ceramic tiles exports came from national customs, who collected data on the total number of squared metres and the total national currency value of exports of ceramic tiles to each destination country. Data were kindly provided by Assopiastrelle and Ascer, the two national entrepreneur associations. To ensure homogeneity in the product I selected the product registered as "CN Code 690890" from the Eurostat-Comext Customs Cooperation Council Nomenclature: "Glazed flags and paving, hearth or wall tiles of stone ware, earthenware or fine pottery,..., with a surface of above 7cm^2". The value of exports does not include tariff levies, the cost of shipping and other transportation costs.

Monthly data were available for all European destinations, but Italian series for non-European destinations are only collected on a quarterly basis. Unit values are quarterly average prices constructed dividing the value by the quantity of trade flows. For the monthly series unit values for each quarter were calculated as the mean average of the corresponding three months. I reduced the volatility of the unit values series by eliminating potential outliers, excluding in my calculations the monthly prices five times larger or smaller than the standard deviation of the annual average in the corresponding year (accounting for 1% of the destination-quarter observations in the Spanish and Italian data).

B. Exchange rates and demand variables

The data on exchange rate and wholesale price were collected from the *International Financial Statistics* of the International Monetary Fund (IMF). The destination-specific exchange rate data refer to the end-of-quarter and are expressed as units of the buyer's currency per unit of the seller's. The adjusted nominal exchange rate is nominal exchange rate divided by the destination market wholesale price level.

I use quarterly data on "new building construction permits" as an indicator of building construction demand. Data were obtained from DATASTREAM and the original sources are OECD and National Statistics. Since some series are not available for all the countries, alternative proxies were utilised. Specifically, the "Construction in GDP" for Italy and South Africa, "Work put in construction" for Hong Kong and Austria, and the "Construction production index" for Israel. Real

private consumption expenditures were used to proxy for the household demand of ceramic tiles. When disaggregated data were unavailable gross domestic production data were employed. The data were obtained from *International Financial Statistics* (IMF). All the series are seasonally adjusted.

References

Aw, Bee-Yan, and Mark Roberts (1998), "Price and quality comparisons for the US footwear imports: An application of multilateral index numbers", in R.E. Feenstra, ed., *Empirical Methods for International Trade*, Cambridge, MA, MIT Press.

Aw, Bee-Yan (1993), "Price discrimination and markups in export markets", *Journal of Development Economics* **42**: 315-36.

Baker, Jonathan B., and Timothy F. Bresnahan (1998), "Estimating the residual demand curve facing a single firm", *International Journal of Industrial Economics* **6**: 283-300.

Bernstein, Jeffrey I. and Pierre A. Mohen (1994), "Exports, margins and productivity growth: With an application to Canadian industries", *Canadian Journal of Economics* **24**: 638-659.

Bresnahan, Timothy F. (1989), "Empirical methods for industries with market power", in S. Richard and R. D. Willig, eds., *Handbook of Industrial Organization,* Amsterdam, North Holland.

Bughin, Jacques (1996), "Exports and capacity constraints", *Journal of Industrial Economics* **48**:266-78.

Dornbusch, Rudiger (1987), "Exchange rates and prices", *American Economic Review* **59**: 93-106.

Froot, Kenneth, and Paul Klemperer (1989), "Exchange rate pass-through when market share matters", *American Economic Review* **79**: 637-54.

Gil-Pareja, Salvador (2002), "Export price discrimination in Europe and exchange rates", *Review of International Economics* **10**: 299-312

Goldberg, Penelopi K., and Michael M. Knetter (1997), "Goods, prices, and exchange rates: What we have learned?", *Journal of Economic Literature* **35**: 1243-1272.

Goldberg, Penelopi K., and Michael M. Knetter (1999), "Measuring the intensity of competition in export markets", *Journal of International Economics* **47**:27-60.

Gross, Dominique M., and Nicolas Schmitt (2000), "Exchange rate pass-through and dynamic oligopoly: An empirical investigation", *Journal of International Economics* **52**: 89-112.

Hausman, Jerry (1978), "Specification tests in econometrics", *Econometrica* **46**: 1251-1272.

Kadayali, Vrinda (1997), "Exchange rate pass through for strategic pricing and advertising: An empirical analysis of the US photographic film industry", *Journal of International Economics* **43**: 1-26.

Knetter, Michael M. (1989), "Price discrimination by US and German exporters", *American Economic Review* **79**: 198-210.

Knetter, Michael M. (1993), "International comparisons of pricing to market behaviour", *American Economic Review* **83**: 473-86.

Porter, Michael E. (1990), *The Competitive Advantage of Nations*, The Free Press.

Sullivan, Dan (1985), "Testing hypothesis about firm behaviour in the cigarette industry", *Journal of Political Economy* **93**: 586-98.

Steen, Frode, and Kjell J. Salvanes (1999), "Testing for market power using a dynamic oligopoly model", *International Journal of Industrial Economics* **17**:147-77.

Yerger, David B. (1996), "Testing for market power in multi-product industries across multiple export markets", *Southern Economic Journal* **62**: 938-56.

Zellner, Andreas (1962), "An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias", *Journal of the American Statistical Association* **57:** 348-68.