Trade performances and the estimation of price-elasticities: Quality matters[+]

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Résumé :

Les estimations des modèles de commerce international ne tiennent généralement pas compte de la qualité des produits, ce qui conduit à sous-estimer fortement les élasticités-prix. Nous montrons que des élasticités-prix plus élevées, et plus conformes avec la théorie, peuvent être estimées dès lors que l'on contrôle la qualité des produits. Pour ce faire, nous avons estimé une équation de commerce international incluant une variable de qualité tirée d'un sondage auprès de firmes importatrices. L'estimation, menée en données de panel sur les quatre principaux pays membres de l'Union Européenne, confirme le rôle important que joue la qualité dans l'estimation des élasticité-prix du commerce, du moins en ce qui concerne les produits hautement différentiés.

Mots clés : Commerce international, équation de commerce, élasticité-prix, Concurrence imparfaite, différentiation des produits, qualité, indices de valeur unitaire.

Abstract :

Traditional trade models ignoring the dimension of product quality generally lead to excessively low trade price elasticities. In this paper, we show that higher estimated trade price elasticities, more in conformity with theory, can be obtained by controlling product quality in trade equations. To do so, we have estimated trade equations including a product quality proxy derived from survey data. Our estimation results, based on panel data for the four main EU member States, confirm the part played by product quality in the estimation of trade price elasticities, at least for traditionally highly differentiated products.

Keywords: Trade performances, trade equations, trade price elasticities, imperfect competition, product differentiation, quality, unit value indices.

JEL: C23, C33, F1, L15.

I. Introduction

Most trade equations, especially in operational macroeconometric models, do not take into account the so-called new theory of trade and stick to the traditional Armington [1969] framework. Such trade equations, however, often suffer from serious estimation difficulties, excessively low trade price elasticities or unstable ones for example[1], notably suggesting underlying problems of missing variables. Some trade models with imperfect competition might solve such problems, especially those which shed light on new sources of trade and comparative advantages by underlining the role played by product differentiation, especially vertical[2]. More recent empirical studies confirm the increasing part played by trade in vertically differentiated products, especially within the European Union (EU). Fontagné, Freudenberg and Péridy [1998] show that, in the mid-nineties, intra-industry trade in vertically differentiated products within EU countries was twice as substantial as intra-industry trade in horizontally differentiated goods. Erkel-Rousse and Le Gallo [2000] highlight the part played by quality in the trade performances of several EU countries, more especially Germany and, to a lesser extent, France. These studies suggest that trade equations should take product quality into account.

Unfortunately, quality levels are usually unobservable, so that introducing such variables into trade equations requires the use of proxies. Most authors choose proxies based on R&D expenses or human capital variables[3]. Such indirect measures of product quality may *a priori* differ significantly from what they are supposed to capture, or at least focus on a specific dimension of product quality, namely technological differentiation.

In this paper, we suggest that it may be worth using more direct measures of product quality, derived from survey data, and injecting them into trade equations. Doing so, we show that higher trade price elasticities can be obtained by controlling product quality in trade equations estimated on panel data. This result is easy to understand, as adding a quality variable in trade equations enables us to suppress the quality dimension of prices from the price factor.

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[1] *Cf.* notably Orcutt [1950], Harberger [1953], Goldstein and Khan [1985] and, more recently, Madsen [1996] and Deyak, Sawyer, and Sprinkle [1997].

[2] *Cf.* Shaked and Sutton [1984], as well as Falvey and Kierzkowski [1987].

[3] *Cf.* Greenhalgh, Taylor, and Wilson [1994], Magnier and Toujas-Bernate [1994], Amable and Verspagen [1995], Anderton [1996 and 1999], Carlin, Glyn and Van Reenen [1997], Eaton and Kortum [1997], Ioannidis and Schreyer [1997], etc.

Consequently, the price factor becomes a pure price effect, which has an unambiguous negative impact on market shares, while the positive influence of quality is taken into account through the quality proxy instead of being mixed with the pure price effect within the price factor. Comparing our quality proxy with an innovation variable derived from the same survey, and replacing the former with the latter into our trade equations, we also provide an *ex post* argument in favour of using indirect quality proxies based on innovation variables.

We present our model in section II. Then, we detail the construction of our quality proxy as well as our econometric methodology in section III. Our main estimation results are analysed in section IV. Finally, we discuss the content of our quality proxy and, more precisely, its relation with innovation, in section V.

II. The model

Our approach is based on a multi-country model of imperfect competition with *K* products. In any country *j*, the consumer utility function is supposed to be separable so that we can focus on the sub-utility U_{kj} derived from the consumption of any product *k*. This sub-utility is assumed to be a *CES* function *à la* Armington of the quantities x_{kij} of product *k* originating from every country $i = 1,...,I$ (including country *j*):

$$U_{kj} = \left[\sum_{i=1}^{I} \alpha_{kij} x_{kij}^{\frac{\sigma_{kj}-1}{\sigma_{kj}}} \right]^{\frac{\sigma_{kj}}{\sigma_{kj}-1}}$$

where $\sigma_{kj} > 1$ is the elasticity of substitution between domestic and imported goods from different origins, and $\sum_{i=1}^{I} \alpha_{kij}^{\sigma_{kj}} = 1$ (normalisation *à la* Hickman and Lau [1973]). Following Erkel-Rousse [1997], we consider that domestic and foreign goods differ by some perceived characteristics resulting from national differences[4]. These differences determine the relative « desirability » of domestic and foreign goods, *i.e.* the $(\alpha_{kij})_{i=1...,I}$ weights. This can be viewed as

[4] The supply side of the model suggested by Erkel-Rousse [1997] provides a theoretical justification of the Armington [1969] assumption according to which products are geographically differentiated, by endogenising producer strategies in terms of brand images.

a sort of « national brand image » of each product as it is perceived by consumers in country j[5].

Maximising each sub-utility U_{kj} subject to the budget constraint $\sum_{i=1}^{I} p_{kij} x_{kij} = R_{kj}$ gives the value of total demand for good k addressed to country i on market j:

$$X_{kij} \overset{Def.}{=} p_{kij} x_{kij} = \left(\frac{\alpha_{kij}^{\sigma_{kj}}}{1} \right) \left(\frac{p_{kij}}{p_{kj}} \right)^{1-\sigma_{kj}} R_{kj} \qquad \forall k, i, j \qquad (1)$$

where R_{kj} represents the share of total revenue allocated to the consumption x_{kj} of product k by the representative consumer of country j and p_{kj} the price of the composite product k, defined with respect to bilateral prices $\left(p_{kij} \right)_{i=1,\dots,I}$ as:

$$p_{kj} = \left[\sum_{i=1}^{I} \alpha_{kij}^{\sigma_{kj}} p_{kij}^{1-\sigma_{kj}} \right]^{\frac{1}{1-\sigma_{kj}}}$$

as is shown in Hickman and Lau [1973].

The share of good (k,i) in the budget allocated to the consumption of good k by consumers in country j (X_{kij} / R_{kj}) is a decreasing function of the relative price of good (k,i) and an increasing function of its relative brand image α_{kij}. The higher the elasticity of substitution σ_{kj}, the more sensitive demands to relative prices and brand images.

The evolution of exporting country i's relative market share in country j with respect to that of some of its main competitors $(i')_{i' \neq i, j}$ expressed in current prices, is equal to:

$$\overset{\bullet}{\left(\frac{X_{kij}}{\sum_{i' \neq i, j} X_{ki'j}} \right)} = \dot{X}_{kij} - \overset{\bullet}{\left(\sum_{i' \neq i, j} X_{ki'j} \right)} = \dot{X}_{kij} - \sum_{i' \neq i, j} a_{ki'j} \dot{X}_{ki'j} = \sum_{i' \neq i, j} a_{ki'j} \left[\dot{X}_{kij} - \dot{X}_{ki'j} \right] \qquad (2)$$

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[5] In this respect, our reading of the $\left(\alpha_{kij} \right)_{i=1\dots,I}$ weights is close to that of Feenstra [1994], who interprets them as quality indicators.

where $a_{ki'j} = \frac{X_{ki'j}}{\sum_{i'' \neq i,j} X_{ki''j}}$ denotes the value of exporting country (i')'s market share in country j with respect to that of some of its competitors ($i'' \neq i, j$)[6].

Replacing bilateral export values with their expressions derived from (1), we get:

$$\dot{\left(\frac{X_{kij}}{\sum_{i' \neq i,j} X_{ki'j}} \right)} = \sum_{i' \neq i,j} a_{ki'j} \left[(1-\sigma_{kj})(\dot{p}_{kij} - \dot{p}_{ki'j}) + \sigma_{kj}(\dot{\alpha}_{kij} - \dot{\alpha}_{ki'j}) \right]$$

or equivalently:

$$\underbrace{Log\left(\frac{X_{kij}}{\sum_{i' \neq i,j} X_{ki'j}} \right)}_{mshare_{kij\bar{i}}} = (1-\sigma_{kj}) \underbrace{Log\left(\frac{p_{kij}}{\prod_{i' \neq i,j} \left(p_{ki'j}{}^{a_{ki'j}} \right)} \right)}_{price_{kij\bar{i}}} + \sigma_{kj} \underbrace{Log\left(\frac{\alpha_{kij}}{\prod_{i' \neq i,j} \left(\alpha_{ki'j}{}^{a_{ki'j}} \right)} \right)}_{image_{kij\bar{i}}} + \underbrace{\Psi_{kij\bar{i}}}_{\text{Structural factors}} \qquad (3)$$

$\Psi_{kij\bar{i}}$ represents the set of invariant structural factors determining relative market shares. It depends on the product k, the importing market j, the exporting country i, and its main competitors $\bar{i} = (i')_{i' \neq i,j}$. We assume that $\Psi_{kij\bar{i}}$ is a linear combination of both miscellaneous fixed effects and three gravity components[7]:

- a relative distance effect (hereafter referred to as $dist_{ij\bar{i}}$), defined as the ratio of the distance between the capital towns of countries i and j to the mean distance between the capital towns of countries $(i')_{i' \neq i,j}$ and j;

- a relative size effect ($size_{ij\bar{i}}$), country size being estimated by the value of *GDP* in 1991[8];

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[6] Time index t is implicit in this whole section. Note that, when reasoning in discrete time, we shall have to replace the $(a_{ki'j})$ coefficients with their lagged values.

[7] *Cf.* for instance Bergstrand [1985; 1989].

[8] 1991 has been chosen as our benchmark year because it is neither too old nor included in the estimation period (1993-1997), which enables us to avoid potential endogeneity problems. Moreover, we have opted for 1991 rather than for 1992, which coincides with a period of monetary disturbances within the *EU*.

- a relative specialisation effect (spe_{kiji}), representing the share of good *k* in country *i*'s total exports compared to the corresponding share calculated for the set of its *I'* main considered competitors in 1991, where $I' = Card(i')_{i' \neq i, j}$.

The combination of the two last terms is supposed to capture a relative size effect at industry level, which could not be directly calculated through, for instance, ratios of GDP at sector level, due to the specific industry classification of the survey data that we used - *Cf*. below.

Consequently, in this model, relative market shares depend on: a traditional factor (relative prices); a non-standard differentiation term (relative brand images); gravity variables and other invariant factors, such as relative distance, size, and specialisation, plus miscellaneous fixed effects. According to this model, exporters can therefore increase their market shares in the short or middle run by lowering their prices with respect to those of their foreign competitors, or by raising their relative differentiation effort in order to modify their relative brand image to their advantage.

III. The data and estimation methods

As usual, this kind of model contains unobservable or imperfectly measured variables, which have to be replaced with proxies.

As for the relative price factor, we have considered that *import* unit values would be a good approximation for bilateral prices, as they take into account price competition between exporters at the *entry* of market *j* (transport and other transaction costs from any exporting country to market *j* being included in import unit values)[9]. For the same reason, import declarations have been chosen as a theoretically more satisfactory measurement of bilateral trade flows than export

[9] Besides, import unit values have been smoothed so as to correspond to what is generally observed in terms of the progressive influence of prices on trade values, as well as to limit potential endogeneity problems. More precisely, if *t* is the current year, unit values have been smoothed using the following weights: 0.3, 0.7 for respectively *t* and *t*-1. These kinds of weights can be found in several macroeconometric models, or derived from impulse functions resulting from dynamic models in time series econometrics. *Cf.* Magnier and Toujas-Bernate [1994] or Erkel-Rousse, Gaulier, and Pajot [1999] for instance.

declarations in the context of our model[10]. All these trade variables have been calculated at a certain product decomposition level (see below) for the four main *EU* member States (France, Germany, Italy, United Kingdom) on the basis of data originating from the *COMEXT* data base of *Eurostat*.

We have explained our interpretation of the structural factor $\Psi_{kij\bar{i}}$ in the preceding section. As far as sources are concerned, *GDP* data originate from the *CHELEM* data base of the *CEPII*, while the specialisation factor has been calculated on the basis of trade values based on export declarations from *COMEXT*.

However, the more interesting feature of our model is the presence of a non-standard explanatory factor based on national brand images. The difficulty is to find a satisfactory proxy for this kind of variable. We have derived ours from the results of the « Image of European products » annual survey of the *COE* (*Centre d'Observation Economique* of the *Chambre de Commerce et d'Industrie de Paris*)[11]. The results of this survey are based on the answers of a panel of importers from different EU member States concerning their perceptions of the relative advantages and disadvantages of products made in other EU countries in their sectors of activity. Specific questions deal notably with product quality, notoriety, degree of innovation, price, and ratio of quality to price, depending on geographic origin. The main advantage of this survey is to provide us with a purely exogenous piece of information (with respect to trade data) on the way products originating from specific member States are perceived from other EU countries. National product images collected from this survey are therefore bilateral. In other words, they depend not only on the respective objective qualities of products from miscellaneous geographic origins, but also on importers' subjective perceptions, which may differ notably from one importing country to the other[12]. Data refer to years 1992 to 1997 for different kinds of products (namely « consumer goods », split up into four sub-sectors: food, hygiene, lodging and clothing, and « other goods », consisting of intermediate products, mechanical equipment and

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[10] The under-estimation of intra-European import declarations since the creation of the *INTRASTAT* system of measurement of intra-EU trade flows in 1993 should be notably limited by the definition of the dependent variable, which is based on a ratio of imports (rather than on import levels).

[11] N.B. Gagey and Vincent [1990] applied the same kind of approach.

[12] This is one of the advantages of this source, brand images in our theoretical model being potentially subjective as well.

electric equipment)[13]. We have decided to focus on the four main EU countries[14] (as producing or purchasing countries), as products originating from smaller EU countries, such as Belgium, do not seem to be clearly known by the panel of importers from other member States (many missing observations, inducing unstable answers from one year to another).

More precisely, we have calculated our brand image proxy on the basis of the answers to the following question asked in the survey: « *In terms of quality levels, do you think that French / German / British / Italian products*[15] *are:*

- *the most competitive ones (mark = 1)*
- *as competitive as those from other countries (mark = 2)*
- *less competitive than those from other countries (mark = 3)*
- *not competitive at all (mark = 4)? »*

For any quadruplet (product *k*, importing country *j* - judge -, exporting country *i* - judged -, year *t*), we define $\tilde{\alpha}_{kijt}$ as the percentage of interviewed answering 1 or 2 to this question in the survey performed in year *t*-1. In principle, a high $\tilde{\alpha}_{kijt}$ must correspond to a relatively good national brand image in terms of the quality of product (*k*,*i*) in country *j*, and *vice versa*. The reason for defining the current $\tilde{\alpha}_{kijt}$ on the basis of the survey made in *t*-1 originates from the month in the year when the survey is performed, namely October, which is rather late. Therefore, we consider that a survey performed in October of year *t* reveals brand images which are closer to those operating in year *t* +1 than in year *t* in terms of consumer choices. Besides, this convention may protect us from endogeneity problems during the estimation process.

Of course, $\tilde{\alpha}_{kijt}$ is not as precise as a real quantitative measurement of the brand image α_{kijt}, but one can expect it to be at least a reasonably robust estimator of what we try to measure, apart from the normalisation aspect, which disappears when calculating the relative indicator:

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[13] See Appendix 1 for a precise description of these sectors and sub-sectors.

[14] Namely France, Germany, Italy and UK. As for Spain, available data are unfortunately insufficient, Spain having been included in the survey since 1996 only.

[15] Each interviewed importer is supposed to answer this question for products from every geographic origin, except from his or her own country. See Appendix 2 for a glance at the survey results concerning this specific question.

$$im\tilde{a}ge_{kij\bar{i}t} \overset{Def.}{=} Log\left(\frac{\tilde{\alpha}_{kijt}}{\prod_{i'\neq i,j}\left(\tilde{\alpha}_{ki'jt}{}^{a_{ki'j}}\right)} \right) \qquad (4)$$

In fact, we tried to work with more sophisticated indicators over-weighting the percentage of marks 1 with respect to that of marks 2, but the simplest indicator proved to lead to the best results, due without a doubt to its higher robustness. We also studied other possibilities in terms of the best criterion that could be used as a basis for the calculation of an estimated brand image. We decided to focus on the survey question dealing with quality rather than more particular criteria (such as innovation for example) because our theoretical brand images encompass miscellaneous perceptions and must not be too specific (however see section V below for a discussion in this respect)[16].

Unfortunately, *COE* surveys deal successively with consumer goods (1992, 1994, 1996) and « other » goods (1993, 1995, 1997). Therefore, we have to reconstitute annual indicators from biennial $\left(\tilde{\alpha}_{kijt}\right)$ ones. Assuming that national brand images are relatively stable structural variables (which is confirmed on the basis of the survey results), we have filled missing years with the simple arithmetic means of two successive biennial brand image *proxies*. Consequently, if t and t-2 correspond to two known $\tilde{\alpha}_{kijt}$ and $\tilde{\alpha}_{kijt-2}$ (derived from surveys performed in t-1 and t-3), we assume that the brand image in t -1 is close to:

$$\tilde{\alpha}_{kijt-1} = \frac{\tilde{\alpha}_{kijt} + \tilde{\alpha}_{kijt-2}}{2}$$

We have now got a sequence of annual proxies $\left(\tilde{\alpha}_{kijt}\right)_{k=1...K,i=1,..,4,j=1,...4,j\neq i}$ from 1993 to 1997 for consumer goods, and from 1994 to 1997 for other goods. From this sequence, we derive our explanatory variable $\left(im\tilde{a}ge_{kij\bar{i}t}\right)_{k=1...K,i=1,..,4,j=1,...4,j\neq i}$ using equation (4).

To sum up, the model to be estimated is:

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[16] Note that the accuracy of our national brand image proxy may be somewhat limited by the existence of multinational companies, which loosens the link between brand image nationalities and the geographic origin of trade flows. We can however expect this potential problem to be minimised by the fact that the interviewed - a sample of professional importers - are supposed to be well informed in terms of the geographic origin of the products they import.

$$\boxed{mshare_{kij\bar{i}t} = (1 - e_k^p)\left(pr\tilde{i}ce_{kij\bar{i}t}\right) + e_k^i\left(im\tilde{a}ge_{kij\bar{i}t}\right) + e^{si}\left(size_{ij\bar{i}}\right) + e^{sp}\left(spe_{kij\bar{i}}\right) - e^d\left(dist_{ij\bar{i}}\right) + c_{kij\bar{i}} + u_{kij\bar{i}t}} \quad (5)$$

where: $c_{kij\bar{i}}$ encompasses an intercept and a set of fixed effects; other coefficients are positive elasticities (referred to by *e*) which may not be equal to theoretical ones, as all variables are proxies of the true ones; the perturbation $u_{kij\bar{i}t}$ originates from the difference between theoretical variables and observable ones; $u_{kij\bar{i}t}$ also takes into account possible exceptional events and the parts of potential missing variables that are orthogonal to our explanatory factors; $t \in$ 1993 (or 1994) to 1997, i, $j \in$ France, Germany, Italy, United Kingdom, $k \in$ food, clothing, hygiene, lodging, intermediate products, mechanical goods, electrical goods, which represents 5×4×3×4 = 240 observations for consumer goods and 4×4×3×3 = 144 for other goods.

We have performed two sets of estimations: one on consumer goods, on the global 1993-1997 estimation period, and the other pooling all goods together, from 1994 to 1997 (*i.e.* using 240 - 48 + 144 = 336 observations). Notice that, due to the relatively small number of observations, we cannot reasonably estimate price and quality elasticities for any couple (*k*,*j*). As big sets of products prove to be more heterogeneous than the importing countries of our sample, we have decided to focus on the estimation of price (e_k^p) and quality (e_k^i) elasticities without differentiating between importing countries.

Each set of estimations has been compared with the results derived from a more traditional sub-model excluding the quality dimension [(e_k^i) restricted to zero]. The interesting aspect of such a comparison is to study how estimated price elasticities are modified when the adding of the image factor in the model suppresses (at least part of) the quality dimension contained in the relative price effect.

Finally, four different econometric methods have been tested, enabling us to confirm the robustness of our results. First, we have performed ordinary least squares (OLS). Then, we have tested three different two stage estimation methods. On the one hand, our quality *proxy* being obviously measured with a high degree of uncertainty, we have used an instrumental variable estimation method (hereafter referred to as 2SLS, for 2 Stage Least Squares), our image proxy being regressed with respect to the other explanatory variables of the model plus a simplest quality indicator defined as follows:

$$im\hat{a}ge_{kij\bar{i}t} \overset{Def.}{=} Log\left(\frac{\hat{\alpha}_{kijt}}{\prod_{i'\neq i,j}\left(\hat{\alpha}_{ki'jt}{}^{a_{ki'j}}\right)}\right)$$

where $\hat{\alpha}_{kijt}$ is calculated in the same way as $\tilde{\alpha}_{kijt}$ but on the basis on the results of the first available survey only (namely 1992 for consumer goods and 1993 for other goods). In order to limit the risk of correlation between this variable and the perturbation of the model, we have performed this instrumental variable method on 1995-1997 for consumer goods, and 1996-1997 for the whole sample (excluding the two first years of the sample enabling us to suppress any reference to the 1992 and 1993 surveys in the $im\tilde{a}ge_{kij\bar{i}t}$ variable and consequently in the current perturbation $u_{kij\bar{i}t}$). On the other hand, to suppress heteroskedasticity and correlation from our estimation residuals, we have performed two quasi-generalised least square (QGLS) alternative methods (see Appendix 3 for a thorough presentation on these two methods). As shall be seen in the next section, the four estimation methods lead to very similar results, which can be viewed as a sign of robustness.

IV. The results

Before examining the estimation results thoroughly, it is interesting to glance at the simple correlations between our dependent variable and both the price and image explanatory factors. Theoretically, we expect the price and quality factors to be positively correlated, as well as quality and market shares (the higher the degree of differentiation the higher the correlation, and *vice versa*). As for the price factor, the expected result is more ambiguous, due to the two dimensions of prices. If the « pure price » dimension predominates, then correlation between prices and market shares should be negative, relatively high prices implying a competitive disadvantage and consequently low market shares. If, however, the « pure quality » dimension dominates, then the sign of the correlation between prices and market shares should be inverted, such a configuration being liable to lead to low price elasticities in traditional trade models ignoring product quality.

In this respect, the second configuration proves to predominate (see Table 1 in Appendix 4). In fact, in most sectors, the simple correlation between relative prices and market shares proves to be clearly positive. The only exceptions concern two sectors in which products are very little differentiated, namely intermediate products and food[17]. For these kinds of products, particularly for intermediate goods, selling at low prices compared to one's competitors appears to play a crucial part in one's trade performances. It is noteworthy that, in these sectors, quality and prices sometimes appear to be negatively correlated. This unusual result is surprising only at first sight. In fact, examining survey answers concerning the quality of food and intermediate goods suggests that the interviewed face some difficulty in defining what quality exactly represents in the case of these almost homogeneous products (particularly for intermediate goods). It seems that the interviewed generally solve this problem by understanding « high quality » as an equivalent of « low price », which is the only clear criterion of differentiation within these products. The very specific feature of intermediate goods has required a specific treatment for this sector in our equations (the food sector proving to be less disturbing, as can be seen in Table 1 and will be confirmed below).

As for other goods, the positive correlation between price and market shares proves to be rather high, especially for goods originating from countries traditionally basing their competitive advantages on quality, namely Germany and France, but also from Italy. In this case, the magnitude of the correlation is essentially due to the clothing sector, which appears to be a highly « quality competitive » sector in this country[18]. However, as an importing country, Italy seems to value low prices more than its other partners (lower positive correlation between price and market shares). Not surprisingly, the higher the expected degree of product differentiation, the higher the positive correlation between price and both market shares and quality. As for clothing, price and quality are so highly correlated that the two factors prove to be nearly collinear (as is confirmed by the Belsley, Kuh and Welsch [1980] collinearity indicators).

Glancing at simple correlations has enabled us to check that our image variable behaved as we expected it to do. Moreover, these simple indicators illustrate the need for controlling quality in trade equations if one does not want to get under-estimated price elasticities. Our estimation results confirm this diagnosis.

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[17] Noteworthy, the intermediate goods taken into account in the *COE* survey consist mainly of quasi homogeneous products, and very little of technological ones (which, without doubt, explains most of our results in this sector). *Cf.* Appendix 1. Besides, note that food appears to be a differentiated sector as far as France and UK are concerned as exporting countries.

[18] *Cf.* Fontagné, Freudenberg and Péridy [1998], as well as Erkel-Rousse and Le Gallo [2000].

Tables 2 and 3 in Appendix 4 summarise our main estimation results, obtained respectively with consumer goods alone (Table 2) and then all goods being pooled together (Table 3). It is noteworthy that results derived from the four tested estimation methods are very much alike. All these estimations confirm our initial hypotheses.

The structural factors of size, specialisation and distance reveal the expected signs. A high relative size or specialisation in a given sector provides a competitive advantage to exporters, which enables them to increase their relative market share in this sector. On the contrary, distance to a foreign market constitutes a competitive disadvantage for exporters. As geographic distance is not highly differentiating within the four main EU Member States, this variable is less significant than the other ones, at least as far as consumer goods are concerned. However, it becomes clearly significant on the pooled sample.

Quality appears to be very significant, a more positive relative brand image in this respect leading to better trade performances on foreign markets. Admittedly, our estimated quality-elasticities prove to be much lower than was theoretically expected, as they are close to 0.2 while theoretical elasticities should be superior to unity. However, as was stressed above, many approximations have been made to get an annual proxy of national brand images, which have undoubtedly prevented us from getting a precise quantitative estimation of quality elasticities. Nonetheless, the modification of price elasticities upon adding our image *proxy* suggests that the latter encompasses at least part of what we have aimed at controlling. In fact, in sub-models excluding quality, we generally get estimated price elasticities (e_k^p) close to 0.9 which are significantly inferior to unity. When controlling quality, price elasticities increase and reach a value (around 1.1) which proves to be significantly superior to unity. Therefore, taking quality in our trade equations into account has enabled us to get estimated price elasticities which are compatible with their theoretical values ($\sigma_{kj} > 1$).

Intermediate products prove to be quite different from other kinds of goods, as their price elasticity is rather high (around 1.8 to 2.0), quality being controlled or not. The reason for this result is contained in Table 1 and explained in our previous comments on its basis. As intermediate goods taken into account in the survey can be roughly considered to be homogenous, export performances in this sector are essentially driven by relatively low prices. Due to the doubtful properties of the quality proxy for intermediate products in the *COE* survey, we have preferred not to take it into account in our estimations, although it would have led to a positive « quality » elasticity. However, as was emphasised before, suspecting this quality proxy to reflect mainly low prices, its presence in the model might have led to a biased price elasticity for intermediate products. Notice that we have not isolated food products from other consumer goods in Tables 2 and 3. The reason for this choice is that we would have found similar kinds of results if we had excluded food from other consumer products. As far as food products themselves are concerned, treating them apart would have led to a price-elasticity for food superior to those of other consumer and equipment goods, but clearly inferior to that of intermediate goods.

V. Quality and innovation

It is interesting to try to clarify the content of our « quality » proxy on the basis of the other results of the *COE* survey. Considering the correlations between our quality proxy and corresponding indicators derived from other *COE* criteria on the basis of questions of the same kind as that dealing with quality[19] and calculated with the same method, we observe that our « quality » indicator is highly correlated with two other *COE* indicators: those based on innovation and notoriety (*Cf.* Table 4 in Appendix 4).

The high correlation between quality and innovation is more interesting to discuss than that between quality and notoriety (which is somewhat tautological). In fact, on the one hand, many theoretical models derived from the so-called new theory of trade establish a tight link between quality and innovation. Moreover, several econometric studies use *R&D* or the number of patents as proxies of quality, which supposes a tight link between quality and innovation[20]. On the other hand, Fontagné, Freudenberg and Ünal-Kesenci [1998] suggest that trade specialisation in quality does not exactly coincide with that in technological products. In the *COE* survey, however, the point of view on innovation differs radically from that of Fontagné and *alii*. In fact, the *COE* survey tries to evaluate the innovating dimension of *any* set of products, while Fontagné and *alii* focus on so-called technological products only. In this respect, the point of view of the *COE* survey seems closer to the problematic of the other quoted papers, and the high correlation between the quality and innovation indicators derived

[19] Replace the word « quality » with either « innovation » or « notoriety » or any other *COE* criterion in the question of the *COE* survey quoted above, in section III.

[20] *Cf.* for instance the references quoted in introduction.

from the *COE* survey argues in favour of their choice of a quality proxy based on an innovation variable.

However, we can go a little further than reasoning on the basis of simple correlations. In this purpose, we have performed a set of estimations on the whole sample as well as on consumer goods considered alone, using brand image proxies based alternatively on the quality or the innovation *COE* criterion in order to compare the estimation results derived from both approaches.

It is noteworthy that results derived from the whole sample are very similar from one approach to the other, the degree of collinearity between quality and innovation being rather high as far as non consumer products are concerned. Consequently, on the simple basis of the results derived from the pooled sample, it would be difficult to discriminate between the two criteria (quality or innovation) and to decide which of the two predominates.

However, results derived from estimations performed on the basis of consumer goods alone prove to be much more conclusive (*Cf.* Table 5 in Appendix 4). Although we get the same qualitative results when replacing our initial quality variable with an innovation *proxy*, the econometric adjustment proves to be more satisfactory when using the quality variable than the innovation indicator. Moreover, an attempt to include both indicators in our trade equation leads to a clear superiority of the quality indicator as an explanatory variable for market shares, in the context of a collinearity diagnosis between quality and innovation which proves to be at most ambiguous as far as the « intercept adjusted » analysis is concerned[21]. Therefore, at least for consumer goods, we can reasonably think that our initial choice of the quality criterion for our image *proxy* was more accurate than the alternative choice of innovation. However, if the quality criterion had not been available, the choice of a quality proxy based on the innovation criterion would have led to perfectly acceptable results, which again argues in favour of a current approach in empirical literature[22].

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[21] Usually, a collinearity problem occurs with certainty when the maximal condition index exceeds 30, and ambiguity begins at about 25, thresholds being lower for the « adjusted intercept » diagnostic, *i.e.* respectively around 25 and 20, sometimes a little lower. *Cf.* Belsley, Kuh, and Welsch [1980].

[22] Even though the two criteria considered in this study are without doubt much closer to one another than if the innovation criterion had been based on R&D expenses, as is the case in most empirical studies...

V. Conclusion

In this paper, we have aimed at showing that more satisfactory estimated trade price elasticities can be obtained by controlling product quality in trade equations. In this purpose, we have estimated trade equations including a product quality proxy derived from survey data. Our estimation results, based on panel data for the four main EU member States, confirm our initial intuition as far as traditionally highly differentiated products are concerned. It is therefore not surprising that traditional models (especially macro-econometric ones) ignoring the dimension of product quality lead to under-estimated trade price elasticities.

However, one might expect true price-elasticities to be even higher than those derived from our estimations, at least for the most competitive industries. In fact, our approach has not led to as high price elasticities as those (estimated using radically different methodologies and kinds of data) by Hummels [1998] or Head and Ries [1999] for instance[23].

We could probably get higher price-elasticities if we were able to use both more accurate *proxies* of quality and better measures of prices. However, even in such an ideal context, we would without doubt need more broken-up data as well, like those used by Hummels or Head and Ries. Unfortunately, we have had to stick to the relatively aggregated product classification of the *COE* survey in this respect, which, besides, has prevented us from studying industry and country heterogeneity.

Some other papers solve this problem by taking things differently. Erkel-Rousse and Le Gallo [2000] estimate the same model on very broken-up data, but using an endogenous quality proxy derived from a descriptive analysis of trade flows. Their resulting price elasticities are very close to ours. So are those found by Anderton [1996] or Ioannidis and Schreyer [1997], whose proxies of quality are based on *R&D* expenses. Besides, Erkel-Rousse and Mirza [2000] try to capture part of the quality dimension through miscellaneous fixed effects and to correct at least part of the measurement errors affecting unit value indexes by regressing them with respect to a set of instrumental variables representative of price components. They find price-elasticities significantly higher than ours in a number of very competitive industries producing lowly differentiated products. The combination of both their results and ours suggests that each of these two papers may have corrected part of the under-estimation of price-elasticities, but not

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[23] These authors get price-elasticities around 7 or 8.

the whole of it. Unfortunately, to our knowledge, there has not been up to now available direct broken-up quality measures which could have enabled us to mix the two approaches.

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Appendix 1: The product classification of the COE survey

	Codes	Description
	CONSUMER GOODS	
Food	02	Meat
	03	Fish
	04	Milk, eggs ...
	07	Vegetables
	08	Fruit
	09	Coffee, tea, spices...
	10	Cereals
	11	Flours
	15	Fats & food oils
	16	Meat-based preparations
	17	Sugar, sweets...
	18	Cocoa & cocoa-based products
	19	Flour-based preparations
	20	Fruit & vegetable-based preparations
	21	Various food preparations
	22	Fruit juice
Clothing	42, 4303, 4304	Leather goods
	61	Hosiery
	62	Clothes other than hosiery
	64	Footwear
	9101	Watches and other accessories in precious metals
	9102	Wrist watches
Hygiene	30	Drugs and medicine
	33	Essential oils, perfumes, make-up...
	3401	Soaps...
	3402	Cleaning products
	3405	Polishes & creams for shoes, wax polish...
Lodging *(and other consumer goods)*	900130, 900140, 900150, 900190, 9003, 9004	Contact lenses, glasses, ...
	9002	Lenses, prisms, photograph lenses
	9005	Binoculars
	9006	Cameras
	900711	Movie cameras <16mn & super 8
	900721	Projectors for films <16mm & super 8
	9008	Slide projectors
	3702	Photograph films
	57	Carpets, floorings...
	63	Linen of household, linen materials ...
	9401, 9403, 9404, 9405, 9406	Non medical furniture
	841821, 841822 841829	Household refrigerators
	842211	Dish washers
	842310	Weighing scales
	8450	Washing machines

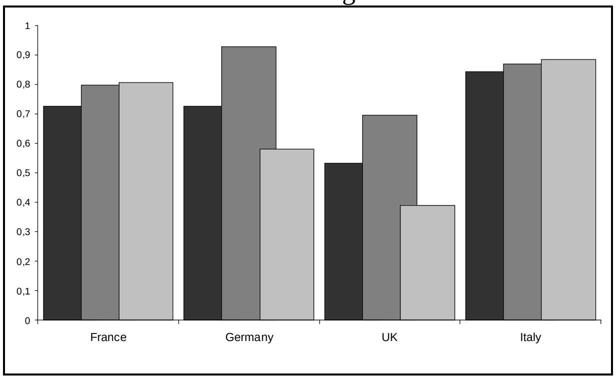
	Codes	Description
	9509	Other electrical household goods
	8510	Electric razors
	8516	Water-heaters, ovens, radiators household cooking stoves
	8519 to 8523	Equipment & electronic & hi-fi consumer accessories
	8527, 8528r	Radios and TV
	71	Jewellery ...
	9501 to 9507	Games, toys, sport articles (other than fair carousels)
	6910, 6911, 6912	Dishes...
	3406	Candles...
	5805	Tapestries
	66	Umbrellas, parasols...
	OTHER GOODS	
Intermediates goods	2515	Marbles and other chalk stones
	2520	Gypsum, plaster
	2521	Stones for lime and for cement...
	2522	Lime
	2523	Cements
	28	Inorganic chemical products
	29	Organic chemical products
	31	Fertilisers
	32	Tannins, pigments, paints, varnishes...
	36	Powders and explosives
	38	Various products of chemical industry
	39	Plastic and plastic products
	40	Rubber and rubber products
	4408 to 4421 and 4502 to 4504	Woods (other than sawed wood... and furniture) + cork
	47	Wood pulp and other fibrous pulps
	48	Paper and cardboard
	50	Silk
	51	Wool
	52	Cotton
	53	Other vegetal fibre textiles
	54	Artificial or synthetic filaments
	55	Artificial or synthetic fibres
	56	Felt, special threads, strings and ropes
	58 (except 5805)	Special material (laces, velvet...)
	59	Impregnated, covered, or laminated material
	60	Materials of hosiery
	68	Stone, plaster cement products...
	69 (except 6911 and 6912)	Ceramics
	70	Glass and works in glass
	72	Cast iron, iron and steel
	73 (except 7302,7309 and 7310)	Works in iron or steel

	Codes	Description
	74	Copper and brass and works in copper
	75	Nickel and works in nickel
	76	Aluminium and works in aluminium
	78	Lead and works in lead
	79	Zinc and works in zinc
	80	Tin and works in tin
	81	Other common metals and works in these matters
	82	Tools and kits
	83	Various works in common metals
	8482	Ball bearings ...
Electric equipment goods	8419	Industrial ovens
	846920	Professional typewriters
	847010	Calculators, electric and electronic cash registers
	8471, 8472,8473	Computers & office machines, and parts of these machines
	8501, 8502	Electric engines and generators
	8503	Parts of machines (8501-8502)
	8504	Electrical transformers
	8505	Electromagnets
	8506,8507	Electrical batteries & accumulators
	8511	Electrical starters & other parts of engines
	8512, 8513	Lamps
	8515	Electrical welders and brazers
	8530, 8531	Electrical signalling
	8532 to 8548 and 9009	Various electronic & electrical equip.
	9001	Optical fibres
Mechanical equipment goods	7302	Elements of railway tracks
	7309, 7310	Reservoirs, casks, vats
	8402 to 8449, 8451 to 8468	Turbines, engines & industrial machines
	8474 to 8480	Specialised machines for particular industries
	8483, 8484 and 8485	Parts of machines
	8508	Electromechanical hand tools
	8710	Tanks
	9011 to 9033	Measuring devices
	93	Arms, munitions & their parts & accessories

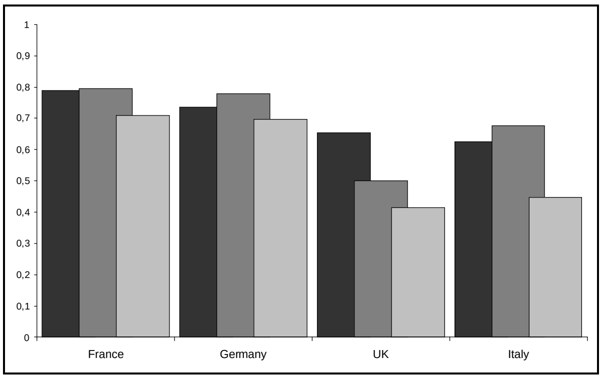
Appendix 2: Evolution of national brand images in the *COE* survey

Consumers goods: *Quality images relative to surveys conducted in 1992, 1994 and 1996*

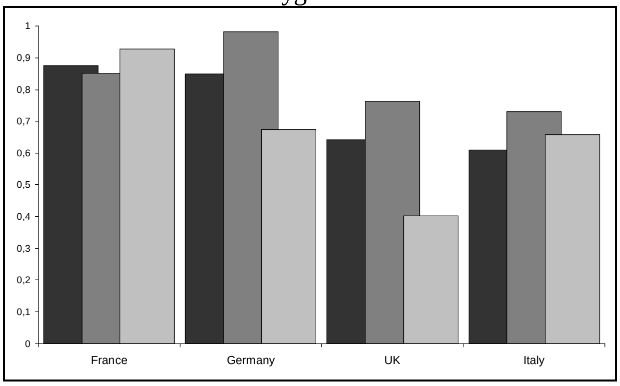
Clothing



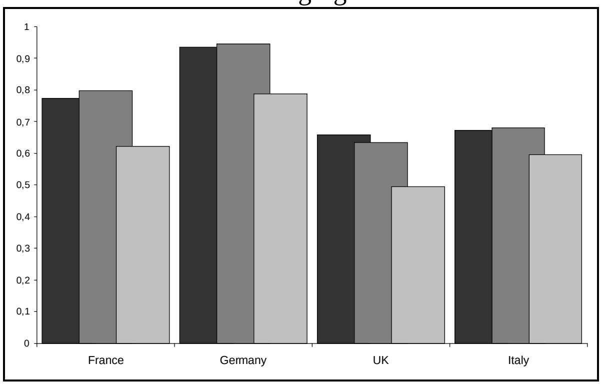
Food



Hygiene

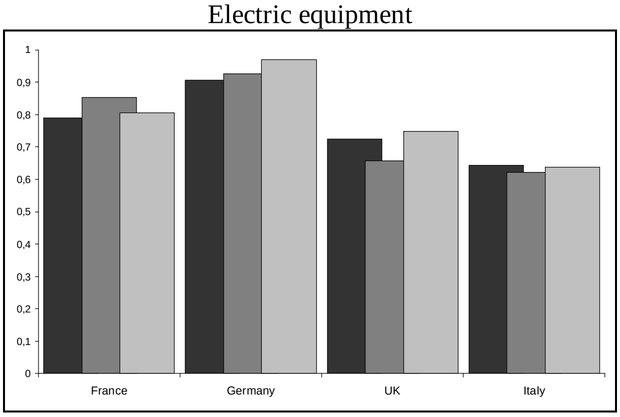


Lodging

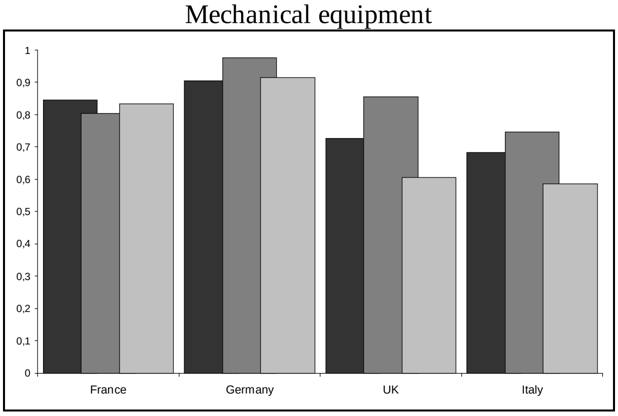


Other goods: *Quality images relative to surveys conducted in 1993, 1995 and 1997*

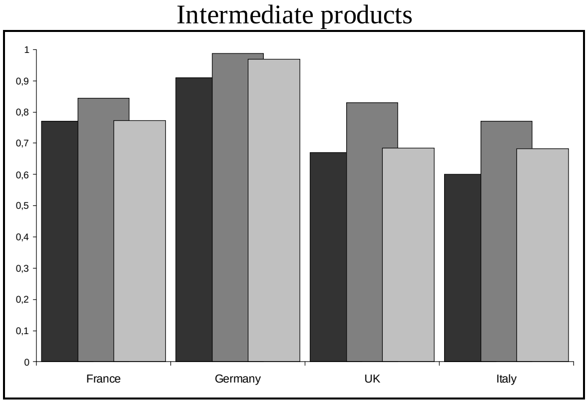
Electric equipment



Mechanical equipment



Intermediate products



In the graphs, we present the share of positive quality images, *i.e.* that of answers 1 or 2 to the question relative to product quality levels (corresponding to the ($\tilde{\alpha}_{ki.t}$) coefficients), for each exporting country *i*, product *k* and year *t*, opinions from all importing firms being mixed together.

Appendix 3: Two alternative Quasi-Generalized Least Squares methods

The presence of heteroskedasticity in models estimated using *OLS* (*Cf.* Table 2, and to a lesser extent Table 3 in Appendix 4) introduces a bias in the calculation of the T-statistic derived from *OLS* estimations and leads to non-optimal although unbiased *OLS* estimators. Moreover, in our multi-dimensional panel data, it is likely that the detection of heteroskedasticity reveals a more complex problem, since the variance-covariance matrix of residuals contains not only variable residual variances but also some non-zero, non-diagonal elements. This feature is easy to understand. In fact, for given sector k and time t, one can expect the trade performances of a given country i on different export markets to be correlated. Similarly, on a given importing market (k, j) at time t, relative market shares of exporters i = 1 to 3 can be expected to be negatively correlated. Our specification of the dependent variable therefore prevents us from simply correcting heteroskedasticity using weighed least squares estimators, since this method would only correct the variance-covariance matrix diagonal.

Whatever the calculation method of the estimated variance-covariance matrix, we have assumed that the essential source of correlation within *OLS* residuals came from cross-sections links (no time autocorrelations).

1) First method (referred to as QGLS 1 in tables 2 and 3):

Here, we aim at taking into account correlations between relative market shares of each exporter i on its three export markets (k,j), j = 1 to 3.

Let C^1_{ki} be the square matrix of (I-1)*(I-1) elements $\left(C^1_{jj'ki}\right)$ calculated as follows:

$C^1_{jj'ki} = \frac{1}{T}\sum_{t=1}^{T}\hat{u}_{kijt}\,.\,\hat{u}_{kij't}$ where $(\hat{u}_{kijt})$ denotes the vector of *OLS* residuals, T the number of years in the panel, and j and j' two importing countries.

Let A^1_k be the square matrix consisting of the I sub-square matrices $\left(C^1_{ki}\right)_{i=1,\ldots,I}$:

$$A^1_k = \begin{bmatrix} C^1_{k1} & 0 & 0 & 0 \\ 0 & . & 0 & 0 \\ 0 & 0 & . & 0 \\ 0 & 0 & 0 & C^1_{kI} \end{bmatrix},$$

Matrix B_1 is now defined as:

$$B_1 = \begin{bmatrix} A_1^1 & 0 & 0 & 0 \\ 0 & . & 0 & 0 \\ 0 & 0 & . & 0 \\ 0 & 0 & 0 & A_K^1 \end{bmatrix},$$

Finally, we have:

$$\Omega_1 = \begin{bmatrix} B_1 & 0 & 0 & 0 \\ 0 & . & 0 & 0 \\ 0 & 0 & . & 0 \\ 0 & 0 & 0 & B_1 \end{bmatrix} \begin{matrix} t=1 \\ . \\ . \\ t=T \end{matrix}$$

The *QGLS* 1 estimator of the multi-dimensional coefficient β in the model:

$$Y_1 = X_1\beta + u_1,$$

where observations are classified by increasing (*t*,*k*,*i*,*j*) ([24]), is:

$$\hat{\beta}_1 = \left(X_1'\Omega_1^{-1}X_1\right)^{-1}\left(X_1'\Omega_1^{-1}Y_1\right).$$

2) Second method (referred to as QGLS 2 in tables 2 and 3):

Here, we aim at taking into account correlations between relative market shares of exporters i = 1 to 3 on each market (k,j).

Let C_{kj}^2 be the square matrix of (I-1)*(I-1) elements $\left(C_{ii'kj}^2\right)$ calculated as follows:

$C_{ii'kj}^2 = \frac{1}{T}\sum_{t=1}^{T}\hat{u}_{kijt}\,.\,\hat{u}_{ki'jt}$ where $(\hat{u}_{kijt})$ denotes the vector of *OLS* residuals, T the number of years in the panel, and i and i' two exporting countries.

Let A_k^2 be the square matrix consisting of the I sub-square matrices $\left(C_{kj}^2\right)_{j=1,\ldots,I}$:

[24] The last index of the quadruplet being the first to move, then the third index, then the sector index, and finally the time index.

$$A_k^2 = \begin{bmatrix} C_{k1}^2 & 0 & 0 & 0 \\ 0 & . & 0 & 0 \\ 0 & 0 & . & 0 \\ 0 & 0 & 0 & C_{kI}^2 \end{bmatrix},$$

Matrices B_2 and Ω_2 are defined with respect to $\left(A_k^2\right)_{k=1,\ldots,K}$ in the same way as B_1 and Ω_1 have been calculated relatively to $\left(A_k^1\right)_{k=1,\ldots,K}$ in the preceding method.

Finally, the *QGLS* 2 estimator of the multidimensional coefficient β in the model:

$$Y_2 = X_2\beta + u_2,$$

where the same observations as previously are now classified by increasing (*t*,*k*,*j*,*i*) (with the same convention as above), is:

$$\hat{\beta}_2 = \left(X_2'\Omega_2^{-1}X_2\right)^{-1}\left(X_2'\Omega_2^{-1}Y_2\right).$$

As is shown in Tables 2, 3, and 5, using matrix Ω_1 or Ω_2 as an estimate for the variance-covariance matrix of *OLS* residuals enables us to suppress heteroskedasticity from our estimations (whereas using a simple diagonal matrix had not been able to).

Appendix 4: Tables

Table 1:

Correlations between the logarithms of relative market shares, price and quality

1-A) *By big product sets*

	quality/price	quality/market shares	price/market shares	Number of obs.
All goods together	0.860	0.838	0.609	336
Exporter = Germany	0.824	0.868	0.701	84
Exporter = France	0.949	0.866	0.746	84
Exporter = Italy	0.783	0.920	0.798	84
Exporter = U. Kingdom	0.916	0.707	0.489	84
Importer = Germany	0.921	0.821	0.647	84
Importer = France	0.841	0.870	0.708	84
Importer = Italy	0.778	0.886	0.527	84
Importer = U. Kingdom	0.719	0.925	0.665	84
Consumer goods	0.892	0.814	0.600	240
Food (& other agric.)	-0.530	0.925	-0.456	60
Clothing	0.997	0.872	0.867	60
Hygiene	0.756	0.881	0.798	60
Lodging	0.558	0.913	0.383	60
Other than clothing	0.311	0.893	0.260	180
Other than food	0.962	0.831	0.764	180
Other than food & clothing	0.684	0.878	0.693	120
Exporter = Germany	0.802	0.795	0.559	60
Exporter = France	0.965	0.851	0.753	60
Exporter = Italy	0.849	0.963	0.867	60
Exporter = U. Kingdom	0.931	0.709	0.509	60
Importer = Germany	0.942	0.848	0.690	60
Importer = France	0.900	0.852	0.748	60
Importer = Italy	0.553	0.891	0.376	60
Importer = U. Kingdom	0.486	0.942	0.533	60
Other goods	0.778	0.913	0.662	144
Electric equipment	0.890	0.915	0.887	48
Mechanical equipment	0.979	0.851	0.900	48
Intermediate products	-0.585	0.959	-0.717	48
Exporter = Germany	0.711	0.910	0.681	36
Exporter = France	0.880	0.935	0.757	36
Exporter = Italy	0.532	0.673	0.575	36
Exporter = U. Kingdom	0.832	0.830	0.513	36
Importer = Germany	0.045	0.878	0.346	36
Importer = France	0.709	0.951	0.684	36
Importer = Italy	0.870	0.902	0.633	36
Importer = U. Kingdom	0.814	0.946	0.787	36

[shaded cell] = significantly negative correlation (at 5 %) in table 1-A), as well as in table 1-B) below.

1-B) *By kind of product*

	quality/price	quality/market shares	price/market shares	Number of obs.
Food	-0.530	0.925	-0.456	60
Exporter = Germany	-0.694	0.852	-0.269	15
Exporter = France	0.499	0.869	0.522	15
Exporter = Italy	-0.860	0.658	-0.381	15
Exporter = U. Kingdom	0.429	0.789	0.545	15
Importer = Germany	-0.755	0.947	-0.743	15
Importer = France	-0.107	0.762	-0.077	15
Importer = Italy	-0.590	0.962	-0.387	15
Importer = U. Kingdom	-0.905	0.991	-0.928	15
Clothing	0.997	0.872	0.867	60
Exporter = Germany	0.979	0.693	0.636	15
Exporter = France	0.998	0.809	0.823	15
Exporter = Italy	0.989	0.909	0.895	15
Exporter = U. Kingdom	0.995	0.951	0.938	15
Importer = Germany	1.000	0.994	0.993	15
Importer = France	0.999	0.990	0.986	15
Importer = Italy	0.992	0.950	0.952	15
Importer = U. Kingdom	0.942	0.988	0.886	15
Hygiene	0.756	0.881	0.798	60
Exporter = Germany	-0.421	0.044	0.738	15
Exporter = France	0.913	0.709	0.537	15
Exporter = Italy	0.632	0.543	0.074	15
Exporter = U. Kingdom	0.899	0.629	0.795	15
Importer = Germany	0.924	0.949	0.977	15
Importer = France	0.100	0.756	0.686	15
Importer = Italy	0.401	0.963	0.570	15
Importer = U. Kingdom	0.916	0.974	0.971	15
Lodging	0.558	0.913	0.383	60
Exporter = Germany	-0.020	0.838	-0.158	15
Exporter = France	0.842	0.776	0.605	15
Exporter = Italy	0.934	0.936	0.942	15
Exporter = U. Kingdom	0.604	-0.090	-0.040	15
Importer = Germany	-0.070	0.969	-0.080	15
Importer = France	0.446	0.931	0.230	15
Importer = Italy	0.783	0.947	0.722	15
Importer = U. Kingdom	0.845	0.680	0.792	15
Equipment goods	0.942	0.904	0.886	96
Exporter = Germany	0.876	0.928	0.854	24
Exporter = France	0.961	0.923	0.823	24
Exporter = Italy	0.841	0.597	0.806	24
Exporter = U. Kingdom	0.992	0.881	0.902	24
Importer = Germany	0.412	0.821	0.713	24
Importer = France	0.893	0.941	0.913	24
Importer = Italy	0.995	0.921	0.894	24
Importer = U. Kingdom	0.966	0.940	0.959	24
Intermediate goods	-0.585	0.959	-0.717	48
Exporter = Germany	0.223	-0.205	-0.162	12
Exporter = France	-0.120	0.966	-0.237	12
Exporter = Italy	-0.722	0.987	-0.771	12
Exporter = U. Kingdom	-0.780	0.899	-0.869	12
Importer = Germany	-0.964	0.952	-0.878	12
Importer = France	-0.986	0.985	-0.946	12
Importer = Italy	-0.503	0.963	-0.716	12
Importer = U. Kingdom	-0.232	0.969	-0.454	12

Table 2: Estimation Results for Consumer goods

Explanatory variables and miscellaneous statistics	1) OLS No quality & Fixed effects	2) OLS Quality + fixed effects	3) OLS Quality & no fixed effects	2) 2SLS Quality + fixed effects	3) 2SLS Quality & no fixed effects	1) QGLS 1 No quality & fixed effects	2) QGLS 1 Quality + fixed effects	3) QGLS 1 Quality & no fixed effects	1) QGLS 2 No quality & Fixed effects	2) QGLS 2 Quality + fixed effects	3) QGLS 2 Quality & no fixed effects
Quality (e_k^i)	-	0.20 (10.57)	0.18 (8.93)	0.22 (8.50)	0.19 (7.15)	-	0.19 (42.83)	0.17 (46.45)	-	0.20 (31.98)	0.18 (36.98)
Price (1- e_k^p)	0.09 (6,63)	-0.13 (-5.42)	-0.13 (-5.01)	-0.15 (-4.70)	-0.14 (-4.27)	0.09 (35.84)	-0.12 (-23.67)	-0.12 (-25.07)	0.09 (35.19)	-0.13 (-15.23)	-0.12 (-18.97)
Size (constant GDP)	1.77 (12.6)	1.02 (7.47)	0.71 (7.62)	0.83 (4.61)	0.54 (4.38)	1.73 (45.47)	0.99 (36.22)	0.71 (47.25)	1.75 (36.38)	1.01 (22.89)	0.73 (25.15)
Specialisation	0.72 (15.2)	0.40 (7.97)	0.58 (12.83)	0.37 (5.69)	0.55 (9.50)	0.73 (85.96)	0.42 (34.13)	0.59 (67.66)	0.73 (65.79)	0.40 (29.74)	0.58 (50.19)
Distance	-0.05 (-1.44)	-0.10 (-3.21)	-0.02 (-0.56)	-0.11 (-2.65)	-0.03 (-0.62)	-0.05 (-8.43)	-0.10 (-15.90)	-0.03 (-4.78)	-0.06 (-6.11)	-0.10 (-13.54)	-0.02 (-2.61)
Intercept	0.66 (5.29)	0.18 (1.57)	-0.11 (-1.79)	0.05 (0.34)	-0.23 (-2.77)	0.62 * (20.49)	0.16 * (7.47)	-0.12 * (-11.12)	0.65* (18.07)	0.17* (4.91)	-0.10* (-4.88)
Fixed effects: **											
Italy (export) × clothing	0.27 (2.38)	0.53 (5.40)	-	0.52 (4.12)	-	0.27 (25.55)	0.51 (40.65)	-	0.26 (15.54)	0.53 (23.53)	-
Germany (export) × hygiene	-0.53 (-4.41)	-0.53 (-5.25)	-	-0.51 (-3.94)	-	-0.50 (-23.49)	-0.49 (-29.04)	-	-0.54 (-15.47)	-0.53 (-15.56)	-
Germany (export) × Other	-0.50 (-4.77)	-0.36 (4.16)	-	-0.36 (-3.23)	-	-0.48 (-27.20)	-0.35 (-27.43)	-	-0.49 (-21.17)	-0.36 (-13.22)	-
Nb. of observations	240	240	240	144	144	240	240	240	240	240	240
R²	0.819	0.878	0.847	0.874	0.842	0.9997*	0.9994*	0.9998*	0.996*	0.997*	0.997*
Root MSE	0.320	0.263	0.293	0.263	0.292	1.010	1.004	0.999	1.015	1.018	1.012
F-Stat	150.36	208.26	259.85	116.88	146.55	85,693.04	39,778.02	210,177.1	7,787.95	7,504.4	12,309.4
DW	2.27	2.10	1.87	2.16	1.88	2.02	2.16	2.17	2.04	2.03	1.97
Highest condition index / interc. adj.	12.63 / 4.70	16.29 / 7.76	9.75 / 6.45	16.63 / 7.94	10.03 / 6.56	89.31 / n.d. *	49.96 / n.d.*	71.72 / n.d. *	25.85 / n.d.*	26.97 / n.d.*	18.09 / n.d.*
If cond. index >25, high var. prop.	-	-	-	-	-	Corrected intercept + size *	Corrected intercept + size *	Corrected intercept + size *	Corrected intercept + size *	Corrected intercept + size *	-
Heteroskedasticity (P-value)	yes (0.0056)	yes (0.0017)	yes (0.0002)	yes (0.0097)	ambiguous (0.0203)	no (1.00)	no (1.00)	no (0.99)	no (1.00)	no (1.00)	no (1.00)

Numbers in parentheses below each estimated coefficient are T-statistics. Nota: In the context of panel estimations, the DW statistic does not have any satisfactory theoretical meaning. However, if it is not close to 2, DW may reveal a specification problem.

* = Corrected R² (the model having no real intercept, but a « corrected » intercept, due to the method of estimation). That is why the « intercept adjusted » collinearity diagnosis cannot be defined in this case. However, collinearity between the corrected intercept and size does not affect the estimated coefficients of the other variables, in particular those of quality and price variables.

** The small number of crossed effects taken into account in the model encompasses all the potential other fixed effects.

Table 3: Estimation Results for All Products Together

3.A) OLS and Instrumental variables

Explanatory variables and miscellaneous statistics	4) OLS No quality	5) OLS Quality	6) OLS No quality	7) OLS Quality (non inter.)	5) 2SLS Quality	7) 2SLS Quality (non inter.)
Quality: (e_k^i)	-	0.18 (11.70)	-	-	0.18 (7.65)	-
Intermediate goods	-	-	-	-	-	-
Other products	-	-	-	0.14 (8.60)	-	0.14 (5.42)
Price: (1- e_k^p)	0.07 (6.30)	-0.10 (-5.64)	-	-	-0.11 (-3.90)	-
Intermediate goods	-	-	-0.83 (-4.83)	-1.07 (-6.81)	-	-1.04 (-4.17)
Other products	-	-	0.09 (7.38)	-0.07 (-3.29)	-	-0.07 (-2.21)
Size (constant GDP)	1.59 (19.76)	1.02 (12.37)	1.52 (19.43)	1.15 (13.81)	0.95 (7.67)	1.09 (8.73)
Specialisation	0.74 (16.92)	0.46 (10.62)	0.72 (17.03)	0.53 (12.01)	0.46 (7.05)	0.53 (8.04)
Distance	-0.10 (-3.66)	-0.12 (-5.47)	-0.07 (-2.77)	-0.10 (-4.19)	-0.12 (-3.73)	-0.10 (-2.84)
Intercept	0.47 (6.60)	0.17 (2.59)	0.44 (6.35)	0.21 (3.14)	0.13 (1.37)	0.18 (1.81)
Fixed effects:						
Equipment products	-0.10 (-2.28)	-0.14 (-3.98)	-0.10 (-2.58)	-0.11 (-3.02)	-0.16 (-3.01)	-0.12 (-2.26)
Italy (export) × clothing	0.34 (3.19)	0.47 (5.19)	0.31 (3.01)	0.44 (4.67)	0.44 (3.24)	0.41 (2.87)
Germany (export) × hygiene	-0.42 (-4.40)	-0.50 (-6.19)	-0.40 (-4.28)	-0.46 (-5.42)	-0.54 (-4.52)	-0.50 (-3.94)
Germany (export) × Other	-0.40 (-5.47)	-0.36 (-5.87)	-0.38 (-5.40)	-0.33 (-5.25)	-0.40 (-4.51)	-0.38 (-4.01)
Germany (export) × interm.	-0.13 (-1.40)	-0.26 (-3.17)	-0.13 (-1.41)	-0.01 (-0.08)	-0.25 (-2.05)	0.02 (0.18)
France (export) × equipment goods	0.29 (3.09)	0.23 (2.98)	0.30 (3.33)	0.26 (3.19)	0.23 (1.99)	0.25 (2.10)
France (import) × equipment goods	0.05 (0.57)	0.08 (1.12)	0.05 (0.62)	0.08 (1.02)	0.08 (0.70)	0.07 (0.64)
Number of observations	336	336	336	336	168	168
R^2	0.841	0.888	0.854	0.881	0.878	0.867
Root MSE	0.283	0.237	0.272	0.245	0.248	0.259
F Stat	155.69	214.04	156.88	183.20	92.75	77.39
DW	1.81	1.99	2.03	2.36	2.02	2.03
Highest condition index / interc. Adj.	10.36 / 3.29	13.17 / 6.41	10.46 / 3..33	13.07 / 6.67	13.43 / 6.73	13.29 / 6.99
If cond. index >25, high var. Prop.	-	-	-	-	-	-
Heteroskedasticity (P-value)	ambiguous (0.013)	ambiguous (0.047)	ambiguous (0.041)	yes (0.002)	no (0.636)	no (0.433)

Numbers in parentheses below all estimated coefficients are T-statistics. Nota*:* In the context of panel estimations, the *DW* statistic does not have any satisfactory theoretical meaning. However, if it is not close to 2, *DW* may reveal a specification problem.

** The small number of crossed effects taken into account in the model encompasses all the potential other fixed effects.

3.B) Quasi generalised least squares

Explanatory variables and miscellaneous statistics	4) QGLS 1 No quality	5) QGLS 1 Quality	6) QGLS 1 No quality	7) QGLS 1 Quality (non inter.)	4) QGLS 2 No quality	5) QGLS 2 Quality	6) QGLS 2 No quality	7) QGLS 2 Quality (non inter.)
Quality: (e_k^i)	-	0.17 (59.85)	-	-	-	0.18 (63.98)	-	-
Intermediate goods	-	-	-	-	-	-	-	-
Other products	-	-	-	0.14 (44.21)	-	-	-	0.14 (39.27)
Price: $(1\text{-}e_k^p)$	0.07 (90.1)	-0.10 (-30.84)	-	-	0.07 (39.84)	-0.10 (-30.45)	-	-
Intermediate goods	-	-	-0.83 (-66.84)	-1.06 (-57.09)	-	-	-0.84 (-42.15)	-1.06 (-29.10)
Other products	-	-	0.08 (69.34)	-0.06 (-15.76)	-	-	0.08 (56.09)	-0.06 (-14.73)
Size (constant GDP)	1.58 (180.56)	1.03 (91.79)	1.51 (182.83)	1.15 (105.62)	1.58 (116.28)	1.03 (73.06)	1.52 (151.76)	1.15 (72.69)
Specialisation	0.74 (116.60)	0.47 (53.40)	0.72 (103.43)	0.54 (57.50)	0.74 (80.44)	0.46 (75.03)	0.73 (76.11)	0.54 (48.99)
Distance	-0.10 (-30.65)	-0.12 (-35.71)	-0.07 (-24.49)	-0.10 (-27.37)	-0.10 (-37.59)	-0.12 (-31.83)	-0.076 (-26.14)	-0.10 (-16.69)
Intercept	0.47 (72.70)	0.17 (22.50)	0.43 (78.34)	0.21 (30.78)	0.47 (45.32)	0.17 (16.12)	0.44 (48.59)	0.21 (30.78)
Fixed effects:								
Equipment products	-0.09 (-70.32)	-0.14 (-49.73)	-0.10 (-57.78)	-0.11 (-48.15)	-0.10 (-12.92)	-0.14 (-19.80)	-0.10 (-13.148)	-0.10 (-12.56)
Italy (export) × clothing	0.34 (66.44)	0.46 (50.30)	0.31 (56.13)	0.43 (42.63)	0.33 (25.23)	0.47 (50.37)	0.30 (20.58)	0.43 (28.86)
Germany (export) × hygiene	-0.41 (-23.73)	-0.49 (-40.12)	-0.38 (-24.31)	-0.44 (-34.17)	-0.42 (-13.27)	-0.51 (-17.65)	-0.40 (-12.32)	-0.45 (-14.78)
Germany (export) × Other	-0.39 (-114.57)	-0.35 (-45.83)	-0.37 (-145.83)	-0.33 (-59.58)	-0.39 (-13.27)	-0.35 (-19.94)	-0.37 (-28.80)	-0.33 (-18.30)
Germany (export) × interm.	-0.13 (-50.93)	-0.26 (-55.12)	-0.13 (-46.03)	-0.01 (-1.69)	-0.13 (-15.27)	-0.26 (-31.16)	-0.13 (-12.79)	-0.01 (-0.77)
France (export) × equipment goods	0.29 (45.41)	0.24 (20.06)	0.30 (29.63)	0.26 (23.36)	0.29 (27.21)	0.23 (30.41)	0.31 (28.69)	0.26 (20.56)
France (import) × equipment goods	0.05 (70.32)	0.08 (18.11)	0.05 (12.94)	0.07 (22.36)	0.06 (2.67)	0.06 (3.71)	0.06 (3.10)	0.06 (3.50)
Number of observations	336	336	336	336	336	336	336	336
R^2	1.0000 *	0.9999 *	0.9999 *	0.9999 *	0.9992*	0.9999 *	0.9997 *	0.9997 *
Root MSE	1.015	1.015	1.017	1.015	1.015	1.016	1.016	1.017
F Stat	$4.7\ 10^6$	$3.9\ 10^5$	$4.7\ 10^5$	$1.9\ 10^5$	$3.4\ 10^4$	$2.1\ 10^5$	$9.7\ 10^4$	$7.6\ 10^4$
DW	1.97	2.04	1.9915	2.07	2.00	1.99	2.03	1.98
Highest condition index	239.31 *	70.46 *	67.92 *	47.88 *	22.12 *	60.68 *	23.46 *	84.9 *
If cond. index >25, high var. prop.	Corrected intercept + size	Corrected intercept + size	Corrected intercept + size	Corrected int. + size + Germany (exp) × interm.	Corrected intercept + size	Corrected intercept + size	-	specialisation + Italy (exp) × clothing
Heteroskedasticity (P-value)	no (1.000)	no (1.000)	no (1.000)	no (1.000)	no (1.000)	no (1.000)	no (1.000)	no (1.000)

Numbers in parentheses below all estimated coefficients are T-statistics. *Nota:* In the context of panel estimations, the *DW* statistic does not have any satisfactory theoretical meaning. However, if it is not close to 2, *DW* may reveal a specification problem.

* = Corrected R² (the model having no real intercept, but a « corrected » intercept, due to the method of estimation). That is why the « intercept adjusted » collinearity diagnostic cannot be defined in this case. However, collinearity between the corrected intercept and size does not affect the estimated coefficients of the other variables, in particular those of quality and price variables.

** The small number of crossed effects taken into account in the model encompasses all the potential other fixed effects.

<u>Table 4:</u>

Correlations between the logarithms of relative quality, innovation and notoriety

	quality/innovation	quality/notoriety	innovation/notoriety	Number of observations
All goods together	0.997	0.997	0.996	336
Consumer goods	0.984	0.997	0.982	240
Food (& other agric.)	0.993	0.992	0.990	60
Clothing	0.982	0.998	0.980	60
Hygiene	0.987	0.995	0.985	60
Lodging	0.980	0.986	0.978	60
Exporter = Germany	0.991	0.992	0.993	60
Exporter = France	0.999	0.999	0.998	60
Exporter = Italy	0.993	0.997	0.994	60
Exporter = U. Kingdom	0.911	0.928	0.970	60
Importer = Germany	0.928	0.941	0.978	60
Importer = Other	0.991	0.993	0.991	108
Other goods	0.997	0.997	0.996	144
Electric equipment	0.992	0.993	0.990	48
Mechanical equipment	0.999	0.999	0.998	48
Intermediate products	0.998	0.996	0.995	48
Exporter = Germany	0.991	0.989	0.985	36
Exporter = France	0.998	0.996	0.996	36
Exporter = Italy	0.989	0.991	0.985	36
Exporter = U. Kingdom	0.996	0.996	0.993	36
Importer = Germany	0.990	0.984	0.982	36
Importer = Other	0.998	0.999	0.997	108

Table 5: Quality or innovation?

As far as consumer goods are concerned, the quality criterion clearly predominates.

Explanatory variables and miscellaneous statistics	1) Neither quality no innovation OLS	2) Quality OLS	8) Quality + innovation OLS	9) Innovation OLS	8) Quality + innovation 2SLS	9) Innovation 2SLS	8) Quality + innovation QGLS 1	9) Innovation QGLS 1	8) Quality + innovation QGLS 2	9) Innovation QGLS 2
Quality	-	0.20 (10.57)	0.17 (4.71)	-	0.25 (7.24)	-	0.16 (17.41)	-	0.18 (19.48)	-
Innovation	-	-	0.03 (1.01)	0.16 (9.11)	-0.07 (-1.53)	0.16 (4.35)	0.04 (4.82)	0.15 (45.74)	0.03 (3.66)	0.16 (19.92)
Price	0.09 (6,63)	-0.13 (-5.42)	-0.13 (-5.51)	-0.09 (-3.99)	-0.11 (-2.51)	-0.08 (-1.98)	-0.12 (-25.18)	-0.09 (-23.96)	-0.14 (-15.76)	-0.10 (-8.94)
Size (constant GDP)	1.77 (12.6)	1.02 (7.47)	0.99 (7.22)	1.09 (7.63)	0.98 (4.68)	1.04 (14.97)	0.97 (34.89)	1.07 (41.52)	0.98 (22.27)	1.07 (20.56)
Specialisation	0.72 (15.2)	0.40 (7.97)	0.40 (7.96)	0.47 (9.53)	0.43 (5.54)	0.46 (15.91)	0.42 (32.77)	0.49 (37.07)	0.39 (29.50)	0.47 (31.67)
Distance	-0.05 (-1.44)	-0.10 (-3.21)	-0.11 (-3.35)	-0.12 (-3.74)	-0.08 (-1.90)	-0.12 (-2.74)	-0.11 (-15.99)	-0.12 (-14.59)	-0.10 (-14.60)	-0.12 (-14.36)
Intercept	0.66 (5.29)	0.18 (1.57)	0.16 (1.39)	0.20 (1.68)	0.15 (0.93)	0.18 (1.11)	0.13 (6.34)	0.18 (10.05)	0.15 (4.26)	0.19 (4.72)
Fixed effects:										
Italy (export) × clothing	0.27 (2.38)	0.53 (5.40)	0.54 (5.46)	0.50 (4.90)	0.47 (3.44)	0.47 (3.45)	0.51 (40.01)	0.48 (27.28)	0.53 (24.52)	0.50 (23.91)
Germany (export) × hygiene	-0.53 (-4.41)	-0.53 (-5.25)	-0.52 (-5.15)	-0.49 (-4.65)	-0.51 (-3.87)	-0.52 (-3.88)	-0.48 (-27.60)	-0.45 (-26.55)	-0.52 (-14.93)	-0.48 (-12.60)
Germany (export) × Other	-0.50 (-4.77)	-0.36 (-4.16)	-0.35 (-4.00)	-0.34 (-3.70)	-0.40 (-3.38)	-0.40 (-3.38)	-0.33 (-25.85)	-0.33 (-33.11)	-0.35 (-12.53)	-0.33 (-11.46)
Number of observations	240	240	240	240	144	144	240	240	240	240
R^2	0.819	0.878	0.879	0.867	0.870	0.862	0.999*	0.999*	0.996*	0.997*
Root MSE	0.320	0.263	0.263	0.275	0.270	0.270	1.005	1.009	1.018	1.017
F Stat	150.36	208.26	185.26	188.39	99.46	105.34	37,709.61	34,689.03	5,211.01	8,804.80
DW	2.27	2.10	2.18	2.22	2.25	0.88	2.17	2.06	2.02	1.98
Highest condition indices / interc. adj.	12.63 / 4.70	16.29 / 7.76	18.48 / 15.56	16.34 / 7.36	22.15 / 14.19	19.52 / 10.87	56.13, 28.20 / n.d. *	50.36, 25.44 / n.d. *	28.84, 17.42 / n.d.*	44.73 / n.d. *
High var. Prop. (>0.4) corresponding to: - highest condition index (if at least ambiguous)	-	-	quality + innovation	-	initial: interc. + size int. adj.: innovation (0.99) + quality (0.44)	-	corrected intercept + size	corrected intercept + size	corrected intercept + size	corrected intercept + size
- 2nd highest cond. ind. (if ambiguous)	-	-	-	-	-	-	quality + innovation	special. + innovation + Germany (exp.) × oth.	quality + innovation	-
Heteroskedasticity (P-value)	yes (0.0056)	yes (0.0017)	yes (0.0011)	yes (0.0019)	ambiguous (0.0252)	yes (0.0017)	no (0.9976)	no (0.9999)	no (0.9997)	no (0.9999)

Numbers in parentheses below each estimated coefficient are T-statistics.