A Restricted Source Differentiated Almost Ideal Demand System, Augmented with Quality in the study of French imports in Manufacturing versus Services

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Abstract

This paper revisits the Restricted Source Differentiated AIDS model by including *both* price and quality variables to correct for the bias in estimating 'true' price and quality elasticities of import demand. To this end, we introduce our own proxy to represent product quality which takes into account not only direct expenditures spent on research and development but also indirect expenditures through positive externalities originating from innovation efforts by other countries. We use bilateral trade data with sectoral disaggregation for the case of French import goods in two manufacturing and two service sectors to estimate our model using FGLS procedures with a SUR estimator, implementing a two-way error components structure to account for country and time effects as random, unobserved import demand determinants. The results show that price (quality) elasticities are higher (lower) for homogeneous goods than for services and differentiated products. Competition is strong in terms of prices for homogeneous products and in terms of quality for differentiated goods and services.

Keywords: AIDS, quality, price elasticity, two-way error component

JEL: C00, D01, D11, F10, F11

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1 Introduction

A classical problem in estimating the true impact of product prices on import demand is how to account for the quality bias when unit values[1] are used as prices. Different unit values of a particular product can reflect different qualities and hence may not impact demand in the expected manner.[2] Empirical trade research generally proposes including a proxy for quality in CES (Constant Elasticity of Substitution) trade models (Khandelwal, 2010; Hallak and Schott, 2011 and Feenstra and Romalis, 2012). Our first marginal contribution in this field is to include a quality variable in the RSD-AIDS (Restricted Source Differentiated Almost Ideal Demand System), which is a more generalized functional form than the CES in some ways, to study price, income and quality elasticities of demand. Our second marginal contribution is to improve the proxy for quality by taking into account the spillovers resulting from innovation efforts. To our knowledge, this is the first attempt to introduce an explicit quality variable in the RSD-AIDS model *and* include spillovers together with innovation efforts as a proxy for product quality.[3]

Our article prefers to use the RSD-AIDS model to the CES in the study of import demand for two main reasons. Firstly, we are interested in studying the competitiveness of countries in terms of price competition which requires the estimation of cross-price elasticities. The CES utility function assumes that cross-price elasticity of a product is zero. Thus, we have a preference for the RSD-AIDS model which allows for the estimation of cross-price elasticities along with own-price and income elasticities. Secondly, the useful functional form of the RSD-AIDS model relaxes the assumption of strictly homothetic preferences (as is the case of the CES) by allowing for quasi-homothetic preferences. Like the CES functional form, the RSD-AIDS incorporates the Armington structure in allowing for imperfect substitutability of a product from different sources. This implies that consumers may perceive the same good from different origins to be different products. The RSD-AIDS also allows for restrictions such as additivity, homogeneity in prices, Slutsky symmetry and block separability to be added to the model. Additivity and homogeneity restrictions hold when consumers possess rational preferences. Slutksy symmetry is true if these preferences are convex, and

[1] Unit values are defined as the nominal value of the product divided by the quantity of the product bought.

[2] Quality tends to be positively correlated with demand while price is negatively correlated with demand. Since unit values are influenced by quality, the use of these values as prices to estimate trade price elasticities tend to under-estimate the 'true' trade price elasticity.

[3] Rolle (1992) made a similar attempt to include a quality variable in the basic AIDS model. However, this is the first time such an attempt is made with the RSD-AIDS model. Similarly, the inclusion of the spillovers in innovation efforts as a proxy for quality has been introduced in two other works by Thanagopal et al. (2012 and 2014) but this quality proxy was introduced in a CES import demand function.

block separability allows the consumer to follow a two-stage decision-making process when allocating their budget to consuming a particular product.

Several economists such as Crozet and Erkel-Rousse (2004) and Fontagné, Gaulier and Soledad (2007) have introduced quality in the CES model. Other authors have tried to extract quality effects from the unit values so as to obtain 'true' or quality-adjusted prices like Diansheng, Kaiser and Myrland (2003), Hallak and Schott (2011), Boysen (2012) and Feenstra and Romalis (2012). We prefer to include an explicit quality variable together with unit values rather than use quality-adjusted prices because we are interested in studying the competitiveness of countries in terms of price *and* quality competition as well as in estimating the quality elasticity of demand.

We introduce our own ordinal proxy for quality to control for the fact that the same product from different sources is considered different due to its different product qualities. This proxy, that we call the 'knowledge' variable, captures the innovation efforts made by the country in improving its technology of production for a particular product but also includes potential externalities incurred for similar investment efforts made in other products or other countries. In practice, the knowledge variable is a function of R&D expenditures as well as patent citations and R&D efforts made in other countries and sectors which are converted using a technology flow matrix to account for externalities (Verspagen, 1997; Johnson, 2002 and Meijiers, 2010).

Our final contribution to this study is the application of our RSD-AIDS model to the case of French imports in manufacturing goods and service sectors using the WIOD (World Input-Output Database).[4] We estimate the linear RSD-AIDS using the technique of Seemingly-Unrelated Regression (SUR) with Feasible Generalized Least Squares (FGLS) procedures, implementing a two-way error components structure to account for country and time effects as random unobserved import demand determinants.[5] The results show that price elasticities are higher for homogeneous goods than for services and differentiated products. Competition is defined by prices for homogeneous products and by quality for differentiated goods and

[4]We were one of the many contributors involved in the creation of the database, WIOD. The main motivation for the creation of WIOD is to eliminate, to some extent, the scarcity of data on trade in services. Research remains highly restrictive in the field of trade in services as data remain scarce. Authors who have attempted to research trade in services have succeeded whenever they have data on trade in services for a particular country. Working papers for the US government and the European Commission have produced significant studies on trade in services by using selective data derived from surveys (Hooper, Johnson and Marquez, 2000; Marquez, 2005; Francois and Hoekman, 2009; Imbs and Méjean, 2010). Acknowledging such data limitations, the WIOD project developed new databases, accounting frameworks and models to increase our understanding of global trade linkages not only in goods but also services.

[5]This technique is borrowed from Boumahdi, Chaaban and Thomas (2004) in the study of Lebanese imports.

services.

The paper proceeds as follows: Section 2 will introduce quality in the RSD-AIDS model. Section 3 will work towards a testable demand system, detailing the creation of our quality variable. Our linear AIDS model will be tested in Section 4. Finally, Section 5 concludes.

2 RSD-AIDS adjusted with Quality

2.1 The AIDS model

The AIDS model (Deaton and Muellbaur, 1980) proposes a functional form to explain the budget share of a representative consumer for a particular product using 'true' or quality-adjusted prices, p^*[6] and the real aggregate income of this consumer,X, obtained by dividing nominal expenditure by a quality-adjusted price index:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln(p_j^*) + \beta_i \ln(\frac{X}{P^*}) \tag{1}$$

where P^* is the quality-adjusted price index defined by

$$\ln(P^*) = \alpha_0 + \sum_i \alpha_i \ln(p_i^*) + \frac{1}{2} \sum_i \sum_j \gamma_{ij}^* \ln(p_i^*) \ln(p_j^*) \tag{2}$$

The subscripts i and j refer to the distinct products consumed by the representative consumer.

The AIDS functional form has three main advantages. Firstly, the functional form is quite general. Unlike the CES functional form, it allows budget share of a particular product to depend on income and the quality-adjusted prices of other products.[7] Secondly, the functional form is derived from consumer preferences unlike, for instance, the Rotterdam model. Hence, it is easy to interpret the parameters and to add or relax restrictions on consumer preferences. Thirdly, econometric estimations based on this functional form are quite easy to implement. Thus, it makes it easy to model complex error components so as to improve the precision of our estimations, as we have done in this article.

We detail in the Appendix how the AIDS functional form is implemented based on the hypotheses on consumer preferences.

[6] By 'true' or quality-adjusted price, we refer to the price that is perceived by the consumer which is not necessarily equal to the unit value or the market price.

[7] It seems too strict an assumption to assume zero cross-price effects. In addition, it is realistic to assume that the richer the country the larger the budget share allocated to high-quality products.

2.2 Introduction of quality

If unit values are used instead of quality-adjusted or 'true' prices, then the cost function has to be modified to take into account these quality effects. An easy way to introduce quality is to suppose that an increase of 1% in product quality is perceived by the consumer in the same way as a decrease of θ% in the 'true' price of the product. Following Deaton (1988), Hallak and Schott (2011) and Feenstra and Romalis (2012), we express the unit value vector, denoted as p, as a function of the quality-adjusted prices of a product, p^*, and the quality of the product, s. Equation (3) is written in logarithmic terms so that the quality-adjusted product price is expressed as the difference between the unit value (henceforth used alternatively with prices) and its corresponding quality.[8]

$$\ln(p^*) = \ln(p) - \theta \ln(s) \tag{3}$$

θ refers to the share of unit value expressed by quality effects.[9] We assume $\theta > 0$.

We can rewrite the AIDS budget share in terms of unit values and quality:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln(p_j) + \sum_j \epsilon_{ij} \ln(s_j) + \beta_i \ln(\frac{X}{P}) \tag{4}$$

where P is a unit value (or price) index defined by

$$\ln(P) = \alpha_0 + \sum_i \alpha_i \ln(p_i) + \frac{1}{2} \sum_i \sum_j \gamma^*_{ij} \ln(p_i) \ln(p_j) + \sum_j \varphi_j \ln(s_j) + \frac{1}{2} \sum_i \sum_j \eta^*_{ij} \ln(s_i) \ln(s_j) + \sum_i \sum_j \epsilon_{ij} \ln(p_i) \ln(s_j) \tag{5}$$

2.3 Adapting the AIDS model to international trade: the RSD-AIDS model

This modified AIDS budget share equation can be easily applied in the international trade framework through the RSD-AIDS model. The budget share equation expressed in the RSD-AIDS model looks at the allocation of an individual across his consumption of distinct products originating from various sources. As in the Armington model, it is supposed that a product isn't perfectly substituable with the same product imported from a different source

[8]For a full-treatment of this model, consult Deaton (1988; 1997), Hallak and Schott (2011) and Feenstra and Romalis (2012).

[9]Feenstra and Romalis (2012) considered θ as a preference parameter.

even if their qualities are the same. This budget share equation is denoted by w_{ih} which represents the individual budget share of a product i from an exporter source, h.

$$w_{ih} = \alpha_{ih} + \sum_j \sum_g \gamma_{ihjg} \ln(p_{jg}) + \sum_j \sum_g \epsilon_{ihjg} \ln(s_{jg}) + \beta_{ih} \ln(\frac{X}{P}) \tag{6}$$

where

$$\ln(P) = \alpha_0 + \sum_i \sum_h \alpha_{ih} \ln(p_{ih}) + \sum_i \sum_h \varphi_{ih} \ln(s_{ih}) + \frac{1}{2} \sum_i \sum_j \sum_h \sum_g \gamma^*_{ihjg} \ln(p_{ih}) \ln(p_{jg})$$
$$+ \frac{1}{2} \sum_i \sum_j \sum_h \sum_g \eta^*_{ihjg} \ln(s_{ih}) \ln(s_{jg}) + \sum_i \sum_j \sum_h \sum_g \epsilon_{ihjg} \ln(p_{ih}) \ln(s_{jg}) \tag{7}$$

The subscripts i and j denote distinct imported products, and the subscripts h and g denote distinct sources (countries from which the products are imported). Let p_{ih} denote the 'true' producer (exporter) price of a product i exported from a country$h$. The amount of budget allocated for the purchase of a particular product i originating from a particular source h depends on all available price and quality information on similar products from different origins g and on different products j.

If we were to use this equation directly, the number of parameters to be estimated would be tremendous, as it increases both with the number of products and the number of import sources. A way around this problem is to impose parametric restrictions on the model by excluding the influence of the price of some products (or sources) on some other products (or sources).

Restriction 1: We suppose consumers practice two-stage budgeting. They first choose which budget share they will allocate to each category of products. Then, for a category of products, they choose the budget share for each possible source of importation depending on unit value, quality of different sources and their real income.

This implies that the cross-price and cross-quality effects, denoted by γ_{ihjg} and ϵ_{ihjg} respectively, are not source differentiated between products, but are source differentiated within a product.

$$\gamma_{ihjg} = \gamma_{jhg} \qquad \forall g{\in}j{\neq}i \tag{8}$$

$$\epsilon_{ihjg} = \epsilon_{jhg} \qquad \forall g{\in}j{\neq}i \tag{9}$$

For instance, an importer country imports dairy products from country h may have a source differentiated cross-price effect for dairy products from other sources g but cross-price responses to non-dairy products are not source-differentiated. This restriction implies an absence of substitutability between products of a different nature and different origins.

This also implies that we can consider each demand system for each product separately. This means that the import demand system for agricultural products is not influenced by the demand for non-agricultural products like banking services. Thus, we can assume that the expenditure decisions on these products can be separated from other import decisions regarding non-agricultural products.

We rewrite the final specification of the model in Equation (6) as the budget share of product i from an exporting country h. This share is expressed as a function of the price and quality of the same product originating from the different sources as well as the expenditure of the importing consumer.

$$w_{ih} = \alpha_{ih} + \sum_{g} \gamma_{jhg} \ln(p_{ig}) + \sum_{g} \epsilon_{jhg} \ln(s_{ig}) + \beta_{ih} \ln(\frac{X}{P}) \tag{10}$$

where

$$\ln(P) = \alpha_0 + \sum_{h} \alpha_{ih} \ln(p_{ih}) + \sum_{h} \varphi_{ih} \ln(s_{ih}) + \frac{1}{2} \sum_{h} \sum_{g} \gamma^{*}_{ihg} \ln(p_{ih}) \ln(p_{ig}) \\ + \frac{1}{2} \sum_{h} \sum_{g} \eta^{*}_{ihg} \ln(s_{ih}) \ln(s_{ig}) + \sum_{h} \sum_{g} \epsilon_{ihg} \ln(p_{ih}) \ln(s_{ig}) \tag{11}$$

Restriction 2: As in the basic AIDS model, we assume the following restrictions of additivity in Equation (12) and homogeneity of price in Equation (13) which are true if consumers have rational preferences locally nonsatiated. We also assume Slutsky symmetry in Equation (14), which is verified if consumer preferences are, in addition, strictly convex.[10]

[10] We verified that these properties are respected in our augmented RSD-AIDS model since the augmented

$$\sum_h \alpha_{ih} = 1 \qquad \sum_h \gamma_{ihg} = \sum_h \beta_{ih} = \sum_h \epsilon_{ihg} = 0 \tag{12}$$

$$\sum_g \gamma_{ihg} = 0 \tag{13}$$

$$\gamma_{ihg} = \gamma_{igh} \tag{14}$$

The augmented RSD-AIDS, with its properties of additivity, homogeneity and symmetry, makes it an ideal demand system to adopt for the framework of international trade. This model, in principle, can be estimated on a time series of observations for various goods from different regions over time. However, practical difficulties still exist as the number of parameters to be estimated remains enormous, depending on the number of goods exchanged and the number of sources considered. The following section aims to simplify our RSD-AAIDS equation into a simpler equation that can be applied to our analysis.

3 Towards a testable equation

3.1 Proxy for $\ln(P)$

From Section 2, we obtained an import share equation defined by a price index P which is non-linear. As a result, our RSD-AIDS model becomes equally non-linear. Our price index differs from that of the original RSD-AIDS model due to the presence of three additional terms: $\sum_h \varphi_{ih} \ln(s_{ih})$, $\frac{1}{2}\sum_h \sum_g \eta^*_{ihg} \ln(s_{ih}) \ln(s_{ig})$ and $\sum_h \sum_g \epsilon_{ihg} \ln(p_{ih}) \ln(s_{ig})$. We can simplify our price index by assuming $\varphi_{ih} = \eta^*_{ihg} = 0$ since these terms have no incidence on the shape of the PIGLOG cost function which ensures that the properties of the AIDS model are maintained. Thus, we obtain a simplified price index which resembles more closely the price index in the original RSD-AIDS, with the exception of the last term:

cost function remains homogeneous in prices in order to represent preferences.

$$\ln(P) = \alpha_0 + \sum_h \alpha_{ih} \ln(p_{ih}) + \frac{1}{2} \sum_h \sum_g \gamma^*_{ihg} \ln(p_{ih}) \ln(p_{ig}) + \sum_h \sum_g \epsilon_{ihg} \ln(p_{ih}) \ln(s_{ig}) \quad (15)$$

There are several ways to transform the system into a linear approximation in order to facilitate estimation. One popular strategy is to include a Stone price index proposed by Deaton and Muellbauer (1980). The Stone price index uses all available prices and is specified as[11]

$$\ln(P) = \sum_h w_{ih} \ln(p_{ih}) \quad (16)$$

Though popular, the Stone index is problematic on two fronts. Firstly, it may introduce a simultaneity bias because w_{ih} is used as both a dependent variable in the demand system and an independent variable in the price index expression. In addition, it leads to a bias when calculating the 'true' price elasticity (Moschini, 1995). Given these problems, Moschini has proposed the use of the 'corrected' Stone index, which is a log-linear analogue of the Paasche price index, expressed as:

$$\ln(P^S) = \sum_h w_{ih} \ln(\frac{p_{ih}}{p^0_{ih}}) \quad (17)$$

where p^0_{ih} denotes a base period price.

Replacing the current share values w_{ih} in the 'corrected' Stone index with the base share values, one obtains a geometrically weighted average price index. This index does not vary with changes in units of measurement up to a multiplicative constant, allowing further simplification necessary for an approximating index. The geometrically weighted index, which is an analgoue of the Laspeyres price index, is written as:

$$\ln(P^C) = \sum_h w^0_{ih} \ln(p_{ih}) \quad (18)$$

We introduce the following lemma to help us reduce our complex price index to an approximative Laspeyres price index.

Lemma 1: Under the restrictions presented in Equations (12)-(14), we let our price

[11] For each good i, the Stone price index is created using a weighted average of the unit values or prices from all sources h of the product.

index P be as shown in Equation (15) and our Laspeyres price index P^C be another linearly homogeneous price index. Supposing $p_i = \lambda_i p_1$ with $\lambda_1 = 1$ and $\lambda_i \geq 0$ for $i = 2, ..., n$, we can define a function Φ such that

$$P = \Phi(P^C) \tag{19}$$

where

$$\Phi(\lambda, s) = \frac{P(\lambda, 1)}{P^C(\lambda)} \exp[\sum_h \sum_g \epsilon_{ihg} \ln(p_{ih}) \ln(s_{ig})] = a(\lambda) b(\lambda, s) \tag{20}$$

Using this lemma, we are faced with a testable linear import demand equation as given below:

$$w_{ih} = \alpha^*_{ih} + \sum_g \gamma_{ihg} \ln(p_{ig}) + \sum_g \epsilon^*_{ihg} \ln(s_{ig}) + \beta_{ih} \ln(\frac{X}{P^C}) \tag{21}$$

where $\alpha^*_{ih} = \alpha_{ih} - \beta_{ih} \ln[a(\lambda)]$ and $\epsilon^*_{ihg} = \epsilon_{ihg} - \beta_{ih} \sum_h \epsilon_{ihg} \ln \lambda_{ih}$.

We can treat $a(\lambda)$ as a constant since it is a low variability factor. The factor $b(\lambda, s)$ can be absorbed in Equation (21) provided that ϵ_{ihg} in Equation (21) is replaced by ϵ^*_{ihg}. As λ is estimable, the ϵ_{ihg} are identifiable.

Once the parametric share equations are estimated using Equation (21), it is possible to infer the substitutability patterns and price and quality effects (Green and Alston, 1990). The Marshallian (uncompensated) own price elasticity measures the change in the quantity demanded for product i from source h resulting from a change in its own price and can be calculated using the following equation:

$$\varepsilon^p_{ihh} = -1 + \frac{\gamma_{ihh}}{w_{ih}} - \beta_{ih}(\frac{w^0_{ih}}{w_{ih}}) \tag{22}$$

Similarly, the Marshallian own quality elasticity measures the change in the quantity demanded for product i from source h resulting from a change in its own quality and can be calculated as follows:

$$\varepsilon^s_{ihh} = \frac{\epsilon^*_{ihh}}{w_{ih}} \tag{23}$$

We can also calculate Marshallian cross-price (cross-quality) elasticity which measures the change in quantity demanded for a product i from source h resuting from a change in the price (quality) of the same product but from a different source g as follows:

$$\varepsilon^p_{ihg} = \frac{\gamma_{ihg}}{w_{ih}} - \beta_{ih}(\frac{w^0_{ig}}{w_{ih}}) \tag{24}$$

$$\varepsilon^s_{ihg} = \frac{\epsilon^*_{ihg}}{w_{ih}} \tag{25}$$

The last elasticity concerns the expenditure elasticity which represents the change in total demand for product i when total expenditure on all products changes and is calculated using Equation (26).

$$\varepsilon^x_{ih} = 1 + \frac{\beta_{ih}}{w_{ih}} \tag{26}$$

For this paper, we are most interested in the import own-price, own-quality, cross-price and cross-quality elasticities as seen from Equations (22) to (25). With the own-price and own-quality elasticities, we are able to predict the change in the quantity demanded for a particular product originating from a particular source when there is either a rise or a fall in its own price and quality. The cross-price and cross-quality elasticities allow us to study the degree of competition between different sources for a particular good.

3.2 Groupwise Separability

We are interested in testing our model using real-life trade data on French imports with 40 trading partners, namely 27 European countries, 5 developed countries (Australia, Canada, Japan, Korea and United States), the BRICs (Brazil, Russia, India and China) and rest of the world (RoW) (comprising Indonesia, Mexico, Taiwan, Turkey and others) over a time period of 17 years (from 1995 to 2011). In this paper, we will study the price and quality elasticities in two manufacturing goods sectors - Metal products and Transport equipment and two market service sectors - Banking services and Telecommunications services.

Since we have 40 different export sources to consider, we would have a total of 80 price and quality parameters to estimate in each sectoral equation. Intuitively, each bilateral price and quality parameter seems less important in our study as we are interested in looking at how French imports in these sectors react to different exporting regions. To simplify the number of parameters to estimate for each equation, we further implement groupwise separability. Under groupwise separability, the importing consumer decides, for each sector, how much to allocate on a particular good coming from a specific region. Thus, the choice of the consumer is based on the source of the good since goods coming from different regions are different according to the importing consumer. Figure 1 provides a graphical illustration of the importer choice.

Given the above groupwise separability, we can estimate the reaction of French imports coming from each of the 5 regions, namely EZ,[12] HEZ,[13] Dev,[14] BRICs[15] and ROW[16] for our sectors. Our testable equation transforms as follows:

$$
\begin{aligned}
w_{i,h\epsilon k,t} = \alpha_{ih} &+ \gamma_{ihh}\ln(p_{iht}) + \gamma_{ih,EZ}\ln(p_{i,\bar{EZ},t}) + \gamma_{ih,HEZ}\ln(p_{i,\bar{HEZ},t}) \\
&+ \gamma_{ih,Dev}\ln(p_{i,\bar{Dev},t}) + \gamma_{ih,BRIC}\ln(p_{i,\bar{BRIC},t}) + \gamma_{ih,RoW}\ln(p_{i,\bar{Row},t}) \\
&+ \epsilon_{ihh}\ln(s_{iht}) + \epsilon_{ih,EZ}\ln(s_{i,\bar{EZ},t}) + \epsilon_{ih,HEZ}\ln(s_{i,\bar{HEZ},t}) \\
&+ \epsilon_{ih,Dev}\ln(s_{i,\bar{Dev},t}) + \epsilon_{ih,BRIC}\ln(s_{i,\bar{BRIC},t}) + \epsilon_{ih,RoW}\ln(s_{i,\bar{RoW},t}) \\
&+ \beta_{ih}\ln(\frac{X_t}{P_t^C}) \qquad (27)
\end{aligned}
$$

where the subscript $(h\epsilon k)$ refers to the source country h within a region k where $k\epsilon(EZ, HEZ, Dev, BRIC, R$ at time t. $\bar{p_{ikt}}$ refers to a weighted regional price index for a product i at time t that includes all source countries in the region except for the country h. Note that the index i refers to the individual sector where i ϵ (Metal products, Transport equipment, Banking services, Telecommunications services).

3.3 Our Quality Variable

Estimating the impact of product quality on import demand remains a challenging feat due to the unobservable nature of quality in products, especially in services. Initially, economists used indirect quality measures such as direct R&D expenditures, number of patent citations and human capital variables as proxies for product quality (Ioannidis and Schreyer, 1997; Anderton, 1999; Eaton and Kortum, 2002 and Thanagopal and Le Mouël, 2014). This trend recently changed as economists increasingly use unit values as quality proxies (Hallak, 2006; Fontagné, Gaulier and Zignago, 2008; Fieler, 2011). However, the recently published works by Khandelwal (2010) and Hallak and Schott (2011) have contested the use of unit values

[12]EZ refers to Euro zone countries comprising Austria, Belgium, Cyprus, Germany, Estonia, Spain, Finland, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovenia and Slovak Republic. In this study, we do not include France as part of the EZ since we are interested in the imports of France with other trading partners in this region and not with itself.

[13]HEZ refers to non Euro zone countries comprising Bulgaria, Czech Republic, Denmark, Hungary, Latvia, Lithuania, Poland, Romania, Sweden and United Kingdom.

[14]Dev refers to developed countries including Australia, Canada, Japan, Korea and the United States.

[15]BRICs refer to the emerging countries namely Brazil, Russia, India and China.

[16]The Rest of the World region comprises Indonesia, Mexico, Taiwan, Turkey and others.

as proxies for quality since export prices are affected by other factors other than quality like production costs and hence prices.

Diverging from the use of prices and quantities to infer product quality, some economists have created their own quality measures, which I call direct quality measures, using micro-data originating from consumer surveys. Crozet, Head and Mayer (2011) used champagne ratings to construct a quality index to compare the quality of different champagne brands in France, while Crozet and Erkel-Rousse (2004) used a quality perceptions survey to determine the preferences of consumers for quality products coming from particular exporting countries. Such measures, despite being extremely precise and revealing of consumer preferences, require mass data accumulation and are difficult to obtain.

Unlike direct measures of product quality, indirect measures have the advantage of being readily available. In addition, much work has been done in this field to establish a strong link between innovation efforts in the form of R&D expenditures and patent creation and product quality, validating its role as a 'good' proxy for product quality. Another advantage of using indirect measures is that they tend to capture technological differentiation which better allows for cross-country comparisons and, as such, are more attractive to us in explaining cross-country differences in terms of innovation efforts, technological progress and hence product quality.

However, simply using R&D expenditures or human capital as proxies for product quality tends to underestimate the 'true' impact of innovation efforts on product quality since such efforts generate spillovers or positive externalities that further generate innovation breakthroughs. Knowledge attained from a successful innovation effort of one firm can be 'used' by other firms that did not participate in the financing of this successful innovation. In addition, this successful innovation can be, in turn, used as a foundation to foster similar innovation breakthroughs in the same field. This effect of 'dwarfs standing on the shoulders of giants' in which previous discoveries are used to build on new discoveries is particularly true in the case of innovation efforts which fuel such knowledge externalities (Silverberg and Verspagen, 2007 and Tavassoli and Carbonara, 2012). In particular, externalities are important when studying the impact of quality effects in services sectors since many of the services sectors tend not to extensively indulge in innovation efforts, yet they do benefit from innovations largely carried out by manufacturing sectors. For instance, the banking sector benefits from innovation breakthroughs in technology which are largely led by the electronics and computer sectors.

Many studies have been dedicated to studying the role of knowledge externalities across sectors and even across countries (Verspagen, 1997 and Audretsch and Feldman, 2003). If innovation efforts are an accepted proxy for product quality, externalities resulting from innovation efforts should also be considered as improvements to product quality. By ignoring these externalities, one tends to underestimate the 'true' impact of innovation efforts on product quality. In fact, much of product quality improvement is a result of spillovers rather than the actual expenditures of a country on research and development (Griliches, 1992; Nadiri, 1993; Fougeyrollas et al., 2006 and Chevallier et al., 2006).

Our contribution to this literature comes via the creation of a unique variable that accounts for product quality determined by innovation efforts and positive knowledge spillovers, hence the inspiration behind its name, the 'knowledge' variable (Thanagopal et al., 2012 and 2014). The knowledge variable allows for international and sectoral interactions in accumulating technological know-how and is thus constructed using both direct and indirect R&D expenditures on a particular sector. Using these expenditures, we are able to correlate the quality of the product with the costs incurred in its production.

3.3.1 Construction of the knowledge variable

The construction of the knowledge variable occurs in two stages. First, we obtain the direct R&D expenditures of all countries in both manufacturing and service sectors; then we convert these direct expenditures into indirect expenditures using a technology flow matrix. Readily available R&D expenditures are generally reported in Main Activity. Expenditures reported in Main Activity only report innovation efforts related to the Main Activity of the sector and tend to under-estimate secondary innovative efforts by sectors outside of their main activity. For instance, an automobile sector may spend its primary R&D expenditures on improving automobile quality. But it may also spend a significant amount of R&D efforts on marketing strategies which are also related to increasing product quality and may be outsourced to another sector. However, the secondary costs of innovation are not reported by the firm under R&D expenditures in Main Activity. Thus, reporting R&D expenditures in Main Activity often under-estimates such secondary spending. As a first step, we corrected for the under-estimation related to reporting these expenditures in Product Field instead of Main Activity.[17]

Once, we have obtained the corrected R&D expenditures, we convert these expenditures into a stock measure by summing them over some period of time and applying a fixed

[17] For a full-treatment of this correction, consult Galand and Thanagopal (2013) as well as Thanagopal and Le Mouël (2013).

depreciation rate (0.2 which is a recommended rate of depreciation) in order to relate this stock to the productivity performance of the sector and country. In this way, we acknowledge the notion that knowledge is cumulative and requires time to bear fruit. Incorporating a fixed depreciation rate also addresses the issue of obsolescence in knowledge, especially in the field of digital technology.

Direct R&D stocks are the actual R&D stocks accumulated by a country h in a particular sector i . Indirect R&D stocks are stocks accumulated by other countries g and other sectors j that affect country h in a particular sector i. These indirect R&D stocks are responsible for product improvement techniques in other countries and sectors that are, in turn, reused by third-party countries that do not directly accumulate these stocks. These countries benefit from such inventions through knowledge transfers that are quantified using patent citations (Verspagen, 1997; Johnson, 2002; Meijiers, 2010). Countries that re-use inventions 'cite' these inventions that have been patented in countries which produced it. In other words, the contribution of the indirect R&D stocks can be calculated by looking at information on patent counts and patent citations which are quantified in the form of technology flow matrices.

Using the methodology by Meijiers (2010), we calculate indirect knowledge stocks using the technology flow matrices. These matrices are constructed using patent citations obtained from the PATSTAT database which contains approximately 64 million patents and 90 million citations. These patents are classified using technology classes while the sectors are classified according to the OECD Concordance Table. The widespread coverage of patents in PATSTAT allows us to account for spillovers coming from not only the countries in our sample but also all other country sources in the world. Inventors of both cited and citing patents are known by country and thus reflect an international technology flow. Each invention is made in the sector of manufacturing (and/or service) which is then 'reused' or 'cited' in another sector of manufacturing (and/or service). Each citation counts for one and is spread over the number of inventors (countries) and the number of sectors.

These technology flow matrices are used as weights in calculating the contribution of each country and each sector towards the overall knowledge stock accumulated by the domestic country in its particular sector. Mathematically, we can calculate the indirect R&D stocks in a domestic country h and a particular sector i, denoted as IRD_{ih}, using the following equation:

$$IRD_{ih} = \sum_{j} w_{ijg} RD_{ig} \tag{28}$$

where w_{ijg} refers to the share of patent citations made in either own domestic country $h = g$ but in another sector j or in another country g and in another or same sector $i = j$. RD_{ig} are the direct R&D stocks accumulated by each country g in its sector i. Figure 2 offers a visual interpretation of the construction of the knowledge variable.

3.4 Data

For import demand, we use data obtained from WIOD (World Input-Output Database) which uses information from National Supply Use Tables to construct international and intersectoral linkages within a country and between trading partners. The import value data was converted to euros from dollars using the exchange rates from the IMF. Since we are interested in European trade, converting the trade values into Euros reduces the exchange rate fluctuations in which trade occurs. We also obtained the unit values[18] from the WIOD database.

We rewrite our final testable equation:

$$\begin{aligned} w_{i,h\epsilon k,t} = \alpha_{ih} &+ \gamma_{ihh}\ln(p_{iht}) + \gamma_{ih,EZ}\ln(p_{i,\bar{EZ},t}) + \gamma_{ih,HEZ}\ln(p_{i,\bar{HEZ},t}) \\ &+ \gamma_{ih,Dev}\ln(p_{i,\bar{Dev},t}) + \gamma_{ih,BRIC}\ln(p_{i,\bar{BRIC},t}) + \gamma_{ih,RoW}\ln(p_{i,\bar{Row},t}) \\ &+ \epsilon_{ihh}\ln(s_{iht}) + \epsilon_{ih,EZ}\ln(s_{i,\bar{EZ},t}) + \epsilon_{ih,HEZ}\ln(s_{i,\bar{HEZ},t}) \\ &+ \epsilon_{ih,Dev}\ln(s_{i,\bar{Dev},t}) + \epsilon_{ih,BRIC}\ln(s_{i,\bar{BRIC},t}) + \epsilon_{ih,RoW}\ln(s_{i,\bar{RoW},t}) \\ &+ \beta_{ih}\ln(\frac{X_t}{P_t^C}) + u_{iht} \end{aligned} \quad (29)$$

According to Equation (29), import demand is determined by the prices (and quality) of product i from a particular country source h, the prices (and quality) of the competing regions as well as the total real expenditures spent on the product. We include u_{iht} which is a disturbance term. To obtain the price (and quality) index of the competing regions namely EZ, HEZ, Dev, BRIC and RoW, we compute a weighted average import price (and quality) for all the sources in the region excluding the source country h. The price index, in this case, will resemble the Laspeyres price index presented in Equation (18) in the following manner:

$$\ln(p_{\bar{ikt}}) = \sum_{g\epsilon k, g\neq h} w_g^0 \ln(p_{igt}) \quad (30)$$

[18]The unit values are normalized for a base year in 2005.

where k = (EZ, HEZ, Dev, BRIC, RoW) and g refers to a country within a region k but different from country h of the same region. We implement the same index to calculate the weighted quality indices for each region.

Expenditures are calculated by adding up all import values from each export source. Expenditure share is derived by dividing the total expenditure by the individual export source. The expenditure variable may be an endogenous variable in the statistical and economic sense, as it depends on the whole price and quality system. Thus, we used predicted expenditure in place of calculated expenditures. These predicted expenditures were estimated using instruments such as time dummies and a selection of prices (Andayani and Tilley, 1997 and Boumahdi, Chaaban and Thomas, 2004) in order to correct for the problem of endogeneity.

3.5 Two-way Error Components

Under groupwise separability, we consider five regions where each region is treated as a panel with the countries as identifiers. We estimate one equation per region. Under this panel data structure, our disturbance term for each equation, u_{iht}, captures the unobserved hetereogeneity in demand shares not explained by either prices or quality. More precisely, the term captures unobserved hetereogeneity related to exporting source h and time t as well as other error terms (mostly originating from the use of proxies rather than actual variable for quality and prices).

We consider the following expression for our disturbance term:

$$u_{iht} = \gamma_{ih} + \lambda_t + \varepsilon_{iht} \tag{31}$$

where γ_{ih} and λ_t are i.i.d error components. The error term ε_{iht} is i.i.d across all dimensions (source country, time).

For the purpose of this article, we follow the same technique as proposed by Boumahdi, Chaaban and Thomas (2004) and Baltagi (2005) in representing our error terms as random effects. As seen in the above section, we can rewrite the two-way error component model in matrix form, as the following:

$$y = X\beta + u \tag{32}$$

with $u = \triangle_1\gamma + \triangle_2\lambda + \varepsilon$ where $\gamma = (\gamma_1, ..., \gamma_N)'$ and $\lambda = (\lambda_1, ..., \lambda_T)'$.

The matrices $\triangle_1$ and $\triangle_2$ are dummy variables that equal 1 if an observation (ih, t) is relevant for the group. We assume that γ_{ih} and λ_t have zero mean and variance σ_γ^2 and σ_λ^2, respectively. This gives us a full n x n variance-covariance matrix of the model as follows:

$$\omega = E(uu') = \sigma_\varepsilon^2 I_n + \sigma_\gamma^2 \triangle_1 \triangle_1' + \sigma_\lambda^2 \triangle_2 \triangle_2' \tag{33}$$

We need to estimate the variance components of the errors so as to obtain the ω, which gives us unbiased estimates for β. In the balanced panel data set, as in our case where each equation is strongly balanced for each (ih, t) group, we can obtain feasible estimates of the variance components via the use of ANOVA estimators when disturbances are normally distributed (Searle, 1987).

Once the variances components are determined, the inverse of the variance-covariance ω can be constructed to compute the FGLS estimator which is done for each of the five equations in our model. We then run a SUR on all the five equations, implementing the additivity, homogeneity and symmetry constraints.

4 Estimation Results

We estimate the following augmented RSD-AAIDS demand system for all the four sectors:

$$\begin{aligned} w_{i,h\epsilon k,t} = \alpha_{ih} &+ \gamma_{ihh} \ln(p_{iht}) + \gamma_{ih,EU-12} \ln(p_{i,E\bar{U}-12,t}) + \gamma_{ih,EU-15} \ln(p_{i,E\bar{U}-15,t}) \\ &+ \gamma_{ih,Dev} \ln(p_{i,\bar{D}ev,t}) + \gamma_{ih,BRIC} \ln(p_{i,B\bar{R}IC,t}) + \gamma_{ih,RoW} \ln(p_{i,\bar{R}ow,t}) \\ &+ \epsilon_{ihh} \ln(s_{iht}) + \epsilon_{ih,EU-12} \ln(s_{i,E\bar{U}-12,t}) + \epsilon_{ih,EU-15} \ln(s_{i,E\bar{U}-15,t}) \\ &+ \epsilon_{ih,Dev} \ln(s_{i,\bar{D}ev,t}) + \epsilon_{ih,BRIC} \ln(s_{i,B\bar{R}IC,t}) + \epsilon_{ih,RoW} \ln(s_{i,\bar{R}oW,t}) \\ &+ \beta_{ih} \ln(\frac{X_t}{P_t^C}) + u_{ihgt} \end{aligned} \tag{34}$$

where $(h\epsilon k)$ refers to all h sources in the region k. Since there are 5 regions in total, EZ, HEZ, Dev, BRIC and RoW, we need to estimate all five equations for each sector. The total number of observations is 2720 for all 4 different sectors.

Table 1 provides a summary of the average import budget shares for each sector for the respective regions over the period of 1995 to 2011. For the service sectors, we observe several zero expenditures (or zero values) in our dataset which we also report in Table 1. Zero expenditures in our dataset occur are due to the fact that France does not buy services from certain countries. The reason for this lack of purchase may be due to either a higher preference for domestic services or due to the fact that services are not easily transferrable.[19]

In the first stage of estimations, we estimate the model in Equation (34) with a random effects specification (using FGLS) and then we obtain the estimates of variance components using the ANOVA estimator. In order to validate the use of the ANOVA estimator, we need to check for the validity of the error components model through the use of the Breusch Pagan Lagrange Multiplier test (LM) test. In the second stage, we check the validity of the random effects specification using the Hausman test. The LM tests confirm the validity of the error components model and the Hausman tests confirm the validity of the random effects specification. The results are displayed on the regression tables (Tables 2 to 5).

We finally implement the FGLS routines for SUR. We imposed the model restrictions of homogeneity (of degree zero) in prices and symmetry in these estimations. Since the sum of all expenditure shares in the RSD-AAIDS must add up to one, the residuals variance-covariance matrix is singular. This means adding the addivity restriction becomes problematic. In order to impose additivity, we need to drop one equation from the estimation. We dropped the estimation for the RoW region. We also included the Root Mean Square Error (Root MSE) as a goodness of fit measure rather than the usual adjusted R^2 since we are interested in comparing errors of different models (Table 2 to 5).

When we turn to the parameter estimates implied in all the estimations and sectors, the own price parameter, denoted by $\ln(p_{ih})$, tends to be significant for some of these estimations (in Line 1 of Tables 2 to 5). Notably, the own price parameter is significant for the regions HEZ and RoW for the sector of Metal products, BRIC for the Transport equipment sector, for HEZ and BRIC in the Banking sector and for EZ, Dev and RoW for the Telecommunications sector. The own quality parameter, denoted by $\ln(s_{ih})$, also tends to be highly significant in most of these estimations (in Line 7 of Tables 2 to 5). In particular, significant own-quality parameters are observed for all regions except BRIC for Metal products, for Dev and RoW in Transport equipment sector, for for EZ, HEZ and BRIC in the Banking sector and for all regions except HEZ for the Telecommunications sector.

We consult the results for the manufacturing sectors that are provided in Tables 2 and 3 (for Metal products and Transport equipment, respectively). Substitution in terms of prices, as inferred by significant cross-price parameters (in Lines 2-6 of Tables 2 and 3), are observed in both sectors for certain region pairs. Positive cross-price parameters indicate substitutability across products while negative cross-price parameters signify complementarity across products. For Metal products (Table 2), exports from EZ are characterized by

[19] Lack of purchase is observed only in the Banking sector for Chinese exports to France. Thus, we did not correct for these zero expenditures.

significant and positive cross-price effects with Dev and BRIC and negative cross-price effect with RoW. Exports from HEZ are characterized by positive and significant cross-price terms with HEZ and Dev competitors, and are complementary to BRIC competitors. Dev exports to France compete aggressively with EZ and HEZ competitors and are complementary to export competitiors from BRIC. BRIC metal products are largely substitutable with products coming from EZ but are complementary to two regions (HEZ and Dev). Finally, RoW is characterised by negative cross-price effects with EZ.

On the other hand, for Transport Equipment (Table 3), competition in terms of prices is largely present as few of the cross-price terms are insignificant. EZ exports are characterized by complementary effects with HEZ, Dev and substitutable effects with other EZ countries and RoW. HEZ exports are complementary with EZ and RoW products while substitutable with Dev products. Dev exports face strong competition from HEZ and BRIC while enjoying complementary links with EZ competitors. BRIC exporters face competition from Dev but are supported by products originating from other BRIC countries and RoW. Lastly, RoW exports are complementary to HEZ and BRIC exports to France.

In terms of cross-quality effects (in Line 8-12 of Tables 2 and 3), we understand negative cross-quality terms to be substitution effects and positive cross-quality terms to be complementary effects. In the Metal products sector, EZ exports are characterised by positive cross-quality terms with EZ and RoW but negative cross-quality terms with Dev. HEZ exports are highly complementary in terms of quality to products orginating from EZ, Dev while these exports compete with exports from HEZ, BRIC and RoW. Dev exports are characterized by positive cross-quality effects with Dev and RoW and negative cross-quality effects with BRIC. HEZ exports report positive cross-quality effects with HEZ and negative cross-quality effects with Dev and RoW. The estimation for Dev equation reports negative cross-quality terms for Dev and RoW. BRIC's exports are highly substitutable to exports from Dev and RoW. Finally, RoW faces positive cross-quality effects from Dev and negative cross-quality effects from RoW.

Similarly for Transport Equipment, cross-quality effects are dominant across regions and these terms are dominantly negative. This suggests that quality competition in this sector is intense. This might be reasonable as the Transport Equipment sector produces highly differentiated products, which make them less substitutable across the globe. EZ exports are substitutable with exports from BRIC but complementary to exports originating from Dev and RoW. Cross-quality parameters are significant and positive for competition between Dev and HEZ and BRIC and negative with EZ, other Dev countries and RoW. BRIC exports are charaterized by strong substitution effects with Dev and RoW. Finally, RoW is characterized by substitution effects with HEZ and RoW and complementary effects with Dev.

When we compare the results for the services sectors that are provided in Tables 4 and 5 (for Banking and Telecommunications, respectively), we observe that most cross-price parameters (Lines 2-6) tend to be insignificant whereas the opposite is true for cross-quality parameters. For Banking services (Table 4), we observe significant and positive cross-price terms in EZ with Dev while these exports are complementary with other countries in EZ. HEZ exports are characterized by positive cross-price effects with Dev and BRIC and are, again, complementary within itself and RoW. Dev exports are highly complementary with other Dev exports and RoW and highly substitutable with exports coming from EZ, HEZ and BRIC. BRIC exports face substitution effects with hEZ, Dev and other BRIC countries. Finally, RoW exports are largely complementary with HEZ and Dev and are substitutable with other RoW competitors.

For Telecommunications services (Table 5), we notice more significant cross-price effects (as compared to Banking services). EZ exports tend to be substitutable with Dev and BRIC competitors, and complementary with other EZ and RoW competitors. Dev exports are largely subsitutable with EZ, BRIC and RoW exports while being complementary with other Dev exports. BRIC is faced with positive cross-price effects with EZ, HEZ and Dev and negative cross-price effects with RoW. Finally, RoW exports contain negative cross-price effects with EZ and BRIC competitors and positive cross-price effects with Dev.

Cross-quality effects (Lines 7-12) tend to be more significant in both the services sectors. For Banking, EZ exports seem to be complementary with BRIC competitors. HEZ exports are characterized by negative cross-quality effects with HEZ and positive cross-quality efffects with EZ competitors. Dev exports are substitutable with EZ and RoW exports and complementary with HEZ and other Dev exports. BRIC is characterized by negative cross-quality parameters for HEZ and Dev and positive cross-quality terms with EZ. For Telecommunications, EZ faces significantly positive cross-quality effects from EZ, HEZ and BRIC and significantly negative cross-quality effect from Dev. HEZ exports are highly substitutable to Dev exports. Dev exports are highly substitutable to EZ and other Dev exporters and are highly complementary to HEZ exporters. BRIC faces positive cross-quality terms for EZ and other BRIC competitors and negative cross-quality terms for HEZ. Finally, RoW exports report significantly negative cross-quality terms with EZ and BRIC and significantly positive cross-quality terms with Dev and other RoW exporters.

Expenditure terms (Line 13) are generally significant though the signs vary across the sectors as well as regions. Negative and significant income effects are present in the Metal products sectors for exports originating from RoW while positive income effects are observed for exports from EZ and Dev. In the Transport Equipment sector, only HEZ exports are characterized with significantly negative income effects. In Banking and Telecommunications services, significantly negative income effects are only present in RoW exports to France.

4.1 Elasticities

We used the estimates from Tables 2 to 5 to calculate the long-run Marshallian own-price, own-quality, cross-price, cross-quality and expenditure elasticities. These elasticities are provided in Tables 6 and 7. Tables 8 and 9 provide the elasticities calculated using patent counts as our quality variable. The zones in the columns indicate how the regions respond to changes in own price, price of other competitors and expenditure. For instance, in Metal products, for ($Column = Dev$, $RoW = EZ$)=(0.054) implies that France will import 0.054% more metal products from Dev for a 1% increase in the price of EZ products.

Own-price elasticities range between -0.3 and -8 for all of the sectors (Table 6). These elasticities tend to be higher (in absolute terms) in the Metal products sector which is a sector that produces highly homogeneous products. Thus, it is justified that this sector has relatively higher own-price elasticities as opposed to sectors producing and providing differentiated products and services. The own-price elasticity for Metal products is lowest for EZ exports, implying that lower substitutability between EZ and other regions for metal products. Despite metal products being highly homogeneous and thus highly substitutable products, French consumers substitute metal products from EZ less readily than metal products from any other regions. The highest (in absolute terms) own-price elasticity is observed for BRIC exports which is to be expected since BRIC countries specialize in producing low-technology goods (such as metal products) at low prices. Thus, for a 1% increase in the price of metal products coming from the BRIC countries would instigate a 8% fall in French demand for these products.

When we compare the own-price elasticities between Transport equipment and the service sectors, we notice few differences. All three sectors record relatively lower own-price elasticities (as opposed to Metal products). Again, the highest (in absolute terms) own-price elasiticities in all three sectors are present in BRIC exports with the exception of Telecommunications (where RoW portrays the highest own-price elasticity, in absolute terms). These results again confirm that high substitutable nature of BRIC exports due to a change in the product price. We also notice that the products coming from EZ and Dev tend to have lower own-price elasticities, rendering them more differentiable according to the French consumer.

Other studies that have estimated price elasticities of manufacturing sectors have shown higher trade price elasticities, ranging between -3 and -5. These lower price elasticities may be due to the level of disaggregation of our data. Several economists (Thanagopal and Le Mouël, 2014; Le Crozet and Erkel-Rousse, 2004 and Erkel-Rousse and Mirza, 2002), have presented higher price elasticities for manufacturing goods when using highly disaggregated bilateral trade data when the data is disaggregated by product classification. Our data, however, is only disaggregated by exporter and sector (which is an aggregation of all product classifications in a particular sector). A more disaggregated database might reveal higher elasticities, even closer to those found in previous studies in the same field for manufacturing sectors.

WIOD remains a useful database for services trade since data are largely lacking in such sectors. Using the similar database for both services and manufacturing products helps to limit the differences between the harmonisation process used in accumulating the data and allows us to compare the results across the sectors. In addition, since very limited studies have been conducted on the elasticities of services trade, it is difficult to comment on the magnitude of such elasticities. Nevertheless, the price elasticities for Transport equipment and services remain relatively weak compared to price elasticities of homogeneous goods which often range between -4 and -7. Since we are looking at manufacturing products sectors that produce differentiated products and services which tend to be differentiated, we can expect a relatively lower price elasiticity, as observed in both Tables 6 and 8.

Expenditure elasticities are all positive and significant, often greater than 1.0, except for HEZ (0.988) and RoW (0.874) in Metal products (0.988), HEZ (0.904) and Dev (0.953) in Transport Equipment (0.335) and RoW for both Banking (0.604) and Telecommunications (0.504). These results are surprising as they indicate a different reaction to import demand from specific region due to an increase in France's real expenditures. An increase in real expenditure in France leads to a less than proportionate increase in demand for services originating from RoW. These results should not be taken as pure income elasticity since expenditure, in our case, is not the total demand of all products in France but rather the total discounted demand for all products within a considered sector. Thus, this income effect should be interpreted as a relative income effect (with respect to the various sources).

Cross-price and cross-quality elasticities reveal the shift in consumption patterns when met with a price or quality change. These results reveal information on the competitiveness of the exporters in making these goods less substitutable so as to protect their market share in France and they also reveal information pertaining to the preferences of the representative French consumer. In the Metal products sector, French consumers prefer to buy more exports from EZ when faced with a price increase in the same product originating from Dev and RoW. On the other hand, EZ exports respond negatively when faced with a price increase in HEZ and RoW. HEZ exports respons positively to a price increase in metal products originating from other HEZ countries as well as from Dev. However, HEZ exports suffer when the price increase is met in BRIC. Dev exports respond positively to a price increase in EZ but negatively to a price increase in BRIC metal products. BRIC exports tend to be complementary to EZ exports, yet they suffer from a price increase by HEZ and Dev. Finally, RoW exports are complementary to EZ exports since an increase in the price of metal products from EZ illicts a 0.086% decrease in French demand addressed to RoW.

Cross-price elasticitities tend to be significantly positive in Transport Equipment. The representative French consumer switches to the consumption of EZ transport equipment when faced with a price increase in the same product originating from other EZ countries and RoW. However, the same consumer prefers to lower his demand for EZ transport equipment when faced with a higher price for HEZ and Dev transport equipment. HEZ exports lose their market share when price of EZ and RoW transport equipment ares lowered but they gain market share when price of HEZ and Dev transport equipment are lowered. Dev exports respond favorably to a price hike originating from HEZ and BRIC but suffer from the same impact applied on EZ products. BRIC countries tend to compete more fiercely with each other as well as with RoW competitors. Yet, they benefit from a price hike in Dev transport equipment. Finally, RoW performs the worst when competing with a price hike in HEZ and BRIC countries.

In the services, we notice less dominant (and more insignificant) cross-price effects. Competition seems to be less in terms of prices and more in terms of quality. In the banking sector, we notice that the French consumer prefers to consume more of such services from other EZ countries when the price of these services are higher in some EZ countries. EZ banking services tend to be complementary to Dev services, according to the French consumer. An increase in the price of banking services in HEZ and RoW leads to a fall in the demand for similar services from HEZ while an increase in the price of the same services in Dev boosts demand for HEZ banking services. Dev services are demanded following an increase in the price of services from HEZ and BRIC but they are complementary to services from other Dev competitors and RoW. France imports more banking services from BRIC when faced with a price increase in similar services in HEZ, Dev and other BRIC countries.

RoW banking services respond favorably to a price hike in other RoW banking services but suffer due to complementary effects with HEZ and Dev exports.

In the Telecommunications services, EZ exports gain market share when these services become more expensive in BRIC but they suffer when the same effect is observed in other EZ countries and in RoW. France imports more services from HEZ when these services become more expensive in BRIC. Dev exports respond favorably to price hikes originating in other EZ services and BRIC but they suffer due to a price hike in HEZ and Dev services. BRIC exports increase following a price increase in EZ and Dev telecommunication services, but they fall when the price increase is in RoW services. Finally, RoW exports are substitutable to exports coming from HEZ and Dev, but complementary to exports from EZ.

When we look at own quality elasiticites (Table 7), the values are significantly positive (ranging between 0.2 and 3). We ignored the negative sign for the own quality parameter when calculating the Marshallian own-quality elasticities. Due to the additvity restriction, we found several negative own-quality parameters. However, negative quality elasticities do not make economic sense. Thus we have decided to ignore the signs when calculating *only* the own-quality elasticities. Generally, we expect a positive relationship between product quality and demand for a particular product. Own-quality elasticities are, generally, lower than the own-price elasticities in magnitude, yet they remain highly signficant for all regions and sectors. The higher own-quality elasticities are commonly found in EZ and Dev (and sometimes RoW) for all sectors. These own-quality elasticities tend to be lower in Metal Products and higher in services and transport equipment.

Improvements in own-quality has little impact in metal products since these products are highly substitutable. An improvement in the quality of metal products originating from EZ has the smallest increase in demand for these products unless this improvement in quality entails a fall in product prices. Improving metal product quality has the highest positive impact for Dev since a 1% improve in product quality entails a 3% increase in French demand for these goods. BRIC has insignificant own-quality elasticities since these countries perform better when competing in terms of prices. For transport equipment, we notice that French consumers respond favorably to quality improvements from RoW, Dev and EZ. For Banking services, Dev benefits the most from a quality improvement followed by BRIC. This results shows the access of emerging markets in specific high-technology services, notably Banking services. For Telecommunications, the highest impact of quality improvement is targeted at EZ exports. We expected our quality variable to better capture product quality in manufacturing products than in services. Indeed, services benefit much more from externalities and hence indirect R&D expenditures than direct R&D expenditures, unlike the manufacturing products. Nevertheless, the fact that we observe significant own-quality elasticities for both manufacturing goods and services confirm that our quality variable is capable of capturing product quality, to some extent, even for services. Much additional work would need to be conducted in services to allow for such comparative studies.

Cross-quality elasticities are mostly insignificant in Metal products while dominant in Transport equipment and services. In Metal products, we notice significantly negative cross-quality effects on EZ exports due to a quality improvement in other competitors in EZ and in BRIC. However, French consumer treats exports from EZ as complements for exports from Dev and RoW when faced with a quality improvement in Dev and RoW exports. HEZ exports benefit from a quality improvement within the region but suffer when the quality of metal products is improved in both Dev and Row. Dev exports perform badly when faced with quality improvements from competitors of the same region and from RoW. BRIC also fails when competing in terms of quality against Dev and RoW but benefits from a complementary relationship with EZ exports. Finally, RoW exports are strongly complementary with Dev exports but strongly substitutable to other RoW exports.

For Transport equipment, EZ exports are less demanded following an improvement in BRIC product quality. But these exports are demanded when faced with quality improvements in Dev and RoW products. The representative French consumer lowers his demand for Dev exports when faced with an improvement in EZ, Dev and RoW product quality but he increases his demand for Dev transport equipment by almost 9% following an improvement in BRIC transport equipment. We notice the trend of emergent countries towards breaking into high-technology sectors from these results. BRIC exports are penalised when quality improvements take place in Dev and RoW yet these values are still small compared to the increase in BRIC when Dev and RoW imrove their product quality. Finally, RoW exports are substitutable with HEZ and other RoW exports but complementary with EZ and Dev.

When we turn to Banking services, we notice less resistance to EZ exports when quality of such services improves in other regions. EZ exports only respond positively to an improvement in BRIC banking services. HEZ, on the other hand, is penalized when banking services improve quality standards within the region. However, these exports benefit from similar improvements in EZ services. Dev exports increase more than proportionately for an improvement in service quality in HEZ (25.8%) and Dev (3.5%) and decrease more than proportionately for an improvement in EZ services (1.2%). BRIC exports are favored by the French consumer when EZ improves its service quality but they suffer from quality improvements in Dev (1.6%) and HEZ (15.8%).

EZ exports in Telecommunications respond positively to quality improvements in other EZ countries,in HEZ and in BRIC but faces competition from quality improvements in Dev. The French consumer prefers to substitute HEZ with Dev exports following an improvement in Dev quality. Dev telecommunication services are highly substitutable to EZ and Dev services and highly complementary to HEZ and BRIC services. BRIC exports are positively correlated to quality improvements in EZ and BRIC and negatively correlated to HEZ. Finally, RoW exports are complementary to Dev exports and highly substitutable to EZ, BRIC and other RoW exports.

We ran robustness tests for our quality variable by replacing our quality variable with a more traditional variable, that is, the number of patent citations. We calculated the long-run elasticities using both our quality variable and patent count as the quality variable. These results are displayed in Tables 8 and 9. Using the knowledge variable as our quality does not drastically change the results on both prices and quality elasticities. However, the magnitudes of price elasticities are smaller and those of the quality elasticities are larger when using our knowledge variable. This is to be expected since the patent count variable may ignore the effect of externalities which tend to increase the impact of quality effects and thereby decrease the impact of price effects. The elasticities calculated are very similar and slightly higher in magnitude for the elasticities calculated from parameters estimated using our knowledge variable. This further affirms our use of the knowledge variable as a measure of product quality. Overall, these results are indicative of the phenomenon that trade in services and differentiated products are characterized more by quality competition than by price competition.

5 Conclusion

This paper revisits the AIDS model with restricted source differentiation by including an explicit quality variable in the model. We introduced several restrictions to reduce the RSD-AIDS model to a testable equation (Restrictions 1 and 2, the Laspeyres price index and groupwise separability), implementing FGLS procedures on SUR with a two-way error components approach to estimate the long-run equilibrium of the model. We attempt to enrich the current literature by using a new knowledge variable, which includes the effect of positive externalities arising from innovation efforts, to represent quality. We apply this approach to the case study of French manufacturing industries (namely Metal products and Transport equipment) and market services (namely Banking and Telecommunications services). The results show that price elasticities are higher for homogeneous goods than for services and differentiated products. Competition is defined by prices for homogeneous products and by quality for differentiated goods and services. Further studies on services trade could provide validation to our findings yet these results are in line with previous similar studies on the estimation of price elasticities (Thangopal and Le Mouël, 2014; Thanagopal, 2014; Hallak and Schott, 2011; Imbs and Méjean, 2010; Francois and Hoekman, 2009; Hooper, Johnson and Marquez, 2000 and Crozet and Erkel-Rousse, 2004).

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6 Figures

Figure 1: Importer Choice among different product sources

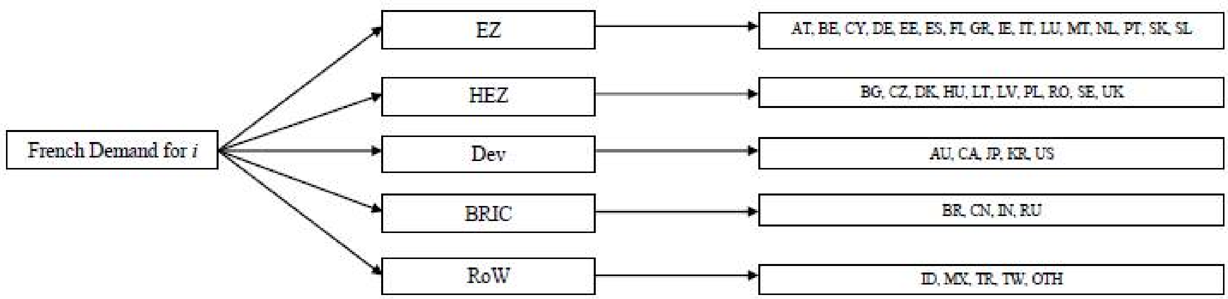
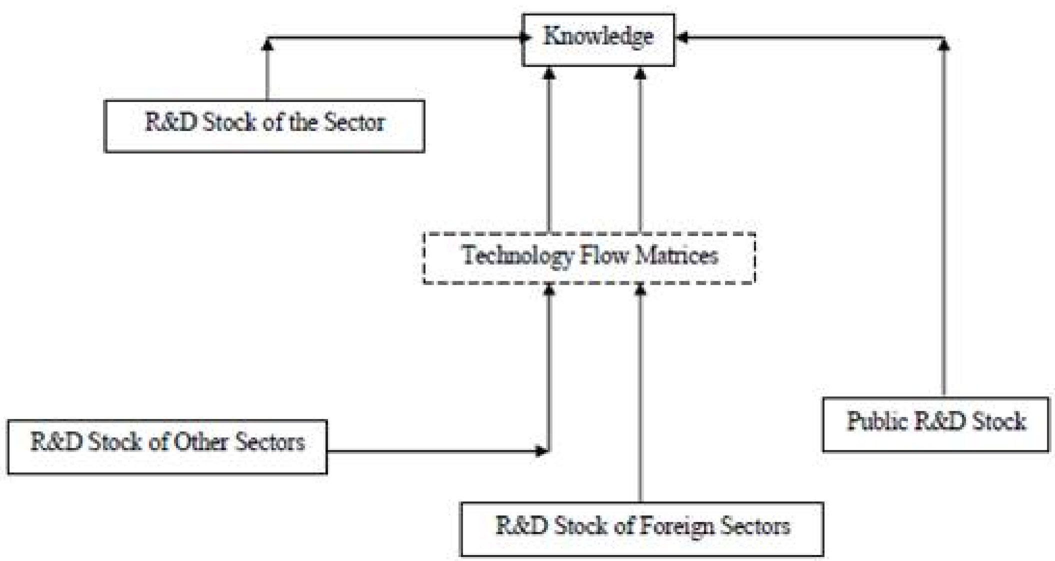


Figure 2: Constructing the Knowledge Variable



7 Tables

Table 1: Weighted average import shares by region - 1995 to 2011 average

Sector	EZ	HEZ	Dev	BRIC	RoW	Total Obs	Missing Obs
Metal products	0.502	0.102	0.149	0.045	0.202	680	0
Transport equipment	0.774	0.099	0.113	0.004	0.010	680	0
Banking services	0.479	0.017	0.107	0.122	0.274	680	17
Telecommunications services	0.210	0.025	0.082	0.456	0.228	680	0

Table 2: French import share equation for Metal products

Variables Region	EZ	HEZ	Dev	BRIC	RoW
$\ln p_{ih}$	-0.042 (0.028)	-0.075** (0.038)	-0.032 (0.027)	0.006 (0.015)	0.144*** (0.054)
$\ln p_{i,EZ}$	0.063 (0.039)	-0.028 (0.017)	0.033*** (0.011)	0.037*** (0.006)	-0.063*** (0.015)
$\ln p_{i,HEZ}$	-0.028 (0.017)	0.079** (0.036)	0.021** (0.010)	-0.015** (0.006)	0.018 (0.014)
$\ln p_{i,Dev}$	0.033*** (0.011)	0.021** (0.010)	-0.027 (0.029)	-0.019*** (0.005)	0.024 (0.020)
$\ln p_{i,BRIC}$	0.037*** (0.006)	-0.015** (0.006)	-0.019*** (0.005)	-0.018 (0.012)	0.009 (0.008)
$\ln p_{i,RoW}$	-0.063*** (0.015)	0.018 (0.014)	0.024 (0.020)	0.009 (0.008)	0.011 (0.033)
$\ln s_{ih}$	0.025** (0.012)	-0.031** (0.012)	0.215** (0.085)	0.011 (0.012)	-0.219** (0.087)
$\ln s_{i,EZ}$	-0.074*** (0.021)	0.012 (0.014)	0.008 (0.017)	0.025*** (0.009)	0.029 (0.032)
$\ln s_{i,HEZ}$	0.000 (0.007)	0.025*** (0.009)	-0.003 (0.008)	-0.005 (0.005)	-0.016 (0.015)
$\ln s_{i,Dev}$	0.056*** (0.021)	-0.040* (0.023)	-0.234*** (0.065)	-0.037*** (0.010)	0.255*** (0.069)
$\ln s_{i,BRIC}$	-0.046* (0.026)	0.050 (0.031)	-0.011 (0.038)	0.017 (0.018)	-0.011 (0.064)
$\ln s_{i,RoW}$	0.020** (0.009)	-0.022* (0.012)	-0.022** (0.009)	-0.017*** (0.005)	-0.258*** (0.097)
$\ln(\frac{X_t}{P_t^C})$	0.021*** (0.006)	-0.001 (0.003)	0.008* (0.005)	0.002 (0.002)	-0.030*** (0.009)
Constant	-0.117* (0.071)	0.133* (0.078)	0.333*** (0.074)	0.147** (0.072)	0.504*** (0.163)
Observations	680	680	680	680	680
Root MSE	0.001	0.004	0.035	0.007	0.004
Hausman test	2.37 (0.994)	1.87 (1.000)	6.18 (0.939)	0.00 (1.000)	8.72 (0.900)
σ_{ih} (source)	1.103	0.132	0.067	0.001	0.307
σ_t (time)	0.000	0.000	0.000	0.000	0.003
LM test for both errors	4829.91 (0.000)	5108.29 (0.000)	4907.21 (0.000)	5119.71 (0.000)	4439.88 (0.000)

Notes: *, ** and *** indicate significance at the 10, 5 and 1% levels. Standard errors are in parentheses. P-values are in parentheses for Hausman test and LM test. Homogeneity and symmetry constraints are imposed. BRIC estimates derived using additive restriction.

Table 3: French import share equation for Transport equipment sector

Variables Region	EZ	HEZ	Dev	BRIC	RoW
$\ln p_{ih}$	-0.028 (0.022)	0.000 (0.010)	-0.024 (0.043)	0.032*** (0.011)	0.021 (0.045)
$\ln p_{i,EZ}$	0.057** (0.028)	-0.022** (0.009)	-0.041*** (0.015)	-0.001 (0.002)	0.036** (0.015)
$\ln p_{i,HEZ}$	-0.022** (0.009)	0.016 (0.010)	0.042*** (0.013)	-0.002 (0.002)	-0.033*** (0.013)
$\ln p_{i,Dev}$	-0.041*** (0.015)	0.042*** (0.013)	0.005 (0.031)	0.010*** (0.003)	0.008 (0.027)
$\ln p_{i,BRIC}$	-0.001 (0.002)	-0.002 (0.002)	0.010*** (0.003)	-0.025*** (0.008)	-0.014**** (0.005)
$\ln p_{i,RoW}$	0.036** (0.015)	-0.033*** (0.013)	0.008 (0.027)	-0.014*** (0.005)	0.003 (0.026)
$\ln s_{ih}$	0.027 (0.027)	0.011 (0.009)	0.072** (0.030)	0.010 (0.014)	-0.121** (0.049)
$\ln s_{i,EZ}$	-0.021 (0.026)	0.025 (0.033)	-0.125** (0.056)	0.025 (0.016)	0.096* (0.050)
$\ln s_{i,HEZ}$	-0.013 (0.018)	-0.001 (0.018)	0.086*** (0.033)	-0.010 (0.008)	-0.063** (0.031)
$\ln s_{i,Dev}$	0.017* (0.010)	-0.010 (0.010)	-0.121** (0.048)	-0.014* (0.007)	0.128** (0.050)
$\ln s_{i,BRIC}$	-0.039** (0.019)	-0.011 (0.016)	0.103*** (0.032)	-0.014 (0.018)	-0.040 (0.034)
$\ln s_{i,RoW}$	0.016*** (0.006)	-0.007 (0.006)	-0.049** (0.021)	-0.009* (0.004)	-0.121** (0.055)
$\ln(\frac{X_t}{V_t^C})$	0.011*** (0.004)	-0.010*** (0.003)	-0.007 (0.006)	0.001 (0.001)	0.005 (0.006)
Constant	-0.024 (0.194)	0.093 (0.245)	0.457 (0.412)	0.186 (0.141)	0.289 (0.396)
Observations	680	680	680	680	680
Root MSE	0.001	0.007	0.047	0.003	0.004
Hausman test	2.89 (0.998)	0.21 (1.000)	2.49 (0.232)	5.19 (1.000)	0.72 (0.902)
σ_{ih} (source)	2.397	0.064	0.062	0.000	0.013
σ_t (time)	0.003	0.000	0.004	0.000	0.003
LM test for both errors	4050.91 (0.000)	4079.53 (0.000)	2187.64 (0.000)	4429.05 (0.000)	4123.46 (0.000)

Notes: *, ** and *** indicate significance at the 10, 5 and 1% levels. Standard errors are in parentheses. P-values are in parentheses for Hausman test and LM test. Homogeneity and symmetry constraints are imposed. BRIC estimates derived using additive restriction.

Table 4: French import share equation for Banking services sector

Variables Region	EZ	HEZ	Dev	BRIC	RoW
lnp_{ih}	0.018 (0.027)	0.062*** (0.020)	0.082 (0.065)	-0.111*** (0.041)	-0.051 (0.079)
ln$p_{i,EZ}$	-0.055** (0.026)	0.013 (0.009)	0.048*** (0.016)	0.000 (0.005)	-0.024 (0.015)
ln$p_{i,HEZ}$	0.013 (0.009)	-0.085*** (0.027)	0.047*** (0.011)	0.004* (0.002)	-0.041*** (0.010)
ln$p_{i,Dev}$	0.048*** (0.016)	0.047*** (0.011)	-0.125* (0.070)	0.046*** (0.009)	-0.098*** (0.036)
ln$p_{i,BRIC}$	0.000 (0.005)	0.004* (0.002)	0.046*** (0.009)	0.038* (0.021)	0.023 (0.027)
ln$p_{i,RoW}$	-0.024 (0.015)	-0.041*** (0.010)	-0.098*** (0.036)	0.022 (0.027)	0.140*** (0.046)
lns_{ih}	-0.094** (0.046)	0.149*** (0.045)	-0.044 (0.031)	-0.104* (0.060)	0.093 (0.091)
ln$s_{i,EZ}$	0.063 (0.060)	0.210*** (0.070)	-0.556*** (0.073)	0.517*** (0.127)	-0.233 (0.176)
ln$s_{i,HEZ}$	0.060 (0.090)	-0.446*** (0.145)	0.692*** (0.118)	-0.424** (0.182)	0.118 (0.262)
ln$s_{i,Dev}$	-0.018 (0.037)	-0.010 (0.020)	0.489*** (0.062)	-0.226* (0.123)	-0.236 (0.149)
ln$s_{i,BRIC}$	0.036* (0.020)	-0.010 (0.011)	-0.015 (0.038)	0.014 (0.086)	-0.025 (0.095)
ln$s_{i,RoW}$	-0.017 (0.011)	-0.008 (0.007)	-0.164*** (0.024)	0.042 (0.033)	0.376 (0.230)
$\ln(\frac{X_t}{P_t^C})$	0.004 (0.005)	0.009*** (0.003)	0.080*** (0.017)	0.004 (0.012)	-0.097*** (0.021)
Constant	-0.138 (0.436)	1.225** (0.514)	-5.559*** (0.643)	2.435* (1.251)	3.306* (1.630)
Observations	663	663	663	663	663
Root MSE	0.005	0.006	0.025	0.018	0.008
Hausman test	5.06 (0.974)	0.03 (1.000)	2.67 (0.998)	4.38 (0.986)	12.10 (0.520)
σ_{ih} (source)	0.539	0.001	0.117	0.239	0.332
σ_t (time)	0.002	0.000	0.007	0.002	0.006
LM test for both errors	4779.44 (0.000)	4771.06 (0.000)	4836.43 (0.000)	4591.18 (0.000)	4340.04 (0.000)

Notes: *, ** and *** indicate significance at the 10, 5 and 1% levels. Standard errors are in parentheses for coefficients. P-values are in parentheses for Hausman test and LM test. Homogeneity and symmetry constraints are imposed. BRIC estimates derived using additive restriction.

Table 5: French import share equation for Telecommunications services sector

Variables Region	EZ	HEZ	Dev	BRIC	RoW
lnp_{ih}	0.076* (0.040)	0.015 (0.022)	0.229*** (0.046)	0.007 (0.030)	-0.327*** (0.078)
ln$p_{i,EZ}$	-0.082** (0.035)	0.005 (0.012)	0.026*** (0.009)	0.039*** (0.008)	-0.064*** (0.020)
ln$p_{i,HEZ}$	0.005 (0.012)	-0.018 (0.014)	-0.012 (0.009)	0.006* (0.003)	0.006 (0.010)
ln$p_{i,Dev}$	0.026*** (0.009)	-0.012 (0.009)	-0.387*** (0.065)	0.029*** (0.005)	0.115*** (0.019)
ln$p_{i,BRIC}$	0.039*** (0.008)	0.006* (0.003)	0.029*** (0.005)	-0.019 (0.021)	-0.063** (0.024)
ln$p_{i,RoW}$	-0.064*** (0.020)	0.005 (0.010)	0.115*** (0.019)	-0.063** (0.024)	0.007 (0.042)
lns_{ih}	-0.492*** (0.162)	0.010 (0.078)	0.104*** (0.028)	-0.143** (0.071)	0.522*** (0.199)
ln$s_{i,EZ}$	0.311*** (0.119)	0.009 (0.046)	-0.114*** (0.028)	0.217** (0.111)	-0.424** (0.180)
ln$s_{i,HEZ}$	0.154** (0.072)	-0.010 (0.095)	0.064** (0.032)	-0.270*** (0.074)	0.062 (0.155)
ln$s_{i,Dev}$	-0.056*** (0.016)	-0.012** (0.006)	-0.122*** (0.033)	-0.005 (0.022)	0.195*** (0.045)
ln$s_{i,BRIC}$	0.078** (0.032)	-0.004 (0.008)	0.039*** (0.012)	0.125** (0.049)	-0.238*** (0.067)
ln$s_{i,RoW}$	0.015 (0.019)	-0.020 (0.014)	-0.006 (0.012)	0.011 (0.034)	0.405* (0.233)
$\ln(\frac{X_t}{V_t^C})$	0.067*** (0.015)	0.005 (0.004)	0.030*** (0.007)	0.014 (0.015)	-0.115*** (0.026)
Constant	0.087 (0.413)	0.311 (0.501)	0.012 (0.277)	0.695 (0.766)	-0.103 (1.065)
Observations	680	680	680	680	680
Root MSE	0.013	0.007	0.009	0.002	0.015
Hausman test	0.28 (1.000)	0.05 (1.000)	0.63 (1.000)	0.36 (1.000)	18.07 (0.155)
σ_{ih} (source)	1.106	0.006	0.387	0.000	0.556
σ_t (time)	0.002	0.000	0.002	0.000	0.012
LM test for both errors	4517.38 (0.000)	4525.61 (0.000)	4588.63 (0.000)	2559.26 (0.000)	4110.45 (0.000)

Notes: *, ** and *** indicate significance at the 10, 5 and 1% levels. Standard errors are in parentheses. P-values are in parentheses for Hausman test and LM test. Homogeneity and symmetry constraints are imposed. BRIC estimates derived using additive restriction.

Table 6: 'True' price elasticity for using Knowledge variable as quality

Zones	Own price	EZ	HEZ	Dev	BRIC	RoW	Exp
Metal products							
EZ	-1.101*** (0.057)	0.096 (0.069)	-0.269* (0.157)	0.402*** (0.136)	1.110*** (0.170)	-0.288*** (0.062)	1.040*** (0.010)
HEZ	-1.665*** (0.340)	-0.050 (0.032)	0.697** (0.317)	0.269** (0.120)	-0.450** (0.186)	0.075 (0.059)	0.988*** (0.027)
Dev	-1.408*** (0.337)	0.054*** (0.020)	0.181** (0.084)	-0.345 (0.356)	-0.603*** (0.167)	0.093 (0.087)	1.097*** (0.057)
BRIC	-8.138*** (0.448)	0.066*** (0.010)	-0.132** (0.054)	-0.244*** (0.068)	-0.553 (0.355)	0.036 (0.033)	1.075*** (0.068)
RoW	-3.651*** (0.228)	-0.086*** (0.028)	0.190 (0.121)	0.323 (0.249)	0.308 (0.237)	0.084 (0.140)	0.874*** (0.036)
Transport equipment							
EZ	-1.051*** (0.034)	0.073* (0.038)	-0.222** (0.091)	-0.299*** (0.106)	-0.152 (0.191)	0.788** (0.340)	1.016*** (0.005)
HEZ	-0.993*** (0.092)	-0.023* (0.012)	0.158* (0.092)	0.303*** (0.090)	-0.146 (0.172)	-0.719** (0.292)	0.904*** (0.028)
Dev	-1.160*** (0.294)	-0.053* (0.021)	0.401*** (0.120)	0.042 (0.223)	0.909*** (0.297)	0.223 (0.637)	0.953*** (0.041)
BRIC	-1.773* (0.903)	-0.003 (0.003)	-0.020 (0.019)	0.071*** (0.024)	-2.152*** (0.674)	-0.334*** (0.124)	1.055*** (0.114)
RoW	-0.540*** (1.024)	0.050* (0.026)	-0.311** (0.133)	0.053 (0.218)	-1.227** (0.476)	0.053 (0.493)	1.066* (0.612)
Banking services							
EZ	-0.964*** (0.060)	-0.127** (0.057)	0.490 (0.323)	0.335*** (0.116)	-0.002 (0.035)	-0.101 (0.063)	1.010*** (0.012)
HEZ	-1.308* (0.753)	0.021 (0.018)	-3.205*** (0.997)	0.321*** (0.075)	0.020 (0.016)	-0.173*** (0.044)	1.322*** (0.117)
Dev	-0.517*** (0.015)	0.030 (0.044)	1.610*** (0.406)	-0.997* (0.511)	0.252*** (0.058)	-0.471*** (0.156)	1.575*** (0.122)
BRIC	-1.821*** (0.292)	-0.003 (0.015)	0.143* (0.080)	0.326*** (0.063)	0.273* (0.162)	0.088 (0.118)	1.029*** (0.091)
RoW	-0.343* (0.200)	0.039 (0.041)	-1.360*** (0.385)	-0.573** (0.249)	0.274 (0.191)	0.657*** (0.200)	0.604*** (0.087)
Telecommunications services							
EZ	-0.677*** (0.195)	-0.478*** (0.182)	-0.040 (0.251)	0.072 (0.064)	0.046*** (0.011)	-0.346*** (0.100)	1.341*** (0.075)
HEZ	-0.709*** (0.040)	0.019 (0.062)	-0.385 (0.285)	-0.095 (0.059)	0.012* (0.006)	0.019 (0.046)	1.094** (0.089)
Dev	-0.571* (0.325)	0.106** (0.047)	-0.310* (0.176)	-2.795*** (0.463)	0.052*** (0.009)	0.465*** (0.084)	1.211*** (0.051)
BRIC	-0.992*** (0.079)	0.185*** (0.039)	0.093 (0.071)	0.184*** (0.043)	-0.061 (0.048)	-0.283** (0.117)	1.036*** (0.039)
RoW	-1.291*** (0.328)	-0.218** (0.088)	0.341* (0.199)	1.012*** (0.142)	-0.068 (0.051)	0.145 (0.204)	0.504*** (0.113)

Notes: *, ** and *** indicate significance at the 10, 5 and 1% levels. Standard errors are in parentheses.

Table 7: Quality elasticity using Knowledge variable as quality

Zones	Own quality	EZ	HEZ	Dev	BRIC	RoW
Metal products						
EZ	0.046** (0.023)	-0.139*** (0.038)	-0.002 (0.059)	0.705*** (0.262)	-1.407* (0.799)	0.084** (0.040)
HEZ	0.277** (0.109)	0.023 (0.026)	0.218*** (0.080)	-0.503* (0.287)	1.549 (0.957)	-0.090* (0.048)
Dev	2.688** (1.064)	0.015 (0.031)	-0.029 (0.074)	-2.933*** (0.812)	-0.337 (1.180)	-0.092** (0.039)
BRIC	0.327 (0.38)	0.046*** (0.016)	-0.048 (0.041)	-0.467*** (0.130)	0.530 (0.552)	-0.071*** (0.020)
RoW	0.912** (0.360)	0.054 (0.060)	-0.139 (0.136)	3.197*** (0.866)	-0.334 (1.970)	-1.076*** (0.406)
Transport equipment						
EZ	0.390*** (0.039)	-0.031 (0.038)	-0.117 (0.171)	0.120* (0.069)	-3.314** (1.662)	0.375*** (0.137)
HEZ	0.102 (0.087)	0.036 (0.047)	-0.006 (0.167)	-0.072 (0.069)	-0.949 (1.330)	-0.171 (0.144)
Dev	0.498** (0.205)	-0.180** (0.080)	0.805*** (0.306)	-0.836** (0.329)	8.843*** (2.770)	-1.143** (0.482)
BRIC	0.888 (1.191)	0.037 (0.023)	-0.090 (0.073)	-0.094* (0.051)	-1.203 (1.505)	-0.210** (0.083)
RoW	2.808** (1.135)	0.138* (0.073)	-0.592** (0.293)	0.882** (0.342)	-3.378 (2.935)	-2.814** (1.288)
Banking services						
EZ	0.315*** (0.002)	0.139 (0.133)	2.246 (3.339)	-0.125 (0.265)	0.265* (0.150)	-0.070 (0.044)
HEZ	0.208** (0.101)	0.465** (0.155)	-16.657*** (5.406)	-0.073 (0.145)	-0.074 (0.084)	-0.032 (0.028)
Dev	5.558*** (1.673)	-1.233*** (0.163)	25.812*** (4.411)	3.495*** (0.445)	-0.112 (0.282)	-0.669*** (0.099)
BRIC	0.765* (0.442)	1.146*** (0.281)	-15.810** (6.790)	-1.611* (0.877)	0.106 (0.634)	0.169 (0.134)
RoW	0.378 (0.371)	-0.517 (0.390)	4.409 (9.784)	-1.686 (1.065)	-0.185 (0.699)	1.529 (0.936)
Telecommunication services						
EZ	2.502*** (0.825)	1.582*** (0.607)	3.147** (1.472)	-0.397*** (0.116)	0.206** (0.083)	0.063 (0.081)
HEZ	0.195 (1.594)	0.048 (0.236)	-0.210 (1.945)	-0.083** (0.042)	-0.012 (0.020)	-0.087 (0.060)
Dev	0.741*** (0.198)	-0.580*** (0.140)	1.310** (0.643)	-0.868*** (0.232)	0.102*** (0.032)	-0.026 (0.051)
BRIC	0.375** (0.187)	1.103** (0.562)	-5.519*** (1.517)	-0.037 (0.156)	0.329** (0.129)	0.046 (0.145)
RoW	2.249*** (0.857)	-2.152** (0.912)	1.273 (3.163)	1.385*** (0.321)	-0.626*** (0.176)	-1.163* (0.658)

Notes: *, ** and *** indicate significance at the 10, 5 and 1% levels. Standard errors are in parentheses.

Table 8: 'True' price elasticity using Patent counts as quality

Zones	Own price	EZ	HEZ	Dev	BRIC	RoW	Exp
Chemicals							
EZ	-1.001*** (0.018)	-0.001 (0.021)	0.010 (0.017)	-0.074** (0.026)	-0.025 (0.019)	0.091*** (0.021)	1.001*** (0.028)
HEZ	-0.983*** (0.010)	-0.050 (0.088)	-0.032 (0.081)	-0.377*** (0.075)	.331*** (0.083)	0.128*** (0.045)	0.860*** (0.084)
Dev	-1.064*** (0.000)	-0.056 (0.167)	-0.415*** (0.105)	-0.378 (0.611)	0.476 (0.348)	0.372 (0.326)	1.571*** (0.235)
BRIC	-1.058*** (0.022)	0.562 (0.710)	2.722*** (0.609)	2.754* (0.286)	-3.502*** (1.080)	-2.535** (0.998)	2.144*** (0.216)
RoW	-0.916*** (0.020)	0.009 (0.038)	0.069** (0.035)	0.126 (0.204)	-0.360** (0.116)	0.158 (0.137)	0.487*** (0.125)
Transport Equipment							
EZ	-0.999*** (0.003)	0.003 (0.012)	-0.010 (0.128)	0.012 (0.011)	-0.001 (0.009)	0.002 (0.003)	0.998*** (0.004)
HEZ	-0.997*** (0.010)	-0.072 (0.080)	0.219 (0.136)	-0.177* (0.100)	0.036 (0.064)	0.010 (0.042)	.972*** (0.082)
Dev	-1.005*** (0.007)	0.052 (0.048)	-0.133* (0.070)	0.099 (0.091)	-0.004 (0.055)	-0.013 (0.025)	1.045*** (0.039)
BRIC	-0.997*** (0.012)	-0.121 (0.450)	0.320 (0.577)	-0.045 (0.683)	-0.015 (0.706)	-0.057 (0.234)	0.498 (0.364)
RoW	-1.025*** (0.019)	-0.001 (0.051)	-0.008 (0.101)	-0.070 (0.095)	-0.045 (0.066)	-0.003 (0.075)	1.131*** (0.096)
Banking services							
EZ	-0.961*** (0.027)	-0.130 (0.104)	0.187 (0.123)	-0.047 (0.057)	-0.088 (0.028)	-0.027 (0.049)	1.012*** (0.064)
HEZ	-1.130*** (0.052)	3.099 (1.947)	-2.702 (2.252)	-0.576 (0.677)	-0.117 (0.184)	-0.353 (0.660)	4.085*** (1.227)
Dev	-1.001*** (0.011)	-0.135 (0.136)	-0.085 (0.132)	0.212 ** (0.090)	0.048 (0.033)	-0.039 (0.055)	1.007*** (0.059)
BRIC	-1.001*** (0.002)	-0.012 (0.029)	0.003 (0.034)	0.050 (0.034)	-0.051 (0.033)	0.011 (0.011)	1.007*** (0.012)
RoW	-0.977*** (0.025)	0.001 (0.054)	0.016 (0.068)	0.018 (0.043)	0.047* (0.027)	0.122 (0.090)	0.916*** (0.115)
Telecommunication services							
EZ	-1.004*** (0.029)	-0.550 (0.386)	0.627* (0.340)	0.176 (0.089)	-0.126** (0.060)	-0.097* (0.055)	1.022*** (0.158)
HEZ	-1.012*** (0.049)	2.488* (1.335)	-2.094 (1.324)	-0.802** (0.343)	0.226 (0.178)	-0.054 (0.134)	1.491*** (0.507)
Dev	-1.013*** (0.021)	0.169 (0.112)	-0.275** (0.118)	0.012 (0.101)	0.027 (0.073)	0.002 (0.015)	1.068*** (0.088)
BRIC	-0.999*** (0.004)	-0.060** (0.029)	0.038 (0.024)	0.018 (0.023)	0.010 (0.023)	0.009* (0.003)	0.997*** (0.112)
RoW	-0.976*** (0.046)	-0.054 (0.082)	0.024 (0.061)	0.034 (0.054)	0.035 (0.047)	0.087** (0.039)	0.895*** (0.196)

Notes: *, ** and *** indicate significance at the 10, 5 and 1% levels. Standard errors are in parentheses.

Table 9: Quality elasticity for using Patents counts as quality

Zones	Own quality	EZ	HEZ	Dev	BRIC	RoW
Chemicals						
EZ	0.712*** (0.004)	0.123 (0.298)	0.039 (0.333)	0.006*** (0.002)	0.825*** (0.314)	-0.747 (0.503)
HEZ	0.078*** (0.003)	1.493 (1.359)	-0.525 (1.374)	-6.321* (3.593)	0.388*** (0.019)	7.677* (4.067)
Dev	0.204*** (0.001)	-0.867** (0.473)	0.257*** (0.031)	5.262 (3.485)	-3.211*** (1.209)	9.084*** (2.858)
BRIC	0.129*** (0.016)	0.168 (0.169)	-0.039 (0.180)	1.999*** (0.374)	0.937*** (0.344)	-3.065*** (0.188)
RoW	0.130*** (0.018)	0.106* (0.059)	-0.043 (0.072)	-0.854 (0.523)	0.693** (0.269)	1.609*** (0.430)
Transport Equipment						
EZ	0.510*** (0.000)	0.030 (0.043)	-0.088 (0.089)	0.003 (0.029)	-0.006 (0.085)	-0.128 (0.086)
HEZ	0.090*** (0.000)	0.154 (0.164)	0.344 (0.335)	-0.092 (0.117)	0.075 (0.296)	-0.481 (0.310)
Dev	0.203*** (0.000)	-0.006 (0.059)	0.046 (0.134)	0.009 (0.109)	0.066 (0.082)	-0.016 (0.106)
BRIC	0.056* (0.013)	-0.065 (0.531)	-1.236 (1.092)	1.976** (0.773)	0.145 (0.525)	0.949 (0.695)
RoW	0.221* (0.127)	-0.042 (0.143)	-0.209 (0.589)	0.179 (0.336)	0.079 (0.315)	-0.007 (0.588)
Banking services						
EZ	0.111*** (0.000)	0.705 (1.364)	0.389 (1.402)	0.001 (0.099)	-0.003 (0.076)	-0.321 (1.443)
HEZ	0.098*** (0.001)	10.995 (16.737)	-3.203 (15.888)	1.993 (2.424)	0.77 (0.882)	-5.723 (17.732)
Dev	0.170*** (0.000)	-0.519 (1.407)	0.152 (1.133)	-0.047 (0.837)	0.133 (0.111)	0.281 (1.174)
BRIC	0.008*** (0.000)	0.123 (0.373)	-0.074 (0.333)	0.047 (0.220)	-0.027 (0.028)	0.022 (0.272)
RoW	0.023*** (0.000)	-0.105 (0.769)	0.467 (0.842)	0.274 (0.272)	-0.016 (0.063)	-0.104 (0.909)
Telecommunication services						
EZ	0.220*** (0.000)	1.256* (0.680)	-1.222** (0.473)	0.124 (0.117)	0.242** (0.110)	-0.152 (0.619)
HEZ	0.098*** (0.001)	-3.378** (1.656)	2.793** (1.195)	-0.238 (0.322)	-0.408* (0.238)	-0.755 (1.561)
Dev	0.110*** (0.000)	-0.076 (0.407)	-0.074 (0.161)	0.008 (0.106)	-0.065 (0.046)	0.075 (0.402)
BRIC	0.001* (0.000)	-0.003 (0.285)	-0.007 (0.119)	0.007 (0.078)	-0.068** (0.035)	0.071 (0.320)
RoW	0.028*** (0.000)	-0.352* (0.200)	0.437*** (0.135)	0.019 (0.049)	0.067** (0.033)	0.022 (0.100)

Notes: *, ** and *** indicate significance at the 10, 5 and 1% levels. Standard errors are in parentheses.

8 Appendix: The AIDS model - theory

In the AIDS model built by Deaton and Muellbauer in 1980, it is assumed that consumers have quasi-homothetic PIGLOG class of preferences. This means that the consumer problem is to minimise a PIGLOG cost function $C(u, p^*)$ for a given level of utility u at a given quality-adjusted price vector p^* as shown below.

$$\ln[C(u, p^*)] = (1 - u)\ln[A(p^*)] + u\ln[B(p^*)] \tag{35}$$

u lies between 0 and 1 so that the positively linearly homogeneous functions $A(p^*)$ and $B(p^*)$ can be treated as the costs of subsistence (when $u = 0$) and as the costs of bliss (when $u = 1$).

This assumption is motivated by the fact that this kind of preferences can be exactly agregated in a nonlinear way. Thus, the same problem for a country with many consumers who possess PIGLOG preferences, can be simplified and represented by a *single* representative consumer who minimises his PIGLOG cost function.

Deaton and Muellbauer choose $A(p^*)$ and $B(p^*)$ such that the PIGLOG cost function is a second order approximation of every possible function and also so that the function becomes easy to manipulate for economic applications.

$$\ln[A(p^*)] = \alpha_0 + \sum_i \alpha_i \ln(p_i^*) + \frac{1}{2}\sum_i \sum_j \gamma_{ij}^* \ln(p_i^*)\ln(p_j^*) \tag{36}$$

$$\ln[B(p^*)] = \ln[A(p^*)] + \beta_0 \prod_i p_i^{*\beta_i} \tag{37}$$

The subscripts i and j refer to the distinct products consumed by the representative consumer.

This leads to the following cost function:

$$\ln[C(u, p^*)] = \alpha_0 + \sum_i \alpha_i \ln(p_i^*) + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln(p_i^*)\ln(p_j^*) + u\beta_0 \prod_i p_i^{*\beta_i} \tag{38}$$

Following the AIDS methodology, we can define the individual budget share of a product i, denoted as w_i, through the logarithmic differentiation of the above cost function (Equation (38)), assuming the Sheppard's law holds.

$$w_i = \frac{\partial \ln[C(u,p^*)]}{\partial \ln(p_i^*)} = \alpha_i + \sum_j \gamma_{ij} \ln(p_j^*) + \beta_i u \beta_0 \prod_j p_j^{*\beta_j}$$
$$= \alpha_i + \sum_j \gamma_{ij} \ln(p_j^*) + \beta_i u \beta_0 \prod_j p_j^{*\beta_j} \quad (39)$$

where

$$\gamma_{ij} = \frac{1}{2}(\gamma_{ij}^* + \gamma_{ji}^*) \quad (40)$$

For a utility maximizing consumer, total expenditure X is equal to total cost $C(u, p^*)$. Thus, we can equate $\ln(X)$ with $C(u, p^*)$ so as to obtain the indirect utility function as shown.

$$u\beta_0 \prod_i p_i^{*\beta_i} = \ln(X) - \alpha_0 - \sum_i \alpha_i \ln(p_i^*) - \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln(p_i^*) \ln(p_j^*) \quad (41)$$

Substituting Equation (41) into Equation (39) gives us our budget share equation as shown:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln(p_j^*) + \beta_i \ln(\frac{X}{P^*}) \quad (42)$$

where P^* is a quality-adjusted price index defined by

$$\ln(P^*) = \alpha_0 + \sum_i \alpha_i \ln(p_i^*) + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln(p_i^*) \ln(p_j^*) \quad (43)$$