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MEASUREMENT, TECHNOLOGICAL CAPABILITY, AND INTRA-INDUSTRY TRADE: EVIDENCE FROM THE EU

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Measurement, Technological Capability,
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Abstract:

In this paper we develop models of intra-industry trade in which the technological infrastructure associated with measurement activity plays a role in determining the ability of firms to differentiate their products, making them more marketable, and hence promoting intra-industry trade. We observe that public support for the measurement infrastructure is an important element of public support for industry, while publicly available technical standards provide a significant means by which firms make use of this infrastructure. As an empirical test for the importance of the measurement infrastructure, we consider bi-lateral intra-industry trade flows between economies in the EU and find that both a measure of the cross industry importance of the measurement infrastructure – as proxied by standards - as well as the degree of investment in the ability to measure – as proxied by the use of instruments – are important correlates of intra-industry trade. The econometric analysis suggests that differences in national measurement infrastructures continue to play an important role in determining EU trade flows.

Key words: Intra-industry trade, technology, product differentiation, manufacturing
JEL Codes: F12, F14, F15, L1, L60

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1. Introduction

It is widely recognised that one of the success stories in the establishment and subsequent development of the European Union has been in the generation of trade between the partners especially in the form of intra-industry trade. Partly in response to such developments, international trade theorists have augmented traditional models - based upon comparative advantage - with elegant explanatory models which emphasise the ability of firms to differentiate their output in the context of internal increasing returns and monopolistic competition. In other models of intra-industry trade firms differentiate their output on the basis of vertical distinctions in quality. In this paper we complement these approaches to understanding international trade by considering the supply side of the process of product differentiation in more detail, examining the role played by measurement activities in facilitating market-based transactions. Measurement deserves this attention for two important reasons:

First, measurement activities provide an important enabling device for product differentiation among firms. While some differentiation may be possible without measurement, many attempts by firms to differentiate their output upon the basis of differing characteristics will require that measurement of those characteristics be feasible and be done in ways that are codified and standardised and hence commonly understood among firms. Measurement infrastructure – providing terminologies, test procedures, reference materials and so on – acts in this way as an enabling device. Moreover it clearly has public good characteristics since use of test methods etc. do not preclude use by others. Additionally, excludability may be difficult. Indeed, insofar as the infrastructure is codified in terms of publicly available standards, excludability is ruled out. One particular implication of this is emphasised in this paper and that is that the provision of the public good inherent in the measurement infrastructure results in investments in measurement technology. Industrial standards play an important role in this process, by helping to ameliorate market failures which may arise in the differentiation process.

Second, measurement forms a coherent set of activities partly defined by institutions operating at both national and, in the case of the EU, at the regional (or supra-national) levels. This raises some important questions about regional integration. To what extent do the institutions, standards etc provided across the EU in respect of measurement make the nationality of firms located in the EU irrelevant? For evidence in relation to this question we conduct an empirical analysis of intra-industry trade within the EU trade using both cross industry differences in the importance of standards relating to measurement and cross-country differences in the extent of instrumentation as explanatory variables.

The paper is organised as follows. The following section describes modern measurement infrastructures and discusses some of their economic implications. Section 3 then shows how measurement infrastructure can be embedded in a model of intra-industry trade.
Section 4 discusses our econometric models and presents the results. Section 5 concludes.

2. The Economic Role of Measurement Infrastructures

Measurement is self evidently a vital component of our everyday lives. A trip to the supermarket is punctuated by measurement episodes – when we stop to fill our car with petrol, whether we buy our mushrooms loose or pre-packed, when we glance at our watch to check whether we still have time to collect the children from school. The ubiquity of measurement does not in itself make it an economically interesting phenomenon. In this section we set out the reasons why measurement should however be so regarded before describing the basic elements of the measurement infrastructure.

Measurement activity in a modern economy forms a coherent set of both public institutions and firms with implications for the ability of firms to innovate in circumstances where innovation takes the form of new product characteristics or new combinations of existing characteristics. The development of new markets based upon new characteristics frequently requires that these characteristics both be measurable and demonstrable in circumstances where information asymmetries may be important. The measurability of these new charcateristics requires what Swann (2000) – in an important contribution to the literature – calls the creation of a 'common pool' of feasible measurements.

From a policy perspective, the importance of the firms and institutions comprising the measurement infrastructure is increased by the burgeoning interest both in technological change as a source of growth, the prevalence of market failures in processes of technological change, and hence in the institutions that shape technological change.and ameliorate market failure. We can perhaps refer to three broad literatures have begun to structure thinking in the area of technology and technology policy (see for example Stern et al 2000). All of these suggest that measurement infrastructures are an important dimension of technological change. First there is the endogenous growth literature. An element of this has demonstrated the importance for economic growth of the generation of new varieties, especially among intermediate inputs. Second, the literature on industrial clusters has emphasised the extent to which technology and spillovers have a geographically bounded character with business competitiveness being conceived in terms of technological interdependence across sectors. Third, there is the literature on National Innovation Systems that has emphasised the role played by idiosyncratic national institutions in shaping the organisation of innovation in ways that cut across industries and sectors.

We begin by presenting a number of stylised facts about the measurement infrastructure in advanced economies.

The measurement infrastructure can be presented in hierarchical fashion. At a national level, and following Williams (2002), it is helpful to distinguish between the National Measurement System (NMS) which provides an upper tier, and the intermediate producers and service providers mainly located in the private sector. The NMS generally embraces national measurement institutes (NMIs), national accreditation agencies, and agencies supporting legal metrology (e.g. for weights and measures legislation). The NMIs maintain and develop national standards for particular measures. The precise institutional arrangements vary enormously from country to country along a number of dimensions such as their number in nay country, their size, degree of decentralisation, source of funding, and their responsibility for legal metrology (Williams 2002).

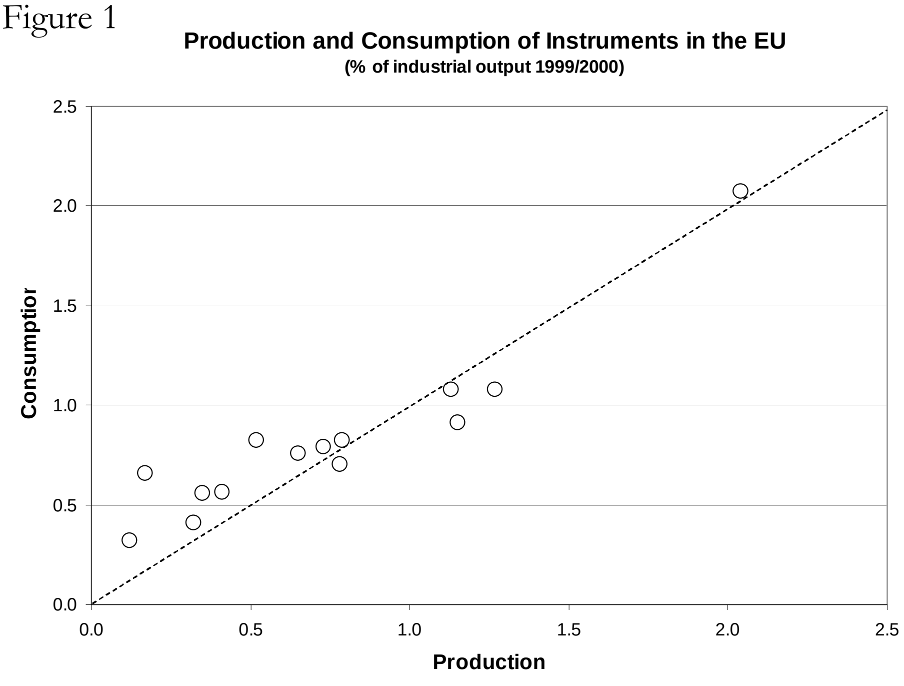
In measurement, national institutions are supplemented by those at the EU and supra-national levels. The Measurement Instrument Directive for example provides a legal requirement for measurement standardization across the EU. The Commission also directly supports research in measurement and testing on a cross-sectoral and cross-country basis and provides assistance to clubs and networks such as EUROMET and EURACHEM (Williams 2002).

There are various intermediate users of measurement who provide a second to the NMS. These users mainly depend upon commercial transactions but provide key linkages between the NMS on the one hand and final customers in industry and the economy on the other. Intermediaries in the measurement industry include laboratories and facilities which test, calibrate equipment, carry out inspections etc. In many instances they are accredited for an activity or a range of activities. A variety of organisations provide third party accreditation of these facilities. Partly because of the cost of accreditation, not all intermediaries - or the measurement activities they provide - are accredited. For example, in Italy, Williams (2002) reports that about 2.5 non-accredited testing certificates are issued for every accredited certificate. He estimates that - as a result - the total certification costs to industry in the EU are currently of the order of 2 billion Euros per annum.

Testing facilities of this sort provide one important source of demand for instruments; however, much measurement is of course carried out in-house by firms, with a derived demand for investment in instruments. Consequently the instrument sector itself provides a further link which is of potential importance in the transmission of spillovers from the first tier in the hierarchy.

Some idea of the extent of demand for measurement activity within firms can therefore be gleaned from the production of the instrument producing sector. Here, Williams (2002) estimates that production in the sector amounts to about 1% of EU industrial production. However he observes that this ratio varies considerably by country – ranging from 0.12% in Portugal to 2.04% in Sweden. More important than production (which will tend to reflect *inter alia* specialisation in these sectors) is the extent of *consumption* of instruments. Figure 1 shows a plot of both the

Figure 1



Source: Williams (2002; EUROSTAT)

production and consumption of instruments for the different economies of the EU, expressed as a proportion of industrial output. Evidently, demand for instruments appears to be important in the location of instrument production, although the larger consumers do appear to have something of a comparative advantage and be net exporters. One tentative explanation - but beyond the scope of this paper - is that geographically bounded technological spill-over effects (emanating in part from the NMS) may be important in either/or the consumption and production of instruments. Later we use the cross-country pattern of instrument consumption as a possible factor in an econometric model of the determination of intra-industry trade.

In addition to the cross-country patterns of the use of measurement, as indicated by the cross country pattern of consumption, it is also important to gauge the extent to which measurement is a genuinely cross-cutting activity, serving a broad swathe of sectors. Here it is difficult to be precise for a number of reasons. Most importantly, one element of the second tier – testing facilities – are not distinguishable[1] in standard industrial classifications from other types of business service and in any event do not appear as a separate product or industry in input-output tables. Here however we make use of the close association between measurement and industrial standards in the form of technical documents made publicly available through national standards bodies (NSBs) such as Germany's Deutsches Institut fur Normung (DIN) or the British Standards Institution (BSI)[2]. The association between measurement and standards has been observed in the recent discussion of the economics of measurement by Swann (2000) who provides several perspectives from which measurement can be analysed. Of importance here is the role that measurement plays in supporting industrial standards which may in turn underpin regulation (Swann 2000). Standards - whether they emanate from market processes or from institutional committees – may have a number of functions, including reduction in variety to achieve economies of scale, the promotion of inter-operability and network externalities, and the reduction of transactions costs in markets. In the context of regulation, they also define minimum qualities. More generally, they also provide a means of information provision. From this functional perspective we may generalise the impact of standards by supposing that they provide local public goods in that they are non-rival and (when publicly created by National or EU-wide standards bodies) have a potentially non-excludable character[3] and typically reduce the cost of using the market – so-called transaction costs. In the current context the existence of a catalogue of standards provides a means of measuring the 'size' of this public goods effect – a methodology initially developed in Swann et al (1996) and which is extended here to measurement related standards.

The extent to which measurement figures in standards can be gauged by a simple count of 'measurement related standards against all standards'. This was based upon the total number of standards in the 'catalogue' of BSI available at end 2003 and as shown in Figure 2. All estimates used the PERINORM© search tool.[4] This shows that at end 2003, nearly 25,000 standards were available to UK producers. We then experimented with search terms which allowed us to count those standards which appeared to be related to measurement. A 'narrow' search term was based on the intersection of measurement and reference to a test procedure, while a 'broad' search term allowed for a reference to either measurement or a test procedure. At end 2003, this showed around 6,600 for the first definition, and 16,800 for the latter. The figure also shows the counts for end 1985 and indicates that while there has been strong growth in the size of the total standards (5.6% per annum over the period), this has been roughly similar for measurement related standards. Importantly much of this growth over the past two decades is attributable to the harmonisation of standards within the EU (see DTI 2005), and of course all the standards available from the BSI catalogue are available to producers anywhere – so that the size of the catalogue cannot realistically be used as a *country* characteristic. However, we were able to count the size of the catalogue by industry and hence provide an *industry* characteristic for our trade model.

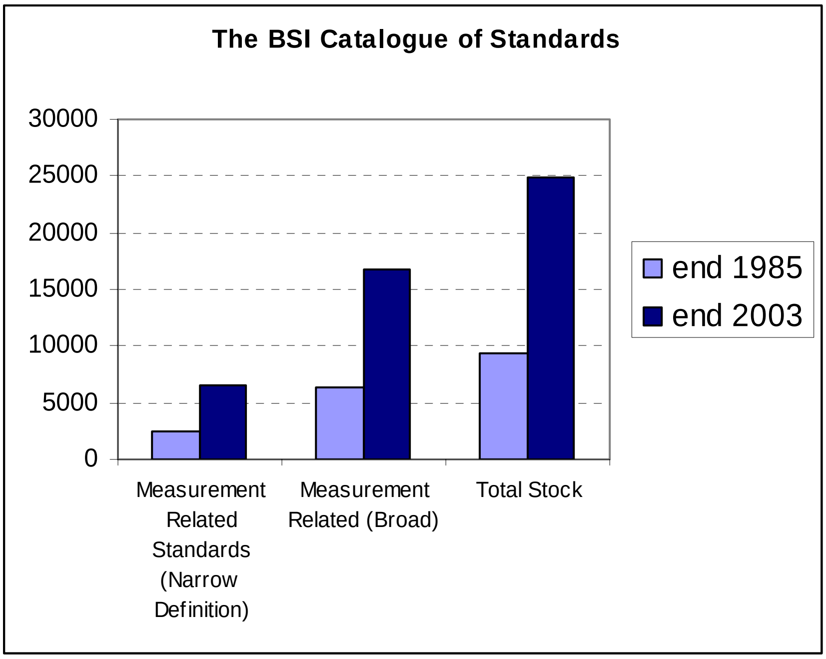
[1] Even at the 4-digit NACE coding testing and measurement facilities are not distinguishable from other types of business service.

[2] These bodies are not of course the only source of standards, since they are also produced by firms themsleves – so called de facto standards typically produced by the largest firms.

[3] In reality of course exclusion of certain agents – such as smaller firms or consumers may incur substantial fixed costs in participating in standardization processes.

[4] A database of standards produced by a consortium of DIN, BSI, and AFNOR

Figure 2



Source: *Perinorm*© April 2004

3. A Model of Measurement and Intra-Industry Trade

In this section we present a simple two-sector general equilibrium model where one sector is competitive and the other is monopolistic. The model is closely related to those of Lawrence and Spiller (1983) and Takahashi (2005). There are two factors of production labour and capital and these factors are assumed to be completely mobile . Our model differs from the above cited papers and indeed the rest of the literature such as Krugman (1979) and Helpman (1981) along two dimensions. First, we introduce the concept of 'measurement-capital' to capture investment in measurement at the level of the firm. Measurement-capital has two implications for the firm. While, on the one hand, like any other factors of production, using measurement-capital is costly and this cost rises with the level of instrumentation installed in the firm. On the other hand, using measurement capital also reduces what might broadly be termed transactions costs, lowering the costs of product differentiation.

In what follows we show that using this simple framework enables us to establish three important propositions. First, the extent of measurement infrastructure available to the individual firm positively affects the number of varieties in the country in a closed economy equilibrium. Second, as the number of varieties increase their prices fall with consequential welfare enhancing effects on households. Third, opening up trade between two countries benefits both countries in that although the pattern of trade between the two trading countries with similar measurement infrastructure remains unchanged, the overall volume of trade between them is bigger and hence intra-industry trade increases with measurement infrastructure but only up to a certain threshold beyond which it is not optimal for firms to deploy more measurement capital. To establish these propositions, we first consider the closed economy case, before moving on to the case of equilibrium trade with two countries.

A Closed Economy

Beginning with consumption patterns among households, consider a representative household maximizing utility: according to a Dixit-Stiglitz (1977) type preferences and which there are two types of good. A homogeneous good *Y,* produced under conditions of perfect competition, and a differentiable good *x* which is produced in n varieties:

$$U = Y^{1-s}\left(\sum_{i=1}^{n} x_i^{\theta}\right)^{s/\theta} \quad ;s<1 \tag{1}$$

The substitution elasticity θ between any x_i and Y, is assumed to be identical. In a richer environment than the one proposed here one can envisage measurement standards affecting utility. Nonetheless, as it is shown later, measurement-infrastructure affects the consumption pattern indirectly though the price mark-up.

Both goods are produced from private inputs. The number of differentiated goods produced in the market is denoted by n. The household obeys a budget constraint,

$$I = \sum_{i=1}^{n} p_i x_i + Y, \tag{2}$$

where income, I, is spent on the purchase of various differentiated goods with their respective prices, p_i, and the price of the homogenous good is normalized to unity. This is so as later we assume that the commodity Y is produced in a competitive market.

Maximizing (1) subject to (2) with respect to x_i and Y, yields, by standard method:

$$p_i = \frac{sYx_i^{\theta-1}}{(1-s)\sum_i^n x_i^{\theta}} \tag{3}$$

The elasticity of demand between various differentiated good is given by $1/(\theta-1)$ for a large n. Imposing symmetry across households and that they purchase goods in equal quantities, i.e., $x_i = x$ allows us to re-write (3) as:

$$p = \frac{sY}{(1-s)nx}. \tag{4}$$

Equation (4) is a typical downward sloping demand equation in which a higher number of varieties reduces the willingness to pay for a given variety.

Turning now to firms, we assume that the output in the homogenous goods sector is produced competitively according to a Cobb-Douglas production function given by:

$$Y = K_Y^{\varepsilon} L_Y^{1-\varepsilon} \qquad 0<\varepsilon<1 \tag{5}$$

The amount of labour and capital used in the production of Y is L_Y and K_Y. For simplicity we assume that the homogenous good does not need any measurement capital. The firms take w and r - the unit cost of labour and capital respectively - as given, so that the profit maximization for a firm producing *Y* leads to the conditions:

$$\varepsilon Y = rK_Y$$
$$(1-\varepsilon)Y = wL_Y \tag{6}$$

In the differentiated goods sector each variety *i (i = 1,….n)* is produced by a single firm which gives the firm some monopoly power over its particular variety. However, these firms are sufficiently small to affect prices in input markets. Alongside capital and labour, firm in this sector also employ measurement capital, the level of which is determined by G - which is a term we introduce to introduce the impact of the size of the measurement infrastructure available to a firm. There are, however, both benefits and costs attached to the use of this infrastructure. While a strong infrastructure (loosely 'the public good effect' described in the last section) reduces conventional costs (such as marketing expenses), it requires a specific investment in measurement related capital encapsulated in the function $Z(G)$. Labour serves as the variable input. The cost function for the production of x_i is then given by:

$$TC_i = (1-G)^{\alpha}[r\gamma + w\beta x_i] + \mathrm{rZ(G)},\ \alpha>1;\ 0<G<1 \tag{7}$$

The first term on the right-hand-side give the cost of employing conventional primary inputs i.e. capital and labour. The first-term in the square brackets is the fixed cost of employing physical capital and to simplify matters it is assumed that all firms use a fixed amount of conventional capital γ. The second term is the variable cost of labour where the production function takes the simple form $x_i = \frac{1}{\beta} L_i$ as in Lawrence and Spiller (1983). The term $1/\beta$ is the marginal product of labour. Total primary costs are a decreasing function of measurement infrastructure G where $\alpha > 1$ ensures diminishing returns to measurement infrastructure. Hence, the existence of a measurement infrastructure introduces costs savings in employing primary factors of production as discussed earlier. The other side of these savings is given by the second term on the right-hand-side and it denotes the cost measurement infrastructure evaluated at the price of physical capital. For example if we let $Z(G) = Q + FG$, as we will assume in our later calibrations, then Q, F denotes some fixed minimum level of measurement infrastructure and a constant respectively. Note that when $G = 0$ there is no public good effect and the model collapses to that of Lawrence and Spiller (1983). Assuming that each firm specializes in the production of one differentiated good, then the profits maximizing condition for our monopolist is simply at the point where MR=MC. By substituting the marginal costs from the total cost function, we obtain the following optimal pricing condition for x_i

$$\frac{P}{w} = \frac{(1-G)^{\alpha}\beta}{\theta} \tag{8}$$

The optimal price is independent of the other competing varieties but is positively affected by the wage rate. This leads to our first proposition:

Proposition 1

Measurement infrastructure is welfare enhancing as it reduces price-markups. As we see

below, this happens due to the increasing returns property of measurement infrastructure on the costs of conventional factors of production.

Assuming that there is a large number of n, firm entry in the industry X will drive profits close to zero and the output produced by the representative firm using (8) therefore is

$$x_i = \frac{r\theta\gamma}{\beta w(1-\theta)} + \frac{r\theta Z(G)}{\beta w(1-G)^{\alpha}(1-\theta)} \quad (9)$$

Equation (9) suggests that the size of the production of x increases with w/r ratio. Capital outlays as well as measurement infrastructure also increases production in the sense that these may be treated as fixed costs and more output is needed to cover larger fixed costs. However, a marginal improvement in infrastructure increases X only when the marginal benefit, in the form of lower variable costs, exceeds the marginal costs of associated with greater instrumentation. These results assume the condition that θ < 1.

At given point in time the total stock of capital (K-bar) and labour (L-bar) in this economy are assumed fixed. The aggregate employment of capital and labour are therefore as follows:

$$\bar{L} = L_Y + nL_x$$
$$\bar{K} = K_Y + n\gamma \quad (10)$$

and L_Y, K_Y, L_X, $n\gamma$ denote the amounts firm of labour and capital used in the production of Y and the differentiated good respectively.

Using (6) (8) (9) (10) we can obtain the total number of varieties of differentiated goods produced in the economy:

$$n = \frac{\bar{K}s(1-\theta)}{\gamma[\varepsilon(1-s)(1-G)^{\alpha} + s(1-\theta)] + Z(G)\varepsilon(1-s)}, \quad \frac{d^2n}{dG^2} < 0. \quad (11)$$

Product variety is therefore inversely related to the extent of capital outlays. The term in the square bracket in denominator is the share of physical capital share in income. The relationship between product variety and the underlying measurement infrastructure (MI) is concave. Using (11) we obtain the first-order condition for maximum n is ,

$$\alpha\gamma(1\text{-G})^{\alpha\text{-}1}=\text{F} \quad (12)$$

The left-hand-side is the marginal benefit from increasing measurement infrastructure. This is the fall in fixed capital investment. The right-hand-side is the marginal costs that consist of the higher MI cost. So, with a higher level of infrastructure fixed physical capital costs are lower but investment in measurement technology is costlier.

The marginal benefit in (12) also depends on α and this parameter determines the effect of MI on primary costs. The optimum level of MI is given by $G^* = 1-(F/\alpha\gamma)^{\frac{1}{\alpha-1}}$. The optimum level of MI varies inversely with its marginal cost. However, high fixed capital stock means a bigger MI as it helps reduce the overall capital outlays. We therefore can state our second proposition

Proposition 2

The relationship between product diversity and measurement infrastructure is concave. At the optimum, the marginal benefit of an extra unit of MI, in the form of a reduction in physical capital costs, is equal to its marginal cost.

The Open Economy

We now consider trade between two economies – Home and Foreign - which are endowed with similar underlying consumer behaviour and firm technologies . Once again we examine the consumer problem followed by that of the firm but must now distinguish between the two economies.

The standard assumption in the literature is for preferences to be identical between the two economies. The utility functions of the consumers in each country can therefore be written as:

$$U = \overline{Y}^{1-s} \left(\sum_{i=1}^{n} \overline{x}_{hi}^{\ \theta} + \sum_{i=1}^{n} \overline{x}_{fi}^{\ \theta} \right)^{s/\theta} \qquad \text{Home}$$

$$U^{*} = \overline{Y}^{*1-s} \left(\sum_{i=1}^{n} \overline{x}_{fi}^{*\theta} + \sum_{i=1}^{n} \overline{x}_{hi}^{*\theta} \right)^{s/\theta} \qquad \text{Foreign} \tag{13}$$

where the asterisks (*) refer to the foreign country and the bar over variables refers to consumption of each good. The subscripts h and f denote home and foreign production respectively. Thus, $\overline{x}_{fi}^{*\theta}$ denotes the consumption in the foreign country of variety 'i'. And $\overline{x}_{hi}^{*\theta}$ refers to the foreign consumption of variety 'i' with the goods produced in the home country. Assuming that varieties produced in home and foreign countries are n and n*, then in equilibrium each country will balance demand with supply such that:

$$P_h n\overline{x}_h + P_f n^{*}\overline{x}_f + \overline{Y} = P_h nx + Y \qquad \text{Home}$$

$$P_f n^{*}\overline{x}_f + P_h n\overline{x}_h + \overline{Y}^{*} = P_f n^{*} x^{*} + Y^{*} \qquad \text{Foreign} \tag{14}$$

The first-term on the left-hand-side is the home country's consumption of home products and the second-term is the value of the home consumption of foreign products. On the right-hand-side we have the value of the n differentiated goods and the homogenous good produced in the home country. Equation (14) implies that trade is balanced between the two countries.

The first-order conditions from utility maximization are:

$$P_i = \overline{y} \frac{s}{1-s} \frac{x_{1i}^{\theta-1}}{\sum x_{1i}^{\theta} + \sum x_{2j}^{\theta}}$$

$$P_j^{*} = \overline{y}^{*} \frac{s}{1-s} \frac{x_{2j}^{\theta-1}}{\sum x_{1i}^{\theta} + \sum x_{2j}^{\theta}} \tag{15}$$

Imposing symmetry in outputs and prices across monopolistically competitive firms the pricing equation becomes

$$P = \overline{y}\frac{s}{(1-s)(n+n^*)\overline{x}} \tag{16}$$

Using the same procedures as for the closed economy, the profit maximization solution for the differentiated goods is given by:

$$\begin{aligned} P &= \frac{\beta w(1-G_h)^{\alpha}}{\theta} \\ P^* &= \frac{\beta w^*(1-G_f)^{\alpha}}{\theta} \end{aligned} \tag{17}$$

Similarly, the profit maximization problem in the competitive sector yields the following first-order conditions

$$\begin{aligned} w &= (1-\varepsilon)k_Y^{\varepsilon} \quad & w^* &= (1-\varepsilon)k_Y^{*\varepsilon} \\ r &= \varepsilon k_Y^{\varepsilon-1} \quad & r^* &= \varepsilon k_Y^{*\varepsilon-1} \end{aligned} \tag{18}$$

The zero profit condition implies that the output produced in each country in the differentiated goods sector is[5]**:**

$$\begin{aligned} x &= \frac{r\theta\gamma}{\beta w(1-\theta)} + \frac{r\theta Z(G)}{\beta w(1-G)^{\alpha}(1-\theta)} \\ x^* &= \frac{r\theta\gamma}{\beta w(1-\theta)} + \frac{r\theta Z(G)}{\beta w(1-G)^{\alpha}(1-\theta)} \end{aligned} \tag{19}$$

The interpretation of the equations (15)-(19) is similar to that discussed in the closed economy and so will not be repeated here.

International Trade

To simplify exposition as we turn to the implications of measufrement for international trade, we introduce the following relations, as in Lawrence and Spiller (1983):

$$\overline{K}^* = a\lambda K \quad \overline{L}^* = (2-a)\lambda L \quad 0 \le a \le 1 \text{ and } \lambda > 0 \tag{20}$$

Where the term a is a measure of the capital-labour differential and λ is a measure of the size of the foreign country relative to the home country. Using these relations, the world capital and labour stock can be defined as:

[5] In the absence of frictions such as taxes or tariffs the solution is symmetric; as there will be factor- price equalization. Moreover, the size of plants will be equalized. P = P*, w = w*, r = r*, ky = ky*, x =x *.

$$K_W = \bar{K} + \bar{K}^* = (1 + a\lambda)\bar{K}$$
$$L_W = \bar{L} + \bar{L}^* = (1 + (2 - a)\lambda)\bar{L} \quad (21)$$

The international capital labour ratio is independent of measurement infrastructure and is given by

$$\bar{k} = \delta k, \quad \delta = \frac{[1 + a\lambda]}{\left[1 + (2 - a)\lambda\right]}, \quad (22)$$

Where k denotes the capital-labour ratio of the home country. The labour and capital endowment constraints for firms in each industry are

$$\begin{aligned}
\bar{L} &= L_Y + nx\beta, \\
\bar{L}^* &= L_Y^* + n^* x^* \beta, \\
\bar{K} &= K_Y + n\gamma_g, \\
\bar{K}^* &= K_Y^* + n^* \gamma_g, \\
G_f &= G_h = G.
\end{aligned} \quad (23)$$

The interpretation of the constraints is similar to before. However, the last condition assumes that both countries have similar levels of measurement infrastructure. We believe that this simple formulation displays many important features within the European markets where – in principle - firms in different countries have access to similar measurement infrastructures. Many features of our model share Lawrence and Spiller (1983) results. For example the total number of varieties produced in the world is same in either open or autarchic; economies - holding constant the level infrastructure G - which is not present in their model. However, the distribution of the production of varieties depends upon capital intensities between countries.

To motivate our empirical analysis, we now consider the effect of measurement infrastructure on trade. Two new results can be established in the context of intra-industry trade. We examine these in turn.

Trade Volumes

In order to analyze the effect of the interrelation between trade and infrastructure, we need to consider the volumes of differentiated goods both produced and consumed. Here we concentrate on the differentiated goods sector which is directly affected by measurement infrastructure.

In order to obtain the output produced in the differentiated goods industry we substitute the international wage rental-cost-of-capital and capital-labour ratios[6] in Eq. (19) to obtain

[6] The authors will provide derivations upon request.

$$x = x^* = \left(\frac{\theta\gamma}{\beta(1-\theta)} + \frac{\theta Z(G)}{\beta(1-G)^{\alpha}(1-\theta)} \right) \frac{1}{\varphi \bar{k}},$$
$$\varphi = \frac{[s\theta + (1-\varepsilon)(1-s)(1-G)^{\alpha}][\gamma(1-G)^{\alpha} + Z(G)]}{(1-G)^{\alpha}\{\gamma[s(1-\theta) + \varepsilon(1-s)(1-G)^{\alpha}] + Z(G)\varepsilon(1-s)\}} \tag{24}$$

As before for the autarchic case, the size of the firms producing the differentiated good increases with the level of measurement infrastructure only when the marginal benefit outweighs the direct marginal cost of investment in measurement; a result we also saw earlier. In addition, the size of any X firm is inversely related to the international capital-labour ratio because any rise in k will lead to increased variable costs.

Using the total number of differentiated goods[7] in the world along with home country's share of world income given by $\pi = z\bar{K}/(\bar{K} + \bar{K}^*) + (1-z)\bar{L}/(\bar{L} + \bar{L}^*)$, where $0 < z < 1$ is capital share of income, the post-trade level of consumption in industry X is obtained by

$$\bar{X} = \frac{\theta \bar{L}[z + (1-z)\delta][\gamma(1-G)^{\alpha} + Z(G)]}{\varphi\delta\beta(1-G)^{\alpha} \bar{K}(1-\theta)(1+a\lambda)} \tag{25}$$

The difference between (24) and (25) is the trade surplus for the differentiated good and it simplifies to take the form

$$\Delta X = X - \bar{X}$$
$$= \frac{\theta}{(1-\theta)} \frac{\gamma}{\beta} \frac{1}{\varphi\delta k} \{ \frac{\gamma(1-G)^{\alpha}(1+a\lambda) + Z(G)(1+a\lambda) - [z + (1-z)\delta][\gamma(1-G)^{\alpha} + Z(G)]}{(1-G)^{\alpha}(1+a\lambda)} \tag{26}$$

Our next step is to find out what happens to the trade surplus at different levels of measurement infrastructure. To simplify matters, let both economies have the same size so that $a = \lambda = \delta = 1$ and assume there are no endowment advantages. Furthermore, assuming that $Z(G) = Q + FG, Z(0) = Q$, the optimal level of measurement infrastructure is given by $G^* = 1 - \left(\frac{F}{\alpha\gamma} \right)^{\frac{1}{\alpha-1}}$ from the profit function. Now let us algebraically and numerically compare the trade surplus at the optimal G^* and $G = 0$ (i.e., the minimum infrastructure).

$$G^* : \Delta X = \frac{\theta}{2(1-\theta)} \frac{1}{\beta k} \frac{\gamma[s(1-\theta) + \varepsilon(1-s)(1-G)^{\alpha}] + Z(G)\varepsilon(1-s)\}}{[s\theta + (1-\varepsilon)(1-s)(1-G)^{\alpha}]} \tag{27}$$

And

$$G = 0 : \Delta X = \frac{\theta}{2(1-\theta)} \frac{1}{\beta k} \frac{\gamma[s(1-\theta) + \varepsilon(1-s)] + \varepsilon Q(1-s)\}}{[s\theta + (1-\varepsilon)(1-s)]} \tag{28}$$

[7] The authors will provide derivations upon request.

The expressions (27) and (28) are not easily compared. However if we set values for the parameters $\gamma = 0.50, \varepsilon = 0.4, s, \theta, F, G = 0.5, Q = 3, \alpha = 2$ which satisfy the conditions for the optimization, we find that at the optimal level of infrastructure the volume of trade is 64% bigger between the two countries. Furthermore, holding all constant, a rise in the relative country size also positively affects the trade surplus, $\partial(\Delta X) / \partial\lambda > 0$. These lead to our final proposition.

Proposition 3

Compared with the situation where measurement infrastructure is minimal, raising the level of infrastructure towards its optimal level also raises intra-industry trade between two equally endowed countries. This is attributable to the increasing returns properties of a measurement infrastructure.

Our model therefore suggests that there is a positive relationship between the sophistication of measurement infrastructure and the level of intra-industry trade over and above that which is dependent upon the impact of market size. We now turn to the empirical analysis of these effects.

3. Econometric Models

The theoretical model suggests that the existence of a measurement infrastructure provides a public good in the form of a common pool of feasible measurements. Empirically this leaves a footprint in the form of a measurement and testing infrastructure, the size of which may be gauged in terms of the existence of measurement related standards and a demand for instrumentation, i.e. the capacity to measure. The econometric models discussed in this section are designed to test whether these empirical counterparts are correlated with the extent of intra-industry trade, whether between countries or between industries. Beyond the key motivation of this paper however, the determinants of intra-industry trade in an EU context is of interest in its own right, no least since it is widely acknowledged that the degree of regional integration has progressed further than any other comparable institution, a process considerably extended in the Single Market Programme.

A large number of econometric studies have been carried out aimed at analysing the determinants of IIT in either a bilateral or multi-country framework. In general, as suggested by Balassa and Bauwens (1987), those determinants can be split into country and industry characteristics. Following this approach, the basic regression model can be written down as:

$$IIT = F(\boldsymbol{Z}, \boldsymbol{X_1}, \boldsymbol{X_2}, \varepsilon)$$

Where IIT is a measure of intra-industry trade and $\boldsymbol{Z}$ is a vector of industry characteristics, $\boldsymbol{X_1}$ is a vector of shared characteristics across a sub-sample (e.g. a common border) , $\boldsymbol{X_2}$ a vector of shared characteristics across the whole sample (e.g. the size of the market), and ε an error term.

The starting point in empirical analysis is a measure of the extent of intra-industry trade provided by the well known Grubel-Lloyd index (Grubel and Lloyd 1975). For any particular country pair i,j, intra-industry trade for any given industry k is given by :

$$1 - \frac{abs(X_{ijk} - M_{ijk})}{X_{ijk} + M_{ijk}}$$

$$0 \leq GL \leq 1$$

Where:

GL the Grubel Lloyd index ith of n industries at a given level of statistical aggregation,
X_i is the value of the exports of product group or country i;
M_i is the value of the imports of product group or country i.

Evidently, the measure varies between 0 and 1. A value close to 1 indicates that the difference between exports and imports is small in relation to total trade while a value close to zero indicates that most trade is predominantly one-way. In estimation, the truncation of the Grubel-Lloyd index at 0,1 suggests the logit transformation and the measure of intra-industry trade we actually employ - *IIT*:

$$IIT = ln ((GL)- ln(1-GL)$$

so that: -infinity < *IIT* < + infinity

This yields unbiased estimates.

The key hypothesis of this paper is that product differentiability is linked to the supply-side through the measurement infrastructure as in Proposition 1. We measure cross-industry differences in the importance of this infrastructure using the standards count discussed in section 2 above. Table 1 shows the distribution of measurement related and total standards as of 1999 (and is derived from King *et al* 2005). It can be seen from the table that that the use of standards varies considerably across industries – with the main users of standards being found in the engineering industries which rely heavily on products of what Nelson (1993) has called 'systems technologies' and relying heavily on the ability of individual firms to utilise the market to source components. In other technologies, e.g. in the chemicals industries, access to components is usually less critical, and so despite the large amounts spent on R&D, 'measurement intensity' is rather less.

In the literature, industry characteristics leading to intra-industry trade are both more complex in character than the country characteristics and generally harder to measure. In addition to the concept of product differentiability – our main concern here - studies have generally focused on the influence of economies of scale, the significance of R&D, and (possibly) the impact of market structure, although the sign of the effect is not always unambiguous. We control for these other industrial characteristics using the logarithm of R&D per person (***leurdpers***), and a measure of concentration at the EU level derived from Davies and Lyons (1996) – which estimates a Herfindhal index of concentration at the three digit level and which depends on both national levels of industrial concentration and the degree of concentration of production among the EU economies (***euconc)***. Finally, allowance is typically made for heterogeneity within an industry where it is possible that constituent goods are produced with quite different technologies, so that what is actually inter-industry trade created by differences in endowment ratios is masquerading as intra-industry trade. This is particularly important given the rather high level of aggregation of our industries. Here we use the logarithm of number of five digit commodities within each industry (***Incomm***). Clearly this variable is also likely to be positively related to the need for standards.

TABLE 1

	STANDARDS stocks			
	Industry (ISIC Rev3)	**Measurement Related Standards - Narrow definition**	**Measurement Related Standards - Broad definition**	**Total Stock**
1	Other Manufacturing	139	**314**	401
2	Professional Goods	864	**1449**	1648
3	Other Transport Equipment	42	**127**	180
4	Aircraft	83	**404**	1028
5	Motor Vehicles	108	**275**	489
6	Shipbuilding & Repairing	26	**48**	74
7	Radio, TV & Communication Equipment	419	**1130**	1373
8	Electrical Machinery	824	**2013**	2443
9	Office & Computing Machinery	28	**288**	519
10	Non-Electrical Machinery	851	**2153**	3299
11	Metal Products	367	**1061**	1916
12	Non-Ferrous Metals	115	**212**	300
13	Iron & Steel	90	**155**	208
14	Non-metallic Mineral Products	285	**695**	908
15	Rubber & Plastic Products	205	**503**	542
16	Petroleum Refineries & Products	195	**291**	325
17	Drugs & Medicines	9	**38**	40
18	Chemicals excluding Drugs	726	**1154**	1291
19	Paper, Paper Products & Printing	181	**358**	470
20	Wood Products & Furniture	57	**167**	225
21	Textiles, Apparel & Leather	256	**670**	822
22	Food, Beverages & Tobacco	472	**660**	705

Source:PERINORM 4/04

We turn now to shared country characteristics in explaining intra-industry trade. First, there are market size effects as indicated by monopolistic competition models of trade, which predict that the higher the average market size of the two countries trading, the greater will be the extent of intra-industry trade (see section 3 above for our own model and also Dixit and Norman 1980). Essentially, with economies of scale, countries with large markets will produce the same number of varieties of a differentiated product at lower cost, and hence will tend to possess a comparative advantage in such industries. In a bilateral context, it is predicted therefore that the extent of intra-industry trade will be greater the larger is the average market size of the two economies. In similar fashion, large *differences in market size* are likely to depress the extent of intra-industry trade. Here the potential exchange of product diversity is reduced by the economic inequality because the smaller country (again where there are economies of scale in differentiated products) will not be able to support as many varieties. Note that while these effects are typically measured as a country specific characteristic (e.g. typically market size is bigger in Germany than in Italy) it also has an industrial dimension (but Italy has a bigger market in wine or pasta). Thus our preferred measure of market size is the value of industrial production measured at an industrial level for each of the 22 industries which form our dataset. Accordingly our measures of market size relate to the logarithms of the average of the value of production of each of the trading partners (***lapi***) and the differerence in the logarithms of their respective levels of production in each industry (***ldiffpi***). The alternative measure frequently used in the literature ignores potential differences across industries by using aggregate GDP (***lagdp*** and ***ldiffgdp***). Further details of all the variables and their sources can be found in the Data Appendix.

Second, there are *wealth effects*. The demand for variety is widely believed to expand with consumer income, and hence the measure of intra-industry trade should be positively correlated with average per-capita incomes. Additionally, *differences* in per capita incomes may be associated with differences in consumer tastes, e.g. Linder (1961). Alternatively, it has been suggested that differences in per capita incomes reflect supply-side differences in factor endowments – e.g. the capital-labour ratio. The bigger these supply side differences, the greater the role of inter-industry trade in bilateral trade. Following the literature, we use per capita GDP to measure these effects (the logarithms of both the average and the difference, ***la_p_gdpp***, ***ldiff_p_gdpp***)

A variety of further influences on intra-industry trade are generally considered in the empirical literature. Geographical distance has been found to influence the extent of intra-industry trade (e.g. Balassa and Bauwens 1987). While geographical distance is generally believed to be a proxy for transport costs and hence to be generally trade reducing, it may also be proxying for cultural differences or processing possibilities in industries where bulk or weight is important and hence particularly important for intra-industry trade (***ldist***). The existence of a common-border or language may exert a similar influence (dummy variables ***cb, lang***). Beyond these, empirical studies have also considered the role of tariff and other trade barriers, although these should be considerably less important in the context of intra-EU trade and we do not use them. In fact the last observation may well be more general, since differences between economies and societies are almost certainly less distinct in the EU context (especially in the pre-enlargement EU being considered here) than in most empirical studies of intra-industry trade, so that these other controls may also be less important.

In addition to the usual controls for country differences discussed above we also need to measure the strength of the public good effect stemming from possible differences in the measurement infrastructure between economies. Here, since as we have argued, the public goods effect operates at several levels, no simple measure is possible. Our proxy measure is therefore the derived demand for instrumentation as implied by the theoretical model – the total consumption/use of instruments (production less exports plus imports). In keeping with the treatment of market size, we allow for both the average level of instrument consumption and the difference to impact upon observed intra-industry trade, with both variables measured in logarithms (***la_cinst***, ***ldiffc_inst***)

Table 2 presents some illustrative results. In each case the dependent variable is ***IIT***. All standard errors reported use the Huber/White sandwich variance estimator which allows for potential heteroscedasticity.

The first two models reported use the industry characteristics and a set of country dummies but without our measure of industry level standards. It confirms various findings in the literature. Concentration at the EU level is found to exert a negative effect on intra-industry trade while R&D (at the EU level) promotes it, reflecting perhaps the importance of product R&D. As expected, the number of commodity groupings within each industry (***lncomm***) has a positive impact on intra-industry trade, reflecting both enhanced product differentiability and the scope in industry level measures for a bias toward intra-industry trade. In equation 2 we add our cross industry measure of standards related to measurement (***lns***) and testing; this is both positive as expected in Proposition 3 and highly significant; it also has the effect of rendering the latter variable insignificant. Throughout these reported experiments we use only the 'narrow' measure of industry standards as discussed in section 2. In general, this variable performed better than either total standards or our alternative broad measure of standards.

Equations 3 and 4 focus on country characteristics, using a set of industry dummies as controls. Equation 3 shows a 'conventional' equation without our measure of instrument consumption. This effectively replicates many of the studies found in the literature. Most variables are correctly signed and significant except for differences in per capita wealth (***ldiff_p_gdpp***) – these are of course much reduced in the EU context compared with those for which differences are much larger. In fact this variable is never significant in any of the reported equations. Neither is the common language dummy. Equation 4 replaces our industry specific measure of market size with the more frequently used GDP based measures, but the results are very similar. Equation 5 introduces our instrumentation variables. Both are correctly signed and significant (the log of average ***la_cinst*** at 1%, ***ldiffc_inst*** at 5%). Importantly, the coefficient on the average market size measure (but not the difference) is substantially reduced.

The final equation combines both the industry and country characteristics. The coefficients on the three variables are of very similar across the three equations in which they figure. The results therefore suggest that there is an important aspect of differentiability captured by our variables that emanates from technological differences between economies and that there may be important differences between countries even with the EU and the Single Market programme notwithstanding.

TABLE 2

EQUATION	(1)			(2)			(3)			(4)			(5)			(6)		
Dependent variable	IIT			IIT			IIT			IIT			IIT			IIT		
Estimation method	OLS			OLS			OLS			OLS			OLS			OLS		
INDEPENDENT VARIABLES																		
	coefficient	Robust standard errors	sig	coefficient	Robust standard errors	sig	coefficient	Robust standard errors	sig	coefficient	Robust standard errors	sig	coefficient	Robust standard errors	sig	coefficient	Robust standard errors	sig
INDUSTRY CHARACTERISTICS																		
heu	-5.253	0.958	***	-3.964	0.976	***	-	-	-	-	-	-	-	-	-	-3.844	1.231	***
eurdpers	0.024	0.010	**	0.021	0.010	**	-	-	-	-	-	-	-	-	-	0.029	0.011	**
lncomm	0.229	0.033	***	0.016	0.046		-	-	-	-	-	-	-	-	-	0.035	0.055	
lns	-	-	-	0.313	0.047	***	-	-	-	-	-	-	-	-	-	0.282	0.053	***
COUNTRY CHARACTERISTICS																		
la_pi	-	-	-	-	-	-	0.558	0.078	***				0.321	0.109	***	0.251	0.071	***
ldiff_pi	-	-	-	-	-	-	-0.277	0.043	***				-0.244	0.046	***	-0.222	0.046	***
la_p_gdpp	-	-	-	-	-	-	2.959	0.548	***	3.679	0.494	***	2.416	0.574	***	2.606	0.586	***
ldiff_p_gdpp	-	-	-	-	-	-	-0.046	0.033		0.032	0.029		-0.018	0.034		-0.020	0.035	
ldist	-	-	-	-	-	-	-0.482	0.118	***	-0.487	0.106	***	-0.455	0.119	***	-0.528	0.123	***
cb	-	-	-	-	-	-	0.267	0.136	*	0.286	0.120	**	0.313	0.137	**	0.320	0.134	**
lang	-	-	-	-	-	-	-0.075	0.160		0.151	0.136		-0.082	0.161		-0.105	0.159	
la_gdpp	-	-	-	-	-	-	-	-	-	0.579	0.062	***	-	-	-	-	-	
ldiff_gdpp	-	-	-	-	-	-	-	-	-	-0.140	0.026	***	-	-	-	-	-	-
la_cinst	-	-	-	-	-	-	-	-	-	-	-	-	0.456	0.132	***	0.444	0.114	***
ldiffc_inst	-	-	-	-	-	-	-	-	-	-	-	-	-0.160	0.065	**	-0.161	0.067	**
constant	0.012	0.254		-0.734	0.272	***	-31.309	6.147	***	-35.861	5.581	***	-24.229	6.361	***	-26.292	6.348	***
country dummies	YES		***	YES		***	NO			NO			NO			NO		
industry dummies	NO			NO			YES		***	YES		***	YES		***	NO		***
Number of obs =	1884			1884			1475			1966			1475			1412		
F(28, 1937) =	34.39		***	36.14			17.41		***	23.41			16.49		***	31.46		***
Prob > F =	0.000			0.000			0.000			0.000			0.000			0.000		
R-squared =	0.258			0.275			0.263			0.256			0.270			0.238		

Notes: *** = significant at 1%, ** = significant at 5%, * = significant at 10%

Summary and Conclusion

This paper suggests that there is an important relationship between an element of the technological infrastructure of modern economies – which can be defined by activities related to measurement – and the economic concept of product differentiation. The existence of a 'pool of feasible measurements' relating to product characteristics on which firms can draw relies heavily on public provision for measurement research and an associated industry based upon measurement, calibration, and testing. Measurement related standards – technical documents providing information regarding test methods, reference materials and so forth - provide an important public good element to product differentiability. A count of such standards provided us with a means of evaluating the relative importance of this infrastructure across industries.

The relationship has potentially important consequences for intra-industry trade and these were examined via a theoretical model in which product differentiability is subject to a public good effect. Ceteris paribus, industries will produce more varieties of product when the public good element is strong, resulting in greater potential for intra-industry trade.

The econometric models in this paper which are based upon the above ideas also provide evidence that there is an important technological/supply side dimension to the idea of product differentiability, which has hitherto been largely ignored in empirical models of intra-industry trade. Our estimates suggest that in addition to variation across industries, countries in the EU may still have differential access to the measurement infrastructure even after controlling for market size effects and other influences on intra-industry trade suggested by the literature.

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DATA APPENDIX

Variables used in Econometric Analysis

DEPENDENT VARIABLE (Source: OECD Bilateral Trade Database for 1998)

IIT Logit transformation of the Grubel-Lloyd Index:

$$GL_{i,j,k} = 1 – [abs (X_{i,j,k} - M_{i,j,k})/ (X_{i,j,k} + M_{i,j,k}))$$

Where i = exporting country 1, ….14 , j = importing country 1,……14, k =industry 1, …..22

Potentially there are 14 x13 x 22/2 = 2002 observations

The index was constructed for Austria, Belgium-Luxembourg, W. Germany, Denmark, Spain, United Kingdom, France, Finland, Italy, Netherlands, Ireland, Portugal, Sweden.

The industries used are from the International Standard Industrial Classification Rev 2 (ISIC rev 2) and are all in manufacturing:

Other Manufacturing
Professional Goods
Other Transport Equipment
Aircraft
Motor Vehicles
Shipbuilding & Repairing
Radio, TV & Communication Equipment
Electrical Machinery
Office & Computing Machinery
Non-Electrical Machinery
Metal Products
Non-Ferrous Metals
Iron & Steel
Non-metallic Mineral Products
Rubber & Plastic Products
Petroleum Refineries & Products
Drugs & Medicines
Chemicals excluding Drugs
Paper, Paper Products & Printing
Wood Products & Furniture
Textiles, Apparel & Leather
Food, Beverages & Tobacco

Potentially there are 14 x13 x 22/2 = 2002 observations

INDUSTRY CHARACTERISTICS

heu (Source: Davies and Lyons (1996))
This was constructed from an estimate of the Herfindahl Index at the EU level at the three digit NACE classification and aggregated using a geometric mean of the constituent industries.

eurdpers (Source: OECD ANBERD-Analytical Business Enterprise Research and Development data for 1998 and STAN- STructural ANalysis data for employment)

Business expenditure on Research and Development (measured in $ PPPs for the EU (exc Ireland and Portugal) in each industry deflated by the aggregate level of employment

lncomm (Source: ***lncomm*** (Source: OECD Databases (ITCS- International Trade by commodity Statistics, SITC Rev3. (2005))
The logarithm of the number of commodity headings at the 5-digit levelSITC Rev 3 in each industry.

lns (Source: PERINORM©, King et al (2005))
This is the logarithm of a cross industry count of publicly available standards published in PERINORM© which incorporate a reference in their descriptors to both measurement and testing. Specially constructed descriptors were used to allocate standards to each industry.

COUNTRY CHARACTERISTICS

la_pi (Source: OECD STAN)
The logarithm of the arithmetic mean of the value of production by industry for each pair of countries in 1998.

ldiff_pi (Source: OECD STAN)
The logarithm of the difference in the value of production between each pair of countries in 1998.

la_p_gdpp *(Source: OECD National Accounts)*
The logarithm of average income per capita for 1998 (measured by GDP/population) between two countries (in Billions).and evaluated in billions of PPP$s as estimated by the OECD

ldiff_p_gdpp *(Source: OECD National Accounts)*
The logarithm of the absolute different income per capita between two partner countries(in Billions)

ldist *(source: Chen 2004)*
The distance between two trading partners in kilometre. The distances between the cities of corresponding regions are measured by the "great circle distance" formula based on the latitudes and longitude of each city. Therefore, All EU 15 countries are split into 206 regions and all these distances are weighted by their related GDP share calculated by GDPm/GDP, where GDPm is the GDP value of a region and GDP is at the whole country level.

cb (dummy variable = 1 if the country pair share a common border)

lang *(du*mmy variable = 1 if the country pair share the same language)

la_gdpp *(Source: OECD National Accounts)*
The logarithm of average GDP values between two countries (in PPP$ billion)

ldiff_gdpp *(Source: OECD National Accounts)*
The logarithm of the difference in GDP between two countries (in PPP$ billion)

la_cinst *(Source: Williams (2002))*
The logarithm of average measurement instrument consumption of two countries (in € million)

ldiffc_inst (Source: Williams (2002))
The logarithm of absolute different measurement instrument consumption between two trading partners (in € million)

Summary Statistics

TABLE A1

	Obs	Mean	Std. Dev .	Min	Max
iit2	1966	0.27	1.87	-8.93	8.90
la_gdpp	2002	6.11	0.80	4.60	7.40
ldiff_gdpp	2002	5.66	1.69	0.26	7.53
la_pi	1483	22.88	1.20	17.83	25.48
ldiff_pi	1483	22.70	1.61	14.05	25.82
la_p_gdpp	2002	10.00	0.10	9.66	10.17
diff_p_gdpp	2002	7.70	1.33	1.84	9.39
ldist	2002	7.10	0.54	5.23	8.05
cb	2002	0.13	0.34	0	1
lang	2002	0.08	0.27	0	1
heu	1911	0.03	0.04	0.00	0.20
lns99	2002	5.08	1.22	2.20	6.76
eurdpers	2002	4028.18	4783.72	145.00	17466.00
lncomm	2002	3.99	1.36	1.61	5.97
la_cinst	2002	7.70	0.97	5.45	9.42
ldiffc_inst	2002	7.63	1.44	3.61	9.57

TABLE A2

Correlation Matrix

	iit2	la_gdpp	ldiff_gdpp	la_pi	ldiff_pi	la_p_gdpp	diff_p_gdpp	ldist	cb	lang	heu	lns99	eurdpers	lncomm	la_cinst	ldiffc_inst
iit2	1.00															
la_gdpp	0.19	1.00														
ldiff_gdpp	0.03	0.58	1.00													
la_pi	0.23	0.61	0.36	1.00												
ldiff_pi	0.06	0.55	0.52	0.80	1.00											
la_p_gdpp	0.35	0.16	0.10	0.18	0.05	1.00										
diff_p_gdpp	-0.18	-0.25	-0.04	-0.15	-0.06	-0.33	1.00									
ldist	-0.37	-0.29	-0.15	-0.23	-0.09	-0.60	0.27	1.00								
cb	0.21	0.22	0.09	0.15	0.09	0.14	-0.24	-0.58	1.00							
lang	0.12	-0.21	-0.10	-0.08	-0.12	0.22	-0.17	-0.41	0.38	1.00						
heu	-0.11	0.07	0.03	-0.14	-0.05	-0.05	-0.04	0.04	-0.01	-0.04	1.00					
lns99	0.20	-0.03	-0.01	0.31	0.25	-0.01	0.02	0.00	0.00	0.00	-0.23	1.00				
eurdpers	-0.06	0.04	0.01	-0.15	-0.08	-0.01	-0.02	0.02	0.00	-0.02	0.43	-0.40	1.00			
lncomm	0.15	-0.04	-0.01	0.39	0.29	-0.01	0.03	0.00	0.00	0.01	-0.19	0.75	-0.46	1.00		
la_cinst	0.24	0.90	0.51	0.57	0.49	0.31	-0.34	-0.37	0.23	-0.05	0.07	-0.03	0.04	-0.04	1.00	
ldiffc_inst	0.09	0.78	0.55	0.47	0.51	0.03	-0.17	-0.21	0.21	-0.09	0.06	-0.02	0.03	-0.03	0.84	1.00