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Web Switching and International Outsourcing : A Matching Approach

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Abstract

Formulating a model which summarises transportation costs, uncertainty and price, we describe how a switch to web-based procurement can impact more readily procured services rather than materials. Uncertainty represents a catch-all factor describing the dovetailing of operations between two neither culturally nor geographically proximate, independent firms.

Using a 3-year panel, we find positive effects of switching to internet procurement and offshoring inputs and we show that the effect is stronger for services offshored than for materials offshoring.

Keywords: Offshoring, heterogeneous inputs, uncertainty, price, transportation costs

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Introduction

The prevalence of Web based outsourcing is uncontested. Also generally accepted is the fact that services, in particular Business and Computer services have experienced international outsourcing (offshoring) growth, admittedly from a low baseline (Amiti and Wei, 2005). This growth in services outsourcing has spawned much interest in the media, Amiti and Wei counting 2,634 newspaper articles in just 5 months in 2004 for the US alone.

What is not yet fully clear is the supposed impact of the Web on the *amount* and *composition* of offshoring carried out.¹ Also missing is a compelling theoretical basis grounding the debate in the experiences of offshoring executives. The transaction cost theory while useful for motivating a ‘make or buy decision’ is arguably less useful for informing a debate concerning: ‘buy domestic or buy overseas decision’. For this we need to formulate a new and intuitively appealing model summarising the experiences of offshoring firms incorporating elements of risk, pricing and transportation.

What do we know about web based procurement and what remains to be explored? First there is the issue of input type: Some preliminary evidence suggests that the *composition* of offshoring matters for productivity i.e. whether inputs are service or material (see Görg, Hanley and Strobl, 2008; Görg and Hanley, 2009). Also the current policy debate articulating the fear sparked by a rise in the *value* and importantly, the *composition*, of international outsourcing. Trefler (2005) neatly summarises this as the fear that “...the ironclad law of comparative advantage does not rule out the possibility that China and India will export high-tech goods and services to us, leaving Americans to mend the socks of Chinese business executives”.

Up to now, there have been three studies attempting to calculate the effect of Internet usage on increases in offshoring (Freund and Weinhold, 2002; Bartel et al., 2005; Abramovsky and Griffith, 2006). In these studies the effect of web usage on imports or offshoring is 1 to 12 percent depending on the model used, the web proxy and aggregation level of the data. This question is not easily answered. Studies are hampered by a high degree of firm heterogeneity. There is a danger of imputing effects where none exist.

What is the contribution of our study? We first attempt to deal with firm heterogeneity by tracking what happens to Web ‘switchers’ in a matching framework. We secondly motivate our

¹ We use the expression ‘offshoring’ to denote the outsourcing of inputs from foreign markets. ‘Outsourcing’ refers to the outsourcing of domestic inputs.

study using a model which incorporates uncertainty, transportation costs and price, all key variables cited by offshoring executives. Our model summarises these stylized facts.

Using data from the EU harmonized ICT-usage and E-commerce survey for Ireland for over 2,000 firms for 3 years, we show that the marginal effect of switching to Web based procurement is a 1.7 percent increase in the proportion of international services carried out and a 3.2 percent increase in the amount of internationally outsourced materials. While the international component of both types of procurement rises, the procurement of international services rises by comparatively more. In real terms, the increase of 1.7 percent corresponds to a overall increase of 13 percent if we define the non-treatment group average as the baseline. For internationally procured materials, the increase is in the region of 7.2 percent. This increase is similar in magnitude to the lower bound of 2 percent reported by Abramovsky and Griffith for the UK and the approximately 3 percent value reported for the US by Bartel et al., (2005).² Our results are robust to different estimation techniques and formulations of the Web variable.

Our findings suggest that policy makers are right to fear, at least in the short run, for the displacement of domestically produced high value added services such as Legal and Accounting or Design by foreign suppliers. Such knowledge-rich, high value services can readily be procured over the internet. However, as Amiti and Wei (2005) point out, outsourcing is a ‘two-way street’, a fact which tends to be forgotten. Accordingly, the net impact of Web enabled offshoring will be codetermined by the value of insourcing.

What we see in our data is the short run impact on services offshoring induced by a switch to internet procurement. Regarding the possible long run impact of internet procurement, this is hard to state with certainty given the length of our time window. It is worth noting that evidence from offshoring business executives describes how many firms are terminating offshoring arrangements due to quality issues³.

Our paper is structured in this way. The next section gives a brief description of offshoring models outlined in the theory and gives evidence for the elasticity of services offshoring to increased Web use. Then follows our model. This is followed by a Methodology section describing the Difference-in-difference approach used. After this is a section describing our data.

² Specifically a 13 percent change in the standard deviation of offshoring in response to a 3.84 percent increase in the standard deviation of ICT intensity

³ Bartel et al (2005) cite from independent W.E Upjohn Institute Employer Survey on Flexible Staffing policies where 31% of firms suspended outsourcing of services because of product and service quality issues

The penultimate section presents the results of our analysis and the final section concludes with some comments on the implications of our findings.

Background

Web usage and the type of input offshored

There is a general consensus in the theory that only certain inputs lend themselves to offshoring. It follows that the switch to Web procurement, should only affect such traded services as Accountancy rather than Building and Construction. Bartel et al. (2005) support this view. They argue that the adjustment costs of outsourcing services such as Buildings Repair are unlikely to be affected by the final goods producer's Web usage and we should not expect to observe any affect of switching to internet procurement for such services. Services such as Legal and Accounting where we would expect to find an effect of Web use on procurement belong more in the category of 'offshorable services'. According to Bartel et al;

"The plausible complementarity between the IT-level of the service and the IT level of the user implies that the reduction in user costs is larger for more IT-intensive services". [pp. 15]

Accordingly, our study focuses on offshored rather than outsourced services. Hence the defining issue is whether the service is tradable. With materials, the dichotomy between what is tradable and what is not is less clear-cut, but nonetheless there is an intuitive reason to argue that transportation costs affect the tradability of material inputs differently. Since all services (tradable and otherwise) can theoretically be outsourced, but only a subset of these services cost-effectively offshored, and here we expect to see Web procurement most effectively applied, we limit our analysis to *offshored* service rather than *outsourced* service inputs. This distinction is easily made in an island economy such as Ireland, surrounded by 'shores', transportation to which involves a non-trivial cost. Given that we use Irish data, we need to be clear on this point.

There is also a growing consensus in the literature that it is appropriate to calculate a different elasticity on firm productivity from offshoring service vis-à-vis material inputs. A raft of existing studies makes this distinction. It is moreover plausible that Web usage confers more of a boost to offshored service than material inputs, on the basis that Web use has given rise to a 'service tradability revolution' (UNCTAD, 2004). On the issue of by how much Web use has made services more tradable, the literature is silent.

Accordingly, the theory has something to say about the type of input which appropriates itself best to Web based offshoring. Much of this work sits in the transactions cost literature. Here ideas of trust (read ‘information leakage’ in the theory) and generality of application (read ‘asset specificity’ in the theory), have been the subject of much theoretical research. Representative papers include Grossman and Helpman (2002), Bartel et al. (2005) and Baccara (2005). Depending on the particular theory invoked in these papers, the type of transaction cost changes but there is some consensus: the costs of contracting should vary across input type because of the degree of input specificity in each case. Irrespective of whether we are dealing with material or service inputs, if a provider/ supplier is required to invest much time and effort tailoring the input, arm’s length supply is not the safest, nor most cost effective option. Therefore, generic inputs are best suited for offshoring. Likewise, inputs requiring a high degree of secrecy are unsuitable for offshoring (Baccara, 2005). If they are offshored, firms have to make provision to secure confidentiality, and guard against information leakage. These extra measures introduce a further source of heterogeneity in the cost of outsourcing for different firms.

ICT usage and the cost of transacting

What does the theory have to say (directly or more likely indirectly) about the predicted effect of a switch to Web based procurement and hence the reduction in transactions costs? Abramovsky and Griffith (2006), applying a standard Grossman and Helpman model of transaction costs offer general predictions on the returns to offshoring when firms apply Information and Communication Technology (ICT). They argue that outsourced services must be complementary to the firm’s core activities. When we think in terms of such core, as opposed to ancillary services, demand for services must represent a fixed proportion of total output produced by the firm $S = \alpha Y$. The firm sets out to minimise production costs by choosing an optimal mix of in-house and external services. The cost of outsourced services is made up of the market price for the service and an adjustment cost (the cost of incomplete contracts, plus monitoring and search costs). Bartel et al. (2005) elsewhere state that these adjustment costs are non-trivial.⁴ As transactions costs are predicted to fall with Web usage, the volume of these transactions is predicted to rise. Using firm level data on externally purchased services for the UK, they report that for every 1 percent increase in the proportion of firms using the internet, outsourcing should increase by 2 percent.

⁴ See Grossman and Helpman (2005) for a discussion about adjustment costs

Using an augmented transaction cost model, Bartel et al. (2005), add the speed of technical change and fixed costs of technology adoption to their transaction cost model. Their model predicts that changes in levels of technical know-how should not affect the level of services outsourced. The effect, rather, is second order (speed of change). This is due to the amortisation of fixed costs.

Bartel et al. find a significant and negative effect of ICT based services on levels of services outsourcing. Services we would consider non-tradable e.g. Janitorial Services, do not show this effect. The magnitude of the effect is a 13 percent increase for a change of 3.84 percent in ICT intensity, equivalent to a 3 percent effect for a 1 percent change in ICT intensity. This is close to the lower value observed in Abramovsky and Griffith (2006).

Freund and Weinhold (2000) apply a sunk cost model to exporting trade flows. Using aggregate trade data, they find that a 10 percent increase in their internet variable (number of internet host sites opened) is associated with a 1.7 percent increase in traded services. They do not differentiate distinguish however. Their calculated elasticity is considerably lower than that obtained in the previous two studies.

Generally, web use facilitates greater access to information on foreign input prices. Since materials are already quite standardized, e.g. the DIN standard, it is quite plausible that there is already an equalization of factor prices among all countries irrespective of increased web use. Consequently factor prices for materials will be equalized among countries, independent of web use. Put differently, a switch to web use will not decrease the factor price by a significant extent. The decision in favor of, or against offshoring, will then be mostly driven by transportation costs. These costs are positive for goods that have to be shipped, $t_m > 0$, and might amount to a significant component of the total factor price. Another similar intuition supporting differing elasticities of web use to input type, is the nature of services and how the quality of a service is only readily established once it has been consumed. Services are typically experience goods. Uncertainty is arguably most acute for non-standardised, services which are especially burdened with the 'experience-good- tag'.⁵ A similar argument can be advanced for transacting in material inputs where there is an adjustment period as a sourcing firm gets to know its partner's quality, often building up ordering incrementally. Rauch and Watson (2003) summarize this literature in the context of asymmetric information and learning models and Watson's (1999) multi-period

⁵ Uncertainty between transacting partners can also be exacerbated by other issues documented in Rauch and Watson (2003) such as the technology gap between the partner countries.

model with renegotiation. It makes sense that offshoring firms may attempt to reduce their risk exposures by establishing their partner firm's quality in a multi-period setting, with reduced first round ordering involving low fixed costs. The issue here is about the *magnitude* to which uncertainty differs for material and service inputs. The uncertainty about an input's quality is likely to be most pronounced for non-standardized service inputs. Buying in service inputs from abroad may well be done most effectively where the buyer orders small volumes in the first-period before increasing the volume ordered in subsequent periods once the quality of the vendor becomes known. This theory in the context of material input procurement was advanced by Watson (1999). However, material inputs due to their more standard nature, are less subject to this issue of quality uncertainty.

Theory

We focus on a risk averse representative firm that produces a certain good using foreign and domestic inputs. The concept of a representative firm thereby allows to capture the aggregate composition of foreign and domestic inputs and hence combining micro and macro perspective of the following empirical part of the paper. Profit maximization (which implies cost minimization) determines both the optimal amount of output and the composition of inputs given the assumption of an exogenous and constant product price that, for the sake of simplicity, is normalized to unity.

Web use provides the possibility for the firms to offshore (at least parts of) their inputs. A firm would do so if it expects as a consequence decreasing factor costs. This would also affect the composition of domestic and foreign inputs according to the following logic: A factor price reduction increases demand for the corresponding factor. Hence offshoring would end up in an increase of the ratio between foreign and domestic factors.

In addition to reduced pure factor prices, web use and the induced possibility of offshoring is also accompanied by the following: (i) the need to transport goods or services in order to overcome physical distance; and (ii) uncertainty of the finally resulting factor price which goes hand in hand with a risk premium and the fact that firms have to calculate with expected factor prices.

All in all, the cost for an offshored factor that a firm actually has to pay is thus composed of several components. In what follows we argue that these components differ between services and materials thereby, though ending up in similar offshoring patterns between the two input, the effect of web use and offshoring will be stronger in case of services.

Model

The representative firm produces the homogenous good, x , thereby utilizing domestic and foreign inputs, v_d and v_f , respectively.⁶ Accordingly, the factor prices are denoted by q_d and q_f and tc reflect transportation costs of the offshored input in order to overcome physical distance. Expected profits are given by

$$E^*[Z(\Pi)] = E^*[Z(pX(v_d, v_f) - v_d q_d - v_f(q_f + tc))] \quad (1)$$

The following optimality conditions result⁷

$$\frac{\partial x}{\partial v_d} = q_d \quad (2a)$$

$$\frac{\partial x}{\partial v_f} = E^*(q_f + tc) + \psi \quad (2b)$$

where ψ denotes the risk premium associated with factor price uncertainty of the offshored input.⁸ Equation (2a) provides the well known relationship in between the value of the marginal product of the factor and its price whereas (2b) includes several components. There value must fall short of the factor price without offshoring if web use will lead to an increase of v_d . In the following we assume that transportation costs are easy to investigate and hence we assume that $E^*(tc)=tc$ and thus the right hand side in (2a) reduces to $E^*(q_f) + tc + \psi$

Basically, this argumentation holds for both services and materials and since web use opens up efficiency gains in the sense that the inputs now may be bought at the cheapest place, decreasing factor costs will end up in an increase of offshored inputs. The crucial question then is to which the argumentation applies to services and materials. We argue that demand for offshored inputs will increase in both cases though for services even more than for materials. This is due to the following reasoning:

⁶ Note that the relationship between the two inputs formally depends on the sign of the cross derivative. Complementarity arises, when an increase in the price of one factor is accompanied by a decrease in demand of both factors. The cross derivative would then be positive whereas a negative sign arises in case of substitutes. Throughout the following argumentation we assume that both inputs are not perfect substitutes.

⁷ See the appendix for a formal derivation of the results.

⁸ Note that ψ may also be interpreted along the argumentation in transaction cost theory thereby reflecting a catch-all variable for all phenomena incorporated in this context.

- Considering transportation costs they are higher in case of materials than for services.⁹
- It is quite reasonable that the risk premium is lower for materials than for services due to two reasonings: Ongoing international product standardization has led to quite homogenous products that fulfil clearly defined quality requirements. In contrast to this, services are experience goods although in this field also certification leads to something similar as standardization in case of products. Hence, altogether we assume that ψ is quite low for both inputs but lower in case of materials.
- Hence the remaining question is how much the expected factor price actually falls short of factor costs without offshoring. In this context the web might even help to collect a variety of information on the offshored factor thereby ending up in quite a low factor price uncertainty especially in case of materials. Here international standardization processes are already quite advanced: One might find homogenous products around the entire world and the internet helps in order to find the cheapest provider. This is not necessarily true for services: Service offshoring is still at a quite low level, there is fewer standardization and hence there have not been many possibilities to realize learning effects in order to precisely calculate the expected factor price.

To conclude: Only those firms will offshore inputs that assume that the entire factor costs consisting of expected factor price, transportation cost, and risk premium will decrease. As a consequence demand for offshoring services and materials increases. What is still unclear is the strength of these effects. Assuming that risk premium plus expected factor price decrease lead altogether to nearly identical effects for materials and services, it's the distinction between transportation costs that makes the difference: It is natural to assume that given input outsourcing the accruing transportation costs for materials exceed those of the services by a significant amount. As a consequence, although altogether overall factor prices decrease as a consequence of outsourcing thereby leading to an increase of both materials and services the overall effect will be higher in case of services.

⁹ Note that also in case of services transportation costs might play a role. This is especially true if the production process requires frequent face-of-face contacts which in case of offshoring implies transportation of people which is quite costly. One might quite well drop these kinds of services from our consideration since, as argued before, we mostly refer to standardized services. Another argument to support such kinds of services is the fact that whenever face-to-face contacts are important, the relationship between proximity and productivity is of special importance thereby representing an agglomeration force that acts in contra to offshoring.

Methodology

The aim of our paper is to investigate whether there is a causal relationship from switching to Web based procurement on the amount of internationally procured services and materials inputs. Our model in the previous section the context for modelling the elasticity of offshoring to an event (switching to Web-based procurement). The advent of Web use helps reduce the uncertainty in transacting with an overseas supplier. This event can be framed methodologically as a ‘switching’ one where we look at average effects within the group of ‘switchers’ and ‘never switchers’, and difference these effects for pre- and post-switch. Not only do we difference for effects *within* the groups, but also *between* the groups, hence the ‘Difference-in-Difference’ framework.

Let $switch_{it} \in \{0,1\}$ be an indicator of whether a firm i switches to Web based procurement in time t and let $serv_os_{it+s}^1$ be the proportion of internationally procured services (international/total service inputs) following the switch. Also denote $serv_os_{it+s}^0$ as the proportion of internationally procured services if the switch had not taken place. The causal effect of switching to Web based procurement on the proportion of internationally procured services is then expressed as:

$$serv_os_{it+s}^1 - serv_os_{it+s}^0$$

A problem arises here. The counterfactual, $serv_os_{it+s}^0$ cannot be observed if a firm makes the choice to switch to Web based procurement. As Girma and Görg (2007) put the problem, “Thus the analysis can be viewed as confronting a missing-data problem” (P.101). The microeconomic literature since Heckman et al. (1997) is equipped to deal with this missing counterfactual by defining the average effect of switching on the proportion of internationally procured services as follows:

$$E(serv_os_{it+s}^1 - serv_os_{it+s}^0 | switch_{it} = 1) \\ = E(serv_os_{it+s}^1 | switch_{it} = 1) - E(serv_os_{it+s}^0 | switch_{it} = 1)$$

where the counterfactual in the last term is inferred. This inferred causal estimate is the proportion of internationally outsourced services the firms would have exhibited, on average, had they not made the switch to Web based procurement.

Of course, it is imperative to base the estimated counterfactual by using a valid control group. If there are missing covariates in the model which are correlated with the variable *switch*, the analysis will suffer from endogeneity and simultaneity bias. This is where the matching process can help. The idea behind matching is to pair each firm that switches to Web based procurement with a firm that never made such a switch. The selection of the paired control is performed on the basis of some observable variables e.g. size or foreign ownership. We apply the matching procedure (propensity score matching) pioneered by Rosenbaum and Rubin (1983) which applies a calculation of the probability of being in the treatment sample (making the switch to Web based procurement in our analysis) conditional on these controlling covariates such as firm size. Accordingly, in a first step, we compute the probability (propensity score) of a firm making the switch to Web based procurement in a probit model

$$P(\text{switch}_{it} = 1) = F(X_{it-1})$$

where X is a vector of covariates observed in the period before the firm made the transition to Web based procurement. Included in this vector is a foreign ownership measure, an industry measure, year dummies, a skills proxy, wages_pw, a measure of firm size (logged employment) and a productivity measure (sales per worker). The intuition for including a foreign ownership measure is that foreign firms are more likely to have more advanced ICT (Information Communication Technology) by default, being embedded into international production networks. Therefore, similar to Abramovsky and Griffith (2006), the most similar study to ours, we include a foreign ownership dummy as well as a controlling for employment size. Finally, larger or more productive firms may have the critical mass or accumulated capital to pay for such procurement systems. Similar to Abramovsky and Griffith (2006), we also include a full set of industry and time dummies. Finally, the intuition behind the inclusion of a skills measure is that the application of Web based procurement requires some component of worker skill.

A conventional matching estimation of the causal effect of switching on the proportion of internationally outsourced services is expressed as

$$\mu = \sum_{i \in A} (\text{serv_os}_i - \sum_{j \in C} g(p_i, p_j) \text{serv_os}_j)$$

where $g(\cdot)$ is a function assigning the weights to be given to the comparison firm j in constructing the counterfactual for the switching firm i . For g , we employ a Gaussian kernel in this paper

which applies diminished weight to firms in the control group further away in the propensity score distribution. Essentially, however, the full distribution of non-treatment firms are used in constructing the averaged effect for the counterfactual.

What are the advantages of using a matching methodology to augment our standard OLS framework? Meyer (1995) gives several reasons why our chosen framework improves the internal validity of our model. Continuous variables such as sales have already been deflated to reduce artificial variation in these variables over time. Despite such efforts to clean data, the presence of omitted variables could still lead us to impute a spurious effect to the treatment variable. These omitted variables may be events not captured in the model but which are correlated with the treatment effect. To give an example of where such an omitted variable would bias outcomes, consider where a Government drive to raise firms' awareness of overseas suppliers coincided with the time that most firms switched to overseas procurement. In order to neutralise the effect of such omitted variables and in order to reduce the joint determination of outcomes, we opt for matching.¹⁰

To summarise, the key idea with matching is that time specific problems, e.g. Government support for offshoring initiatives, are screened out. Both treatment and non-treatment groups are affected by the same contemporaneous effects.

As well as capturing the switching phenomenon, we control for several other covariates in order to reduce the amount of inter-firm heterogeneity

Data

We use plant level information from data collected by Forfás, the Irish policy and advisory board with responsibility for enterprise, trade, science, and technology in Ireland. Specifically, our data source is the Annual Business Survey of Economic Impact (ABSEI), covering the period from 2000 until 2004. This survey extracts information on many dimensions of firm performance. Importantly for this study, the survey also included questions on ICT usage for the period 2002 to

¹⁰ We also employed nearest neighbourhood matching in an earlier version of the paper but the results were not robust because of an insufficient number of observations

2004. These ICT questions were harmonized across the EU for comparability and some recent work is now emerging for other EU member states using this data.¹¹

Since the web usage variables were covered only in the period from 2002 (although we had data from as early as 2000), we had 3 years of Web coverage data in our sample frame. The ABSEI survey is an annual survey of plants in Irish manufacturing with at least 10 employees, although a plant, once it is included, is generally still surveyed even if its employment level falls below the 10 employee cut-off point. The response rate is estimated by Forfás to be around 55 to 60 percent of the targeted population per year. This data contains information on services purchased, distinguishing between imported and domestic service inputs. Further data available from this source that is relevant to the current paper are total sales (as a measure of output), employment, exports, nationality of ownership and the four digit sector of production.

Data cleaning and variable generation

We started with the initial balanced panel comprising 3 years of data (2002 – 2004) where we have information about the ICT activities of the firms surveyed. All continuous variables in our data containing nominal values such as sales were deflated by multiplying by the appropriate index in each case.

Some variables used in our analysis had to be generated from the raw data. Our most important generated variable, ‘any_web_trans’ denotes whether a firm used the internet to carry out either sales or purchases. One novelty of our paper is identification of ‘switchers’.

To identify ‘switchers’, we needed to identify 3 groups of firms. The first was the set of firms who had always used the internet from the beginning of our records. The second set of firms was those who had never used the internet at any stage in the data. The final set of firms, a subset of whom we identified as switchers, moved to internet procurement during the 3-year time window.

We see from Table 1, that the majority of our sample, 1,395 firms never made the transition to web based procurement. 954 firms moved to Web based procurement during the time window.

¹¹ See ‘Information society: ICT impact assessment by linking data from different sources’, Eurostat Report, August 2008 with contributions for Sweden and Italy by Hagsten and Svanberg (2008) and de Panizza (2008) respectively.

However, within these 945 firms, the ‘sample of switchers’, we see that we only have a full 3 years data for 73 percent of the sample. The corresponding proportion for the non-treatment, ‘never-switched’ group is 69 percent. Finally, it is clear that the proportions of firms to switch to Web based procurement increases over time. In 2003, within the group of firms that had switched at any stage, 83 percent had switched by 2003 and 94 percent by 2004.

[Table 1 here]

We now report some breakdowns for the firms which were used in our subsequent regressions. Table 2 shows the average proportion of internationally procured service and material inputs across the group of firms that switched to Web based procurement compared to the average for the non-treatment sample. A simple t-test reveals significant differences for the average proportions of internationally procured services in 2002 and 2004 (at the 10 percent level).

[Table 2 here]

Finally, since we will at a later stage in part match firms based on characteristics such as foreign ownership and industry sector, it is interesting to see what proportions of firms in each category have made the switch to Web based procurement or not.

Table 3 reveals that within the non-treatment group of ‘never switchers’, 28 percent were foreign owned compared to 23 percent of the treatment sample. This difference in proportions is significant. Similarly, the firms in the non-treatment group were marginally more likely to have a manufacturing background, 75 percent vis-a-viz 60 percent.

[Table 3 here]

Analysis

In this section we estimate offshoring of services and materials, applying in turn random and fixed effect estimators. As a further robustness check, we estimate the effect of Web based

procurement on the proportion of internationally outsourced service and material inputs using the propensity score matching technique outlined in the methodology section.

In Table 4 we report our initial findings for the standard panel regressions with fixed effects and random effects respectively. Columns 1 and 2 report the impact on the proportion of internationally outsourced services, *serv_os*, for firms citing Web use for as a procurement tool. Columns 3 and 4 report the corresponding impacts for internationally outsourced materials. Overall, the average effect is about 1.5 percent for internationally outsourced service inputs and significant at the 5 percent level. The results for internationally outsourced materials are more ambiguous with a surprising coefficient reversal for the FE estimate and non-significance for the RE estimator. The signs on the other covariates are in line with expectations. Larger, more highly skilled, productive and foreign owned firms are generally more likely to use a higher proportion of international inputs

[Table 4 here]

Figure 1 illustrates graphically what is happening in terms of the distributions of the predicted values (kernel density estimates). The peak of the distribution in Figure 1 which charts the predicted distribution for the switch to internet for services offshoring (any transactions motive), migrates from below 10 percent (red arrow) to above 10 percent (green arrow).

[Figure 1 here]

However, these panel-regressions are unsatisfactory in the sense of not controlling for the real shock induced by a transition to Web based procurement. Other omitted variables possibly correlated with the variable ‘*any_web_trans*’ could similarly have produced the impacts witnessed in Table 4. Therefore, we ideally need to address this problem within a matching framework as described in the Methodology section. Table 5 presents the results from our Propensity Score Matching estimations.

[Table 5 here]

Here we see that the marginal effect of switching to Web based procurement is a 1.7 percent increase in the proportion of international services carried out and a 3.2 percent increase in the

amount of internationally outsourced materials. While the international component of both types of procurement rises, the procurement of international services rises by comparatively more. In real terms, the increase of 1.7 percent corresponds to a overall increase of 13 percent if we define the non-treatment group average as the baseline. For internationally procured materials, the increase is in the region of 7.2 percent (3.2/44.5). This is in line with our expectation that Web enabled procurement is most useful for international services which are weightless and carry extensive negotiating costs.

Predicted effect of switching on offshoring and comparisons with literature

How do our computed effects compare with those observed in the literature? Our panel estimations represent a lower bound where we report increases of about 1.4 percent for internationally procured services on making the transition to Web based procurement. For international procurement of material inputs, our results are more ambiguous. Abramovsky and Griffith (2006) reported an approximately 1.3 percent increase offshored service inputs following a switch for UK data in their OLS estimations. In Bartel et al. (2005), the magnitude of the effect is approximately 3 percent for outsourced services (13 percent change in standard deviation / 3.84 percent change in internet intensity). Our reported values for the panel regressions are much more in line with Abramovsky and Griffith (2006) and Bartel et al. (2005) than the 0.17 percent increase reported in Freund and Weinhold (2000).¹² However, our findings when applying the Matched technique are more upbeat for the role of Web based procurement than those seen thitherto in the literature where the effects are 13 and 7.2 percent for international service and material inputs respectively.

Conclusion

Building a model which summarises key offshoring drivers as reported in surveys of offshoring firms (i.e. transportation costs, uncertainty and price), we describe how the elasticities for offshored services to web use may differ from the elasticities for offshored material inputs to web use. Uncertainty represents a catch-all factor which describes the dovetailing of operations between two non-culturally nor geographically proximate, independent firms.

¹² The latter find that a 10 percent increase in their internet variable (number of internet host sites opened) is associated with a 1.7 percent increase in traded services

We then apply a Propensity Score Matching technique to a sample of firms that switch to Web based procurement and a sample of firms that do not. Using data from the EU harmonized ICT-usage and E-commerce survey for Ireland, and find that ‘switcher’ firms report increases in internationally outsourced inputs by between 7.2 and 13 percent, depending on the type of input. This increase is larger than that previously reported in the literature, and especially large for service inputs.

Our difference in results for services and materials offshoring cautions against a ‘one model fits all’ approach to inputs procurement and suggests instead that if we want to ultimately make predictions as to the hollowing out of production, we should instead estimate separate models for different input types. It underscores the model predictions that we expect different elasticities to ICT use for offshored service and material inputs. Much of this difference in results may be due to the role of uncertainty, (streamlining of operations between two neither culturally nor geographically proximate, independent firms), which is less acute as ICT enabled communications between partners improve.

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Mathematical appendix

FOC for profit maximization arise

$$\frac{\partial E^*}{\partial v_d} = E^* \left[Z' \left(\frac{\partial x}{\partial v_d} - q_d \right) \right] = 0 \quad ; \text{ domestic input; no uncertainty} \quad (3a)$$

$$\frac{\partial E^*}{\partial v_f} = E^* \left[Z' \left(\frac{\partial x}{\partial v_f} - q_f - tc \right) \right] = 0 \quad ; \text{ foreign input; uncertainty} \quad (3b)$$

With respect to the foreign input the following relationships hold:

$$\frac{\partial E^*}{\partial v_f} = E^* \left[Z' \left(\frac{\partial x}{\partial v_f} - q_f \right) \right] \quad (4a)$$

$$= E^* [Z'] E^* \left[\frac{\partial x}{\partial v_f} - q_f \right] + \text{cov} \left[Z', \underbrace{\frac{\partial x}{\partial v_f}}_{\text{well-known}} - q_f - tc \right] \quad (4b)$$

$$\text{with } \dots \quad \text{cov} \left[Z', \frac{\partial X}{\partial v_f} - q_f - tc \right] = \text{cov} [Z', -q_f - tc] = -\text{cov} [Z', q_f + tc] \quad (4c)$$

$$\frac{\partial E^*}{\partial v_f} = E^* [Z'] \left(\frac{\partial x}{\partial v_f} - E[q_f + tc] \right) - \text{cov}[Z', q_f + tc] \stackrel{!}{=} 0 \quad (4d)$$

Define the risk premium as

$$\frac{\text{cov}[Z', q_f]}{E^*[Z']} \equiv \psi \quad (5)$$

Then demand for v_f results be dividing (4d) by $E^*[Z']$ and utilizing (5).

$$\frac{\partial x}{\partial v_f} = E^*[q_f + tc] + \psi \quad (6)$$

Table 1 Unbalanced Panel (2002 – 2004)

switchers				never switched			
Freq	%	Cum. %	Pattern	Freq	%	Cum. %	Pattern
697	73.06	73.06	111	966	69.25	69.25	111
129	13.52	86.58	.11	196	14.05	83.30	11.
105	11.01	97.59	11.	191	13.69	96.99	.11
11	1.15	98.74	..1	18	1.29	98.28	.1.
6	0.63	99.37	1..	15	1.08	99.35	1..
4	0.42	99.79	.1.	9	0.65	100.00	..1
2	0.21	100.00	1.1	1395	100.00		
954	100.00						

Firms that have switched at any stage: annual panel composition			
2003			
have not yet switched		155	16.58
have switched		780	83.42
Total		935	100.00
2004			
have not yet switched		43	5.13
have switched		796	94.87
Total		839	100.00

Table 2 Comparison of Pre-Treatment Values : Intensity of International Outsourcing

International services outsourced (serv_os)									
	2002			2003			2004		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Firm Never switched to Web sales and purchases	1246	13%	21%	1397	13%	21%	1179	13%	22%
Firm Switched to Web sales and purchases (pre-switch values)	332	11%	18%	157	11%	17%	43	8%	10%
<i>difference</i>		2,0%*			2%			6%*	
Significance of means t-test: Ha: diff != 0		0.10			0.32			0.08	
International materials outsourced (mat_os)									
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Firm Never switched to Web sales and purchases	1092	47%	38%	1204	46%	38%	1018	47%	38%
Firm Switched to Web sales and purchases (pre-switch values)	290	50%	37%	132	48%	38%	668	48%	37%
<i>difference</i>		-3%			-4%			-1%	
Significance of means t-test: Ha: diff != 0		0.18			0.52			0.52	

Notes: *: t-test significant at 10 percent level

Table 3 Foreign and Manufacturing firms in Treatment and Non-Treatment Groups

	Obs	Foreign firms	Std. Dev.
Never switched to Web sales and purchases	4296	28%	0,01
Switched to Web sales and purchases	2892	23%	0,01
Significance of proportions Z-test: Ha: diff != 0		4%	0.00
		Manufacturing firms	
	Obs		Std. Dev.
Never switched to Web sales and purchases	4338	75%	0,006
Switched to Web sales and purchases	2904	60%	0,009
Significance of proportions Z-test: Ha: diff != 0		15%	0.00

Table 4: Effect of Switching on International Outsourcing: Panel Regressions

	Internationally outsourced services (serv_os)		Internationally outsourced materials (mat_os)	
	(1)	(3)	(2)	(4)
	FE	RE	FE	RE
any_web_trans	0.0147** (0.00733)	0.0152** (0.00604)	-0.0318** (0.0149)	-0.0176 (0.0129)
sales_pw	0.00161 (0.00287)	0.00592*** (0.00226)	0.00241 (0.00686)	-0.00284 (0.00519)
employ1	0.00455 (0.00723)	0.0103*** (0.00333)	0.0183 (0.0126)	0.00649 (0.00607)
wages_pw	0.0127* (0.00699)	0.0127** (0.00529)	0.0171 (0.0118)	0.0146 (0.00945)
foreign	0 (0)	0.0918*** (0.0109)	0 (0)	0.203*** (0.0194)
Year dummy	yes	yes	yes	yes
Sector dummy	yes	yes	yes	yes
Constant	0.0613 (0.0430)	0.0204 (0.0228)	0.345*** (0.0774)	0.302*** (0.0445)
Observations	6406	6406	5471	5471
Number of firms	2369	2369	2049	2049
R-squared	0.004		0.007	
F	1.662		2.113	
Baseline log likelihood	8129		4961	
Log likelihood	8143		4979	
chi2		131.3		180.1

Table 5: Effect of Switching on International Outsourcing: PS Matching

	No web-based sales or purchases (control)	Web based sales or purchases (treatment)	Effect of treatment	Bootstrapped Standard Error	t
Mean internationally outsourced services	12.6%	14.3%	1.7%	0.006	2.861
Mean internationally outsourced materials	44.5%	47.7%	3.2%	0.011	2.781
Observations	7,260				
Number treated	2,099				
Number controls	4,401				

Notes:

Variables used in the kernel matching:

Labour productivity (sales_pw), firm size (logged employment), foreign ownership dummy, manufacturing dummy, year dummies.

Balancing tests (not reported here) passed. Number of blocks = 7. Number of repetitions for bootstrap = 50.

Figure 1 Predicted values of International Services Outsourcing



