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What happened to Foreign Outsourcing when Firms went Online?*

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Abstract
The possibility to outsource over the internet should revolutionize foreign outsourcing, especially for services (UNCTAD, 2004). Our model describes materials and services input allocation from domestic vs. foreign suppliers. Allocations change when firms outsource online due to *access* and *competition* effects. Using data for 99 firms who started outsourcing online in 2003 together with a control group (never outsourcing online) of over 682 Irish firms, we apply OLS and Propensity Score Matching with Difference-in-Differences to find that 42-48 percent of foreign services inputs growth arises from online outsourcing.

Keywords: International Outsourcing, Propensity Score Matching, Input Price Uncertainty, Input Demand

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1 Background

The introduction of the Internet was expected to revolutionize the way in which *services* are exchanged. Many services such as legal, financial, R&D or technical services are traditionally exchanged at a distance but 'technical constraints, habits or customs' had hitherto prevented this from happening (p.148, UNCTAD, 2004; Bhagwati et al., 2004). These 'technical constraints' have largely been removed with improvements in information technology, e.g. online payments, faster Web connections and better user interfaces and visual cues. Economists are silent about the predicted effects for *materials* outsourcing. But should it automatically follow that the outsourcing of international materials has remained unaffected by the new possibilities of transacting online? Materials are after all tangible and their quality can be more easily gauged at the time of purchase. Take the example of a textile manufacturer. A product like a chemical pigment can be identified by its chemical formula and other physical attributes. Therefore, the textile firm should have a definite idea of the price-quality relationship when purchasing units of the dye. This is not the case for a consultant advising on the organization of the textile firm's financial accounts. Here the price-quality relationship is more ambiguous, communications and 'troubleshooting' are likely to be ongoing and only ex-post can the textile firm say with certainty that the service delivered value for money.

It is by now generally accepted that outsourcing increased significantly over the last years, an increase arguably helped by the role of the internet in facilitating exchanges (UNCTAD, 2004; Bhagwati et al., 2004). The consensus among economists is that foreign *services* patterns are highly sensitive to this increased scope for arms' length exchange. Amiti and Wei (2006) recorded growth rates of 6 percent in foreign services outsourcing as early as 2000, largely pre-dating the growth in online transactions. This growth was largely based on the low starting-levels for services in the economy vis-à-vis outsourced materials.

Hijzen et al. (2010) recently show that outsourcing is so expensive in terms of transaction costs that, on average, in-house production is more efficient. Transaction cost economics spells out how technological advances such as ICT (Information and Communication Technologies) can reduce these transacting costs (Milgrom and Roberts, 1990; Grossman and Hart, 1986). The scope to streamline firm-supplier exchanges with increased internet use, makes outsourcing generally more attractive for firms looking to outsource foreign inputs. This is especially true for non-core inputs which garner only a small share of the firm's overall production cost (Acemoglu et al., 2010).[1] Abramovsky and Griffith (2006) show how profit maximizing firms set out to minimize their outsourcing costs, costs which are minimized as the number of buyer-supplier online exchanges grows. Their estimations for a

[1] Somewhat analogously, Bartel et al. (2005) show that what matters most in explaining outsourcing differences between firms are changes in external technologies because the pace of change makes it more cost-effective for firms to outsource from specialized outside firms. The increase in outsourced Software and Accounting services is 8 percent when ICT intensity increases by 3.8 percent.

cross-section of UK firms show that firms which use online outsourcing are 6 percent more likely to outsource foreign services than firms conducting no online outsourcing.

The above studies show the predicted and actual effects impacts on outsourcing as transaction costs fall. But there are other reasons to expect changes in the quantities of foreign outsourced inputs: namely the introduction of firms to a wider supplier pool. While advances in ICT help both domestic and foreign outsourcing, it is arguably the widening availability of international input suppliers (many more firms coupled with intensified competition) that tips the balance towards foreign intermediates. Moreover, international suppliers take advantage of cheap labour which can be internalized in the input price (Lileeva and van Biesebroeck, 2008). The result: cheaper inputs from foreign suppliers. But the appetite of firms for foreign inputs may have more to do with growth and capacity constraints than a preference for foreign inputs as revealed in labour demand functions by Falk and Koebel (2002).[2] If so, estimations must control for a firm's sales growth if anything meaningful can be said about overall impacts of ICT improvements on foreign outsourcing.

Summing up: any reduction in transactions costs (e.g. online outsourcing) is expected to tip the balance towards foreign outsourced inputs. Other factors (i.e. widened supplier availability or better value for money from foreign suppliers whose prices internalize cheaper overseas labour) can affect all domestic firms equally, even those that do not switch to online outsourcing. Moreover, economists predict positive impacts of internet improvements for quantities of foreign outsourced services, not materials. It is time to organize these stylized facts into a simple but coherent model.

We stylize the input outsourcing set-up, allowing firms to grow and increase their input demand (foreign vs. domestic inputs) irrespective of whether they switch to internet procurement or not. Separate impacts of the internet for both internet switchers (treatment group) and non-switchers (control group respectively) are derived. In sum, our simple model of input demand describes four components of the foreign vs. domestic outsourcing decision; 1) differences in domestic vs. foreign input prices internalizing cheaper foreign input, 2) uncertainty about whether this factor price correctly reflects value for money of the input, 3) the firm's attitude towards risk and 4) supplier-purchaser transactions, of which (at least for materials) transport cost is a major component. Internet improvements increase the visibility of foreign services and material inputs. Nevertheless, uncertainty remains as to whether foreign services confer value for money at the listed price.[3] Moreover, although

[2] The Falk and Koebel (2002) paper arguably pre-dates the boom in Internet procurement and it would have been interesting to observe whether the weak domestic/foreign substitution effect would be seen for post-2000 data.

[3] The price-quality relationships for foreign outsourced services can be weak. To illustrate: consider the outsourcing of foreign services by the Cisco (US) from the supplier Huawei (China). Houseman (2007) reports that '…the amount of work hours required by Huawei's engineers to develop the product is roughly double that required by Cisco engineers (purchasing firm), but because labor costs of Chinese engineers are dramatically lower than those of their American counterparts, the cost of R&D in China is about one-fifth that in the United States (Houseman, 2007; p. 14). Accordingly, a potential outsourcer cannot easily benchmark the price of foreign vis-à-vis domestic services, due to productivity differences. Some Indian IT suppliers are hiring US

the cost of transacting exchanges falls, transport costs remain for materials inputs. Therefore, while we expect the (optimal) ratio of foreign to domestic outsourced inputs to change with the switch to online outsourcing, the direction of this change is ambiguous. This is because uncertainty about value for money (affecting mostly service inputs) may be offset by transport costs (affecting mostly materials inputs).

We then take our model to Irish data for a sample of 99 firms who started outsourcing online in 2003 together with a control group (never outsourcing online) of over 682 firms from the EU harmonized ICT usage survey and the E-commerce survey.[4] The questions we tackle are (i) whether the growth in the foreign/total input ratio is higher for firms initiating online outsourcing and (ii) whether some of these growth differences are attributable to the firm's switch to online outsourcing. By inputs, we mean both service *and* material inputs. This is the gap that our paper aims to fill.

To do this we use a standard regression methodology as well as checking the robustness of our estimations using a Propensity Score Kernel Matching model with a Difference-in-Differences (DID) estimator. This latter robustness check helps eliminate variation in foreign outsourcing growth rates caused by other observable variables which co-determine the firm's move to online outsourcing (e.g. worker skills, firm size, labour productivity, ownership status or sector). Moreover, the combined DID methodology allows us to net out growth differences arising from common shocks (e.g. generally increasing the supply of traded services).[5]

Applying OLS and Propensity Score Matching with Difference-in-Differences we find that the move to online outsourcing is associated with a 42-48 percent increase in foreign outsourced services. The effect on foreign materials outsourcing is either weak or insignificant, depending on the methodology used.

Our paper is set up as follows. The next section describes our basic model. Then follows a section outlining our methodology before we describe our data. We report the results for our regressions before concluding in a final section.

2 Simple Model of Foreign Outsourcing Growth

The model provides a stylization of an input outsourcing set-up that allows for growing input demand irrespective of whether or not firms switch to internet procurement. For simplicity, we move

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software programmers to improve the productivity of service delivery in a phenomenon known as 'reverse outsourcing'.

[4] Over 91 percent of Irish firms surveyed in the E-commerce survey used computers in 2003 though by 2004 this had jumped to almost 100 percent (Haller/ESRI, 2008). Between 2002 and 2004 there was a 32 percent increase in the number of firms offering services online. Our observation period 2002-2004 was marked by the piloting of the E-commerce survey and considerable increases in online transactions for firms

[5] See Girma and Görg (2007)

beyond the make-or-buy decision.[6] We first derive the composition of foreign and domestically outsourced inputs as a result of optimal factor demand. Subsequently, we isolate the impact of the internet for both internet switchers (treatment group) and non-switchers (control group respectively) thereby focussing on foreign outsourced service inputs as an application. Our argumentation is based on the interaction of several effects concerning demand for and prices of the foreign outsourced input: (i) Input demand is affected via a *competition effect* which is due to the mere existence of the internet as well as via an *access effect* which is exclusively based on internet usage. The latter thus only comes into play for those firms already using the internet or switching to internet usage during the considered period. (ii) Besides, foreign input procurement is accompanied by factor price uncertainty. Since inputs are new to the firms and firms are unclear as to the exact value they will get for their money, the input price for a given quality is then stochastic. It includes the expected factor price, the firms' degree of risk aversion and transportation costs. If any of these components increases up to a significant point, this may even tip the scales against international outsourcing. Overall, the firms' demand for foreign outsourced inputs is co-determined by the interaction of the aforementioned effects.

Our following stylization of the input outsourcing set-up allows firms to increase their input demand irrespective of whether they switch to internet procurement or not. The model also allows us to derive the part of foreign input demand traceable back to the internet switch. Due to the different properties of materials and services input, the discussion distinguishes between them. We provide a simple factor demand model that may be applied to both materials and services. After presenting the model setup, we derive the optimal allocation between foreign and domestically outsourced inputs (Section 2.2). The model predictions will later be interpreted in the light the differential effects of internet usage for outsourcing services and materials inputs respectively, given their different properties (Section 2.3). A graphical illustration in Figure 1 highlights the argumentation for the specific case of foreign outsourced services, thereby assigning the effects to switching and non-switching firms.

2.1 Formal representation of optimal input demand

To formalize the problem, we rely on the seminal work of Sandmo (1971) and Leland (1972). We assume a risk averse representative firm that produces a homogenous good thereby utilizing foreign and domestically outsourced factor inputs. The firm is well informed about the price and quality of domestically outsourced inputs whereas there is uncertainty w.r.t. the price/quality relationship for foreign outsourced inputs. Formally spoken, the price a firm has to pay for the domestically outsourced input is deterministic whereas the price for the foreign input is stochastic. The

[6] One might argue that the make-or-buy decision was already finalized as a first part of a two step- optimization problem.

objective of the optimizing firm is to maximize expected utility $\left(E^*[Z]\right)$ out of profits $\left(\pi\right)$ as given by[7]

$$E^*\left[Z\{\pi\}\right] = E^*\left[Z\left\{p \cdot X(v_d, v_f) - v_d \cdot q_d - v_f \cdot (q_f + t_c)\right\}\right] \tag{1}$$

Outsourced inputs comprise domestic (*d*) and foreign (*f*) shares, the amounts thereof denoted by v_d and v_f for domestic and foreign inputs respectively. The corresponding input prices are q_d and q_f. The parameter t_c denotes transportation costs. The firm's production conditions are given by a generalized production function $X(v_d, v_f)$ and we assume perfectly competitive input and product markets. For the sake of simplicity, we normalize the price of the final product, p, to unity. The first order conditions then reflect the equalization of the value of the marginal product with that of the considered factor price. For both the domestic and foreign outsourced inputs, the first order conditions can be shown to be as follows;[8]

$$v_d^* \quad \Leftrightarrow \quad \frac{\partial X}{\partial v_d} = q_d \tag{2}$$

$$v_f^* \quad \Leftrightarrow \quad \frac{\partial X}{\partial v_f} = E^*[q_f] + \psi + t_c \tag{3}$$

As argued before, there is no uncertainty concerning the domestically outsourced input and q_d represents the corresponding deterministic factor price (compare (2)). In contrast to this, uncertainty about foreign inputs requires us to assume an expected input price, $E^*[q_f]$. In this vein, increasing the transparency on (national and international) factor markets, induces a convergence of domestic and international factor prices $\left(E^*\left[q_f\right] \; q_d\right)$. Moreover risk aversion is captured in a (input specific) risk premium, ψ. Physical transportation, t_c, may represent a significant part of the overall factor price a firm has to pay (especially when outsourcing materials inputs). All three components on the right hand side in (3) together with the factor demand function co-determine equilibrium demand for the foreign outsourced input. It is reasonable to assume that these components differ for services and materials.

[7]The fact that the firm maximizes expected utility out of profits and not just expected profits is due to the assumption of risk aversion. This is a characteristic of firms which can later be connected to some of the drivers of outsourcing (See empirical part in Section 5).

[8]For a formal derivation of (3) and especially the composition of the risk premium, ψ, see Appendix 3.

2.2 Optimal allocation of foreign and domestically outsourced inputs

Equations (2) and (3) also capture the optimal ratio of foreign and domestic outsourced inputs, $\left(v_f / v_d\right)^*$.[9] We first assume a constant output level for the final good. Other arguments come into play if output increases, thereby inducing higher overall input demand (as verified in Section 2.3). For a *given output level*, the optimal ratio between foreign and domestically outsourced inputs is then determined by the marginal rate of substitution

$$\left(\frac{v_f}{v_d}\right)^* \quad \Leftrightarrow \quad \left|\frac{dv_d}{dv_f}\right| = \frac{E^*[q_f]+\psi+t_c}{q_d} \tag{4}$$

This implies a reallocation e.g. in favor of foreign at the expense of domestically outsourced inputs, the lower the stochastic price of the foreign input ($E^*[q_f]+\psi+t_c$) compared to the deterministic domestic input price (q_d). The resulting ratio $\left(v_f / v_d\right)^*$ is thus mainly driven by the aforementioned components that result from the input's properties.[10] For example, it is reasonable to assume that the level of the risk premium is affected by the degree of input standardization (which e.g. is easier to gauge for materials than for services with the consequence that ψ is smaller for materials than for services). Conversely, while transportation costs are negligible for services, these remain a relevant cost component for materials.

2.3 The role of the internet: an application to demand of foreign services

The outsourcing of foreign services is still a growing field and the accompanying efficiency gains for firms are not yet fully exhausted. Amiti and Wei (2006) documented an average annual rate of 6.3 percent for US manufacturing, albeit from low starting levels. In this sense, the internet allows firms to select inputs from an ever widening menu of options ('access effect'). Since there are stronger limits to standardization, the outsourcing of services is frequently tied to uncertainty over value for money. Another moderating influence in the purchasing of services is the magnitude of a firm's risk aversion. Why should the firm's degree of risk aversion matter? Purchasing firms can experience higher ex post costs with foreign IT suppliers (e.g. supplying software programming), where purchasers find that service inputs may need reworking. Providers of services inputs (e.g. R&D) in locations such as China may be less efficient in producing a product comparable with that of a domestic supplier.

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[9] Notice that $v_f/v_d = \dfrac{v_f/v}{v_d/v}$ with $v = v_f + v_d$. Our measure of these ratios v_f/v and v_d/v is discussed in the empirical part of the paper and the notes to Table 5.

[10] Notice that the optimal ratio $\left(v_f / v_d\right)^*$ may also change if the two inputs exhibit different growth.

In what follows, we focus on the impact of the internet on demand for foreign outsourced services. We restrict ourselves to considering the quantity effect (change in foreign outsourced inputs) instead of the aforementioned compositional effects (ratio of foreign over domestically outsourced inputs) and discuss the incentives for switching vs. non-switching firms. Our starting point is the stylized fact that foreign outsourced services are expected to become more tradable with the advent of internet technologies and more easily purchased at arm's length. The basic argumentation for materials is analogous despite our expectation of a different overall effect due to the specific properties of materials inputs, as discussed later on in this section.

With respect to the factor demand functions, two effects are to be distinguished: The *competition effect* increases transparency across international factor markets thereby inducing a convergence of domestic and foreign input prices $\left(E^*\left[q_f\right] \square\, q_d\right)$. This effect basically holds independent of internet usage and it is stronger, the more standardized the inputs and the more transparent the factor markets are. Moreover, it is reasonable to assume that the competition effect is more pronounced for firms using the internet as they are better informed. This allows them to realize even higher savings on purchased inputs. Altogether, the overall demand for foreign outsourced inputs increases and the impact on quantity demanded may be assigned to switching and non-switching firms. In contrast to this, the *access effect* is exclusively due to internet usage and does not apply for non-switchers. It provides (exclusively) switching firms access to so far unknown factor markets, e.g. to state-of-the-art processes from specialized suppliers. Concerning the overall input demand, 'internet switch', may then be interpreted as an exogenous shock.[11]

(Figure 1 about here)

In line with the uncertain quality of foreign services inputs above, Figure 1 illustrates the underlying effects of the internet on demand for foreign outsourced services. The initial situation (no internet, no switch) is given by point A with amount v_A and price for services q_A.[12] The *competition effect* leads to an overall factor price decline from $q_A > q_B$, thereby inducing an increase in demand as represented by a move along the factor demand function from point A to point B in Figure 1 (green arrowed line; quantity $\overline{v_A v_B}$). As argued before, this effect is due to the mere presence of the internet and arises independent of internet usage. Additionally, switching firms get an even clearer picture of the potential input suppliers, allowing them to benefit from still stronger price reductions, e.g. up to q_C with v_C, respectively. This effect is probably the more pronounced, the less

[11] It is reasonable to assume that the access effect impacts small firms more strongly vis-à-vis large firms. The former are not integrated into more complex organizations and therefore the marginal utility of switching to online outsourcing should be higher for smaller firms.

[12] Notice that the index, *f*, is suppressed since the entire discussion now refers to the demand for foreign outsourced services. Besides, as aforementioned, the stochastic input price as reflected by the horizontal q lines covers all three components, $E^*[q] + \psi + t_c$.

standardized the inputs are. The overall quantity effect of increased *competition* is thus $\overline{v_A v_C}$ which may be assigned to non-switchers ($\overline{v_A v_B}$) and switchers ($\overline{v_B v_C}$). The *access effect* is illustrated by a shift of the factor demand function in Figure 1 to the right, thus reflecting increased access to specific inputs ('widening menu of options' as argued before), a benefit enjoyed by online outsourcing firms only. Given the 'initial' factor price q_C, demand for foreign outsourced services would increase even more, up to v_C'. The entire access effect thus covers the quantity $\overline{v_C v_C'}$. It may only be realized by switching firms.

So far we did not address the impact of the stochastic factor price. It is quite reasonable to assume that for service inputs from as yet unknown suppliers, actual demand crucially depends upon the purchasing firm's characteristics, among them its degree of risk aversion. Another component of the stochastic factor price is transportation costs; however these are probably low for services. Both risk aversion as well as transportation costs result in an upward shift of the stochastic factor price line as indicated by q_D. The extent of the shift depends upon the actually prevailing levels of risk aversion, ψ, and transportation costs, t_c. For services, we assume that the former may play a significant role whereas the latter may be almost neglected.[13] Accordingly, a positive shift of the factor price line reduces the actual demand, e.g. to v_D.[14] The final equilibrium outcome is co-determined by the stochastic factor price and the input demand function. In Figure 1 this equilibrium is denoted by the quantity $\overline{v_A v_D}$.

To summarize: The net increase in quantity is based on the *competition* and the *access effect*, on the one hand, and *risk aversion* and *transportation costs*, on the other hand. The competition effect induces a movement along the factor demand function which as a consequence of the access effect shifts to the right. As a consequence, overall demand increases. Different levels of risk aversion and transportation costs are associated with an upward shift of the stochastic factor price line up to q_D .which basically dampens the overall effect.

Concerning *materials*, similar effects should be observed for firms which outsource materials inputs as those witnessed for services inputs. However, it is reasonable to assume that the magnitude of the effects differs. Specifically, in contrast to services, the market for material inputs is likely to be more mature and hence more saturated (Amiti and Wei, 2006). Higher transparency due to enhanced scope for standardization of materials inputs also helps underpin the competition effect.15 Thus the

[13] In case of materials the opposite argumentation applies (see below).

[14] Notice that q_D and accordingly v_D have been chosen randomly. Depending upon the actual level of ψ or t_c, any 'final' amount smaller than v_C' would be feasible.

[15]Put differently: dye is just dye, independent of the internet and its usage.

scope for both the competition and access effect to affect the demand for inputs is likely to be rather small for materials. Even if one negates the impact of risk aversion (which does not affect materials significantly), the potential gains for foreign outsourcing are modest due to remaining transportation costs shifting the line of the stochastic factor price, q, significantly upwards. Compared to services, the overall effect of the internet and its usage on outsourced materials are likely to be more modest or insignificant.[16]

The arguments discussed so far are picked up in the empirical part of the paper. We show that the overall the ratio of foreign to domestic inputs increases as a consequence of the mere existence of the internet. We also derive which share of the increase arises from the internet switch and which increase would have been registered even by non-switching firms. As argued before, it is reasonable to assume that the access effect is quite important in case of services. This assumption would furthermore support our later empirical findings whereby foreign vs. domestical outsourced services respond more to the internet switch than materials.

3 Methodology

When we examine the web switching/outsourcing relationship, we face a standard selection problem. If firms which commence outsourcing services online ('internet switchers') happen to be already highly involved in outsourcing services from supplier firms (compared with other firms which avoid using the internet for outsourcing), we would expect to witness above-average outsourcing quantities for 'internet switcher' firms even if they had not started to use the online outsourcing. Internet switchers could be a self-selecting group, in which case, the impact on outsourcing growth has less to do with the move to online outsourcing and more to do with inherent characteristics of this group.

The lack of statistically relevant and intuitively compelling instruments for online switching (factors prompting firms to switch to online usage but which do not affect outsourcing growth) makes it difficult to deal with self-selection unless we isolate from our sample the group of newly switching and non-switching firms. Following Heckman et al. (1997) we can calculate the average effect of switching to online outsourcing on expected outsourcing growth. Specifically, y_{t+s}^{1} and y_{t+s}^{0} represent outsourcing quantities pre- and post the switching period respectively for firms switching to online outsourcing (*SWITCH* = 1) as:

$$E\{y_{t+s}^{1} - y_{t+s}^{0} | SWITCH_{it} = 1\} = E\{y_{t+s}^{1} | SWITCH_{it} = 1\} - E\{y_{t+s}^{0} | SWITCH_{it} = 1\}.$$

[16] Note that, although made explicit in figure 1, our argumentation can be extended to explain a decrease in foreign input demand as a consequence of internet procurement.

where the last expression term is needed in order to infer the foreign outsourcing intensities for the group of firms that did not switch to online outsourcing. To get this term, we match each firm that switched to online outsourcing with a derived counterfactual, constructed over the distribution of non-switching firms. We apply the *STATA* propensity score routine, *psscore*, based on Rosenbaum and Rubin (1983). Specifically, the first-stage Probit captures the likelihood that firms switch to online outsourcing based on observable pre-switching attributes of the firm (firm size and ownership status, R&D status, technology status and growth).[17] Both control (never using online outsourcing) and treatment (newly online outsourcing) firm groups are then assigned to strata according to the propensity score and the balancing property checked for each stratum.[18]

A note on the covariates used to explain outsourcing growth. Amiti and Wei (2006) argue that there might be a concern that foreign services outsourcing is correlated with omitted variables such as total outsourced inputs (levels). This would make it difficult to interpret the overall impact of a switch on quantities of foreign services/materials outsourced. To address this, we include lagged outsourcing (levels) in some specifications of the empirical model. The transactions cost literature suggests a strong connection between a firm's technological ability and its outsourcing intensity (e.g. see Bartel et al., 2005). Therefore, we control for firm-level R&D to prevent overstating the impact of online outsourcing on foreign outsourcing growth. To derive our outsourcing intensity measure, we scale the share of inputs from foreign suppliers by the total amount of inputs supplied (foreign and domestic).[19]

In our empirical analysis, size is measured as number of employees, R&D is a firm's total R&D divided by sales and the ownership dummy indicates whether a firm is foreign owned. Finally, our outcome variable foreign outsourcing is defined as foreign services (materials) used, divided by total services (materials).[20]

In estimating foreign outsourcing, we opt for the *STATA attk* procedure proposed by Heckman et al. (1997) which builds on traditional pairwise matching by using the full distribution of firms falling under common support in the pre-exporting Probit.[21] The nonparametric matching estimator constructs a match for each firm which has just begun outsourcing online using a kernel-weighted average over multiple firms which do not carry out online outsourcing. Assuming that the common

[17] Labour productivity and firm age are also likely drivers of foreign outsourcing growth. They were used in earlier regressions though their relative inability to explain variations in outsourcing growth led to them being subsequently dropped.
[18] We assume that the assumption of conditional independence holds: i.e. that firms in the control and treatment group largely select into online outsourcing based on these observable pre-switching attributes. Specifically, their differing willingness/ability to manufacture in-house vs. to outsource.
[19] See footnote 10
[20] In this we depart from Abramovsky and Griffith (2006) or Görg and Hanley (2011) who both scale foreign outsourcing by sales. Our rationale for scaling by total outsourced inputs is to discern the changing bias between foreign and domestic inputs with online outsourcing.
[21] We use the *STATA* default Gaussian kernel with bandwidth 0.06. Smith and Todd (2005) give an excellent summary of this and other matching techniques. An advantage of this matching technique is that it reduces the asymptotic mean squared error found in traditional pairwise matching.

support conditions hold, we now have a consistent estimator of the growth in foreign outsourcing for firms newly outsourcing online, had they not decided to outsource online: $E\{y_{t+s}^{0}|SWITCH_{it} = 1\}$

Our empirical analysis outlines how foreign outsourcing growth is expected in both groups (treatment and control) in line with the *competition effect* as the internet becomes widespread with implications for the supply of services and materials. Accordingly, it is possible (though improbable) for firms in both groups to draw equally on this wider palette of suppliers, even if they do not transact online. Hence the need for Propensity Score Matching with Difference-in-Differences (DID) to net out these growth differences due to the *competition effect* (a common shock) and isolate the impact of online outsourcing on foreign outsourcing growth.

In combining Propensity Score Matching with DID, we follow Girma and Görg (2007) allowing us to tackle both endogenous selection into online outsourcing where firms select into this group on the basis of covariates found to be significant in the literature whilst neutralizing the bias of common macroeconomic shocks (DID).

4 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. The ABSEI survey is an annual survey of Irish plants 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 at circa 55 to 60 percent of the targeted population per year. This data contains information on foreign and domestic services outsourced. Further data available from this source relevant to the current paper are total full time employment, sales, R&D expenditure, firm age, nationality of ownership and the four digit sector of production.

Importantly for this study, the survey also included questions on ICT usage for the period 2002 to 2004. Some recent work is now emerging for other EU member states where the same ICT usage survey was carried out (See Abramovsky and Griffith, 2006 for the UK).[22]

Data cleaning and variable generation

Since the Internet usage variables were covered only in the period from 2002 when the E-commerce survey was piloted and the last year where information is recorded for outsourcing is 2004, this means that our sample frame contains 3 years of data. A main novelty of our paper is estimating the impact

[22] See 'Information society: ICT impact assessment by linking data from different sources', Eurostat Report, August 2008.

of having switched to online outsourcing on foreign outsourcing growth. Accordingly, we identify 2003 as the year in which a switch to online outsourcing is made and divide the 3-year time window into pre-treatment (2002), treatment (2003) and post-treatment (2004) periods respectively. The raw data contained 2,022 firms in the initial ABSEI sample (Table 1). 22 percent of the sample was discarded because it comprised firms which were already outsourcing online from before 2003. 99 firms were assigned to the treatment sample (7.9 percent of the raw data), if they used online outsourcing for the first time in 2003 but had not already done so the previous year. Analogously, 691 firms were assigned to the control sample (70.1 percent of the raw data) if they had never at any point during the 3-year time window done any of their outsourcing online. All covariates such as sales were deflated by the Consumer Price Index.[23]

The key variable of interest in our analysis is the proportion of foreign outsourced inputs (services vs. materials) for firms moving to online outsourcing (treatment group) compared to the proportion for firms which avoid online outsourcing (control group). Accordingly, Table 2 gives the breakdown of foreign outsourcing across these two groups for the pre-treatment period (2002) and thereafter.

Looking at the composition of outsourced foreign *services*, what is clear is that firms in the treatment group start out with low levels of foreign outsourcing (13 percent vs. 20 percent). Once treatment firms introduce online outsourcing in 2003, the differences between both groups are reduced (18 percent vs. 22 percent). The greatest convergence in foreign services outsourcing between the treatment and control groups is contemporaneous with the switch to online outsourcing (2002-2003) and not thereafter (2003–2004). This same pattern of convergence seen in foreign services outsourcing is not replicated for materials where the composition of foreign materials outsourcing (pre- and post- treatment) remains stable at 49 - 52 percent. Figure 2 illustrates the same information graphically. What is clear from Figure 2 is the relatively minor role played by foreign services compared to foreign materials inputs (e.g. high transportation costs would shift q_B upwards thereby inducing a decrease in the demand for foreign outsourced inputs). However, over the period 2002-2003, there is some growth in foreign services inputs. Although overall, firms increased their intake of foreign services from 19 to 21 percent over the 3-year period, compared to an increase of 50 to 51 percent in materials inputs, much of the foreign services growth seems to have come from the 99 firms in the treatment group who started online outsourcing between 2002 and 2003 where the increase in foreign services amounts to 8 percent (from 13 to 21 percent).

Figure 2 makes two points clear: 1) the market for foreign outsourced services is small compared to that for foreign outsourced materials and 2) this market in foreign services appears to be growing. These two points are consistent with Amiti and Wei (2006) who used data for the US.

(Figure 2 about here)

[23] See Appendix 1 for a full list of variables used in our analysis

How similar are firms in both treatment and control groups? Table 3 reports the breakdown of key covariates for both groups of firms in the pre-treatment period. However, firms switching to online outsourcing (treatment) appear to be, at first glance, smaller, Irish-owned, higher-growth and more R&D intensive than their non-switching counterparts. One possibility is that larger, foreign firms that do not make the move to online outsourcing are perhaps better vertically integrated into global production networks. Moreover, the propensity to move online seems to be, to some extent, conditioned on high-growth (e.g. see Falk and Koebel, 2002). These are arguments that support the aforementioned *access effect* where a reduction in transacting costs may confer relatively higher utility to firms with little ability to procure within a global production network. However, we need to examine this growth-outsourcing nexus in a multivariate framework. The patterns in Table 3 showing the bias towards small, Irish, higher-growth firms hint that a matching framework might be in order. This approach would help correct the pre-treatment biases and allow us to observe the effect of a switch to online outsourcing for 'observationally equivalent' treatment and control firms in 2002.

5 Analysis

The next step is to regress the online outsourcing dummy on foreign outsourced services growth while controlling for lagged values of key variables found significant in the literature. Table 4 shows the results of this exercise. In column 1, we merely control for firm size and ownership while in columns 2 and 3 lagged growth and R&D intensity are added sequentially. In the latter two estimations, the online outsourcing dummy is found to be significant at the 5 percent level where a switch to online outsourcing is associated with a 45 percent increase in the average ratio of foreign to total outsourced services. Consistent with our earlier observation that larger firms are likely to be more vertically integrated, an inverse relationship is reported on the firm size coefficient. When we repeat the procedure for outsourced foreign materials (columns 4 – 6), the effect is significant but smaller than for that of services. Much of the explained variation in foreign outsourcing growth can be explained by the firm's current outsourcing profile. If current foreign outsourcing levels are high, outsourcing growth will be lower the next year.[24]

Earlier, in the descriptive statistics (Table 3) we observed differences in the average firm size, ownership, R&D intensity, growth and sector in the pre-treatment period. This hinted at the possibility that the switch to online outsourcing may be endogenous to these covariates. To check for endogeneity of the 'internet switch' indicator, we follow Eichenbaum et al. (1988), by calculating the Difference-in-Sargan statistic (C-statistic) with p-values of 0.0109 and 0.0842 for the switch to online outsourcing for services and materials inputs respectively. This indicates that we are correct in rejecting the null that the switching dummy is exogenous.

[24] Amiti and Wei (2006) highlighted the importance of including this measure of total imports (levels) in regressions in order to reduce the bias in the elasticity of foreign inputs growth to online outsourcing.

Having verified that the switch to online outsourcing is endogenous to the lagged regressors, we proceed to the Propensity Score Matching procedure which will allow us to condition the switching dummy in a first step on the covariates and calculate a propensity score. In a second step, subject to the *STATA* procedure (*STATA* 'attk') having performed the balancing tests satisfactorily (See Appendix 2 for balancing tests), we can move to the Kernel matching to see whether there are any systematic differences in foreign outsourcing growth rates for treatment and control firms.

In the selection equation, we see that larger and foreign-owned firms are significantly less likely to start outsourcing online (Table 5a). Arguably, they are better vertically integrated and have thereby less use of this outsourcing mode. The high and positive coefficient for R&D intensity may have to do with the complementarity between these activities e.g. a presence of systems savvy staff involved in R&D is perhaps helpful when a firm is working out ways of outsourcing online. Table 5b reports the findings for the Propensity Score Matching procedure for the effects of the switch to online outsourcing on growth (reduction) in the foreign outsourcing share. Our estimations report Difference-in-Difference estimates, thereby purging any common time-variant shocks which would affect would groups of firms (see Girma and Görg, 2007).

The foreign services ratio grew over the treatment period by 70 and 22 percent for firms in the treatment and control groups respectively. This corresponds to a 48 percent increase for firms in the treatment sample vis-à-vis firms in the control sample. The difference is marginally significant (at the 10 percent level) for the bootstrapped standard errors. However, the corresponding growth increase of 22 percent for foreign materials outsourced is insignificant. The estimates of 48 percent from Propensity Score Matching compare reasonably well with those obtained under standard OLS (Table 4) where increases of 42 – 46 percent were registered.

6 Conclusions and Policy Implications

Consistent with the *competition effect* outlined in our model, firms grew their share of foreign outsourced services inputs over the treatment and post-treatment periods (2003–2004) by 22 percent.[25] Consistent with the *access effect*, firms switching to online outsourcing registered increases in the ratio of foreign outsourced service inputs of 48 percent, a result broadly in line with the OLS estimates (42 – 46 percent). Our estimates for the effects of switching to online procurement represent a lower bound for the overall potential effect of the internet on foreign outsourcing. When both competition and access effects are added together, the overall effect is 70 percent (22 percent + 48 percent).

The Propensity Score Matching estimates reveal online outsourcing to be the choice of firms not integrated into global production networks (e.g. not foreign-owned or large). Such firms lack the

[25] 22 percent corresponds to the exogenous growth in the foreign services share of control firms during the period and therefore reflects the background growth in the sector as more services become tradable and their visibility rises.

critical mass and global reach to get their inputs in other ways (through overseas vertically integrated sister firms or in-house domestic production).

Our study dates from the time when online outsourcing was a relatively new phenomenon. Would the impacts for foreign services outsourcing be the same if the growth in foreign services outsourcing had already peaked? Our estimates for the period suggest promising foreign services growth (compared to the market for materials inputs). Estimates using more recent data might reveal fewer differences in the growth rates for service vis-à-vis materials inputs as the market for traded services matures.

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Appendix

Table 1 Breakdown of raw data/ final sample

Firms in 2003 (t)	Firms in ABSEI raw data *(%)*	Final sample*
Control	1,418 *(70.1)*	691
Treatment	159 *(7.9)*	99
Excluded**	445 *(22)*	
Total firms	2,022	790

*firms with non-missing data for response variable and covariates
** excluding firms continuously buying services online in 2002 (before treatment commenced)

Table 2 Composition of Foreign Outsourcing for Firms Switching to Online Outsourcing (Treatment) vs. Control Fims

					Outsourced Foreign Services				
		2002			**2003**			**2004**	
	$outs_F/(outs_F+outs_D)$	S.D.	firms	$outs_F/(outs_F+outs_D)$	S.D.	firms	$outs_F/(outs_F+outs_D)$	S.D.	firms
Treatment	13%	0.176	99	18%	0.213	99	18%	0.21	99
Control	20%	0.231	691	22%	0.236	691	22%	0.236	691
Total	19%	0.226	790	21%	0.234	790	21%	0.233	790
t-statistic			**2.8276**			1.5256			1.3804
					Outsourced Foreign Materials				
			2002		**2003**			**2004**	
	$outs_F/(outs_F+outs_D)$	S.D.	firms	$outs_F/(outs_F+outs_D)$	S.D.	firms	$outs_F/(outs_F+outs_D)$	S.D.	firms
Treatment	52%	0.394	99	49%	0.392	99	50%	0.391	99
Control	49%	0.376	691	50%	0.373	691	51%	0.373	691
Total	50%	0.378	790	50%	0.376	790	51%	0.375	790
t-statistic			-0.7667			0.2665			0.0963

Notes:

$outs_F/(outs_F+outs_D)$: ratio of foreign outsourced inputs over total outsourced inputs

Table 3 Pre-2003 Differences between Treatment and Control Firms

	Control	Treatment	χ^2
Small firm (%)	32	45	**6.7***
Domestic firm (%)	60	78	**11.4*****
Manufacturing (%)	80	72	**3.6***
High sales growth (%)	49	61	**4.3****
High R&D to sales (%)	55	64	**2.8***

Table 4 Foreign Outsourcing Growth (OLS)

	Outsourced Foreign Services (serv_os_gth2003)			**Outsourced Foreign Materials** (mat_os_gth2003)		
	(1)	(2)	(3)	(4)	(5)	(6)
online outsourcing begins (t)	0.458**	0.455**	0.415**	0.189**	0.188**	0.197**
	(0.205)	(0.206)	(0.206)	(0.0914)	(0.0916)	(0.0915)
service outs. levels (t)			-0.868***			
			(0.313)			
material outs. levels (t)						-0.227**
						(0.0945)
employment size (t-1)	-0.0536	-0.0502	-0.0330	-0.0128	-0.0128	-0.0173
	(0.0571)	(0.0578)	(0.0579)	(0.0259)	(0.0259)	(0.0263)
foreign firm	-0.249	-0.248	-0.156	0.0269	0.0290	0.0724
	(0.153)	(0.156)	(0.159)	(0.0676)	(0.0679)	(0.0705)
sales growth (t-1)		0.0720	0.0771		0.0184	0.00781
		(0.136)	(0.136)		(0.0604)	(0.0604)
R&D intensity (t-1)			-0.0377			0.0297
			(0.138)			(0.0620)
constant	0.561*	0.502	0.414	-0.275*	-0.305	-0.212
	(0.337)	(0.466)	(0.465)	(0.162)	(0.189)	(0.215)
industry dummy	yes	yes	yes	yes	yes	yes
observations	790	790	790	623	623	623
R-squared	0.017	0.017	0.027	0.020	0.020	0.030
F	3.410	2.324	3.105	3.185	2.563	2.692

Notes:
***p < 0.01; **p < 0.05; *p < 0.10. Standard errors in parentheses

Table 5a Determinants of the firm's decision to start online outsourcing
1st stage Probit:

	Online Outsourcing (0:1)	Online Outsourcing (0:1)	Online Outsourcing (0:1)	Online Outsourcing (0:1)
	(1)	(2)	(3)	(4)
service outs. levels(t)	-0.6875**	-0.6803**		
	(0.3243)	(0.3246)	0.4150**	0,4439***
material outs. levels(t)			(0.1725)	(0,1751)
employment size (t-1)	-0.0738	-0.0768	-0.0856*	-0,0878*
	(0.0519)	(0.0528)	(0.0522)	(0,0532)
foreign firm	-0.2709*	-0.2190	-0.4008***	-0,3526**
	(0.1440)	(0.1475)	(0.1449)	(0,1486)
sales growth (t-1)		0.1668		0,1942
		(0.1193)		(0,1201)
R&D intensity (t-1)		0.1619		0,1656
		(0.1218)		(0,1221)
industry dummy	yes	yes	yes	yes
constant	-0.7004	-1.2620	-0.9443	-1.5781
	(0.2867)	(0.4075)	(0.3143)	(0.4349)
Number of obs	790	790	790	790
LR chi2(6)	23.09	27.00	24.04	28.75
Prob > chi2	0.0001	0.0001	0.0001	0.0001
Pseudo R2	0.0387	0.0453	0.0403	0.0482

Table 5b Effect of starting online outsourcing on change in foreign outsourcing share
2nd stage Propensity Score Matching (Average Δ: DID):

Online Services Outsourcing:	**Mean % change:**	**# firms**	**std. error**	**t**
Treatment (firms starting online services outsourcing)	+70%	99	0.281	1.707
Control (firms with no online services outsourcing)	+22%	684		
Overall Effect for Online Services Outsourcing:	+48%*			

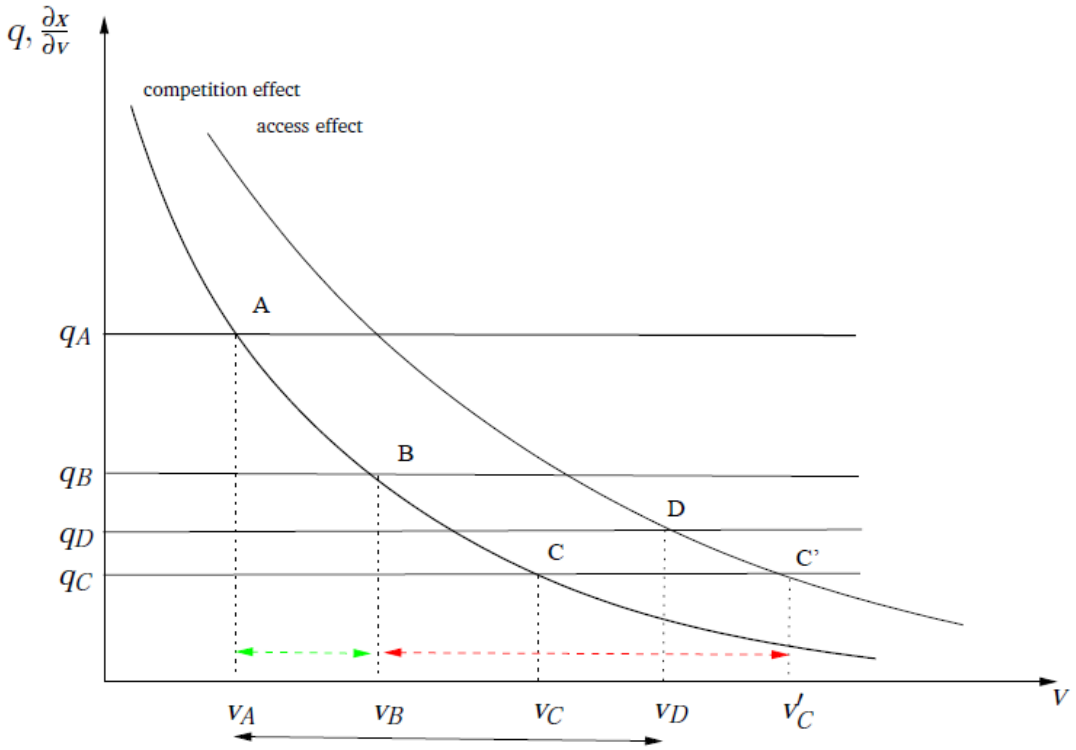
Online Materials Outsourcing:	**Mean % change:**	**# firms**	**std. error**	**t**
Treatment (firms starting online materials outsourcing)	22%	99	0.215	1.040
Control (firms with no online materials outsourcing)	-1%	685		
Overall Effect for Online Materials Outsourcing:	22%			

Notes:

***Significant at 1 percent level. Stata 'attk' kernel based matching . Balancing tests (Appendix 2) passed. Matching with common support
Number of repetitions for bootstrap = 50. Propensity score matching carried out using estimates from Selection Equations (2) and (4) for international services and materials outsourced respectively

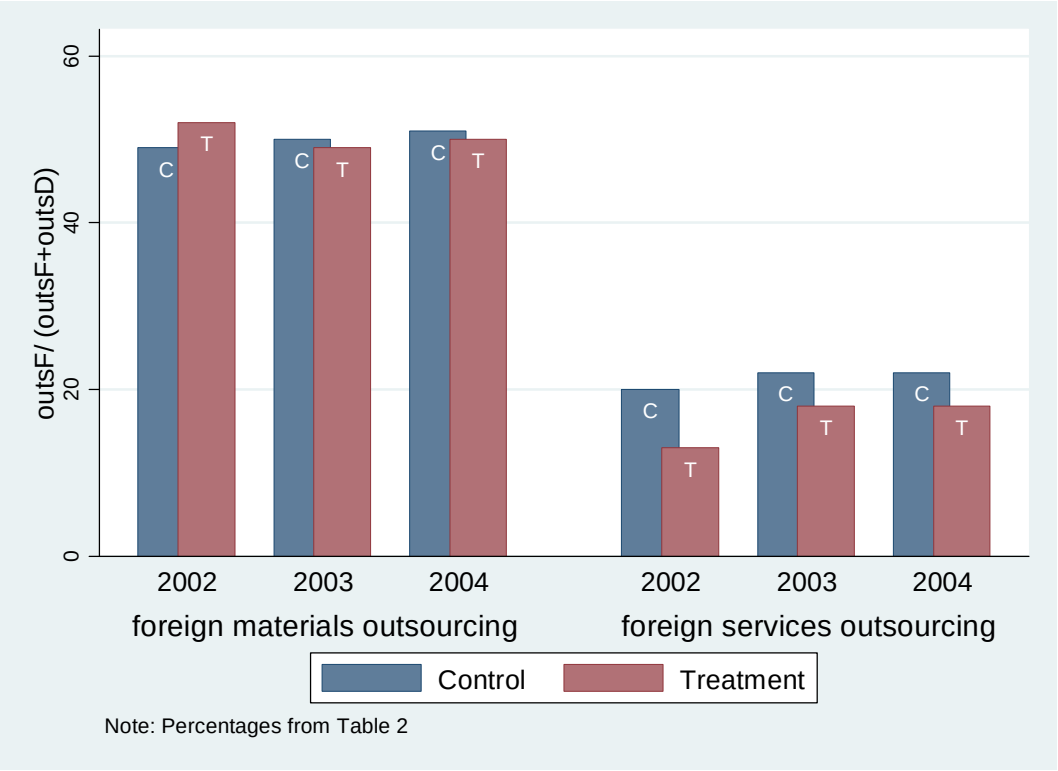
Figures

Figure 1: Effects of the internet on demand of foreign outsourced services



Notes:
competition effect: $\overline{v_A v_C}$ (non-switchers, $\overline{v_A v_B}$, switchers, $\overline{v_B v_C}$); access effect: $\overline{v_C v_D}$ (only switchers); green: non-switchers; red: switchers; total effect: black arrowd line

Figure 2: Proportion of Foreign Inputs to Total Outsourced Inputs



Note: Percentages from Table 2

Appendix 1: Description of variables used

Variable labels	**Variable description**
emp_dum2002	dummy for large firm (t-1): has at least 30 employees
employ2002	employment size (t-1)
exports_hi~2002	dummy for higher exports (t-1): exports exceed median
manuf	manufacturing firm
mat_os_gth2003	foreign materials growth (t+1)
owner	foreign owned firm (t-1)
rd_high_int2002	high R&D intensity (t-1): R&D intensity exceeds median
sales_high~2002	high growth firm (t-1): sales growth exceeds median
serv_os_gth2003	foreign services growth (t+1)
switcher2003	online procurement begins (t)

Appendix 2: Balancing t-tests for propensity score

	online procurement begins (t)		
Distribution of treated and controls across blocks	control	treatment	t-test for difference in propensity score
Total	691	99	
Of which:	# (average propensity score)	# (average propensity score)	Test statistic (p-value)
Block 1	617 (0.107)	68 (0.120)	-2.3075 (0.0213)
Block 2	74 (0.234)	31 (0.247)	-1.6217 (0.108)
Variables serv_os2002, employ2002, sales_high_growth2002, rd_high_int2002, owner and manuf balanced for blocks 1 and 2			

Appendix 3: Derivation of the FOC (3) and the risk premium ψ

The following argumentation is based on Sandmo (1971) and Leland (1972). Due to uncertainty, the FOC of (1) with respect to the foreign outsourced input arises as

$$\frac{\partial E^*}{\partial v_f} = E^*\left[\frac{\partial Z}{\partial \Pi}\cdot\frac{\partial \Pi}{\partial v_f}\right] = E^*[Z'\cdot\Pi'] \tag{5}$$

where both Z' and Π' are random. Applied to (1) and utilizing the law of displacement, the underlying covariance (Z',Π') is defined as

$$cov(Z',\Pi') \equiv E[Z'\cdot\Pi'] - E[Z']\cdot E[\Pi'] \quad \Rightarrow \quad E[Z'\cdot\Pi'] = cov(Z',\Pi') + E[Z']\cdot E[\Pi'] \tag{6}$$

The profit function is given from (1) and its first derivative w.r.t. q_f as well as the covariance result as

$$\Pi' = \frac{\partial X}{\partial v_f} - q_f \quad \text{(given p=1)} \tag{7}$$

$$cov(Z',\Pi') = cov(Z',\frac{\partial X}{\partial v_f} - q_f) = cov(Z',-q_f) = -cov(Z',q_f) \tag{8}$$

Utilizing these relationships, (5) may be rewritten as

$$\frac{\partial E^*}{\partial v_f} = E^*[Z']\cdot E^*[\Pi'] - cov(Z',q_f) \overset{!}{=} 0 \tag{9}$$

Define the risk premium as

$$\psi \equiv \frac{cov(Z',q_f)}{E^*[Z']} \tag{10}$$

and divide (9) by $E*[Z']$, the FOC (3) results.

Interpretation: If there is factor price uncertainty, the expected utility out of profit is maximized if the marginal value of the factor equals its expected factor price plus an individual risk premium (that, e.g., might differ for the firms). If we assume risk neutral firms ($\psi = 0$), an optimum results if the marginal value of the foreign outsourced input equals its expected factor price. If we assume risk aversion ($\psi > 0$, which is reasonable, e.g., in case of small firms), the marginal value of the foreign outsourced input must also 'pay off' for the risk premium. This dampens demand for the foreign outsourced input.