

# Greasing the wheels of international commerce: how services facilitate firms' international sourcing

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*Abstract.* We use plant-level data to study the link between the local availability of services and the decision of manufacturing firms to source materials from abroad. We develop a model to generate predictions about how the intensity of international sourcing of materials depends on the availability of services and firm characteristics. These predictions are supported by the data. Greater availability of services across regions, industries, and time increases firms' foreign sourcing of materials relative to sales. The impact of services differs by firm type. National firms' sourcing responds to changes in regional service conditions, whereas multinationals tend to be less affected. JEL classification: F12, L23

*Lubrifier les rouages du commerce international: comment les services facilitent l'approvisionnement international.* À l'aide de données au niveau des établissements, on étudie le lien entre la disponibilité locale de services et la décision des entreprises manufacturières de s'approvisionner en biens à l'étranger. On développe un modèle pour engendrer des prédictions quant à savoir jusqu'à quel point l'intensité de l'approvisionnement en biens à l'étranger dépend de la disponibilité des services et des caractéristiques de l'entreprise. Ces prédictions sont supportées par les données. Une plus grande disponibilité de services à travers les régions, les industries et le temps accroît l'approvisionnement en biens à l'étranger des entreprises en pourcentage des ventes. L'impact des services diffère selon le type de firme. L'approvisionnement à l'étranger des entreprises domestiques répond

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aux variations régionales dans les conditions de service, alors que les entreprises plurinationales tendent à être moins affectées.

## **1. Introduction**

International sourcing plays a very important role in global production. As a matter of fact, the growth in intermediate-goods trade is often referred to as a factor that distinguishes the current wave of globalization from previous ones.<sup>1</sup> Just consider the many sources of inputs for an iPod, sold by the U.S. company Apple. Dedrick, Kraemer, and Linden (2010) show that the hard drive is produced by the Japanese company Toshiba using affiliates based in China. The display module and display driver are produced in Japan, while some smaller inputs are supplied from Korea. The final assembly is carried out by a Taiwanese company in a plant in China. Furthermore, U.S. suppliers provide the video/multimedia processor as well as the portal player CPU.

Firms' international sourcing (also referred to as offshoring) decisions and their implications have been the subject of much recent theoretical and empirical analysis.<sup>2</sup> This is not surprising in light of public concerns about the impact of offshoring on domestic wages and especially on low-skilled labour employment. This concern, in part, also feeds the need to better understand what drives offshoring, which inevitably is linked to studying the different forms in which firms are organizing their production globally.

In this paper, we investigate an aspect of offshoring that, so far, has received little attention in the economics literature. We study the role that services play in organizing and optimizing manufacturing firms' sourcing processes.<sup>3</sup> With an increasingly important service sector worldwide and with growing research on services, this lack of attention is somewhat surprising. There are, however, a few notable exceptions. Francois (1990), Deardorff (2001), Jones and Kierzkowski (1990), as well as Golub, Jones, and Kierzkowski (2001) were among the first to emphasize how the increased availability of more differentiated or more affordable services can trigger international fragmentation of production. In particular, services can make it easier for firms in non-service sectors, irrespective of whether they are multinationals or not, to exploit the international division of labour and to split production into parts that can be made in different locations. Also the literature on multinational corporations has, to some extent, highlighted the link between services and offshoring in that multinationals' headquarter services help

1 See, for instance, Hummels, Ishii, and Yi (2001). Yi (2003) has hypothesized that the increased fragmentation of production and the resulting trade in intermediates is a key factor behind the growth of international trade.

2 See Helpman (2006) for a recent survey of the literature.

3 Our focus is primarily on the demand for producer services and how it relates to the production side of the economy. Note that there is an older literature that analyzes the demand for consumer services in an open economy. Much of that literature relates to the Balassa-Samuels effect and the 'Baumol disease.' See Francois and Hoekman (2010).

rationalize multinationals' sourcing decisions (See Helpman 2006; Antras and Helpman 2004). At this point, however, there is little empirical evidence to link manufacturing firms' sourcing decisions to services beyond the general observation that any reduction in service-related costs will, just like any reduction in transportation costs, increase trade.

While the link between services and international sourcing has not received much attention in the economics literature, the business literature, for some time now, has emphasized the importance of services for organizing a firm's production. Supply-chain management, in particular, sees the challenge exactly in coordinating and integrating an increasingly sliced-up-value chain (See Gachon and Terwiesch 2009; Corbett 2004). Offshoring and outsourcing have matured, it is often argued, and the main question is no longer whether or not a well-defined intermediate input should be produced by an affiliate or stand-alone firm abroad or at home. Rather, the current focus is on managing and integrating the whole process of production across its different stages from the purchase of raw materials to the distribution to the customer. It is in this process that service firms, and in particular those providing business and computing services, have a vital role to play.

Consider, for example, a car producer with an extended supply chain of hundreds of suppliers. These suppliers send their parts at different times, through different channels and in different packages to the car manufacturer. Not only is it important that the parts eventually reach the car producer, but there is ample room to optimize this process. The time and arrival of parts have to be coordinated, damage and losses have to be minimized, international customs paperwork has to be taken care of for the pieces coming from abroad, and parts have to be warehoused before being shipped to the manufacturer. There are ample opportunities for third-party service providers to get involved in this process.<sup>4</sup> Moreover, many service firms have extended their operations into the IT sphere and become increasingly more involved in the manufacturer's operations; they can set up a tracking system where companies can see in real time where their supplies are and make suggestions for the optimal bunching of suppliers.

To study the link between the availability of services and firms' sourcing of intermediate manufacturing goods, we use the rich, but tractable, monopolistic competition setting of Melitz and Ottaviano (2008) that introduces heterogeneity through differences in firm productivity while allowing for variable markups. Subsequently, we test the predictions of the model with firm-level data. Exploiting the variation in service availability across regions, time, and industry, we show how the increased availability of services raises the ratio of imported intermediates to sales, which confirms the general intuition that services should grease the

4 The business literature sometimes refers to third-party service providers as third-party logistics firms. There are ample case studies of such third-party logistics firms, including UPS (<http://www.ups-scs.com/solutions>) in the United States, and Accenture in Ireland ('Guide to strategic outsourcing in Ireland,' <http://www.accenture.com/xdoc/ir/locations/ireland/insights/guide.pdf>).

wheels of international commerce. More important, however, we find that the impact of more services differs by firm type. National firms' sourcing, in particular, responds to changes in regional service conditions, whereas multinationals tend to be less affected. This result confirms our prediction that the specific way in which services are provided matters. It makes a difference whether services are provided locally by a third party or whether they are provided in-house or attracted from abroad. Our findings thus bring together the earlier hypotheses by Dearnorff (2001), Jones and Kierzkowski (2001), and others on the impact of services on offshoring and the theory of the multinational. Indeed, multinationals by definition internalize some company-wide services through their headquarter services, and affiliates of multinationals can easily draw on these services from afar. It can thus be argued that the reason why we find that multinationals are less affected by local service conditions is exactly that they are large and productive enough to incur the fixed cost of setting up their own company-wide service operation or to draw on foreign services, which shields them somewhat from local service conditions.

To investigate the empirical relevance of our predictions about the sourcing behaviour of firms, we use an unbalanced panel of Irish plants from the *Annual Business Survey of Economic Impact* that runs from 2000 to 2004. The data set is quite unique in that it documents the sourcing behaviour in great detail, explicitly distinguishing between materials and services as well as between domestic and international sources. Note that for Irish firms domestic and international sourcing are just a fact of life: In our sample, around 90% of manufacturers source some foreign-produced materials and virtually all manufacturing firms (94%) source materials in the Irish economy, which is why we focus on how much is offshored, rather than whether there is any offshoring occurring at all.<sup>5</sup>

As far as services go, the *Survey* focuses on business and computing services, which are directly relevant for our study. In the empirical analysis, we exploit a particular feature of the data to get at the impact of services on the extent of material imports of firms. The *Survey* indicates whether a plant is located in one of three of Ireland's relatively different regions: the capital Dublin, the South, and the rest of the country. In our analysis we investigate how variations in the availability of services across regions, time and/or industry affect the international sourcing intensity of Irish plants, specifically the ratio of off-shored inputs to sales. We rationalize this focus on the local availability of service with the distinguishing characteristics of services: As Oldenski (2010) documents, services are much more dependent on face-to-face contact than manufacturing. Our

5 Görg, Hanley, and Strobl (2008) show, using similar firm-level data, that the level of international sourcing has positive effects on firm productivity. Examining how much firms offshore rather than whether they offshore or not is one way in which our analysis differs from Antras and Helpman (2004). A second difference is that we do not deal with the question of whether the production of materials is done in-house or by independent suppliers. Rather, we focus on the question of how firms procure the services needed for importing materials.

empirical analysis utilizes various estimation strategies to establish the robustness of our results: pooled data, fixed effects, and instrumental variables estimation.

Ireland is singularly fit for studying the questions that we are investigating. First, it is a small open economy with a trade to GDP ratio of over 80% that is widely regarded as a very well-positioned entry point into the European market. Ireland has attracted multiple well-known multinational corporations in electronics, pharmaceuticals, and medical appliances and more recently in services, some of which have chosen it as a base for offshoring.<sup>6</sup> Moreover, in terms of services and service trade Ireland has clearly excelled. In spite of its size, Ireland was, according to the OECD (2009), in absolute terms about the world's ninth largest exporter of services in 2007. Second, Ireland wants to promote itself increasingly as an area that is especially well suited for supply chain management. As a matter of fact, the Irish Development Agency (IDA), which tries to promote Ireland's image abroad, explicitly links Ireland with supply chain management in its publications.<sup>7</sup> Moreover, the Irish success story has been built to a large extent on sectors that should be especially conducive to supporting offshoring in goods: Ireland has an impressive IT sector, and has increasingly been able to attract financial, insurance, R&D and headquarter services.

The rest of the paper is structured as follows. In the next section, we lay out the model. Comparative static effects are derived in section 3. In section 4, we present the empirical model, and in section 5 we describe the data set. The results of our estimation are reported in section 6 and section 7 concludes. A technical appendix, available at the CJE online archive at [cje.economics.ca](http://cje.economics.ca), contains formal proofs and additional robustness checks.

## 2. The model

In this section, we develop a stylized model in which we integrate the material-input sourcing decision into the Melitz/Ottaviano (2008) model of monopolistic competition and firm heterogeneity.<sup>8</sup> To some extent, we tailor the setup to the data that we have available to test the predictions of the model.

There is a continuum of manufacturing firms selling their finished products in the domestic (Irish or European) market. From the consumers' point of view, these products are differentiated varieties. We index firms by  $i \in \Omega$ , and assume

6 A good reference on the service discussion in Ireland is *Catching the Wave. A service Strategy for Ireland, Report of the Service Strategy Group, 2008*; [http://www.forfas.ie/publications/forfas080912/forfas080912\\_services\\_strategy.pdf](http://www.forfas.ie/publications/forfas080912/forfas080912_services_strategy.pdf)

7 For a discussion of supply chain management in Ireland, see Sweeney et al. (2008).

8 The model builds also on Raff and Schmitt (2012), who study sourcing decisions of retail firms, and on Bas (2009), who studies the effect of trade barriers in input and final goods markets on production and exporting decisions.

that all consumers share the same quasi-linear utility function:

$$U = \alpha \int_{i \in \Omega} q_i^c di - \frac{1}{2} \beta \int_{i \in \Omega} (q_i^c)^2 di - \frac{1}{2} \gamma \left( \int_{i \in \Omega} q_i^c di \right)^2 + y, \quad (1)$$

where  $q_i^c$  denotes the quantity per capita bought from firm  $i$ , and  $y$  the consumption of the numeraire good. Parameter  $\beta$  describes the degree of substitutability within the set of different varieties of manufactures,  $\Omega$ .

Assuming that the demand for the numeraire is positive, and denoting by  $L$  the number of consumers and by  $N$  the mass of active firms, the market demand faced by firm  $i$  can be expressed as a function of the firm's own price,  $p_i$ , and the average price in the market,  $\bar{p}$ :

$$q_i(p_i) \equiv Lq_i^c = \frac{\alpha L}{\gamma N + \beta} - \frac{L}{\beta} p_i + \frac{\gamma N}{\gamma N + \beta} \frac{L}{\beta} \bar{p}. \quad (2)$$

Firms are monopolistically competitive. That is, they take  $N$  and  $\bar{p}$  as given when deciding on prices. In what follows, we will drop firm subscripts whenever possible.

Labour, the only factor of production, is inelastically supplied and perfectly mobile across sectors. Since the numeraire good is produced by a competitive industry under constant returns and a unit labour requirement of one, the price of labour in the economy is equal to one. All costs can therefore be expressed in terms of labour requirements.

Since we are particularly interested in firms' sourcing decisions, we assume that finished goods are produced using labour ( $l$ ) and a composite material input ( $x$ ) according to the Leontief technology  $q = \min \{l/c, x\}$ , where  $1/c$  represents labour productivity.<sup>9</sup> The composite material input ( $x$ ) combines domestic materials ( $z$ ) and imported materials ( $m$ ) according to the CES production function  $x = (z^\phi + m^\phi)^{\frac{1}{\phi}}$ , where  $0 < \phi < 1$ . Domestic and imported materials are hence imperfect substitutes, with an elasticity of substitution equal to  $\theta = 1/(1 - \phi)$ . For simplicity we assume that both  $z$  and  $m$  are produced using one unit of labour per unit of output, which is tantamount to having prices of  $z$  and  $m$  equal to one.

Firms first decide whether to enter the market and thus whether to incur the sunk cost  $F_E$ . Upon entering, each firm learns its labour productivity  $1/c$ . We assume that  $1/c$  follows a Pareto distribution, so that the cumulative distribution of the marginal labour cost is  $G(c) = (c/c_M)^k$ , with  $k \geq 1$  and support on  $[0, c_M]$ .

Then follows the decision on what price to charge and how to procure materials. Sourcing materials from abroad requires services of the type described in the introduction. We distinguish two ways in which these services can be provided.

9 The assumption that labour and materials are complements is made for analytical convenience. Our results would go through even if labour and materials were substitutes, provided that the elasticity of substitution is not too big.

Firms can either buy services from local service providers or they can instead choose to provide these services themselves or buy them from abroad. When a firm takes the first option and buys services from local service providers, we refer to these firms as mode- $D$  firms. In this case, we assume that the margin paid to local service firms is  $\delta - 1$  per unit of imported materials with  $\delta > 1$ . Since imported materials trade at a price of unity, the gross price of imported materials in mode- $D$  (including the service margin) is  $\delta$ . In the empirical section, we will take mode- $D$  firms as the benchmark case against which we will evaluate mode- $I$  firms, that is, firms that provide services internally or import them from abroad. We will use a measure of local services availability to proxy for the service margin  $\delta - 1$ . The idea is that a greater availability of local services leads to lower service prices and greater service variety, which implicitly reduces the cost of using local service providers.<sup>10</sup>

A firm that chooses mode  $I$  incurs a fixed cost,  $F_I$ , associated with operating an own service department, or with identifying and communicating with foreign service providers. Incurring this fixed cost, however, means that the margin on service purchases is reduced below  $\delta - 1$ ; for simplicity, we normalize this margin to zero, so that imported materials in mode  $I$  carry a gross unit price of one. Mode  $D$  is hence associated with a higher variable cost than mode  $I$ . A trade-off occurs in the choice of mode because mode  $I$  involves a fixed cost.

Cost minimization by a manufacturer implies the following conditional demands for imported materials depending on the sourcing mode:

$$m^D(q) = \delta^{\frac{1}{\phi-1}} \left( 1 + \delta^{\frac{\phi}{\phi-1}} \right)^{-\frac{1}{\phi}} q \quad (3)$$

$$m^I(q) = (2)^{-\frac{1}{\phi}} q. \quad (4)$$

The total cost of materials is hence given by

$$C^D(q) = \Delta_D q \quad (5)$$

$$C^I(q) = \Delta_I q + F_I, \quad (6)$$

where  $\Delta_D \equiv (1 + \delta^{\frac{\phi}{\phi-1}})^{\frac{\phi-1}{\phi}}$  and  $\Delta_I \equiv (2)^{\frac{\phi-1}{\phi}}$  represent the variable costs of materials under the two modes, and  $\Delta_D > \Delta_I$ .

A firm that uses mode  $j = D, I$  then sets its price to maximize  $(p - c)q(p) - C^j(q)$ . Defining  $c_D \equiv \frac{\beta\alpha + \gamma N \bar{p}}{\gamma N + \beta} - \Delta_D$ , we can use (2) to show that the price elasticity

10 The motivation for choosing firms that use services locally as a benchmark is entirely pragmatic. It is much harder to observe and measure internally provided services, as well as measure the complete set of internationally available services.

of demand is given by

$$\eta \equiv -\frac{dq(p)}{dp} \frac{p}{q} = \frac{p}{c_D + \Delta_D - p}. \quad (7)$$

The profit-maximizing price of a firm with marginal labour cost  $c$  choosing mode  $D$ , respectively  $I$ , is hence given by

$$p^D(c) = \Delta_D + \frac{1}{2}(c_D + c) \quad (8)$$

$$p^I(c) = \frac{1}{2}(c_D + c + \Delta_D + \Delta_I). \quad (9)$$

The corresponding maximized profits are

$$\pi^D(c) = \frac{L}{4\beta}(c_D - c)^2 - F_E \quad (10)$$

$$\pi^I(c) = \frac{L}{4\beta}(c_D - c + \Delta_D - \Delta_I)^2 - F_E - F_I. \quad (11)$$

Since the entry cost is sunk, only firms able to cover their marginal labour and material costs and, in case of mode  $I$ , the fixed cost  $F_I$  are active in the market. (10) indicates that the critical value of the marginal labour cost at which a firm that has chosen mode  $D$  earns zero operating profit and hence is indifferent between being active and becoming inactive is  $c_D$ . A firm that has chosen mode  $I$  has a lower marginal cost of materials than a mode- $D$  firm, as  $\Delta_D > \Delta_I$ . A comparison of (10) and (11) confirms that mode  $I$  yields a higher variable profit than mode  $D$ , but also requires an additional fixed outlay of  $F_I$ . Mode  $I$  is hence only attractive to firms whose output, and hence variable profit, is sufficiently big to allow them to offset  $F_I$ . These are the firms that have drawn a sufficiently high labour productivity,  $1/c$ . By equating  $\pi^D(c)$  and  $\pi^I(c)$ , we can derive the critical value of the marginal labour cost, denoted by  $c_I$ , at which a firm is indifferent between modes  $D$  and  $I$ :

$$c_I = c_D + \frac{(\Delta_D - \Delta_I)}{2} - \frac{2\beta F_I}{L(\Delta_D - \Delta_I)}. \quad (12)$$

In order to make sure that not all entrants prefer mode  $I$  to mode  $D$  we have to assume that  $F_I$  is sufficiently large. On the other hand, we do not want  $F_I$  to be too large so that not even the most efficient firm (with  $c = 0$ ) would choose mode

I. Hence, we assume

$$\frac{L}{4\beta} (\Delta_D - \Delta_I)^2 < F_I < \frac{L}{4\beta} ((\Delta_D - \Delta_I)^2 + 2c_D(\Delta_D - \Delta_I)). \quad (13)$$

This assumption, together with the quadratic form of the profit functions, ensures that the value of  $c_I$  solving (12) is unique and lies strictly between zero and  $c_D$ . The two cut-off values of the marginal cost,  $c_D$  and  $c_I$ , thus define three categories of firms. Firms whose labour productivity is sufficiently high ( $c \leq c_I$ ) choose mode  $I$ ; firms whose labour productivity is in the middle range ( $c_I < c \leq c_D$ ) opt for mode  $D$ ; and firms with very low labour productivity ( $c > c_D$ ) are inactive because they are not able to cover their marginal costs. Note that this classification of firms is quite intuitive. Stylized facts confirm, for example, that larger firms, such as multinationals, tend to be more productive firms. At the same time, they are more likely to provide company-wide internal services, and they are also known to import more services.

Finally, in equilibrium the mass of entrants has to be large enough so that the expected profit of a firm at the entry stage is equal to zero:

$$\int_0^{c_I} \pi^I(c) dG(c) + \int_{c_I}^{c_D} \pi^D(c) dG(c) + \int_{c_D}^{c_M} (-F_E) dG(c) = 0. \quad (14)$$

In the next section we explore the equilibrium of the model, focusing on those comparative static effects that allow us to formulate testable hypotheses.

### 3. Comparative statics

We are interested in understanding the variation in international sourcing across firms and, in particular, in figuring out how this variation is related to differences in local services availability (and thus the size of local service margins) and to firm characteristics. The variables that we observe at the firm level include the spending by a firm on domestic materials ( $z$ ), the spending on imported materials ( $m$ ), the value of the firm's sales ( $pq$ ), and the status of a firm as either a multinational or a national firm. We can thus investigate directly how, in equilibrium, the ratio of imported materials to sales ( $m/(pq)$ ) changes with  $\delta$  as well as with the firm's labour productivity,  $1/c$ . In the empirical implementation we will proxy for mode- $D$  firms with domestic firms and, by construction, equate mode- $I$  firms with multinationals, which is why we also want to investigate how the imported materials ratio varies by mode. A formal proof of the results is relegated to the technical appendix.

Consider first the effect of a marginal change in  $\delta$ . A mode- $D$  firm's ratio of imported materials to sales can be computed using (3) and (8):

$$\frac{m^D}{p^D q^D} = \frac{\delta^{\frac{1}{\phi-1}} (1 + \delta^{\frac{\phi}{\phi-1}})^{-\frac{1}{\phi}}}{\Delta_D + \frac{1}{2}(c_D + c)}. \quad (15)$$

The numerator of (15) corresponds to  $m^D/q^D$ , and it is easily verified that  $d(m^D/q^D)/d\delta < 0$ , as an increase in  $\delta$  leads to a substitution of domestic materials,  $z$ , for imported materials,  $m$ . The denominator of (15) represents  $p^D$ . A marginal increase in  $\delta$  raises  $p^D$  in two ways, namely, by raising the marginal cost of materials,  $\Delta_D$ , and by lowering the price elasticity of demand,  $\eta$ . The effect on  $\eta$  works through changes in  $c_D$  and  $\Delta_D$ , as can be seen in (7). First, a higher  $\delta$  implies a lower  $c_D$ , which boosts  $\eta$ . The reason why an increase in  $\delta$  decreases  $c_D$  is that it lowers the profits of mode- $D$  firms, thus forcing the least efficient mode- $D$  firms to become inactive. Second, a rise in  $\delta$  increases  $\Delta_D$ , which reduces  $\eta$ . This second effect dominates the first, so that  $d\eta/d\delta < 0$ .

As  $dp^D/d\delta > 0$  and  $d(m^D/q^D)/d\delta < 0$ , we have  $d(m^D/(p^D q^D))/d\delta < 0$ . Thus, a marginal increase in the cost of local services reduces material imports of mode- $D$  firms relative to their sales. We now compare this outcome with the effect of a marginal increase in the cost of local services on the material imports of mode- $I$  firms.

In the case of mode- $I$  firms, we can use (4) and (9) to obtain

$$\frac{m^I}{p^I q^I} = \frac{(2)^{-\frac{1}{\phi}}}{\frac{1}{2}(c_D + c + \Delta_D + \Delta_I)}. \quad (16)$$

Obviously, the numerator,  $m^I/q^I$ , does not depend on  $\delta$ . But a rise in  $\delta$  affects mode- $I$  firms indirectly, since, as shown above, it decreases the price elasticity of demand,  $\eta$ , and thus induces them to raise  $p^I$ . As a result,  $d(m^I/(p^I q^I))/d\delta < 0$ , so that a marginal increase in the cost of local services also implies a smaller ratio of imported materials to sales for mode- $I$  firms. Mode- $I$  firms should, of course, be less affected by changes in  $\delta$  than mode- $D$  firms, because their cost of material imports is independent of  $\delta$ , and because the price response of mode- $I$  firms is smaller:  $dp^I/d\delta < dp^D/d\delta$ . After all, mode- $I$  firms raise prices only in reaction to the decrease in the demand elasticity, whereas mode- $D$  firms also raise prices because they experience an increase in the marginal cost of imported materials. A sufficient condition for  $m^I/(p^I q^I)$  to react less to a change in  $\delta$  than  $m^D/(p^D q^D)$  is for  $\delta$  to be sufficiently close to 1. For reference, with CES preferences, as, for example, in Antras and Helpman (2004), prices and outputs of mode- $I$  firms would be a constant mark-up over their own marginal cost and hence would not react to changes in  $\delta$  at all. In sum, we expect both types of firm to be affected by changes in  $\delta$ , but mode- $D$  firms more so than mode- $I$  firms. This is a prediction we can test empirically.

Next, consider how the ratio of imported materials to sales depends on labour productivity,  $1/c$ . Since  $m^I/q^I > m^D/q^D$  and  $p^I < p^D$ , it has to be the case that  $m^I/(p^I q^I) > m^D/(p^D q^D)$ . Given that mode-*I* firms have strictly greater labour productivity than mode-*D* firms, it follows directly that firms with a higher labour productivity import more materials relative to sales than firms with low labour productivity, which we can check empirically. This prediction can be refined still further, since, even within each mode, firms with lower labour productivity (higher  $c$ ) will set higher prices than more productive firms; that is,  $d(m^D/(p^D q^D))/dc < 0$  and  $d(m^I/(p^I q^I))/dc < 0$ . Hence, the ratio of material imports to sales unambiguously rises with the firm's labour productivity, which we can also investigate in our empirical analysis.

Lastly, notice that a change in  $\delta$  affects  $c_I$ . In particular, a fall in the cost of locally provided services raises  $c_I$  and hence induces some mode-*I* firms to switch to mode *D*. This also implies that mode-*I* firms will have a greater labour productivity premium over mode-*D* firms the lower is the cost of local services.

#### 4. Empirical model

We now turn to the empirical investigation. As pointed out in the previous section, we do not directly observe the cost of services,  $\delta$ , in our data. Instead, we use a measure of the availability of local services as a proxy. The reasoning for this proxy is that a greater availability of locally available services implies lower prices and greater service variety, which implicitly reduces the cost of using local service providers.

The aim is to investigate how the international sourcing of firms is influenced by the availability of services and firm productivity. To do so we estimate variants of the following empirical model based on the theoretical ideas developed in the previous sections:

$$\ln(m/(pq))_{it} = \ln(\text{services})_{jrt}\beta_1 + LP_{it}\beta_2 + X_{it}\beta_3 + d_t + d_j + d_r + \epsilon_{it},$$

where  $m/(pq)$  is the ratio of imported materials over sales for manufacturing plant  $i$  at time  $t$ , and  $\text{services}$  is a vector of variables capturing the availability of services in industry  $j$  and region  $r$  in which plant  $i$  operates.<sup>11</sup>  $LP$  is labour productivity (calculated as total wage bill per employee).<sup>12</sup>  $X$  is a vector of control variables to account for heterogeneity at the plant, industry, and regional levels. We also include a full set of time, 3-digit industry and region dummies ( $d_t$ ,  $d_j$ ,  $d_r$ , respectively), while  $\epsilon_{it}$  denotes the final error term.

11 In order to avoid taking the log of zero, the variable is calculated as  $\ln((m/pq) + 1)$ . The same goes for all other logged variables in the empirical model.

12 Unfortunately, we do not have capital stock or investment data, so we cannot estimate production functions to calculate total factor productivity.

We calculate for our baseline estimation the number of services firms located in region  $r$  at time  $t$  as the measure of the availability of local services. This is a proxy for the pool of service providers in the region in which plant  $i$  is located and to which it has easy access in the domestic economy. Note that this variable has no variation across the industry dimension for different  $is$ , as this represents the total availability of services for all firms in manufacturing industries. Hence, the implicit assumption is that all manufacturing firms in the region have access to, and use in the same intensity, the same pool of services providers.

In order to show that the lack of variation along the industry dimension does not pose a problem for our econometric analysis, we also calculate an alternative measure that varies across industries, based on input-output linkages between manufacturing and services sectors. Utilizing plant-level information on the location and 2-digit sector of services firms we are able to calculate for each region  $r$  the number of services firms in service sector  $s$ ,  $n_s$ . From the Irish input-output table for 2000, we use the input coefficients  $a_{js}$ , which give us the amount of inputs from service sector  $s$  used in manufacturing industry  $j$  as percentage of output of industry  $j$ .

Our alternative measure is then calculated as an ‘effective services availability,’

$$effective\_services_{jrt} = \left( \sum_s a_{js} * n_{st} \right) / n_{mt}.$$

We scale this variable using the number of manufacturing firms in region  $r$ ,  $n_m$ .<sup>13</sup>

In the baseline model, we include a number of control variables at the firm level in order to be able to properly identify the effect of services availability on material imports. We control for plant size (measured in terms of employment) as well as dummy variables for exporters, foreign multinationals, and domestic multinationals in our sample. These variables control for aspects of plant-level heterogeneity that have been highlighted in the recent theoretical and empirical literature.<sup>14</sup> The information on multinationals, however, also allows us to link our analysis back to the theoretical model, which shows that there are differences in the importance of local services availability for mode- $I$  and - $D$  firms. In other words, the coefficient  $\beta_1$  is likely to differ for mode- $I$  and mode- $D$  firms. Multinationals are more likely to internalize service provision within their company structure. In addition, they are also the ones that most heavily rely on imported services. Therefore, multinationals are likely to be mode- $I$  firms, and we can

13 In the technical appendix we present some summary statistics on the variation of the effective availability measure within and across regions. We see that, as is true for the standard thickness measure, Dublin has the highest values and BMW the lowest. There is also substantial variation within regions, as indicated by the standard deviation.

14 In extensions to our baseline model below, we also include further observable region-, time-, and industry-varying covariates in addition to a battery of fixed effects in order to aid identification of the coefficients on the services measures and address endogeneity concerns.

compare their sourcing behaviour and its sensitivity to changes in the availability of local services with that of national firms.

Note that we also include a whole battery of dummies. Time dummies should capture the effect of time-varying factors, such as, for example, changing factor prices, on firms' sourcing behaviour. The inclusion of regional and industry dummies is essential to control for systematic differences in sourcing behaviour that are related to the different production processes in various industries or regions. In addition, these dummies allow us to address some concerns about endogeneity of services availability. For example, firms may decide to locate in regions in which there are many firms in order to benefit from agglomeration economies. This would potentially introduce a correlation between the services measures and the error term. In short panels such as ours, where the location of firms does not change over time, it is a reasonable assumption that we can proxy this unobserved part of the error term using time-invariant regional dummies. To be on the safe side, we also include a set of time-varying regional variables. A similar argument could be made for unobserved effects at the industry level. If certain industries use services heavily, and if this is not fully captured by our time-varying industry variables, then this may lead to an endogeneity problem. Since, in our data, no firm switches industries, this is captured using the industry dummies.

In the first instance, we estimate our baseline model using simple OLS, allowing the error term to be clustered at the regional level, as our key variable of interest varies only at the regional level. This estimation technique allows us to utilize both the cross-section as well as time variation in our data. However, as a downside, it does not control adequately for plant-specific time-invariant unobserved effects. In order to control for such effects, we also estimate the model using a fixed-effects estimator. This has the additional advantage that the plant fixed effect also allows us to control further for potential endogeneity problems in the empirical model. If there are common factors at the plant level that drive the left- as well as right-side variables in the model, these will be taken care of, as long as they are assumed to be time invariant. We also relax this assumption and estimate the model using an instrumental variables approach.

## 5. Description of the data

We use recent plant-level data from the Republic of Ireland. These data are collected by Forfás, the Irish policy and advisory board with responsibility for enterprise, trade, science, and technology. Specifically, our data source is the *Annual Business Survey of Economic Impact (ABSEI)*, covering the period 2000 until 2004. This is an annual survey of 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. The survey includes plants in manufacturing

as well as services. In terms of services, the focus is on internationally tradeable services; firms in other services industries are neglected.

In particular, the focus is on NACE sectors 72 (computing services) and 74 (business services). These non-financial services are directly relevant for our analysis. They include a wide range of professional business services, including management consultancy, market research, and technical services such as engineering, hardware and software consulting. In 2004, out of 538 service-sector firms in the total sample, roughly 82% were in NACE sectors 72 and 74.

The data set provides information at the plant level on materials and services purchases, distinguishing imported and domestically procured materials and services.<sup>15</sup> Further data available from this source that are relevant to the current paper are total sales, employment, exports, nationality of ownership, 3-digit sector of production, and region of location. Within Ireland, a relatively small country, three regions are distinguished: Greater Dublin (the capital), South West & South East, and Borders/Midlands/West (BMW). There is substantial heterogeneity in economic development across these three regions, with most of economic activity concentrated in Dublin; the South is also fairly well developed, while there is less manufacturing industry in the BMW region.

The information on nationality of ownership allows us to establish whether a plant is an affiliate of a foreign-owned multinational. This information is recorded as a binary variable indicating whether a plant is under majority ownership of a foreign owner or not. The recent literature has highlighted that identifying foreign multinationals is only one part of the picture. In order to have a complete idea about the importance of multinationals, domestic firms with affiliates abroad also need to be recognized. In 2000, Forfás, as part of the ABSEI survey, also asked firms whether they had affiliates abroad. We use this unique information and classify those domestic firms that have affiliates abroad as domestic multinationals.<sup>16</sup>

In 2004, our sample contains 1,206 manufacturing plants. Of these, 343 are affiliates of foreign multinationals, 108 are domestic multinationals, 557 are domestic exporters, and 198 are domestic without exports or foreign affiliates.

Table 1 describes the development of material imports over sales, and the main measure of local services availability, on aggregate over the time period covered in our sample. On average, Irish plants import intermediates worth about 20% of sales, and there are about 150 services providers in the average region. On aggregate, these figures have not changed much over the five-year period.

15 Unfortunately, however, we do not know what type of materials or service are purchased.

16 Girma, Görg, and Strobl (2004) use this data to investigate productivity differentials between domestic multinationals, exporters, and purely domestic firms. To the best of our knowledge, there are no other studies that have been able to identify domestic multinationals in Ireland in large micro-level data sets. In the technical appendix we report descriptive regressions, which show that there are productivity and size premia for exporters and multinationals, as would be expected from the firm-level heterogeneity literature. We also find that exporters and multinationals have higher material import ratios. This is consistent with our theoretical model, which predicts that this ratio should be higher for high-productivity establishments.

TABLE 1  
Development of (imported materials/sales) and service availability measure over time

Year	Imported materials/sales		Services firm availability	
	Mean	Std. dev.	Mean	Std. dev.
2000	0.212	0.147	135.23	1.71
2001	0.200	0.151	150.96	1.77
2002	0.188	0.149	163.20	1.73
2003	0.181	0.147	175.21	1.68
2004	0.190	0.146	149.16	1.64

NOTES: Services firm availability is defined as number of services firms in region  $r$  at time  $t$ .

TABLE 2  
Summary statistics across regions, 2004

Region	Dublin	South West & East	Borders/Midlands/West
Imported materials/sales	0.182 (0.172)	0.210 (0.178)	0.200 (0.169)
# of services firms	289	174	75
# of MNC services firms	72	64	20
# of domestic services firms	217	110	55
# of manufacturing firms	242	586	378
Services sales/total regional sales	0.458	0.116	0.078
Services employment/total regional employment	0.478	0.136	0.137

NOTES: Table reports means and standard deviations in parentheses. Imported materials/sales is defined as total value of imported materials over total value of sales.

However, the aggregate figures hide substantial heterogeneity across industries and plants, as indicated by the high standard deviation.

Table 2 provides some evidence on regional variations in our main variables of interest in 2004. While firms have on average imported material intensities of around 20%, there is variation across regions in this variable. In particular, the import share is lowest in the Dublin region, which is the region with the highest number of services firms. At the same time, it is the smallest region in terms of manufacturing firms. In order to investigate the link between imported materials and services at the firm level, it therefore appears necessary to control for such differences in regional characteristics.

Table 2 also illustrates the relative importance of services compared with manufacturing. In particular, in the Dublin region services firms slightly outnumber manufacturing firms. These services activities contribute to just under half of regional sales and employment. However, this is different in the two other regions. There are about three times as many manufacturing firms as services firms, and these services firms contribute to around 10% of sales and 13% of employment in both regions.

TABLE 3

Variation of (imported materials/sales) and service availability measure over sectors, year 2004

NACE description	Imported materials/sales		Services firm availability	
	Mean	Std. dev.	Mean	Std. dev.
Food & beverages	0.119	0.128	151.11	1.69
Tobacco	0.189	0.144	129.15	2.03
Textiles	0.264	0.134	128.38	1.71
Apparel	0.273	0.131	159.49	1.82
Leather	0.221	0.126	123.72	1.82
Wood products	0.152	0.140	115.12	1.65
Pulp & paper	0.226	0.163	199.94	1.68
Publishing & printing	0.143	0.135	222.29	1.69
Coke & petrol	0.232	0.071	75.19	1.09
Chemicals	0.238	0.142	184.56	1.64
Rubber & plastic	0.243	0.151	135.10	1.71
Non-metallic minerals	0.144	0.128	141.74	1.73
Basic metals	0.203	0.182	161.42	1.59
Fabricated metals	0.180	0.150	157.28	1.65
Machinery	0.208	0.145	149.90	1.67
Office machinery	0.230	0.184	170.89	1.78
Electrical machinery	0.230	0.162	157.43	1.73
Radio & communications	0.224	0.161	177.15	1.62
Medical & optical instruments	0.203	0.133	145.33	1.68
Vehicles	0.265	0.119	124.21	1.57
Other transport equipment	0.258	0.136	215.94	1.60
Other manufacturing	0.186	0.126	146.64	1.79

In table 3, we depict differences across industries. The first columns show means and standard deviations of the imported-materials-to-sales ratio by 2-digit industry for the year 2004. The means range from 12% (NACE 15—Food) to 27% (NACE 34—Transport Equipment). The subsequent columns also show summary statistics for the number of services firms in the region. Again, the statistics show differences across industries and firms. For these summary statistics there is a negative raw pairwise correlation between the ratio of imported materials to sales and the number of services firms. However, the correlation coefficients are not statistically significant. This suggests again that it is important to control for plant-level heterogeneity in order to uncover the relationship between material imports and services availability at the plant level.

## 6. Empirical results

We now turn to the estimation of our empirical model described in section 4. Table 4 provides results for our baseline model, where the availability of services is calculated using the simple measure of the number of services firms located in region  $r$  at time  $t$ . The specification also includes time, region and industry

TABLE 4  
 Baseline model for all firms  
 Dependent variable:  $\ln$  (imported materials/sales)

	(1) All	(2) All	(3) All	(4) Irish MNEs	(5) Foreign MNEs	(6) Domestic
Services firm availability	0.129 (0.022)**					
Foreign MNC services firm availability		0.043 (0.013)*	0.050 (0.012)*	0.221 (0.095)	0.043 (0.005)**	0.013 (0.022)
Domestic services firm availability		0.087 (0.009)**	0.084 (0.009)**	0.082 (0.041)	0.026 (0.009)	0.085 (0.010)**
Labour productivity	0.003 (0.005)	0.003 (0.005)	-0.018 (0.004)*	-0.017 (0.034)	-0.049 (0.014)*	-0.005 (0.007)
Dummy domestic MNC			0.020 (0.002)**			
Dummy foreign MNC			0.051 (0.006)**			
Dummy exporter			0.051 (0.009)**	0.179 (0.050)*	0.047 (0.038)	0.051 (0.006)**
Firm size			0.008 (0.003)	0.030 (0.016)	0.001 (0.007)	0.010 (0.005)
Observations	5478	5478	5478	466	1527	3485
R-squared	0.16	0.16	0.20	0.38	0.19	0.21

NOTES: Regressions with year, 3-digit industry, and region dummies. Robust standard errors, clustered around regions, are in parentheses. \* Significant at 10%; \*\* significant at 5%. Regressions include constant term. Services firm availability is defined as the number of services firms in region  $r$  at time  $t$ . Foreign MNC services firm availability and domestic services firm availability are defined as the number of foreign and domestic services firms in region  $r$  at time  $t$ , respectively.

dummies, and is estimated using OLS. Hence, this estimation approach allows us to use the variation across establishments and time to identify the effect of services availability on the ratio of material imports to sales. Column (1) presents the most basic version of the empirical model, including the measure of the availability of services firms in the same region as plant  $i$ . The results show that, when unobserved heterogeneity at the industry and region levels are controlled for, greater services availability is associated with a higher ratio of materials imports to sales by manufacturing establishments. This is in line with our theoretical model, whereby services are needed to facilitate the successful import of materials. While we also find a positive coefficient on labour productivity, as predicted by the model, this is statistically insignificant in the baseline specification.

One aspect we need to take into account is the empirical importance of multinationals also for the provision of services inputs. It could be the case that our results not so much reflect the importance of the domestic provision of services (by local firms) as they just pick up the importance of multinationals for linking up firms with suppliers abroad. Our data allow us to look into this in more detail. We calculate our service availability measures separately for domestic establishments and foreign multinationals and include these as separate regressors in the

model. The results, reported in column (2), indicate that the availability of domestic providers of services seems more important than the presence of foreign multinational service firms, judging by the size and statistical significance of the two coefficients.

The results in columns (3) to (6) allow us to dig deeper into plant-level heterogeneity. First, we control for establishment status by including dummies for foreign multinationals, Irish multinationals, and exporters. Furthermore, in columns (4) to (6) we run the regression separately for domestic multinationals, foreign multinationals, and domestic plants. These specifications also allow us to investigate whether the effect of services availability differs between mode-*I* and mode-*D* firms. As argued above, multinationals are more likely to internalize service provision within their company structure, and they rely most heavily on imported services. Therefore, multinationals are more likely to be mode-*I* firms, and national firms are likely to be mode-*D* firms.

What is especially noteworthy in the results is that the availability of local service providers matters only for purely domestic establishments. Irish or foreign multinationals, by contrast, are not affected by the presence of domestic services. This is consistent with the theoretical model, assuming that multinationals are more likely to be internalizers of services provision. Moreover, this finding squares well with the observation in the data that of all manufacturing firms, multinationals import services most intensively.<sup>17</sup> Furthermore, there is evidence that foreign multinationals' international sourcing is positively correlated with the availability of services provided by foreign firms. However, this result is not robust to changes in specifications. Once we add firm fixed effects and additional sectoral covariates, this coefficient changes in sign and significance (see tables 6 to 8 below).

We also find that the coefficient on productivity is still statistically insignificant for domestic multinationals and purely domestic firms, but negative and significant for foreign multinationals. However, this result is difficult to interpret, since it may reflect other aspects of plant heterogeneity that are not controlled for. It should also be kept in mind that the coefficient on labour productivity is conditional on other covariates. In particular, the model includes size, which is likely to be correlated with productivity (but does not feature in our theoretical model). Note that size consistently returns a positive coefficient; that is, larger plants have higher ratios of imported materials.

Overall, our baseline results are in line with the theoretical idea that services are needed to 'grease the wheels of international commerce.' In what follows we check how robust our baseline results are to changes in the specification of the

17 The regression results showing this are reported in the technical appendix. Some fraction of the imported intermediates by multinationals will be intra-firm trade. By definition, stand-alone firms are not involved in intra-firm trade. Our data do not allow us to distinguish between intra-firm and arms' length trade of multinationals. However, anecdotal evidence suggests that intra-firm trade is significant for services.

TABLE 5  
 Baseline model for exporters only  
 Dependent variable: ln (imported materials/sales)

	(1) All	(2) Irish MNEs	(3) Foreign MNEs	(4) Domestic
Foreign MNC services firm availability	0.056 (0.009)**	0.239 (0.101)	0.05 (0.004)***	0.019 (0.023)
Domestic services firm availability	0.092 (0.010)**	0.090 (0.038)	0.031 (0.006)**	0.103 (0.015)**
Labour productivity	-0.025 (0.001)**	-0.018 (0.037)	-0.048 (0.016)*	-0.009 (0.012)
Dummy domestic MNC	0.025 (0.001)**			
Dummy foreign MNC	0.051 (0.002)**			
Firm size	0.009 (0.003)	0.033 (0.017)	0.002 (0.007)	0.010 (0.005)
Observations	4496	454	1469	2573
R-squared	0.19	0.37	0.18	0.22

NOTES: Regressions with year, 3-digit industry, and region dummies. Robust standard errors, clustered around regions, are in parentheses. \* Significant at 10%; \*\* significant at 5%. Regressions include constant term. For a definition of service availability measures see table 4.

model.<sup>18</sup> For instance, the availability of services may affect not only imports of materials but also exports of firms, which is a feature not captured by our theoretical model. In order to take this into account, we include only exporters in our regression sample. In table 5 we replicate table 4 but for exporters. The result indicating the importance of services availability for domestic establishments holds.

One may be worried about endogeneity of our service availability measures, which may bias our results obtained thus far. We attempt to deal with endogeneity in the further analysis. First, as pointed out above, we argue that in a short panel plant fixed effects, which also capture time invariant industry and regional characteristics, take care of this to a large extent. Another concern is that the services measure is region specific and may therefore just pick up any region specific time-varying characteristic. In order to alleviate these concerns, we estimate the model with firm fixed effects and include further time-varying variables at the region and industry level, which may capture any potential correlation between

18 One hypothesis from our theory that we have not considered yet is that (low-productivity) mode-*D* firms should react more strongly to changes in the availability of services providers than (high productivity) mode-*I* firms. In order to investigate this empirically, we report in the technical appendix regressions, where we interact the service thickness variables with plant-level labour productivity. While we still find the importance of local services availability for domestic firms, the interaction terms do not turn out to be statistically significant. The lack of statistical significance either may reflect that our sample splits cover adequately the distinction into *I* and *D* firms, or it may signal that we are asking too much of our service variables.

TABLE 6  
 Extended model with additional covariates, for exporters only  
 Dependent variable: ln (imported materials/sales)

	(1) Irish MNEs	(2) Foreign MNEs	(3) Domestic
Foreign MNC services firm availability	0.241 (0.046)**	-0.088 (0.018)**	0.009 (0.016)
Domestic services firm availability	0.098 (0.069)	-0.024 (0.014)	0.103 (0.006)**
Labour productivity	-0.025 (0.019)	0.016 (0.014)	0.017 (0.015)
Firm size	-0.033 (0.010)*	0.039 (0.011)*	0.013 (0.007)
Industry total services intensity	-0.016 (0.026)	0.005 (0.008)	-0.001 (0.013)
Industry local services intensity	0.164 (0.035)**	-0.143 (0.085)	-0.028 (0.018)
# of foreign MNC manufacturing firms in region	-0.027 (0.075)	0.003 (0.025)	-0.000 (0.019)
# of domestic manufacturing firms in region	-0.006 (0.031)	0.011 (0.030)	-0.017 (0.022)
Region size	0.064 (0.041)	-0.006 (0.005)	0.007 (0.012)
Observations	454	1469	2573
# of firms	205	482	966
R-squared	0.10	0.05	0.02

NOTES: Regressions with firm fixed effects. R-squared for regression on within transformed variables, any impact of time invariant explanatory variables is purged. Robust standard errors, clustered around regions, in parentheses. \* Significant at 10%; \*\* significant at 5%. Regressions include constant term and year dummies. For a definition of availability measures see table 4.

our services availability measure and the error term. At the regional level, we include the number of manufacturing firms (foreign and domestic) as well as total sales in the region. The former is included in order to address the possibility that the service availability measure just captures general agglomeration effects, which may influence firms' sourcing decisions. The second measure is included in order to capture the size of a region. At the industry level, we control for the service intensity of the industry (value of total services inputs over total sales in the industry) as well as the intensity with which the industry uses locally sourced services (value of locally sourced services over total services inputs). These measures allow us to control for heterogeneity in the use and sourcing of services inputs in different industries.

The results are reported in table 6. Some points are particularly noteworthy. First, the result that the availability of local services firms matters for sourcing decisions of domestic establishments holds. Second, as alluded to above, we now find that the availability of foreign multinational services firms negatively affects the sourcing decisions of foreign multinationals and positively affects those of

TABLE 7

Extended model with effective availability measure, for exporters only

Dependent variable: ln (imported materials/sales)

	(1) Irish MNEs	(2) Foreign MNEs	(3) Domestic
Foreign MNC services firm availability	-0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)
Domestic services firm availability	0.000 (0.000)	-0.000 (0.000)	0.001 (0.000)*
Labour productivity	-0.027 (0.019)	0.017 (0.014)	0.017 (0.015)
Firm size	-0.026 (0.008)*	0.039 (0.010)*	0.014 (0.007)
Industry total services intensity	-0.021 (0.024)	0.005 (0.009)	-0.000 (0.015)
Industry local services intensity	0.134 (0.027)**	-0.152 (0.083)	-0.027 (0.018)
# of foreign MNC manufacturing firms in region	-0.018 (0.065)	0.003 (0.026)	0.005 (0.021)
# of domestic manufacturing firms in region	0.015 (0.024)	-0.002 (0.027)	-0.007 (0.023)
Region size	0.072 (0.055)	-0.024 (0.010)	-0.035 (0.009)*
Observations	454	1469	2573
# of firms	205	482	966
R-squared	0.08	0.05	0.01

NOTES: Regressions with firm fixed effects. R-squared for regression on within transformed variables, any impact of time invariant explanatory variables is purged. Robust standard errors, clustered around regions, in parentheses. \* Significant at 10%; \*\* significant at 5%. Regressions include constant term and year dummies. For a definition of effective availability measures see section 4.

Irish multinationals. However, these effects are not robust to further changes to the model; hence, we do not place much emphasis on them.

The services measure employed thus far varies only across regions and time. In order to deal with this, we use the 'effective service availability' measure described in section 4. It is based on multiplying the number of services firms in a region and 2-digit service sector by the input use coefficient of the 2-digit service in manufacturing industry  $j$  and summing over region and industry  $j$ .

Using this alternative measure we re-estimate the empirical model in table 7. The results show a statistically significant and positive coefficient on the the availability of local services for domestic establishments. As before, we do not find any evidence that the availability of local services matters for domestic or foreign multinationals in Ireland. Furthermore, the coefficients on the availability of services provided by foreign multinationals are now statistically insignificant.

Arguably, the inclusion of plant fixed effects as well as of a number of time-varying firm, industry, and regional variables is likely to be sufficient to alleviate

endogeneity concerns, especially in our short panel. Still, we proceed further and test whether, conditional on the inclusion of all these covariates, the service availability measures are likely to be endogenous in our empirical model. To do so, we re-estimate the models presented in table 7 using an IV estimator. Our main excluded instrument is an annual regional house price index for Ireland.<sup>19</sup> We use the lag of this variable as instrument. This can be assumed to be highly correlated with the availability of services (i.e., be a relevant instrument), considering that services firms may be responsive in their location decisions to the cost of buying or renting premises. Hence, we expect a negative correlation between availability of services and the house price index. On the other hand, we may assume this to be a valid instrument in that it is unlikely to be correlated with the error term in the estimating equation. In other words, the lagged average house price in a region is unlikely to have a direct effect on sourcing at the firm level, conditional on the covariates included in the empirical model. In order to aid identification we also include two further instruments, namely, the interaction of the lagged house price index with the lagged dependent variable. Assuming validity of the lagged house price index, we can test orthogonality of these additional two instruments using a Sargan test. The estimations are reported in table 8. Note that the overidentification tests suggest that these are valid instruments, while the first stage F-tests suggest strongly that they are also relevant.<sup>20</sup> The results support our earlier findings on the importance of services availability for domestic firms only.<sup>21</sup>

## **7. Conclusion**

It is a well-known fact that most developed countries are, to a large extent, service economies. Only a small percent of their labour force is employed in agriculture, some 20% to 30% work in manufacturing, and the rest, between 60% and 70% work in services. Still, the vast majority of international trade is in goods, not services. These basic facts beg the question of how international goods trade can be linked to services and whether services grease the wheels of international commerce.

There are various ways in which international trade and services are linked. We chose to focus on the sourcing behaviour of firms in the ongoing process of

19 The annual regional house price index data are available at [http://www.esri.ie/irish\\_economy/permanent\\_tsbesri\\_house\\_p/](http://www.esri.ie/irish_economy/permanent_tsbesri_house_p/) (accessed 26 October 2010). Note that the index distinguishes only two regions, Dublin and outside Dublin. Hence, the interaction terms add additional variation to the instrument set.

20 The first-stage results (not reported here to save space) also show that the three instrumental variables candidates are individually highly statistically significant. There is a negative correlation between changes in house prices and domestic services firms, and a positive correlation for the number of foreign services firms. Note also that the endogeneity tests do not allow us to reject the null hypothesis of exogeneity of regressors in two out of three cases.

21 In the technical appendix we present IV estimations using the simple measure of services availability used in tables 4 to 6. The results are similar to those presented in table 8.

TABLE 8

Instrumental variables estimation with effective availability measure, for exporters only  
 Dependent variable: ln (imported materials/sales)

	(1) Irish MNEs	(2) Foreign MNEs	(3) Domestic
Foreign MNC services firm availability	0.007 (0.003)**	0.000 (0.001)	-0.002 (0.001)
Domestic services firm availability	0.000 (0.001)	-0.001 (0.000)*	0.001 (0.000)*
Labour productivity	-0.036 (0.023)	-0.063 (0.013)**	-0.014 (0.009)
Firm size	0.029 (0.008)**	0.003 (0.004)	0.014 (0.003)**
Industry total services intensity	-0.022 (0.055)	-0.015 (0.022)	-0.023 (0.022)
Industry local services intensity	0.068 (0.219)	-0.122 (0.114)	0.058 (0.100)
# of foreign MNC manufacturing firms in region	-0.087 (0.026)**	-0.004 (0.021)	-0.011 (0.010)
# of domestic manufacturing firms in region	-0.094 (0.029)**	0.063 (0.020)**	-0.012 (0.012)
Region size	0.120 (0.134)	0.009 (0.076)	0.005 (0.056)
Observations	306	987	1644
First-stage Shea Partial R2 (Foreign MNC services firm availability)	0.55	0.61	0.58
First-stage Shea Partial R2 (Domestic services firm availability)	0.36	0.50	0.49
Sargan (p-value)	0.27	0.10	0.05
Endogeneity (p-value)	0.14	0.65	0.91

NOTES: IV regressions. Services firm availability is endogenous variables. Instruments are lagged regional house price index and interaction of lagged house price index with lagged endogenous variable. Standard errors are in parentheses. \* Significant at 10%; \*\* significant at 5%. Regressions include constant term, 3 digit industry, regional and year dummies. For a definition of effective availability measures see section 4.

fragmentation of production and to investigate the extent to which services facilitate this process. We specifically examined what effect services have on offshoring in manufacturing at the micro-level. With firm-level data from the Republic of Ireland we have shown that the availability of local services induces manufacturing firms to source more material inputs from abroad, which confirms the basic intuition that services should grease the wheels of international commerce. We found, however, that the availability of local services matters, especially for purely domestic firms. This finding is robust to a number of estimation techniques, in particular controlling for endogeneity of the services measures. Our result is quite intuitive and of particular interest. It indicates that firms, such as non-multinationals, that are too small or inefficient to internalize the provision of services or to attract services from abroad will depend more clearly on local

service market conditions. Our finding thus brings together the earlier hypotheses on the impact of services on offshoring and the theory of the multinational, since multinationals, by definition, internalize some company-wide services through the headquarter services they provide and since affiliates of multinationals can easily draw on these services from afar.

In a way, it could be argued that our current approach looks only at one side of the service-sourcing link. It is true that we consciously only look at the side of the service-sourcing link that, from an empirical point of view, is most easily observable. Indeed, we establish that services matter for firms by looking at the local market and by showing that local services affect non-multinational firms that are very dependent on local conditions. Our finding that these local services do not matter much for multinationals' offshoring behaviour does not imply that services as such are not important for multinationals. On the contrary, only because multinationals internalize services and only because they can draw more easily on foreign services are local service conditions not all that critical for them. It would be nice to directly tackle the link between services and offshoring from the angle of the multinationals themselves and the total (international) services that they face, especially since multinationals tend to be larger and more important for international trade. Needless to say, however, with multinationals' services spread all over the globe, this is, from an empirical perspective, an almost impossible task given the current data availability.

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