Local sourcing services and efficiency*

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Abstract

Using an exhaustive dataset on firm-to firm sales in Belgium, we examine how firms choose their local sourcing strategy based on geography and their productivity. We document that most firms trade only locally, and that they follow a predictable pecking order among source sectors. These empirical findings motivate and guide the development of a model with endogenous choice of tasks produced in-house. Consistent with the model, we show that the probability of a trade relationship increases with the efficiency of both the supplier and the buyer and decreases with the distance between them. Finally we run a counterfactual exercise to asses to what extent local trade frictions shape the productivity distribution. Our results tend to indicate that reducing trade frictions on services to levels similar to those of goods could lead to an average increase of efficiency of 4.3%.

*The views expressed in this paper are those of the authors and do not necessarily reflect the views of the National Bank of Belgium. Statistical evidence presented complies with the statistical legislation. No confidential information about individual firms is released in this document. Remaining errors are ours only.

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1 Introduction

Dramatic advances in communication, information, and transportation technologies have led firms to reassess the traditional way of organizing themselves and have contributed to a fragmentation of production processes and to a specialisation of firms into a narrower set of activities. Firms are increasingly focusing on their core competencies and hiring outside companies to provide tasks that were previously done in-house (see Weil, 2014, for a qualitative survey). Labor cost savings are an important driver behind this mechanism (Goldschmidt and Schmieder, 2016) but it also creates value for the firms [1]. This behaviour is widely spread in the economy and is typically related to the sourcing of non specific material inputs or services. For instance, according to the Belgian Structure of Enterprises Survey 2010, 77% of Belgian firms were sourcing (part of) their accounting services, 72% some office administrative services, 57% their legal services and 38% their cleaning services. In 2015, these shares were respectively of 80%, 76%, 66% and 51%. These inputs do not represent a large fraction of the total costs of the firm, as on average each category accounts for 1 or 2% of total input consumption, but most firms tend to prefer to buy them from other firms instead of producing them in house.

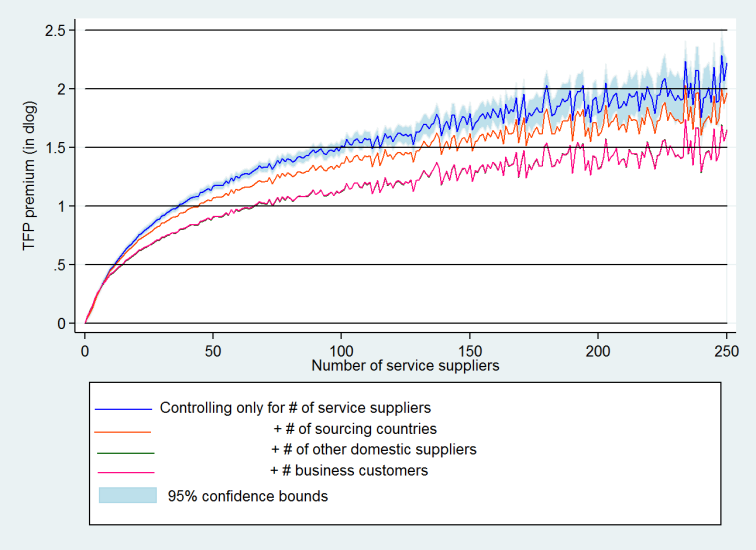
In this paper, we stress the role of the extensive margin of local sourcing on production efficiency. Figure 1 illustrates that the TFP premium at the firm level is increasing in the number of domestic service suppliers. A firm with only 5 service suppliers is already 25% more productive than a firm that does not source any services. Firms that are able to source from 37 services suppliers seems to be twice as productive as the non sourcing firms. This fact extends the evidence on global sourcing that the relative size advantage of manufacturing firms is increasing in the number of countries from which they source (Antràs et al., 2017). These efficiency advantages are suggestive of fixed cost of sourcing at the firm-to-firm level, which limits the ability of less efficient firms to select into sourcing from a large set of specialized suppliers. Controlling for other dimensions that may be correlated to the number of service providers, such as the number of other providers, the global sourcing strategy of the firm or the number of its business customers reduces the TFP premium associated to the nmber of domestic suppliers but does not fundamentally change the pictures. Firms that are able to manage many service suppliers seems to be more productive / profitable / cost-effective.

The goal of this paper is to document local sourcing, and more specifically domestic sourcing of services by using an exhaustive dataset on firms' buyer-seller linkages in Belgium[2]. In contrast to the Structure of Enterprises Survey which documents the sourcing strategy of a few thousand firms, this dataset

[1] It is quite common to see statements that suppliers provide value to the sourcing firms (see for instance the Google's Supplier site (www.google.com/corporate/suppliers/) or the BASF suppliers and partners web page (www.basf.com/global/en/who-we-are/organization/suppliers-and-partners.html)).

[2] See Dhyne, Magerman, Rubinova (2015) for a description of that dataset and Tintelnot et (2018) or Bernard et al. (2018) for most recent applications of this dataset.

FIGURE 1 : TFP Premia and domestic sourcing



Note : To construct the blue line, we regress the log TFP on cumulative dummies for the minimum number of domestic suppliers of services from which the firm sources, and sector and time dummies. For the orange line, we add cumulative dummies for the minimum number of domestic suppliers from which the firm sources. For the green line, the set of cumul dummies for the minimum number of other domestic suppliers is added. Finally, for the pink line, we also add cumulative dummies for the minimum number of domestic business customers to which the firm sells. Value added based TFP is estimated at the NACE 2 digit sector level for sectors with at least 1,000 observations using the Wooldridge LP estimator.

allows us to characterize the local sourcing strategy followed by the universe of Belgian firms, even if we restrict ourself to the sample of firms for which we can estimate a Cobb-Douglass production function at the NACEREV 2 2 digit level. First, we provide descriptive statistics on the domestic and international sourcing strategies followed by Belgian firms and how domestic trade is geographically organized in Belgium. We find that distance between the supplier and the buyer seems to be an important driver of B2B relationships as most firms tend to trade with local partners located in a narrow perimeter of their own location. We also find evidence that sourcing of services is relatively common accross industries and do not seem to be specific to the activity of the sourcing firm. Excluding sourcing from the wholesale, retail and network industries (energy provider or telecommunications)[3], the ten most common sectors from which Belgian firms source inputs are mostly service sectors (8 out of 10). Legal and accounting activities, office administrative support activities and computer programming are sectors ranked 1 to 3.

Our paper directly relates to the growing literature on the determinants

[3]In the 2010 Structure of Earning survey, around 90% of the sampled firms were reporting the consumption of electricity and telecommunication services.

of domestic (Bernard et al., 2017, Furusawa et al., 2017) and foreign sourcing (Amiti and Koning, 2007, Goldberg et al., 2010, Halpern et al., 2015, Bøler et al., 2015, Antràs et al., 2017) and their impact on firm efficiency. To guide the empirical analysis, we modify the global sourcing model of Antràs et al. (2017) to allow for the possibility that firms choose endogenously the amount of tasks performed in-house in order to produce a final good or service. We exploit the complementarity mechanism herein to rationalize the sourcing decisions made by firms. This simple model puts us in a position to derive some testable assumptions on the sourcing decisions. More efficient and less distant suppliers are more likely to be chosen. The share of tasks is increasing in the supplier's productivity and decreasing both in the geographic distance between the supplier and the buyer and in the buyer's productivity. The results obtained in the empirical part are basically in line with the predictions of the model. Finaly, we use our empirical framework to run several counterfactual exercises to estimate the potential gains generated by a reduction in the trade costs of services.

Belgium provides a particularly interesting setting to conduct an analysis of the determinants of local sourcing and of potential trade frictions that may affect these decisions, since we expect trade frictions to be at a lower bound[4]. Belgium is a bilingual country, so admittedly cultural barriers to trade between firms located in the Flemish or the Walloon region may be at play and specific regional regulations may also affect the sourcing of services across regions. In the empirical section, we will therefore introduce a control in our regression to take these cultural or regulatory barriers into account. Otherwise, with more than 780,000 firms within a geographic area of 30,000 km2, Belgium has one of the highest firm density in Europe. We consider that, because of its small size, Belgium deserves specific attention. Distance between firms is at most 277km. Belgium has a very dense transportation infrastructure (155,000 km of roads, 3,500 km of railways and 2,000 km of waterways) and no natural geographical obstacles such as lake or mountain that may hamper trade between firms. Despite of this, we show that productivity distribution is shaped by geography.

The paper proceeds as follows. Section 2 discusses our data sources and presents some empirical evidence that will guide our model presented in Section 3. Section 4 present our empirical design and results. The final section concludes.

2 Data and descriptive evidence

A full description of the local sourcing strategy of firms is seldomly available. In most countries researchers can access to firm level information on imports by country of origin and by products, but only few information are available

[4]One might be concerned by the fact that Belgium is a very open economy, where import and export amount to 80% of GDP. However, even in a very open economy as Belgium, most of the trade between firms occurs locally. At a more microeconomic level, we also observe that only a small fraction of Belgian firms (around 5% in 2012) are sourcing inputs abroad.

regarding domestic transactions between firms. The Compustat data for the US provide some information about the 10 largest suppliers of their sampled firms, and the Japanese data used in Bernard et al. (2017) provide qualitative data on Japanese firms domestic linkages. For this paper, we use a detailed firm level dataset for Belgium. Referred to as the NBB B2B dataset in Dhyne, Magerman and Rubinova (2015), it provides a full description of all domestic transactions between any pair of Belgian VAT affiliates, as long as one of these two affiliates is buying from the second one for at least 250 EUR in any given year. This dataset has been used in recent papers (f.i. Dhyne and Rubinova, 2016, Magerman et al., 2016, Bernard et al., 2018, Tintelnot et al., 2018, Kikkawa et al., 2018). Observing the amount traded between two firms is a unique feature of the Belgian dataset compared to other datasets (similar data is becoming available for other countries, f.i. Costa Rica or Turkey). However, we have no information of what is traded between two firms, except the main activity of the supplier.

The NBB B2B dataset can be viewed as a kind of a annual input-output matrix where each row and each column is a firm. Still, this dataset departs from traditional input output table in many dimensions. First, the way trade intermediaries are recorded in the B2B dataset is fundamentally different from standard IO tables. In standard IO tables and national accounts, the contribution of the wholesalers and retailers to the economy and their intermediate deliveries to other sectors is measured in terms of the value added provided by wholesalers and retailers to the economy. In our transaction data, we observe gross transactions to or from trade intermediaries. The contribution of wholesalers and retailers in the network is therefore much larger than in standard IO tables. Second, as mentionned above, the B2B transaction data does not discriminate between the delivery of inputs (material or services) and of capital goods.

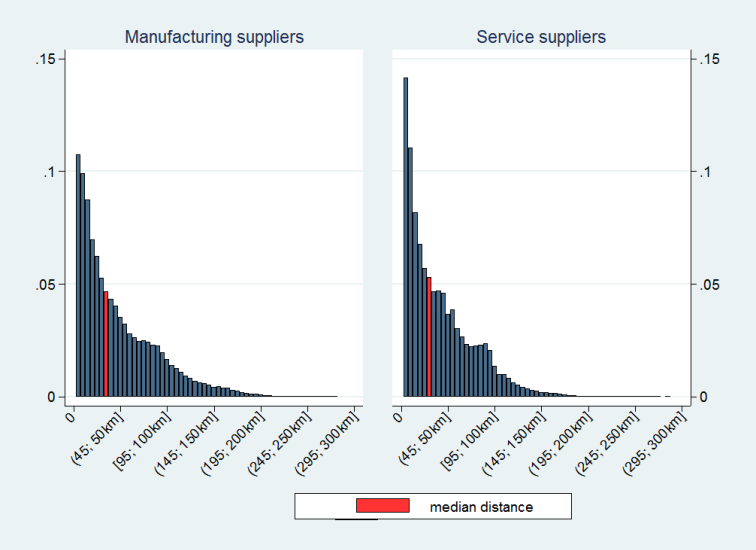
The domestic transaction data can be merged with other datasets (firm level balance sheet data, firm level international trade) that provide firm level information such as its location, its number of establishments, its international trade status, its size and its productivity, and the fact that it may be part of a domestic or international group[5]. Data on domestic transactions are available from 2002 up to 2014.[6].

We first provide some empirical evidence that will guide the development of the model in Section 3. Firms tend to interact mostly with local partners (see Figure 2), with 14% of service sourcing relations taking place within a 5 km range. The median distance for a service sourcing relation is 28km. Evidence points to smaller trade frictions for manufacturing. Only 11% of manufactur-

[5]Belgian firms are localized according to the ZIP code of their headquarter. Concerning the international trade status, we define three status based on the fact that firm may only import, only export or be involved in both types of foreign trade. The firm size is measured by its employment in full time equivalent and its productivity by the TFP estimated at the NACE Rev.2. 2 digit level using the Wooldridge LP estimator (Wooldridge, 2009). Using data on domestic and international financial linkages, we also observe if a firm belongs to a group or not.

[6]The results presented are however robusts across various cross-section and a panel analysis limited to a smaller set of firms confirmed our main results.

Figure 2: Distribution of distance between domestic trading partners (in 2014)



ing relations take place within a 5 km range and the median distance for a manufacturing sourcing relation climbs to 32km.

Figure 1 has emphasized the role of the extensive margin of local sourcing. From now on, we restrict our sample to the 104,180 firms for which we estimated TFP in 2012. Although the distribution of the number of suppliers is highly skewed, firms have onverage 71.9 domestic suppliers. Excluding suppliers that are operating in the wholesale, retail, and utility industries (electricity, gas and water), this average number falls to 38.2. The fixed cost associated with a purchase to the formers, and in particular to the distribution sector, cannot be very high, so we should not expect those sectors to be crucial in explaining the heterogeneity in productivity. Among the remaining suppliers, services represents a large fraction as the average firm sources from 17.9 service suppliers (NACE Rev 2 55 to 82) and only 8.3 manufacturers (NACE Rev 2 10 to 33). While domestic sourcing concerns the vast majority of firms, only very few firms are involved in international sourcing. Moreover, it is not a big surprise that manufacturing firms typically have more suppliers and display higher heterogeneity in their sourcing strategy.

In this paper, we will emphasize the role of services in shaping the productivity distribution. Table 2 lists the top ten sourcing sectors, ranked by the number of buyers. Consistently with the results obtained from the Structure of Enterprises Survey, 8 sectors in that Top 10 are service providers. It seems that this rank is relatively independent of the activity of the sourcing firm. For all sectors, however, sector rank based on the number of customers does not equal the rank based on transaction values. This is suggestive of firm level heterogeneity in fixed cost of sourcing to those sectors.

Table 1: Descriptive statistics - Local sourcing strategies in 2012

	p10	p25	p50	p75	p90	Mean
All firms (104,180 firms)						
Number of suppliers	17	29	49	82	140	71.9
excluding wholesalers, retailers, utility providers	8	13	23	42	78	38.2
Number of support services suppliers	4	6	11	19	36	17.9
Number of manufacturing suppliers	0	2	4	9	19	8.3
Number of source foreign countries	0	0	0	0	3	1.0
Manufacturing firms (11,750 firms)						
Number of suppliers	25	42	73	134	234	114.4
excluding wholesalers, retailers, logistic or utility providers	11	19	36	70	129	62.0
Number of support services suppliers	4	7	13	27	50	23.6
Number of manufacturing suppliers	3	6	13	24	43	19.8
Number of source foreign countries	0	0	0	2	10	2.7

Note : Based on the sample of 104,180 Belgian firms in 2012 taken from Figure 1.

Table 2: Services sectors ranked by the number of sourcing firms

Sector of activity	% of all firms sourcing from...	Ranking (only manuf.)	Rank by value (all firms)
82. Office administrative, office support and other business support activities	95.2	1	16
69. Legal and accounting activities	93.6	2	26
43. Specialised construction activities	77.7	3	2
81. Services to buildings and landscape activities	56.8	6	23
66. Activities auxiliary to financial services and insurance activities	56.0	7	43
62. Computer programming, consultancy and related activities	54.4	11	12
18. Printing and reproduction of recorded media	48.8	10	29
77. Rental and leasing activities	47.0	14	14
64. Financial service activities, except insurance and pension funding	46.8	13	11
70. Activities of head offices; management consultancy activities	45.8	12	5

Note : Top ten sourcing sector. Based on the sample of 104,180 Belgian firms in 2012 taken from Figure 1.

3 Theoretical framework

We develop a model along the lines of Antràs et al. (2017) by exploiting the complementarity mechanism herein. Complementarity between suppliers has the strong implication that there should be a strict hierarchical order in the extensive margin of outsourcing. We however modify their multi-country model to allow for the possibility that firms endogenously chose the set of tasks they will perform in-house. In this model, we assume that, in order to produce a final good, firms need to perform a continuum of tasks that they can decide to do in-house or to outsource. The motivation of outsourcing is production efficiency as firms are heterogeneous in their ability to perform a specific task. In our framework, firms will tend to specialize themselves in the set of tasks they are better at performing while they will outsource the remaining tasks. Setting a trading relationship with any supplier implies a fixed cost, which reflects the fact that outsourcing tasks requires some coordination or negotiation with the trading partner. This model of trade in tasks is one of the simplest we can think of that can square with the facts. It enables us to abstract from complex solvability issues, arising in any model of trade in goods due to double marginalization (see Tintelnot et al, 2017). It departs from existing models by dropping the exogenous assumption of upstream and downstream firms. This enables our model to come to terms with some features of the data by allowing firms to sell both at final consumers and at any other firm[7]. Our simplifying framework comes at a cost, however, since in the data we do not observe trade in task but trade in goods and services. Still, we believe that it does not alter the prediction of our model as, when a firm source intermediate inputs from a supplier, this can be viewed as the fact that the firm is sourcing the tasks needed to produce those inputs to the supplier. So for instance, when a car manufacturer sources the tires of its cars to a tire producer, it in fact outsources the task of designing and producing those tires instead of performing those tasks itself. The determinants of the trade relationship between those two firms are still the same than those highlighted in our model.

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Market structure

We consider the sourcing strategy of a firm i producing a final good. Suppose firm i owns a blueprint to produce a single differentiated variety of final product. Consumers value the consumption of differentiated varieties of products according to a standard symmetric CES utility function. These preferences give rise to the following demand for firm i :

$$q_i = Ap_i^{-\sigma} \tag{1}$$

where A is a demand-shifter that the firm treats as exogenous.

[7] In 2012, 67% of the firms in our dataset were selling to other domestic firms, 74% to final demand and 53% to both.

Production of final-product varieties require the assembly of a continuum of measure one of tasks, assumed to be imperfectly substitutable with each other, with a constant and symmetric elasticity of substitution equal to ρ. The marginal cost of a firm i is

$$c_i = \left(\int_0^1 z_i(t)^{1-\rho} dt \right)^{\frac{1}{(1-\rho)}} \tag{2}$$

where $z_i(t)$ is the price of an individual task t paid by firm i.

Local sourcing

All firms can produce all tasks with labor under constant-returns-to-scale technologies. We denote by $a_i(t)$ the unit labor requirement associated with the production of task $t \in [0,1]$ by firm i. We treat the (infinite-dimensional) vectors of tasks efficiencies $1/a_i(t)$ as the realization of an extreme value distribution. More specifically, the efficiency of firm i in producing a task t is a realization of a random variable from the Frechet distribution $Pr(a_i(t) \geq a) = e^{-\varphi_i a^{\theta}}$. As in Eaton and Kortum (2002), θ determines the variability of productivity draws across tasks. These draws are assumed to be independent across firms and tasks. The firm's core efficiency φ_i which scales the ability to produce any task is the source of firm-level heterogeneity in our framework. For instance, this parameter may reflect the managerial capabilities of the firm. By assuming that management competence is an important component of firms' total factor productivity, we follow a growing literature emphasizing the role of management in shaping the patterns of efficiency distribution (Bloom et al., 2012, Bloom et al., 2013, Bloom et al., 2017, Syverson, 2011).

The firm can potentially produce all tasks in-house. Alternatively, the firm can decide to concentrate on its core activities (i.e. the tasks for which it gets the better draws) and outsource the remaining tasks. Trade in tasks however requires the payment of fixed and variable costs. To purchase a bundle of tasks from a particular firm j, firm i must incur a fixed cost f_{ij} paid in terms of labor[8]. Furthermore, trade in tasks is subject to iceberg trade costs τ_{ij}.

To simplify matters, we assume that firms sell tasks at their marginal cost. In the Nash bargaining between buyer and supplier, the buyer has therefore the full bargaining power and extracts the entire surplus (Tintelnot et al., 2017). Since by assumption in any firm-to-firm trade the buyer has the full bargaining power, firms do not make profits from sales to other firms. While restrive, this assumption together with the trade in tasks framework allows us to abstract from complex fixed-point issues.

As a result, the price of an individual task t paid by the firm i is

$$z_i(t) = \min_{j \epsilon J_i} \{ a_i(t), \tau_{ij} a_j(t) \} \tag{3}$$

[8]This fixed cost may for instance represent the cost associated to the set-up of a specific contract between the two firms. In the Belgian context, these fixed cost may also reflect cultural barriers to trade if buyers and sellers are located in different Belgian regions.

where J_i is the set of firms for which firm i has paid the associated fixed cost of outsourcing f_{ij}.

At this stage, it is worth discussing our framework. The way we introduce trade in tasks is close in spirit to the idea of trade in value-added (Timmer et al., 2014, or Johson and Noguera, 2012 and 2017). It is motivated by the empirical fact that local production chains look more like spiders than snakes (as labelled by Baldwin and Venables, 2013). The average length of international production chains is close to 3 (see Antràs et al., 2012). As shown in Table 1, in the 2012 Belgian network, the average number of suppliers is 29.9, with 10 percent of firms having more than 65 suppliers. One reason why sequential production is less pervasive than expected is because most of the previous literature has focused on manufacturing processes of production. Services need much less fragmented production chain. Yet, once we consider the whole economy, one should note that trade in service accounts for the largest part of trade between firms. According to IO table for Belgium, trade in service amounts to 70% of the total value.

Optimal sourcing strategy

Using the properties of the Frechet distribution, one can show that the firm will source a positive measure of tasks from each supplier in its sourcing strategy set J_i. Furthermore, the share of tasks sourced from any supplier j is simply given by

$$\chi_{ij} = \frac{\varphi_j \left(\tau_{ij}\right)^{-\theta}}{\varphi_i + \Theta_i} \tag{4}$$

Following Antràs et al. (2017), we call $\Theta_i = \sum_{k \epsilon J_i} \varphi_k \left(\tau_{ik}\right)^{-\theta}$ the sourcing capability of firm i and J_i the sourcing strategy of firm i. The overall marginal cost faced by firm i can be expressed

$$c_i = \gamma \left(\varphi_i + \Theta_i\right)^{-1/\theta} \tag{5}$$

where $\gamma = \left[\Gamma\left(\frac{\theta+1-\rho}{\theta}\right)\right]^{1/(\rho-1)}$ and Γ is the gamma function. As we assume that firms act as monopolistic competitors when selling their product to final consumers, they charge a constant mark-up over marginal cost. Using (5), the properties of the Frechet distribution and the constant markup over marginal cost, firms profit can be written as:

$$\pi_i = \left(\varphi_i + \Theta_i\right)^{(\sigma-1)/\theta} B - \sum_j f_{ij} \tag{6}$$

where $B = \frac{\gamma^{\sigma-1}}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} A$. The problem of maximizing (6) is not straightforward to solve because the decision to include a supplier j in the set J_i depends on the number and characteristics of the other suppliers in this set. When deciding whether to add a new supplier j to the set J_i, the firm trades off the

reduction in costs associated with the inclusion of that supplier in the set J_i against the payment of the additional fixed cost f_{ij}. Using a first-order Taylor rule, this net gain of adding supplier j can be approximated by:

$$\Delta_{ij}(\Theta_i) = \frac{\sigma - 1}{\theta} (\varphi_i + \Theta_i)^{\frac{\sigma-1-\theta}{\theta}} \varphi_j (\tau_{ij})^{-\theta} B - f_{ij} \tag{7}$$

The marginal gain from adding a supplier is higher for more productive firm whenever $\sigma - 1 > \theta$, which we hencerforth assume. In this case, efficiency and outsourcing display complementarities, which is consistent with the Figure 1 in Introduction. If, instead, $\sigma - 1 < \theta$, more efficient firms outsource less tasks as they find more profitable to capitalize on their comparative advantage in producing tasks more efficiently.

Interestingly, under the condition that $\sigma - 1 > \theta$, Equation (7) also exhibits complementarities between suppliers. A firm with a larger sourcing strategy will find more profitable to outsource tasks to one more supplier. This is more likely when consumer demand is elastic and efficiency draws are heterogeneous. This feature of the model was already in Antràs et al. (2017) and explains why firms would follow a predicted pecking order. Firms rank their potential suppliers according to their attractiveness, which is simply dictated by $\varphi_j (\tau_{ij})^{-\theta}$ and f_{ij}. The pecking order in terms of sectors, and in particular in services sectors, suggests that suppliers within the top ranked sector tend to exhibit favourable productivity associated with relatively low fixed cost. They are choosen in priority by firms that seek to outsource tasks. There are however reasons why this hierarchy is not strictly followed by firms. Two perfectly similar firms would strictly follow a predicted pecking order. But firms differ in various respects. They have their own specific draws of tasks efficiencies. They also differ in terms of geography (trade cost) and relation-specific fixed costs.

Our model also puts us in a position to derive some testable predictions. From Equations (7) and (4), we have that:

More efficient and less distant suppliers are more likely to be choosen. The share of tasks is increasing in the supplier's productivity and decreasing both in the geographic distance between the supplier and the buyer and in the buyer's productivity.

4 Econometric results

4.1 Production efficiency and local sourcing strategy

The model presented in 3 show how the level of the core efficiency of a firm, φ_i, affects its sourcing strategy. However, in standard production function estimation, the estimated TFP of a given firm in a given period captures the "post sourcing strategy decision" of a given firm. If this may be the relevant metric to evaluate the contribution of a potential supplier, this is not a correct measure for the core efficiency and would lead to a endogeneity issue when evaluating the impact of firm i efficiency on its probability to set up outsourcing relationships.

Table 3: Production function controlling for firm i's service sourcing strategy - all sectors - 2002-2014 : dependent variable : y_{it}

	(1)	(2)	(3)
l_{it}	0.678^{***}	0.663^{***}	0.665^{***}
	(0.017)	(0.017)	(0.018)
k_{it}	0.082^{***}	0.077^{***}	0.081^{***}
	(0.004)	(0.006)	(0.004)
$service\ suppliers_{it}$	-	0.073^{***}	0.080^{***}
		(0.029)	(0.031)
$manufacturing\ suppliers_{it}$	-	-	-0.036
			(0.026)
$source\ countries_{it}$	-	-	0.034^{***}
			(0.008)
Year X Sectoral dummies		Yes	
Observations		1,068,519	

Note:$service\ suppliers_{it}$, $manufacturing\ suppliers_{it}$ and $source\ countries_{it}$ are respectively the inverse hyperbolic sine of the number of domestic suppliers active in the service sector (NACE REV2. 55 to 82), of the number of domestic suppliers active in manufacturing (NACE REV2. 10 to 33) and of the number of countries from which firm i imports. Production function estimated using the Wooldridge LP approach. Clustered standard errors at the NACE Rev2 2 digit level. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

To get an estimate of the core efficiency of a firm, we consider as a first step the estimation of the following specification as a production function

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \beta_1 service\ suppliers_{it} + \varphi_{it} + \varepsilon_{it} \tag{8}$$

where $y_{it}$is the log of real value added of firm i in period t, l_{it}, the log of its labor force in FTE, k_{it} the log of its real capital stock, $service\ suppliers_{it}$ is the inverse hyperbolic sine of the number of domestic suppliers of services (NACE REV2. 55 to 82) .

Results presented in 3indicate that the sourcing of local services is an important way to create value at the firm level. Computing TFP using those estimated coefficients, we find that service providers improve in 2012 the observed productivity of a firm ($y_{it} - \beta_l l_{it} - \beta_k k_{it}$) between 6.6% and 58.4%, with a median effect of 24%, in our sample of firms compared to its intrinsic productivity ($y_{it} - \beta_l l_{it} - \beta_k k_{it} - \beta_1 service\ suppliers_{it}$).[9] This intrinsic productivity is a key parameter of our domestic sourcing model. This gain in efficiency or profitability of firms associated to the sourcing of services reflects the greater specialisation of firms on the tasks or production steps for which they a competitive advantage. These gains are not biased by ignoring other sourcing decisions like the domestic or foreign sourcing of material inputs. The benefit from increasing the number of service suppliers is by far the largest one

[9]Still, the gains of choosing imported inputs over dometiscally produced ones is more than the direct effect of increasing the number of sourcing markets or market x products as it leads to substitution between domestic and foreign suppliers.

of the 3 channels. Diversifying your sourcing of domestic material inputs do not seem to generate similar gains.

4.2 The determinants of the decision of local sourcing

In a second step, to confront our model with data, we use our estimates of intrinsic TFP in comibination with the NBB B2B dataset described in section 2. As mentionned above, this dataset provides the researcher with a complete description of all the business relationships managed by Belgian firms. For every registered corporation in Belgium, we therefore have a complete view of its domestic suppliers. Simultaneusly, we know which Belgian firms were not considered by a firm as a potential supplying partner.

Based on our model, the selection of a specific trading partner relies on both geographical (f.i. the distance between the firm and a potential supplier) and economical (the level of economic performance of both trading partners) factors. In this section, we rely on the estimation of a Probit equation characterizing the decision of firm i to source inputs from firm j to test the empirical predictions of our model.

In our model, firms that trade domestically may face some trade costs. Geography, as illustrated in Figure 2, shapes the structure of the Belgian production networks. Cultural or regulatory differences between Flanders and Wallonia may also be an important determinant of the organization of the domestic production network. Belgium is indeed a country with 3 regions, with Flanders being Dutch-speaking, Wallonia French-speaking and Brussel bilangual and the 3 regions are reponsible for the definition of market access conditions, especially for service providers. In many instance, service providers need to apply to region specific agreements that restreint their ability to serve the other regions. Therefore, even if there is no formal border or any tariff barriers to trade within Belgium, there can be sizeable fixed costs of trade between firms located in different regions (Flanders versus Wallonia).

Therefore, following our modeling strategy and equation (7), we assume that the probabibilty that j belongs to the set of suppliers of firm i is given by

$$P\left[I\left(Sales_{ijt}>0\right)|X_{ijt}\right]=\Phi\ \Big(\beta_0+\beta_1 dist_{ij}+\beta_2\neq Regions_{ij}+\beta_3\widetilde{tfp}_{i,t-1}+ \beta_4 tfp_{jt}+\beta_5 l_{i,t-1}+\beta_6 l_{jt}+\beta_7 Participation_{ijt}+...\Big)$$

where :

- $dist_{ij}$ is the log distance between the Belgian headquarter of firm i and its potential supplier j's Belgian headquarter ;
- $\neq Region_{ij}$ is a binary variable reflecting the fact the Belgian headquarters of firms i and j are located in two regions not sharing a common language (either Flanders or Wallonia) ;
- $\widetilde{tfp}_{i,t-1}$ is the log total factor productivity of firm i purged from the contribution of its sourcing strategy, in t-1, in order to capture the intrinsic

ability of firm i before it takes its sourcing decision for time t. This measure should reflect the φ_i parameter as the ex-ante ability of the firm to combine all the tasks needed for its production, to allows for sectoral differences in technology, we estimated firm level productivity using estimations of equation 8 at the NACE Rev2 2 digit level ;

- $\widetilde{tfp}_{jt}$is the log of the total factor productivity of firm j purged from the contribution of its sourcing strategy in time t ;
- $l_{i,t-1}$ and l_{jt} are respectively the log employment of firm i in t-1 or in year t for firm j.
- $Participation_{ijt}$is a binary variable reflecting the fact that there exist a financial participation between firm i and the potential supplier j at time t;
- Additional controls includes the internation trade status of both firms, dummies reflecting the sector of activity of both firms, dummies characterizing the zip code of both firms,...

In order to estimate a Probit, one needs both "0"s and "1"s. If our transaction dataset provides us with all the "1"s in a given year, we need to sample the "0"s. To perform our estimation, we randomly selected a given number of potential transactions (effective or not) for any Belgian firm in our dataset. We have built three samples for the estimation of our baseline regression.

The first one considers either as a buyer or as a potential supplier all the firms included in our sample for which we observe the location of the headquarter, its employment and an estimate of its total factor productivity, at least during one year in our estimation period going from 2003 to 2012. This sample covers all sectors of activity, from manufacturing to services including wholesalers and retailers and network industries. For this sample, we consider 100 randomly selected potential suppliers for every firms, ending up with 100,759,547 potential supplying relations, out of which 42,454,703 effectively ongoing.

The second one only considers the subset of firms active in service sectors NACE 55 to 82 as suppliers and all firms that source from this subset as buyers. This sample covers 22,569,291 potential transactions with 8,377,937 real transactions.

Finally, a third sample only considers the subset of manufacturing firms as suppliers and firms that source from this subset of suppliers as buyers. This sample covers 2,493,550 potential transactions, out of which 1,646,796 are real transactions.

"1"s are naturally over-represented in our three samples. Therefore, we estimated a weighted Probit equations that corrects for this feature of our datasets. Results are summarized in Table 4. In addition to the estimated coefficients, we also present the estimated average elasticity of the probability of a transaction with respect to our set of explanatory variables, computed considering all supplier-buyer pairs in our sample in 2012.

Table 4: Sourcing choice of firm i : dependent variable : $I\left(sales_{ijt} > 0\right)$

	All suppliers / All firms		Service suppliers / All firms		Manufacturing suppliers / Manufacturing firms	
	Est. coef.	Avg. elast (in 2012)	Est. coef.	Avg. elast. (in 2012)	Est. coef.	Avg. elast. (in 2012)
$dist_{ij}$	-0.231^{***}	-0.917	-0.241^{***}	-0.972	-0.182^{***}	-0.667
	(0.0004)		(0.0007)		(0.0015	
$\neq Region_{ij}$	-0.238^{***}	-0.613	-0.316^{***}	-0.723	-0.205^{***}	-0.529
	(0.0012)		(0.0017)		(0.0035)	
$\widetilde{tfp}_{i,t-1}$	0.046^{***}	0.183	0.049^{***}	0.199	0.035^{***}	0.129
	(0.0023)		(0.0015)		(0.0029)	
$\widetilde{tfp}_{jt}$	0.056^{***}	0.224	0.064^{***}	0.256	0.033^{***}	0.121
	(0.0003)		(0.0006)		(0.0018)	
$l_{i,t-1}$	0.113^{***}	0.447	0.129^{***}	0.519	0.125^{***}	0.457
	(0.0008)		(0.0008)		(0.0015)	
l_{jt}	0.127^{***}	0.504	0.142^{***}	0.572	0.069^{***}	0.252
	(0.0002)		(0.0004)		(0.0010)	
$Participation_{ijt}$	1.470^{***}	33.9	1.978^{***}	143.8	1.590^{***}	32.0
	(0.045)		(0.101)		(0.184)	
Year dummies	Yes		Yes		Yes	
i and j district dummies	Yes		Yes		Yes	
i and j sector dummies	Yes		Yes		Yes	
Additional controls	Yes		Yes		Yes	
Observations	$100,759,547$		$22,569,291$		$2,493,550$	

Note: Sample of all B2B transactions observed in Belgium, completed by 100 potential transactions for each buyer, for the 2003-2012 period. $I(sales_{ijt} > 0)$ is a binary variable that indicates whether firm i sources inputs from firm j at time t. $dist_{ij}$ is the log of the "as the crow fly" distance in km. $\neq Region_{ij}$ is a binary variable indicating that firms i and j are located in two different regions that do not share a common language. $\widetilde{tfp}$ is the log of total factor productivity estimates purged from the contribution of the sourcing strategy followed by the firm (at the NACE 2-digit level using the Wooldridge-LP estimator). l is the log of number of employees, in FTE. $Participation_{ijt}$ is a dummy variable indicating that i or j owns at least 50% of the capital of the other firm. Additional controls include sectoral dummies for i and j, dummies for the degree of internationalization of i or j (exporter, importer, MNE) or if i or j are multiplant firms. Standard errors of the estimated coefficients are clustered at the sourcing firm level. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The results obtained are basically in line with the predictions of our model. Most productive firms tend to source from more suppliers, and better suppliers are more likely to be selected. Distance is also a key determinant of the likelihood of a business relationship. Our results are also consistent with the fact that trade costs may embodied cultural barriers to trade as a common language increases the probability to trade.

Comparing results across sectors, we observe that a supply relationship between two firms located on either side of the linguistic border is particularly difficult when services are exchanged instead of manufacturing goods. This reflects the fact that personal contacts are a true component of a service transaction while trading goods do not necessarily requires a common language. Considering the effect of distance, the impact of distance is also smaller for the decision to supply manufacturing goods and services.

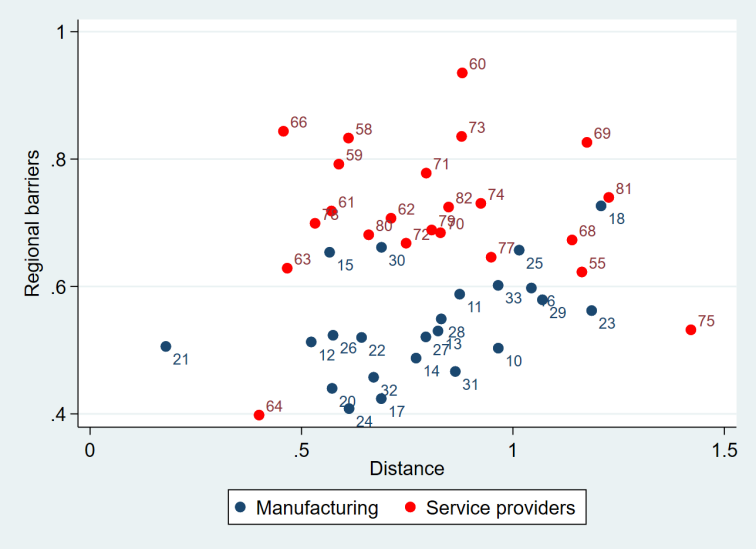
Finally, vertical integration is naturally a strong determinant of business transaction, implying almost always a transaction between the parent and the affiliate[10].

These results are robust to alternative specifications involving different level of localisation dummies (at the zip level) or firm fixed effects. To check the robustness of our results, and especially of the results related to our geographical variables, we've estimated for the 2012 cross-section a logit equation with buyer and seller specific fixed effects. Because of the large number of coefficients evolved in those specification, the two dimensional fixed effect logit specification is prefered as it can be efficiently estimated using a linear transformation with reghdfe. These estimations have been conducted for each two digit sector separately on the supplier side and only include transaction ij specific explanatory variables ($dist_{ij}$ and $\neq Region_{ij}$) . Estimating at the nace 2 digit level for only one single cross-section allows us to include all the "0" in our specification for each supplying sector. In this case, we model carefully why firm i has decided to source some tasks from firm j and not from firm k, while k and j are in the same industry. The results related to the impact of distance and of the regional barriers for manufacturing and service industries are summarized in Figure 3. Globally, they are in line with our baseline results in Table 4.

From this sectoral analysis, it seems that the impact of distance, even if it is always sizeable, varies strongly across sectors both within the manufacturing or the services sectors but do not differ signifcantly across those two broad sectors. However, the influence of the regional barriers seems to be larger for services. If the semi-elasticity associated to that variable seems to be below 0.6

[10]This result raises the issue of the definition of the firm's border in the empirical literature. The increased phenomenon of spin-offs and the organisation of some firms among multiple legal units for any kind of fiscal or organization reason, especially of large corporations challenges the way we not only define business transactions (is it a relevant sourcing decision ?) but, in other contexts, how we measure firms performance. Ideally, a researcher would like to observe the flows between production units and the characteristics of those production units (employment, production) but in most case, what is available is information at the level of a legal unit (in Belgium, a VAT unit) and according to the organisational form of the firm, you may end up either observing transactions between multiple VAT numbers or no intra-firm trade.

Figure 3: Elasticity with respect to $\log Distance_{ij}$ and $\neq Region_{ij}$ based on FE Logit estimates by supplying sector, only using 2012 cross-section



Note: Elasticities are reported in absolute value. All estimated elasticities are negative.

in manufacturing, in most service sectors, it is above that threshold.

4.3 The intensive margin of local sourcing

In section 4.2, we investigate the determinants of the decision to establish a business relationship with a potential supplier. In this section, we exploit the value of the transaction to analyse how firms and geographic characteristics affect the amount supplied by firm j to firm i. We therefore estimate a Eaton-Kortum Tobit equation of the amount traded between i and j, censoring our dependent variable to the minimum amount delivered by supplier j to any firm in the Belgian network. The dependant variable is expressed in relative term with respect to the total sales of i. We then take the log of that share. Results are presented in Table 5.

The results obtained are in line with Equation (4) of our model. When firms source from remote locations, they tend to trade less because of increasing variable costs. Similarly, variable costs are associated to the cultural barriers. Controlling for their total sales, firms naturally source more tasks to more efficient or bigger suppliers. The degree of "intrinsic efficiency" of the firm however reduces the relatve amount traded with the other firms. This reflects two phenomenoms. First, as more efficient firms source from more suppliers, each of them may represent a smaller share of the total sales of firm i. Second, as*i* is more intrinsicly efficient, it's own contribution to the value of the final good may be larger. In terms of sectoral differences, it seems that transportation costs are

Table 5: Contribution of firm j to firm i's total sales: dependent variable : $\ln \frac{sales_{ijt}}{sales_{it}}$

	All suppliers / All firms	Services suppliers / All fims	Manufacturing suppliers / Manufacturing firms
$dist_{ij}$	-1.556^{***}	-1.522^{***}	-1.348^{***}
	(0.0031)	(0.0045)	(0.0112)
$\neq Region_{ij}$	-1.627^{***}	-1.987^{***}	-1.523^{***}
	(0.0084)	(0.0113)	(0.0271)
$\widetilde{tfp}_{i,t-1}$	-0.219^{***}	-0.204^{***}	-0.221^{***}
	(0.0155)	(0.0097)	(0.024)
$\widetilde{tfp}_{jt}$	0.528^{***}	0.619^{***}	0.395^{***}
	(0.0028)	(0.0045)	(0.0147)
$l_{i,t-1}$	0.085^{***}	0.125^{***}	0.241^{***}
	(0.0057)	(0.0054)	(0.0130)
l_{jt}	0.759^{***}	0.762^{***}	0.459^{***}
	(0.0021)	(0.0031)	(0.0084)
$Participation_{ijt}$	11.134^{***}	13.191^{***}	12.984^{***}
	(0.2913)	(0.5569)	(1.2507)
Year dummies		Yes	
i and j district code dummies		Yes	
i and j sector dummies		Yes	
Additional controls		Yes	
Observations	$100,503,555$	$2,489,522$	$22,506,683$

Note: Sample of all B2B transactions observed in Belgium, completed by 100 potential transactions for each buyer, for the 2003-2012 period. The explained variable is the log of the ratio of $sales_{ijt}$, the amount in EUR of tasks / inputs sourced by firm i from firm j at time t and the total sales of firm i. $dist_{ij}$ is the log of the "as the crow fly" distance in km. $\neq Lang_{ij}$ is a binary variable indicating that firms i and j do not share a common language. $\widetilde{tfp}$ is the log of total factor productivity estimates purged from the contribution of the sourcing strategy followed by the firm (at the NACE 2-digit level using the Wooldridge-LP estimator). l is the log of number of employees, in FTE. $Participation_{ijt}$ is a dummy variable indicating that i or j owns at least 50% of the capital of the other firm. Additional controls include sectoral dummies for i and j, dummies for the degree of internationalization of i or j (exporter, importer, MNE) or if i or j are multiplant firms. Standard errors of the estimated coefficients are clustered at the sourcing firm level.Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

larger for the supply of manufacturing inputs while cultural barriers are more effective when services are exchanged. The large impact of vertical integration on the amount of trade also strengthens the argument of the relevance of the definition of the boundary of the firms when analysing B2B transactions.

5 The cost of imperfect integration

Using the results of our Probit estimates, we are able to compute firm-specific average responses to changes in trade costs or in cultural / regional trade barriers. Using those heterogenous responses, we can than evaluate the impact of several scenarios on the number of B2B relations created or destroyed by those changes, especially how many service suppliers may be added / dropped in the firm specific sourcing strategies.These responses can then be used to assess the TFP gains or losses implied by those changes.

In this section, we have consider 5 different scenarios of trade cost changes (measured as changes in the distance coefficient of our probit equation for services sourcing) and 5 different scenarios of changes in regional barriers (measured as changes in the different language dummy of the same equation).

The 5 scenarios considered for each shock k ($k = 1$ represents a variable trade cost shock, $k = 2$ represents a regional trade barrier shock) are :

- No variable trade cost / regional barriers : $\beta_k = 0$
- Reduction of variable trade costs / regional barriers by 50% : $\beta_k = .5\hat{\beta}_k$
- Reduction of variable trade costs / regional barriers by 10% :$\beta_k = .9\hat{\beta}_k$
- Increase of variable trade costs / regional barriers by 10% : $\beta_k = 1.1\hat{\beta}_k$
- Increase of variable trade costs / regional barriers by 50% : $\beta_k = 1.5\hat{\beta}_k$

We also consider a scenario where both variable trade costs / regional barriers for services are set simultaneously at their level for the sourcing of industrial inputs, $\beta_{k,services} = \beta_{k,manufacturing}$and a scenario where the cost of matching would be zero implying that all service suppliers would suppliers every firms in our sample.

A reduction of variable trade costs could be achieved by ICT developments, reduction of traffic congestion, improvement of transport infrastructure while an increase would translate worsening quality and congestion of the transport and telecommunication infrastrucure. Reduction of regional barriers may be achieved by a better knowledge of the other national languages and reduction of barriers to entry in the different regional markets.

Those scenarios and their combinations generate the following average relative probability changes $\left(\frac{\Delta P}{P}\right)$ and its implied changes in the service outsourcing strategy at the firm level :

These new firm specific sourcing strategies are used as inputs in the production function 8 and a counterfactual level of apparent productivity is computed

Table 6: Average relative connection probability changes, average number of connection created or destroyed and average productivity gains
implied by changes in trade costs and/or regional barriers

[p5-p95] range in brackets

	Relative change in probability		Implied change in # of connections		Implied TFP gains	
	$dist_{ij}$	$\neq Lang_{ij}$	$dist_{ij}$	$\neq Lang_{ij}$	$dist_{ij}$	$\neq Lang_{ij}$
$\beta_k = 0$	44.7	2.48	358.5	1.94	0.22	0.006
	[25.7 ; 71.0]	[0 ; 3.09]	[42.8 ; 978.9]	[0 ; 9.43]	[0.15 ; 0.29]	[0 ; 0.033]
$\beta_k = .5\hat{\beta}_k$	6.2	0.86	53.5	0.70	0.10	0.002
	[4.4 ; 8.4]	[0 ; 1.05]	[6.0 ; 151.9]	[0 ; 3.41]	[0.05 ; 0.15]	[0 ; 0.013]
$\beta_k = .9\hat{\beta}_k$	0.49	0.13	4.5	0.11	0.016	0.0004
	[0.40 ; 0.59]	[0 ; 0.16]	[0.49 ; 13.1]	[0 ; 0.53]	[0.006 ; 0.028]	[0 ; 0.0.002]
$\beta_k = 1.1\hat{\beta}_k$	−0.33	−0.11	−3.1	−0.09	−0.014	−0.0004
	[−0.37 ; −0.28]	[−0.144 ; 0]	[−9.0 ; −0.33]	[−0.47 ; 0]	[−0.026 ; −0.004]	[−0.002 ; 0]
$\beta_k = 1.5\hat{\beta}_k$	−0.86	−0.45	−8.2	−0.38	−0.05	−0.0015
	[−0.91 ; −0.79]	[−0.52 ; 0]	[−24.5 ; −0.86]	[−1.89 ; 0]	[−0.098 ; −0.012]	[−0.008 ; 0]
$\beta_k = \hat{\beta}_{k,manuf}$	1.72		14.80		0.043	
	[1.31 ; 2.19]		[1.45 ; 43.67]		[0.017 ; 0.071]	

Note: The relative probabilty changes measure the impact on the probability of a firm to trade with any other firm in Belgium.

and compared with the current apparent productivity level. Removing the variable trade cost ($\beta_1 = 0$) leads to an average productivity gains of 22% of a similar magnitude as the gains implied by current level of sourcing compared to a no sourcing scenario. Reductions of trade costs by 10 or 50% lead respectively to average productivity gains by 1.6% and 10%. Removing cultural barriers have a much smaller impact. On average, a complete removal of regional or cultural barriers between the Walloon Region and Flanders lead to a very modest average productivity gain of 0.6%. Still this average impact for Belgium hides large regional discrepancies. In fact, removing regional and cultural trade barriers between Flanders and Wallonia would mostly benefit to Walloon firms. On average a firms located in the Walloon Region could benefit from a 1.6% increase in production efficiency through an easier trade with its Flemish counterparts. Firms located in Flanders, on the oppositive would only marginally increase their productivity (on average by 0.25%). If trade in services was as easy as trade in manufacturing goods, this would lead to an average increase of productivity of 4.3%.

All in all, these productivity gains are not negligeable and plead for a deeper integration of the Belgian economy, especially by reducing the variable trade costs.

6 Conclusion

In this paper, we document the local sourcing strategy of Belgian firms. Exploiting an exhaustive dataset on firms' buyer-seller linkages in Belgium, we are able to fully describe the sourcing behaviour of each individual firm. First, we provide descriptive statistics on the distance between the supplier and the buyer by stressing the fact that most firms tend to trade with local partners. Perhaps more surprisingly, selection into local sourcing exhibits complementarities across sectors of activities. As a result, firms follow a predictable pecking order in their sourcing decision. Even though most firms buys inputs from suppliers operating in the wholesale, retail, transportation or network industries (energy provider or telecommunications), inputs from services sectors and, to a lesser extent, from the manufacturing sectors are crucial in explaining the heterogeneity in the extensive margins of local sourcing.

Based on a modified version of the global sourcing model of Antras et al. (2017), we model local sourcing as trade in tasks, with firms deciding on the set of tasks they want to keep in house and the ones they want to outsource to other (domestic) firms. Under this framework, more efficient and less distant suppliers are more likely to be chosen. The share of tasks is increasing in the supplier's productivity and decreasing both in the geographic distance between the supplier and the buyer and in the buyer's productivity.

The results obtained in the empirical part are basically in line with the predictions of the model. These results are robust to alternative specifications involving different level of localisation dummies or firm fixed effects. From a sectoral analysis, we show that the impact of distance, even if it is always

sizeable, varies strongly across sectors both within the manufacturing or the services sectors but do not differ significantly across those two broad sectors.

We finaly show that the location of the firm has some strong impact on this performance as it affects its connectivitity in the Belgian network.Firms located in places where connectivity to suppliers is high exhibits higher productivity levels. Our estimates suggest that total factor productivity in Belgium would be on average 4.3% higher if all firms were as well connected as in the best connected area in Belgium. Removing regional trade barriers would also improve the global efficiency of Belgian firms, especially in the Walloon region, by allowing an easier access to the denser economic fabric of Flanders.

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