Local sourcing and production efficiency

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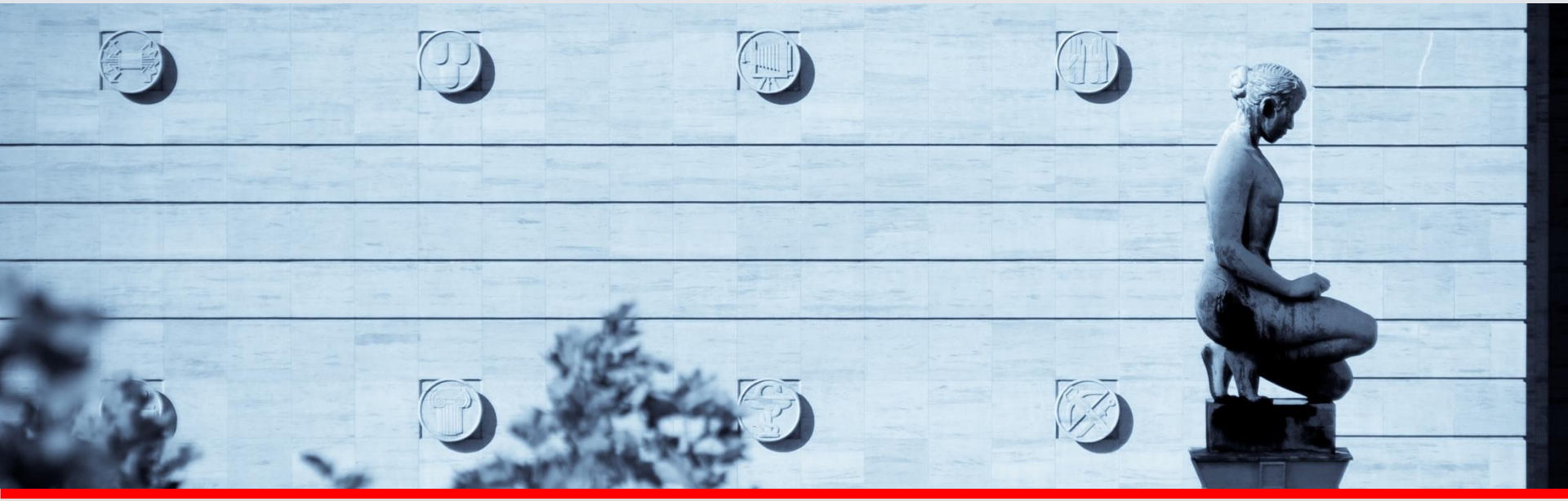
Emmanuel Dhyne (BNB, UMONS)
Cédric Duprez (BNB)



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Structure

- Motivation
- A model of local and global sourcing
- The Belgian production network
- Bringing the model to the data
  - Using individual transactions data
  - Using firm x province data
  - Using firm data
- Concluding remarks

Motivation

- Reduction in trade costs + ICT revolution has totally alter the organization of production within firms
- => increased fragmentation of production process
- Old model : (Almost) all the tasks required to produce a final good (design, production, supporting activities) were done in house
- New model : Each firm focuses on its core abilities and outsource / offshore its non core activities
- Global Value Chains : well documented phenomenon in the international trade literature + well-know examples (Apple, Airbus)
- Local Value Chains : less documented, mostly because of lack of data but…
- … 84% of trade in intermediaries are domestic trade

Efficiency gains drives the local / global fragmentation of the production process

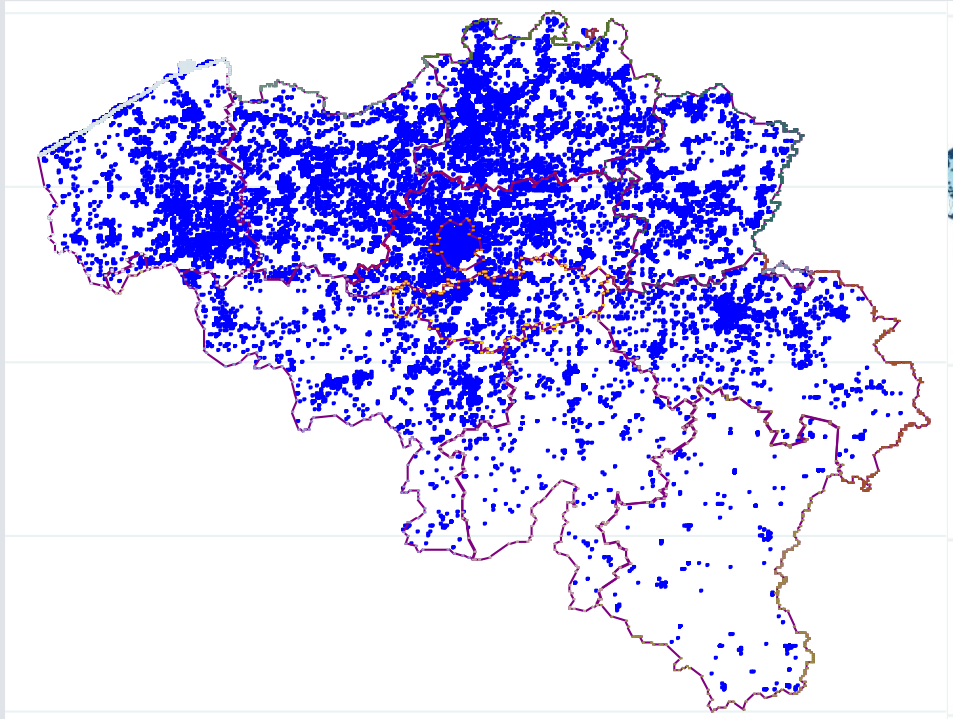
Guy Spends 6 Months, $1,500 To Make A Sandwich Entirely From Scratch

By Mary Beth Quirk September 16, 2015

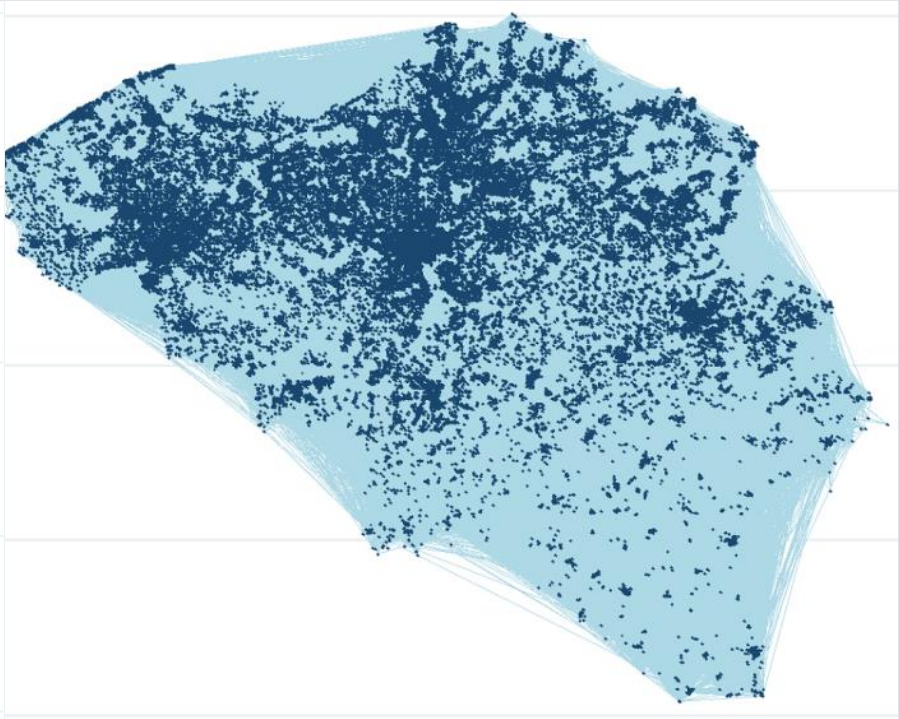
(How to Make Everything)

A complex domestic production network

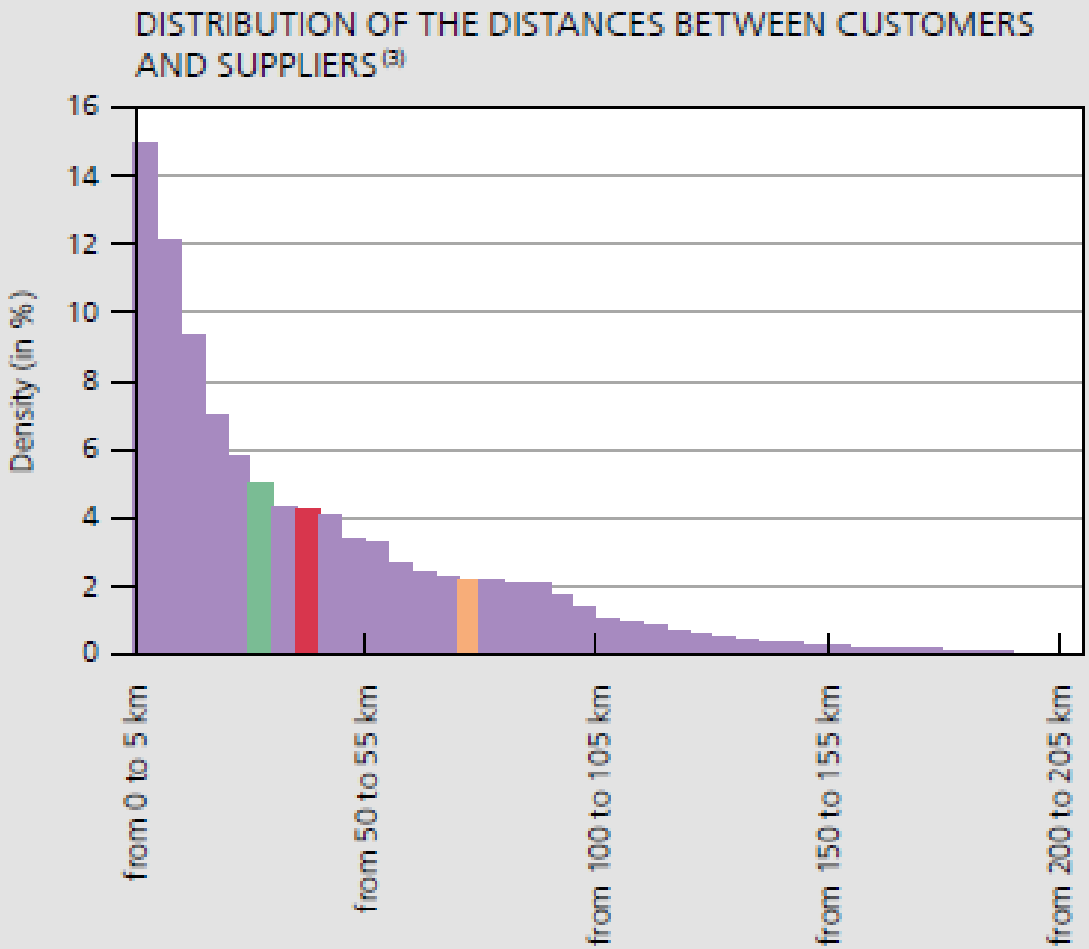
Number of nodes (+700k firms)



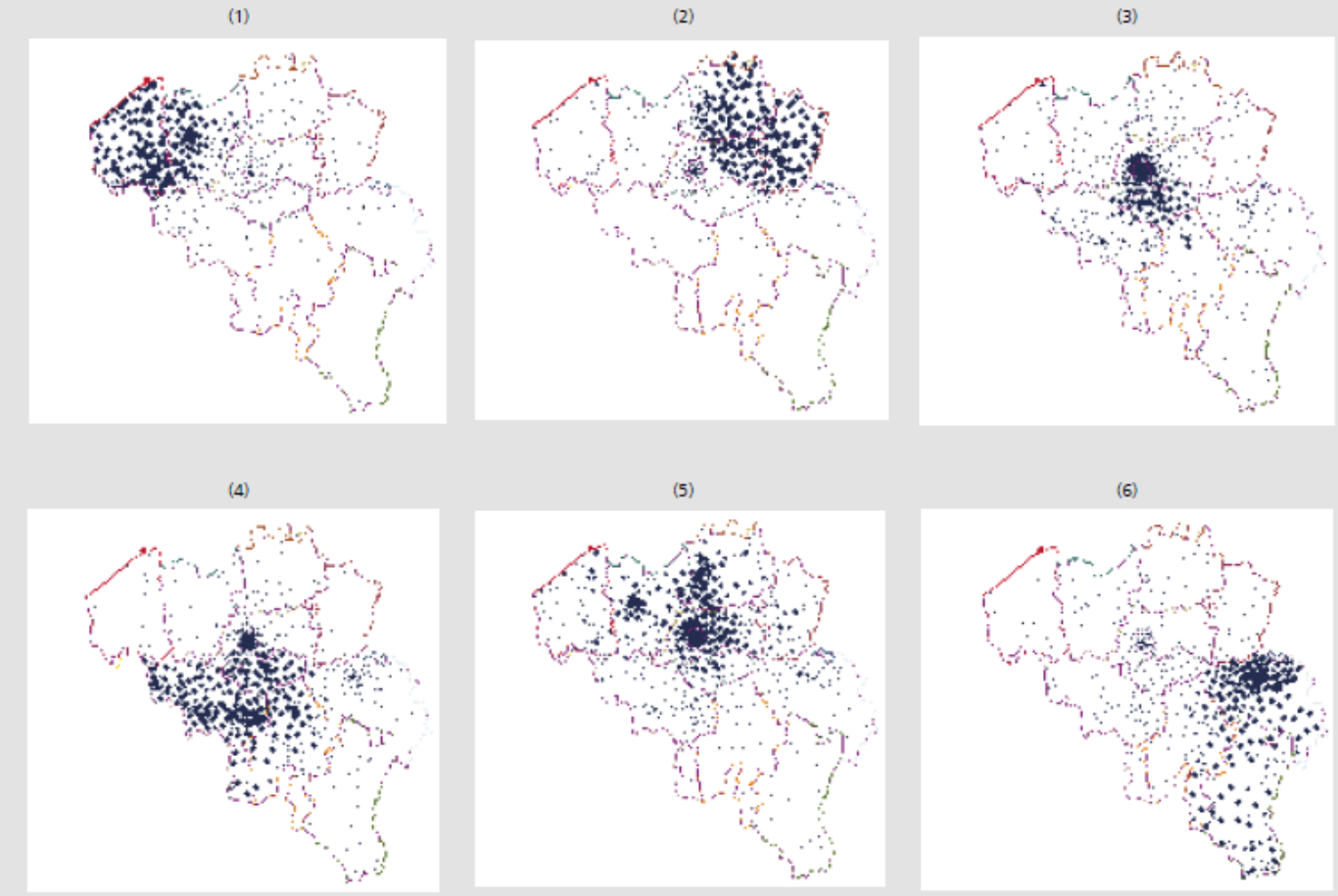
Number of links (+16,000k transactions)



Gravity matters even within a small country like Belgium



Domestic trade organizes itself within clusters



Related literature

- Determinants of foreign sourcing
  - Amiti and Konings (2007), Golberg *et al.*, (2010), Halpern *et al.* (2015), Bøler *et al.*, (2015), Antràs, Fort and Tintelnot (2017)
- Determinants of local sourcing
  - Bernard *et al.*, (2015), Furusawa *et al.*, (2017)
- Organization of production network
  - Oberfield (2013)
- Characterization of the production chain
  - Antràs *et al*. (2012), Fally (2011)

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A model of local and global sourcing

- Adaptation of AFT (2017) multi-country sourcing model at a local level
- Model with firms producing final goods by aggregating intermediate tasks
- Firms do not trade intermediate goods but tasks
- Main driver of inter-firm trade : heterogeneity in the ability to perform a subset of tasks
- Tasks can be traded locally and internationally
- Trade in tasks entails fixed and variable costs

Ex: Why do some bakers only bake and some only sell ?

- Final product : Bread
- Tasks required to sell bread to final consumer :
  - (1) Conception and R&D : development of a new recipe + design of the bread loaf
  - (2) Sowing, growing and harvesting the wheat
  - (3) Milling the wheat
  - (4) Mixing the flour with water (endowment)
  - (5) Baking the bread
  - (6) Selling the bread
  - (7) + book-keeping, marketing, finance (customer credit),….
- The baker's abilities are in tasks (4) and (5) and potentially in (1) and (6). Outsourcing tasks (2), (3) and (7) may raise profits,
- Extreme case : Only good in (6), outsourcing all other tasks

Set-up

- Preferences are CES. Demand in country *c* for variety ω is

$$q^c(\omega) = E^c(P^c)^{\sigma-1}p^c(\omega)^{-\sigma}$$

- Monopolistic competition. Each firm owns a blueprint to produce a single variety ω

- Production requires the assembly of a unit continuum of tasks. Marginal cost of firm *i* is

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

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

Set-up

- Firms draw all their unit labor requirements associated with task t, $a_i(t)$, from the Frechet distribution (EK, 2002)

$$Pr(a_i(t) \geq a) = e^{-\gamma_i a^{\theta}}$$

- γ_i, the ability to manage tasks, is the source of firm heterogeneity (cf. Bloom *et al.*, 2017, Syverson, 2011)

- All firms can produce all tasks in-house, or they can concentrate on their core (good draws) tasks and outsource the remaining tasks

- Outsourcing entails fixed (f_{ij}) and variable costs (τ_{ij}) $z_i(t) =$

$$\min_{j \in J_i} \{\tau_{ij} a_j(t) w_j\}$$

with *Ji* the set of firms (including *i*) for which *i* has paid the fixed cost f_{ij} (f_{ii}=0)

Optimal sourcing strategy

- From Frechet distribution, the share of tasks sourced from any supplier j is

$X_{ij} = \frac{\gamma_j (\tau_{ij} w_j)^{-\theta}}{\Theta_i}$ with sourcing strategy $\Theta_i = \sum_{k \in Ji} \gamma_k (\tau_{ik} w_k)^{-\theta}$ (AFT, 2017)

- Using the properties of the Frechet and constant mark-up, firms' profit is

$$\underset{I_{ij} \in \{0,1\}}{\text{Max}} \left(\sum_j I_{ij} \gamma_j (\tau_{ij} w_j)^{-\theta} \right)^{(\sigma-1)/\theta} B_i - w_i \left(\sum_j I_{ij} F_{ij} \right)$$

- If $\sigma - 1 > \theta$, sourcing exhibits complementarities. The marginal gain from adding a new supplier increases with the addition of other suppliers.

Empirical predictions

- Under the complement case ($\sigma - 1 > \theta$),

  more efficient firms (i) have more suppliers.

  To do so, (ii) they follow a predictable pecking order

  by adding to their supplier's set (iii) more remoted suppliers and/or

  (iv) less efficient suppliers

- If $\frac{dF_{ij}}{d\gamma_j} > 0$, then more efficient firms are able to choose more efficient suppliers

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The Belgian production network

- Based on four firm level data sources
  - Annual accounts of the firms (financial declarations providing info on value added, employment, capital stock and turnover and total input consumption for large firms, …)
  - VAT annual declaration at the tax administration (turnover and input consumption)
  - Annual imports and exports by country of origin / destination at the firm level
  - Annual declaration of domestic sales to business customers, by customers (see Dhyne, Magerman, Rubinova, 2015)
    - Provides all B-to-B transactions between two Belgian VAT entities (firms, not plants)
    - Reporting threshold of a B-to-B transaction : 250 EUR per year
    - Raw data of 166 millions transactions (17 millions in 2012)
    - Similar to an annual (700k x 700k) input-output matrix between firms
    - Allows to characterize the domestic organization of production chains in Belgium

The sourcing strategies of Belgian firms

Descriptive statistics - Sourcing strategies in 2012

	p10	p25	p50	p75	p90	Mean
Number of domestic suppliers	1	4	9	23	47	21.2
Share of importers (in %)	-	-	-	-	-	5.1
Number of sourcing foreign countries (conditional on international sourcing)	1	1	2	4	9	3,8

Note : Sample size = 797,596 Belgian firms

The geography of domestic sourcing

Ranking of Belgian provinces by outsourcing area

	Outsourcing area											
	BXL	BRW	BRF	ANV	LIM	LIG	NAM	HAI	LUX	FLC	FLR	BE
BXL	1	2	3	2	4	2	2	2	2	3	3	1
BRW	4	1	7	9	9	10	7	8	11	9	8	9
BRF	2	3	1	3	3	4	4	3	5	5	4	3
ANV	3	5	2	1	2	3	6	4	6	4	2	2
LIM	10	10	5	5	1	7	11	10	9	6	6	6
LIG	8	7	9	8	7	1	5	9	4	8	9	8
NAM	9	6	10	10	10	6	1	5	3	10	10	10
HAI	5	4	7	7	8	5	3	1	7	7	7	7
LUX	11	11	11	11	11	11	8	11	1	11	11	11
FLC	7	8	6	6	6	9	9	6	8	1	5	5
FLR	6	9	4	4	5	8	10	7	10	2	1	4

Peaking order of sourcing area is not random

Table 3: Compliance with the peaking order in actual data and counterfactual

	Data	Random entry
At the firm level:		
Belgian provinces	37.2%	15.8%
At the relation level:		
Belgian provinces	67.4%	39.1%
Belgian provinces+ foreign countries	64.5%	37.2%
Belgian districts	44.2%	23.5%
Belgian districts + foreign countries	42.7%	22.7%
Belgian Province/Sectors of activity	26.5%	13.5%
Belgian district/Sectors of activity	16.8%	8.2%

Note : Each cell represents the fraction of firms or transactions that follow exactly the peaking order of suppling areas (either provinces or districts, crossed or not with NACE sectors) in the data and in a counter-factual exercise of random selection of supplying areas. Bootstraps based on 1,000 replications of both measures show that the two measures are significantly different at the 1% level.

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Using individual transactions data

- Estimation of Heckit model
  - Heckman 1st stage : Probit equation of a transaction between *i* (buyer) and *j* (supplier)
  - Heckman 2nd stage : Amount traded between *i* and *j*, conditional on selection
- Use only one cross section for 2012
- Similar results obtained for other cross-sections
- 1st stage equation :
  - we observe all the “1”s (5,023,543 transactions with explanatory variables), involving 110,129 firms, but too many “0”s (12,123,262,969 potential transactions)
  - Random selection of 8,659,331 “0”s + weighting Probit
  - Selection variable : *i* and *j* belong to the same sub-network

Why does *i* outsource some tasks to *j* ?

Table 5: Probit equation : firm i sources inputs from supplier j [1]

	Estimated coefficient	AME
$Distance_{ij}$ [2]	-0.263***	-0.364***
TFP_i [3]	0.124***	0.159***
TFP_j [3]	0.148***	0.189***
Firm i in Flanders, supplier j in Wallonia	-0.243***	-0.244***
Firm i in Flanders, supplier j in Brussels	-0.103***	-0.126***
Firm i in Wallonia, supplier j in Flanders	0.006	0.008
Firm i in Wallonia, supplier j in Wallonia	0.099***	0.160***
Firm i in Wallonia, supplier j in Brussels	0.039***	0.059***
Firm i in Brussels, supplier j in Flanders	-0.093***	-0.115***
Firm i in Brussels, supplier j in Wallonia	-0.102***	-0.124***
Firm i in Brussels, supplier j in Brussels	-0.357***	-0.311***
Firm i and supplier j are financially linked	2.943***	222.3***
Firm i and supplier j in same sub-network	0.358***	0.555***
Firm i has multiple establishments	0.137***	0.202***
Supplier j has multiple establishments	0.253***	0.412***
Number of observations	13,469,723	
Pseudo R^2	0,163	

(1) The equation also include two sets sectoral dummies, the first one for firm i and the second for supplier j, two sets of dummies identifying in which sub-network i or j belong and dummies for the degree of internationalization of i or j (exporter, importer, MNE). Clustered standard errors by firms are in brackets. *** means significant at the 1% level. Average Marginal Effects are multiplied by 1,000. (2) Inverse hyperbolic sin of the “as the crow fly” distance between firm i and supplier j . (3) Total factor productivity, in log, estimated using the Wooldridge LP method.

How much does *i* outsource to *j* ?

Table 6: Heckman 2 stage estimation : log of annual deliveries from supplier j to firm i[1]

	Linear regression
$Distance_{ij}^{(2)}$	0.114***
$Size_{i}^{(3)}$	0.168***
$TFP_{j}^{(4)}$	0.102***
Firm$i$ in Flanders, supplier j in Wallonia	0.108***
Firm i in Flanders, supplier j in Brussels	0.060**
Firm i in Wallonia, supplier j in Flanders	0.029***
Firm i in Wallonia, supplier j in Wallonia	-0.081***
Firm i in Wallonia, supplier j in Brussels	-0.014**
Firm i in Brussels, supplier j in Flanders	0.057***
Firm i in Brussels, supplier j in Wallonia	0.018
Firm i in Brussels, supplier j in Brussels	0.268***
Firm i and supplier j are financially linked	2.439***
Firm i has multiple establishments	-0.018**
Supplier j has multiple establishments	-0.177***
Inverse Mills Ratio	-0.421***
# of observations	4,810,382
R^2	0,115

(1) The equation also include two sets sectoral dummies, the first one for firm j and the second for supplier i and dummies for the degree of internationalization of i or j (exporter, importer, MNE). Clustered standard errors by firms are in brackets. *** means significant at the 1% level. (2) Inverse hyperbolic sin of the “as the crow fly” distance between supplier j and firm i. (3) Employment in full time equivalent, in log. (4) Total factor productivity, in log, estimated using the Wooldridge LP method.

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Using firm x province level data

- Aggregating transactions at the province level for either the suppliers or the customers
- Number of suppliers of firm *i* by province
- Number of customers of firm *i* by province
- Unbalanced panel of firms observed between 2002 and 2012

How many suppliers / customers by Belgian province ?

Table 7: Analysis of the characteristics of firm i's suppliers or customers located in province j

Dependent var.	# of suppliers		# of customers	
$TFP^{(1)}_{i;t-1}$	1.511***	0.322***	3.141***	0694***
$Size^{(2)}_{i,0}$	1.776***	-	3.141***	-
$Importer_{it}$	1.164***	0.301***	1.708***	0.461***
$Exporter_{it}$	0.676***	0.133***	0.979***	0.253***
$Two\ way\ trader_{it}$	1.396***	0.442***	2.675***	0.516***
$Belgian\ group_{it}$	0.908***	0.194***	1.079***	-0.109
$Belgian\ MNE_{it}$	12.593***	0.883***	5.619	3.138
$Foreign\ MNE_{it}$	6.737***	0.407	21.071***	1.366
$Multiple\ establishments_{it}$	1.658***	0.927***	6.455***	2.775***
Firm FE	No	Yes	No	Yes
# observations	10,568,690	10,568,690	9,108,803	9,108,803
R^2	0.294	0.482	0.073	0.449

Note : All specifications include a set of sectoral dummies at the NACE rev 2. 2 digit level, a set of dummies indicating the peaking order of Belgian provinces that prevail in the province of firm I and a set of year dummies for the 2002-2012 period. Clustered standard errors by firms are in brackets. *** means significant at the 1% level. (1) Total factor productivity, in log, estimated using the Wooldridge LP method. (2) Initial size, in log, measured by the level of employment in the first year of observation of the firm in our estimation sample,

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Using firm level data

- Aggregating at the firm level data allows to analyze the characteristics of the suppliers of firm *i*
- Maximum distance between *i* and one of its suppliers
- TFP of the least efficient supplier
- TFP of the most efficient supplier
- Unbalanced panel of firms from 2002 to 2012

Characteristics of the set of *i*'s suppliers

Table 8: Analysis of the characteristics of firm i's suppliers

Dependent var.	Largest distance between i and suppliers in j		TFP of ... less productive supplier		TFP of ... most productive supplier	
$TFP^{(1)}_{i;t-1}$	8.951***	2.262***	-0.259 ***	-0.087***	0.079***	0.018***
$Size^{(2)}_{i,0}$	7.949***	-	-0.333***	-	0.046***	-
$Importer_{it}$	9.782***	2.053***	-0.388***	-0.097***	0.027***	0.011***
$Exporter_{it}$	7.896***	1.379***	-0.381***	-0.068***	0.035***	0.013***
$Two\ way\ trader_{it}$	5.320***	1.200***	-0.214***	-0.139***	0.004*	0.018***
$Belgian\ group_{it}$	0.748***	0.641***	0.131***	-0.011	-0.0301***	-0.003
$Belgian\ MNE_{it}$	1.455*	1.429*	0.139***	-0.051	-0.034***	0.006**
$Foreign\ MNE_{it}$	-5.561***	1.260*	0.351***	-0.037	-0.090**	-0.0003
$Multiple\ establishments_{it}$	1.159***	2.593***	-0.050***	-0.079***	-0.016***	-0.001
Firm FE	No	Yes	No	Yes	No	Yes
# observations	808,534	996,908	954,266	954,266	954,266	954,266
R^2	0.436	0.784	0.142	0,596	0.041	0,452

Note : All specifications include a set of sectoral dummies at the NACE rev 2. 2 digit level and a set of year dummies for the 2002-2012 period. Clustered standard errors by firms are in brackets. ***, ** and * mean significant at respectively the 1%, the 5% and the 10% level, . (1) Total factor productivity, in log, estimated using the Wooldridge LP method. (2) Initial size, in log, measured by the level of employment in the first year of observation of the firm in our estimation sample.

How large is the fixed cost to outsource from *j* ?

- To assess the importance of the fixed cost associated to source from a specific supplier, we compare
- *j*'s rank in terms of number of business customers
- *j*'s rank in terms of total deliveries
- Firms with few (many) customers but high (low) total sales may be characterized by high (low) fixed cost

How large is the fixed cost to outsource from *j* ?

Table 7: Difference between firm rank based on number of customers and firm rank based on total annual deliveries

Dependent var.	Ranking difference	
$TFP^{(1)}_{j;t-1}$	0.148***	0.028***
$Size^{(2)}_{j,0}$	0.055***	-
$Importer_{jt}$	-0.100***	-0.007**
$Exporter_{jt}$	0.008	-0.002
$Two\,way\,trader_{jt}$	0.008	-0.017***
$Belgian\,group_{jt}$	0.064***	-0.014***
$Belgian\,MNE_{jt}$	0.285***	0.002
$Foreign\,MNE_{jt}$	0.592***	-0.006
$Multiple\,establishments_{jt}$	-0.156***	-0.037***
Firm FE	No	Yes
# observations	489,088	513,440
R^2	0.202	0.925

Note : The dependant variable is the log difference. All specifications include a set of sectoral dummies at the NACE rev 2. 2 digit level, a set of geographical dummies at the zip code level and a set of year dummies for the 2002-2012 period. Clustered standard errors by firms are in brackets. *** means significant at the 1% level, ** at the 5% level. (1) Total factor productivity, in log, estimated using the Wooldridge LP method. (2) Initial size, in log, measured by the level of employment in the first year of observation of the firm in our estimation sample,

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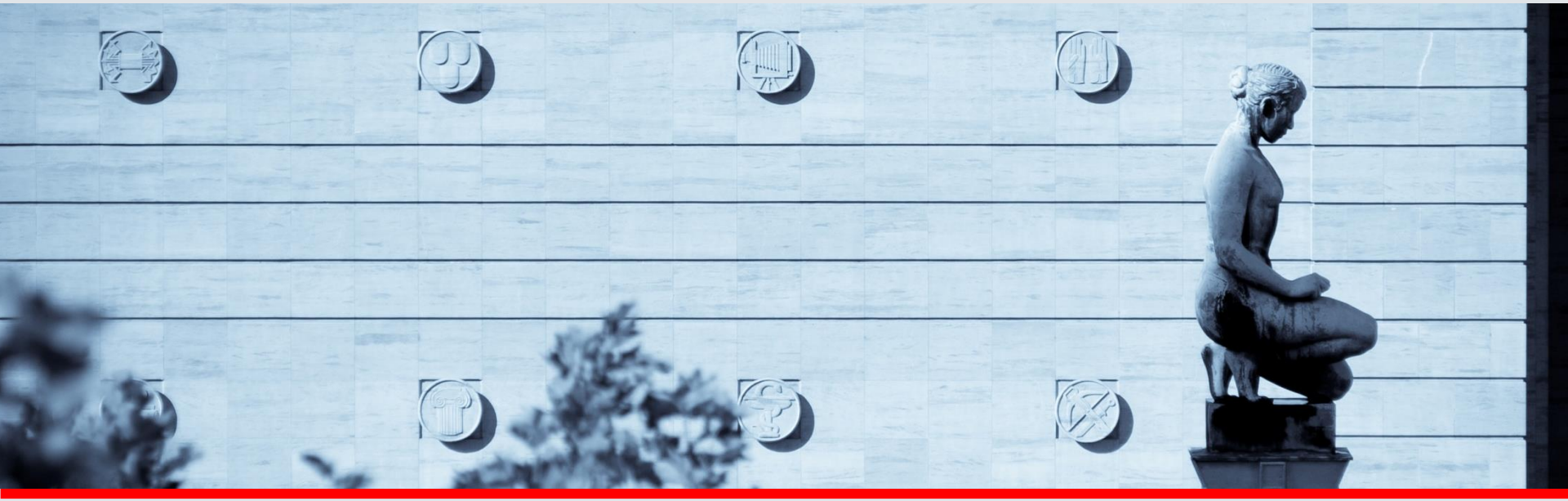
Tentative conclusions (1)

- In this paper, we present a model of local and global sourcing of intermediate tasks and confront its main prediction to the Belgian production network
- We find that even at the national level, outsourcing decisions are strongly influenced by geography
- Firms tend to source mostly locally
- Most efficient firms are able to source from more suppliers, located in more distant places, being either very efficient (high fixed costs) or marginally less efficient.
- They tend to source more from closer or more productive areas.

Tentative conclusions (2)

- The fixed costs of sourcing tasks from a given firm is increasing in its…
  - TFP
  - Size
- Firms that own multiple plants have a lower fixed trade cost
- Importers are also cheaper sourcing partners.



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Discussion

- Trade in tasks enables us to abstract from complex fixed-points model
- Trade in tasks ≈ trade in value-added
- Local production chains are more « spiders » than « snakes »
  - Average length of international production chains is 3 (Antras *et al.*, 2012)
  - The average number of suppliers is 21 in the Belgian production network (10% having more than 47 suppliers)
- Less convenient for sequential manufacturing production chains
  - But trade in intermediate services is prevalent in our data (70% of total trade in intermediates)