Local or global sourcing and firms' performance : Empirical evidence from the Belgian Production Network

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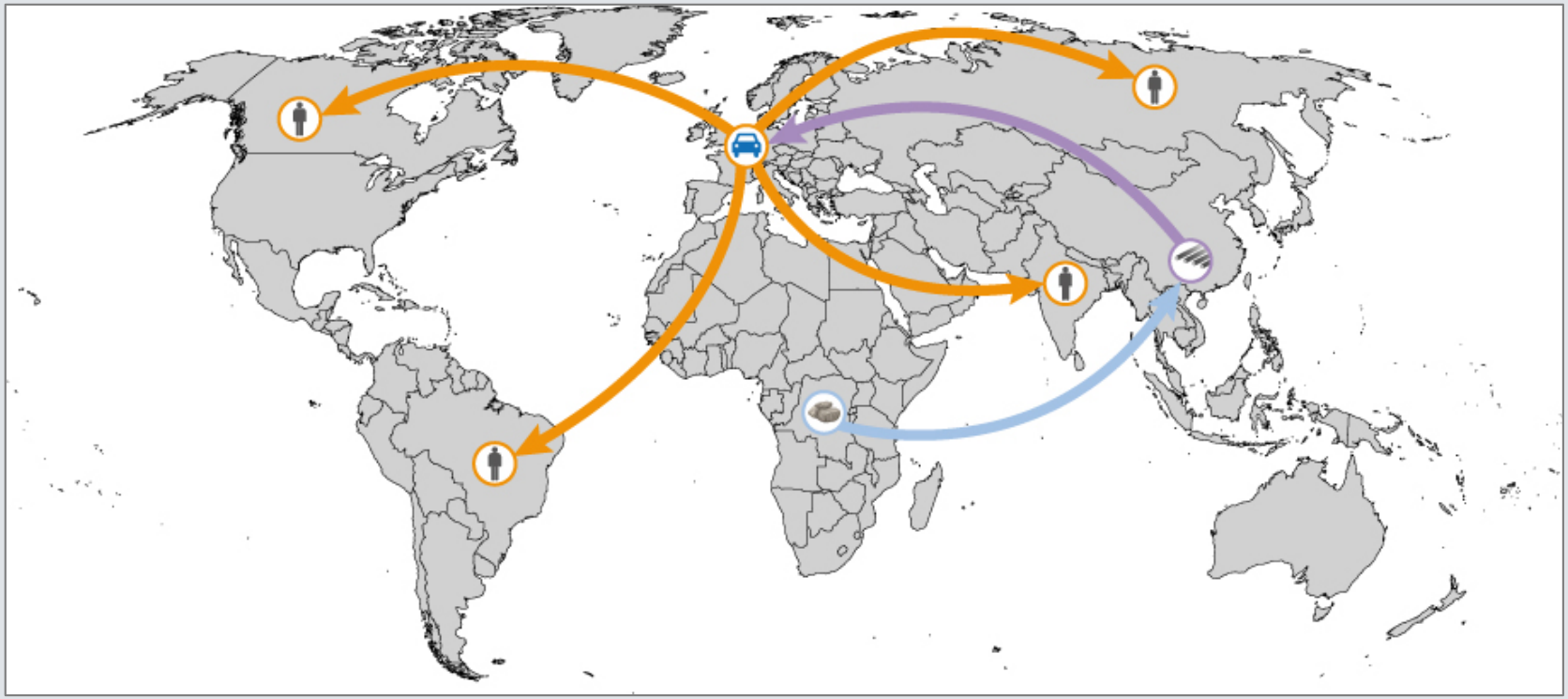
National Bank OF BELGIUM
Eurosystem

Motivation

- Belgium = Small open economy
- X/GDP ratio around 80% but VAX/GDP only 30%
- Only around 9,000 (15,000) firms are exporting (importing) in a given year out of the 300,000 (based on annual accounts database) / 700,000 (based on VAT data that includes self-employed) firms active in Belgium
- Are these firms the only Belgian firms participating in GVCs ?
- Do non exporters also contribute to domestic exported value added ?
- Are non importers able to access to the foreign inputs ?
- To answer these questions, you need to address the international and local organization of the production chains.

Motivation

- Production processes are sequential in nature, not only at the global level…



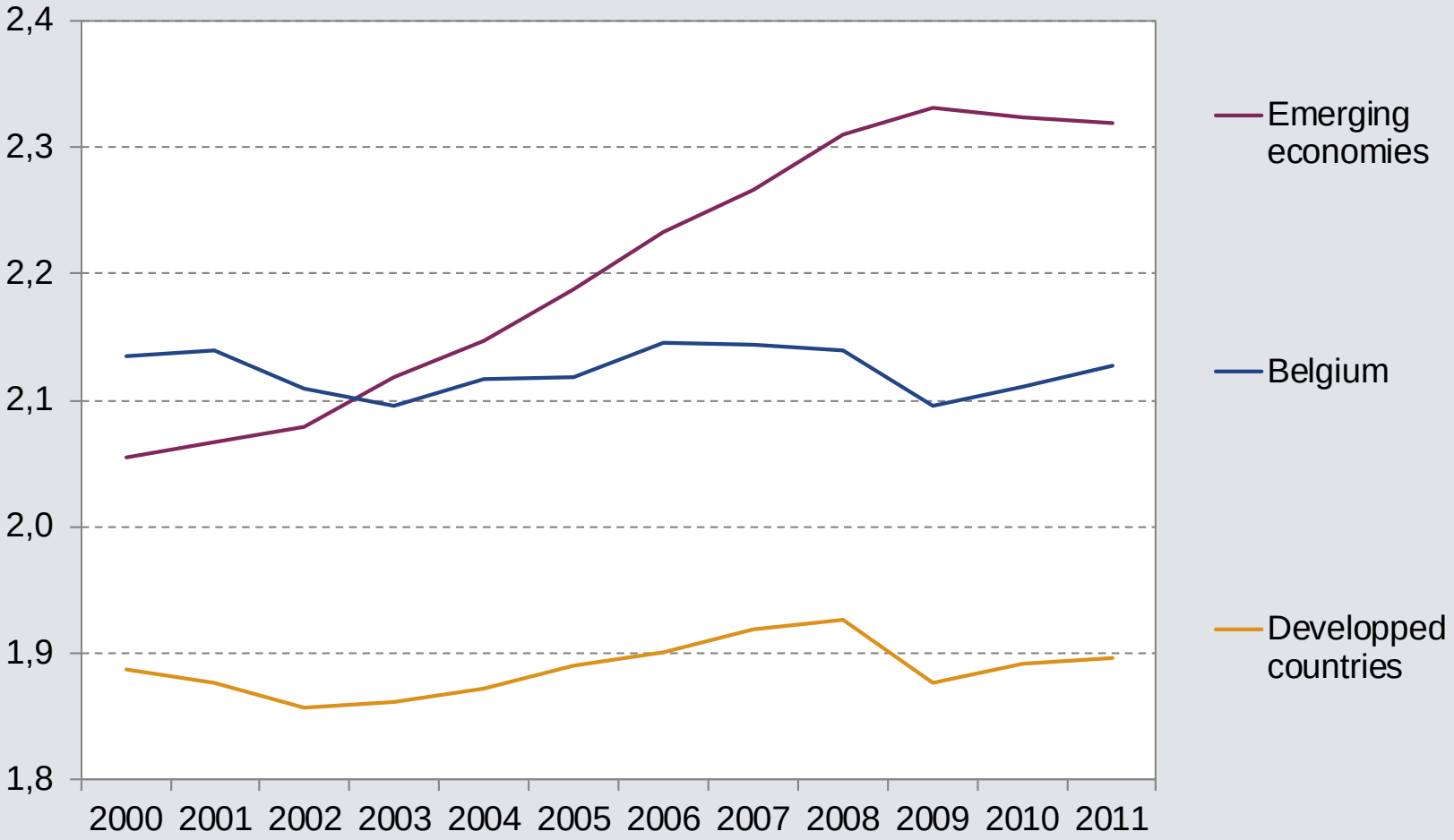
Motivation

- … but also locally.

- What are the implications of sequential production for firm size, performance and survival?

Motivation

- Upstreamness at macro level



Related literature

- Domestic suppliers of exporters
  - Dhyne and Rubinova (2016), Bernard *et al.* (2014)
- Production network
  - Atalay et al. (2011) for the US , Bernard *et al.* (2015) for Japan
- Characterisation of the production chain
  - Antràs *et al*. (2012), Fally (2011)
- Implications of sequential GVCs for the workings of general-equilibrium models
  - Alfaro *et al.* (2015), Fally and Hilberry (2014), Kikuchi *et al.* (2014), Antràs and Chor (2013), Costinot *et al.* (2013)
- Implications for the quantitative consequences of trade cost reductions
  - Fally and Hilberry (2014), Johnson *et al*. (2014), Yi (2003)

Structure

- A model of global and local organization of production chains
- Data – The Belgian production network 2002-2012
- Characterizing the organization of the production chains
- Preliminary results
  - Productivity and position in the G/L VCs
  - Survival / long run growth and position in the G/L VCs
  - Contribution to VA and position in G/L VCs
- Concluding remarks

Formal environment: a Coasian model

- Optimal sequential allocation of tasks between firms participating in a production chain
- Based on Kikuchi *et al*. (2014) and Fally and Hilberry (2014) rooted in Coase's work (1937) on firm boundaries
- Partial equilibrium, supply side
- Minimizing the cost of production for one unit of a single final good
- A continuum of tasks [0,1] has to be sequentially undertaken
- "Snake" organization of production: each firm chooses to carry out a range of tasks in-house and to outsource the remaining ones to one upstream firm

Diminishing return to management

- Cost of carrying out *t* tasks in-house *c(t)* is strictly convex

$$c(0) = 0,\ c' > 0,\ c'' > 0$$

- If it outsources, a firm incurs an iceberg transportation cost τ
- Purchase price of intermediate good completed up to task $j = \tau \cdot P(j)$
- A firm selling intermediate good completed up to task s chooses an optimal $t \leq s$ that solves: $\underset{t}{\text{Arg min}}\, c(t) + \tau P(s-t)$
- Two countervailing forces:
  - Diminishing return to management makes in-house production more expensive
  - Trade frictions impede full fragmentation
- Perfect competition, complete contracts, no entry costs

Optimal organization of tasks along the chain

- Cost minimizing allocations are the allocations of tasks $\{t_n\} = \{t_1, t_2, \ldots, t_N\}$ that solve:

$$\underset{N,\{t_n\}}{\text{Arg min}}\, P(1) = c(t_1) + \tau c(t_2) + \tau^2 c(t_3) + \cdots + \tau^{N-1} c(t_N)$$

$$\text{s.t. } \sum_{n=1}^{N} t_n = 1$$

- FOC: $c'(t_n) = \tau c'(t_{n+1}) \quad \Leftrightarrow \quad t_n > t_{n+1}$

- Prediction 1: firm scope is higher the further downstream in the value chain (Kikuchi *et al*., 2014)

- The model generates a nontrivial size distribution of firms, despite ex-ante identical producers

Introducing firms heterogeneity

- Firms differ in their productivity
- Firm *i* cost of carrying out task $t = c(\boldsymbol{A_i} \cdot t)$
- $\underset{N,\{t_n\}}{\text{Arg min}}\, P(1) = c(A_1 t_1) + \tau c(A_2 t_2) + \tau^2 c(A_3 t_3) + \cdots + \tau^{N-1} c(A_N t_N)$
- Prediction 2: firm's productivity is higher the further downstream in the value chain
- Ex. If we assume that $c(t) = \frac{t^{\theta+1}}{\theta+1}$,

$$P(1) = \frac{\tau^2}{\theta+1}\left[\tau^{\frac{2}{\theta}} A_1^{-\frac{\theta+1}{\theta}} + \tau^{\frac{1}{\theta}} A_2^{-\frac{\theta+1}{\theta}} + A_3^{-\frac{\theta+1}{\theta}}\right]^{-\theta}$$

A_n carries a higher weight than A_{n+1}

International (or regional) trade barriers

- Additional trade costs τ^{int}
- Why international chains?
  - Geographical distribution of raw materials
  - Different capacity to manage tasks (cf. Fally and Hilberry, 2014)
- A simple 2 countries case

$$\underset{N^D,N^U,\{t_{Dn}\},\{t_{Un}\}}{\text{Arg min}} \; P(1) = \underbrace{c(t_{D1}) + \cdots + \tau^{N^D-1} c(t_{DN})}_{\text{Home country}} + \tau^{int} \left[\underbrace{c(t_{U1}) + \cdots + \tau^{N^U-1} c(t_{UN})}_{\text{RoW}} \right]$$

- Prediction 3 (Fally and Hilberry, 2014) : a decline in trade barrier τ^{int} leads to
  - (i) more fragmentation: at any given stage, a smaller firm scope
  - (ii) more offshoring: a reduction of tasks range at home, a rise in the RoW
  - and, with a sufficiently large decrease, a (iii) cleansing effect: most upstream / less productive firms at home exit

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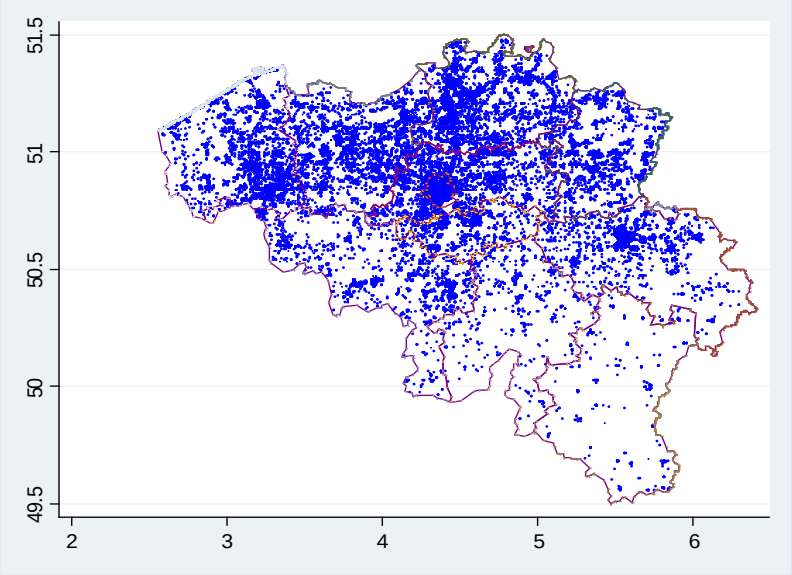
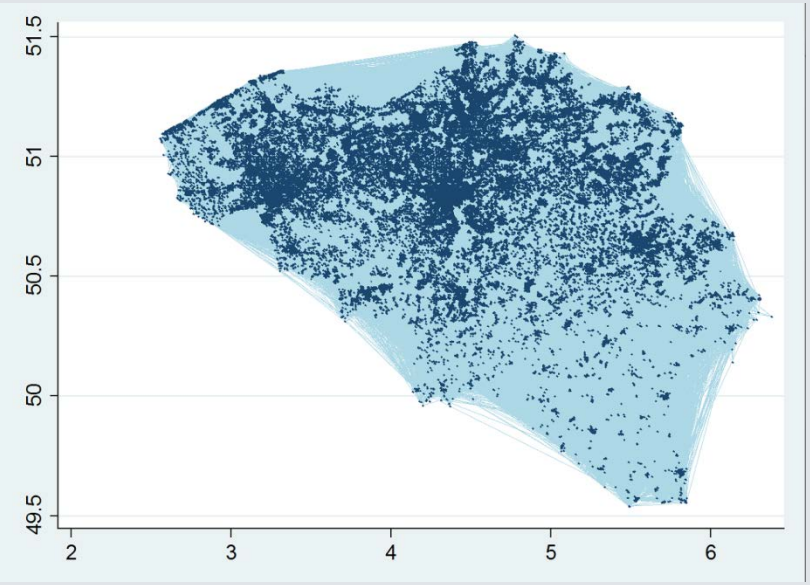
The Belgian production network – 2002 - 2012

- 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 (700,000 x 700,000) input-output matrix between firms
    - Allows to characterize the domestic organization of production chains in Belgium
- + WIOD data to characterize organization of the production chains abroad

A complex production network in 2011





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Characterizing the position of a firm in G/L VCs

- 5 indicators based on Antràs *et al*. (2012), Fally (2011) and Alfaro *et al*. (2016)
  - U_{it}, the average degree of upstreamness of firm *i* at time *t*
    - How many production stages are needed in order for all production of firm *i* to reach final demand, on average over all the production chains to which firm *i* contributes in year *t*
    - Equals 1 if firm *i* serves only final demand and is therefore at the end of the chain
  - D_{it}, the average degree of downstreamness of firm i at time t
    - How many production stages that separate firm *i* from the untransformed raw materials, on average over all the production chains to which firm *i* contributes in year *t*
    - Equals 1 if firm *i* transforms only raw materials using no inputs supplied from other firms and is therefore at the beginning of the chain

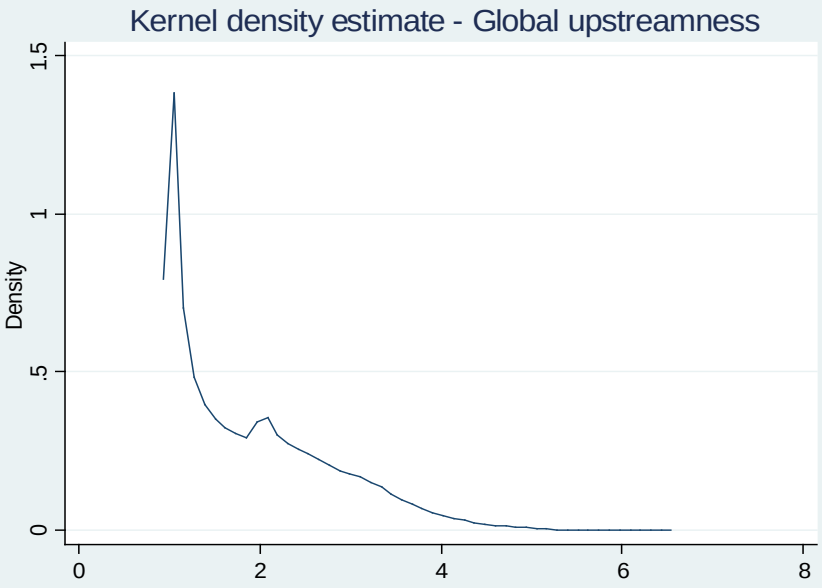
Characterizing the position of a firm in G/L VCs

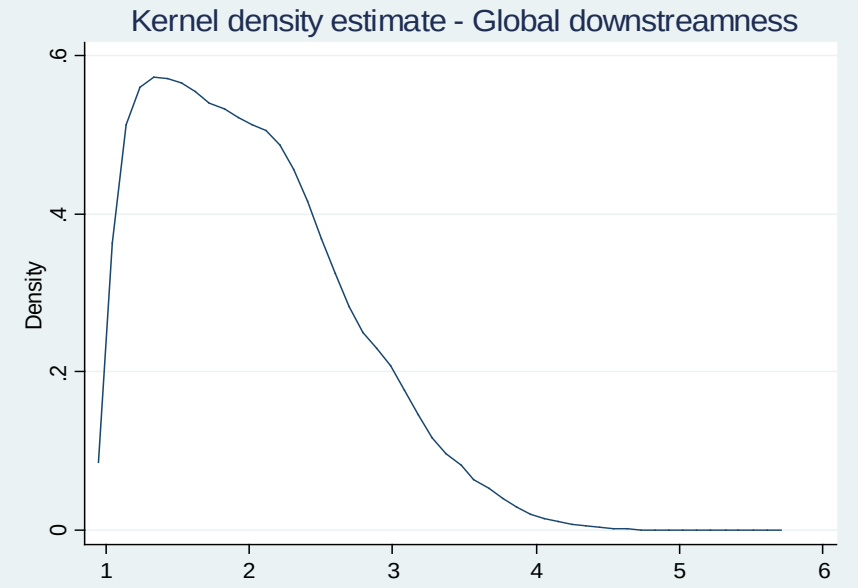
- 5 indicators based on Antràs et al. (2012), Fally (2011) and Alfaro et al. (2016)
  - Total length$_{it}$, the average lengths of the production chains to which firm *i* at time *t*
    - $U_{it} + D_{it} - 1$
    - Equals 1 if firm *i* serves only final demand using only raw materials
  - Relative position$_{it}$, the average relative position occupied by firm i in the different production chains to which it participates
    - $(D_{it} - 0,5)$ / Total length$_{it}$
    - A value close to 0 indicates that the firm operates on average at an early stage of production
    - A value close to 1 indicates that the firm operates on average at a final stage of production

Characterizing the position of a firm in G/L VCs

- 5 indicators based on Antràs et al. (2012), Fally (2011) and Alfaro et al. (2016)
  - U_{ijt}, the relative upstreamness of firm *i* with respect to firm *j* at time *t*,
    - How many production stages separate the inputs produced by firm j from firm I at time t
    - Degree of upstreamness of firm *j* output in the production chain that ends in firm *I*
- Indicators computed
  - at the domestic level, considering imports as raw materials and exports as final demand
  - at the global level using WIOD data to take into account downward / upward international production stages for Belgian exports / imports

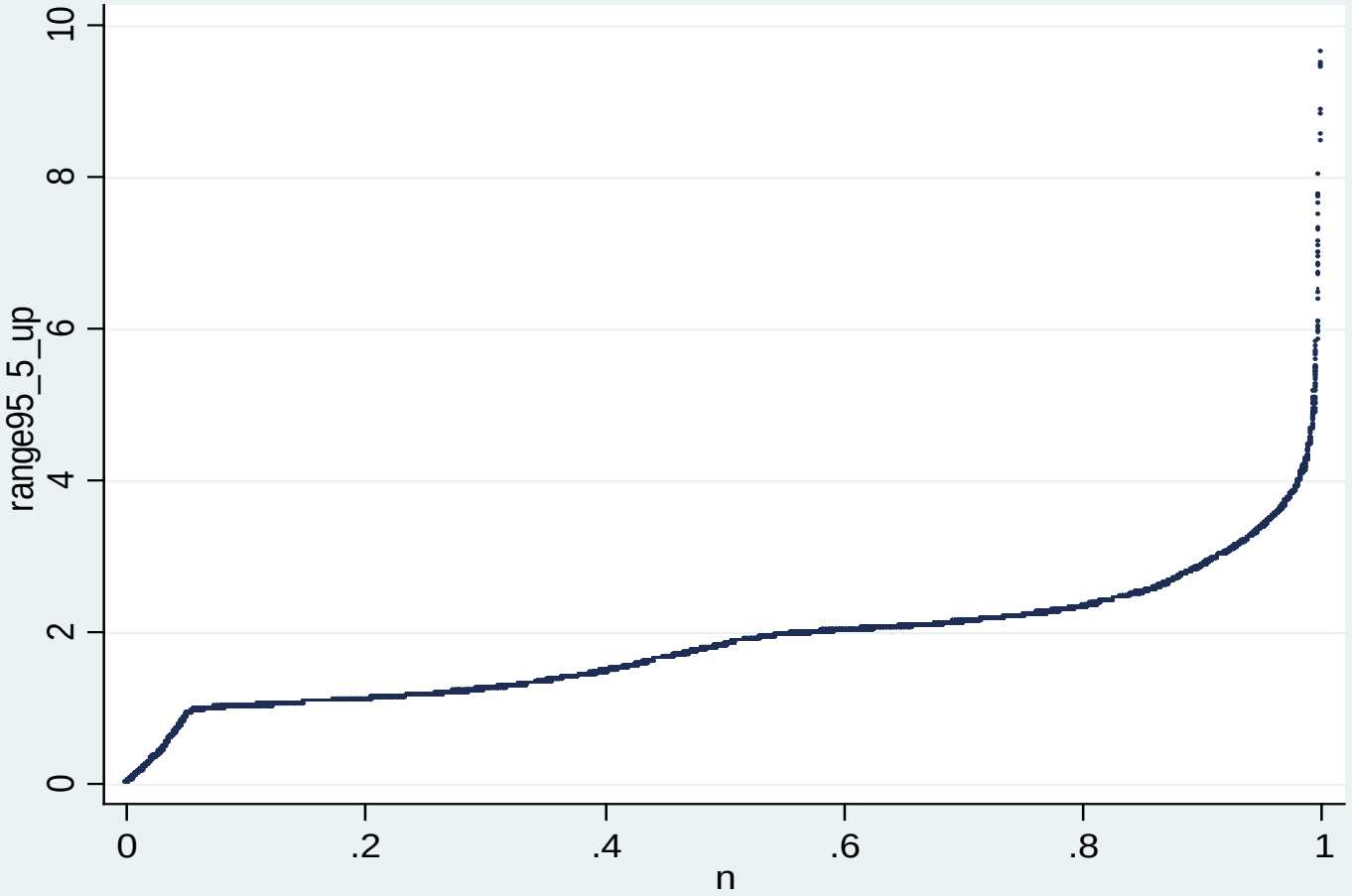
Distribution of firm level upstreamness and downstreamness, in 2011





Upstreamness heterogeneity by production chains, in 2011

Difference between the 95th and 5th percentile of relative upstreamness of firm i considering a sample of 18,000 random production chains



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Preliminary results

1. Productivity and position in the G/L VCs

- Dhyne, Rubinova (2016) : link between TFP and distance to export markets

Table 7: Exports supply chain premia - productivity

	All firms			*Manufacturing firms*		
V:	**Labour productivity**	**TFP**	**Capital per employee**	**Labour productivity**	**TFP**	**Capital per employee**
D_X	0.481[a]	0.375[a]	0.688[a]	0.468[a]	0.365[a]	0.750[a]
	(0.0389)	(0.0314)	(0.108)	(0.0632)	(0.0600)	(0.0826)
D_{X1}	0.267[a]	0.203[a]	0.392[a]	0.242[a]	0.186[a]	0.334[a]
	(0.0273)	(0.0242)	(0.0771)	(0.0453)	(0.0448)	(0.0506)
D_{X2}	0.111[a]	0.0805[a]	0.215[b]	0.149[b]	0.123[b]	0.185[a]
	(0.0171)	(0.0112)	(0.0631)	(0.0405)	(0.0397)	(0.0400)
D_{X3}	0.0199	0.0103	0.109[c]	0.0691	0.0565	0.119[c]
	(0.0128)	(0.0087)	(0.0450)	(0.0392)	(0.0364)	(0.0515)
D_{X4}	-0.0295[c]	-0.0274[c]	0.0348	0.0042	0.0040	0.0120
	(0.0124)	(0.0116)	(0.0374)	(0.0350)	(0.0295)	(0.0620)
N	1214949	1214949	1214949	153721	153721	153721
R^2	0.181	0.945	0.137	0.130	0.959	0.087

Industry-clustered standard errors in parentheses.

[a] $p<0.001$, [b] $p<0.01$, [c] $p<0.05$.

Labour productivity, TFP and Capital per worker are in logarithms. Each regression includes the log of employment, the IHS of the number of customers and industry-year dummies (NACE 2 dgt.).

Preliminary results

1. Productivity and position in the G/L VCs

	Explained variable : firm level TFP (in logs)[1]				
	Using local average upstreamness			Using global average upstreamness	
	in levels		in logs	in levels	in logs
	(1)	(2)	(3)	(4)	(5)
VARIABLES					
Upstreamness	0.071***	-0.078***	-0.129***	-0.036***	-0.072***
	(0.002)	(0.002)	(0.004)	(0.002)	(0.003)
Belgian group	0.318***	-0.002	-0.001	-0.002	-0.002
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Belgian MNE	0.241***	-0.011	-0.011	-0.011	-0.011
	(0.008)	(0.012)	(0.012)	(0.012)	(0.012)
Foreign MNE	0.770***	0.041***	0.041***	0.041***	0.041***
	(0.006)	(0.011)	(0.011)	(0.011)	(0.011)
Exporter only	0.230***	0.023***	0.023***	0.030***	0.030***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Importer only	0.313***	0.050***	0.050***	0.050***	0.051***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Two way trader	0.578***	0.076***	0.076***	0.086***	0.086***
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Firm F.E.	No	Yes	Yes	Yes	Yes
Observations	948,078	948,078	948,078	948,078	948,078
R-squared	0.257	0.790	0.790	0.789	0.789

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[1] Estimated using Wooldridge LP method at the NACE Rev. 2, 2 digit level.
All specifications include a constant term + time and sector dummies.

Preliminary results

2. Firm survival between t and t+5 and position in the G/L VCs

	Probability that firm i observed in t survives until t+5			
	Using local value chains characteristics		Using global value chains characteristics	
VARIABLES	(1)	(2)	(3)	(4)
TFP (in logs)	0.379***	0.381***	0.378***	0.382***
	(0.007)	(0.007)	(0.007)	(0.007)
Employment (in logs)	0.052***	0.052***	0.051***	0.052***
	(0.004)	(0.004)	(0.004)	(0.004)
Donwstreamness	0.238***	-	0.182***	-
	(0.013)	-	(0.008)	-
Total length	-	0.113***	-	0.079***
		(0.008)		(0.005)
Relative position	-	0.632***	-	0.712***
		(0.039)		(0.032)
Constant	-2.572***	-2.792***	-2.527***	-2.810***
	(0.077)	(0.082)	(0.075)	(0.078)
Observations	154,410	154,410	154,410	154,410
Standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				
All specifications include time and Nace Rev 2. 2 digit sector dummies + international trade status + domestic and international group status. Estimated only for 2002 and 2007.				

Preliminary results

3. Long run growth (between t+5 and t), conditional on survival, and position in the G/L VCs (Heckman two-stage)

	Log(TFPt+5) – Log(TFPt)			
	Using local value chains characteristics		Using global value chains characteristics	
VARIABLES	(1)	(2)	(3)	(4)
Employment (in logs)	0.119***	0.120***	0.106***	0.109***
	(0.006)	(0.006)	(0.006)	(0.006)
Downstreamness	0.268***	-	0.184***	-
	(0.025)		(0.015)	
Total length	-	0.146***	-	0.086***
		(0.015)		(0.009)
Relative position	-	0.606***	-	0.689***
		(0.074)		(0.064)
Inverse Mills ratio	2.894***	2.896***	2.895***	2.897***
	(0.090)	(0.090)	(0.090)	(0.089)
Observations	131,582	131,582	131,582	131,582
Standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Preliminary results

4. Contribution to value added and position in the G/L VCs

- Based on simulated data using the Belgian firm level input output matrix in 2002, 2007 and 2011, for 6,000 randomly selected production chains
- Assuming that only one firm sells to final demand (1,000,000 EUR), what is the production of all other Belgian firms ?
- For each production chain, compute the value added of each participating firm and relate their value added contribution to their relative upstreamness with respect to the firm that sales to final demand

Preliminary results

4. Contribution to value added and position in the G/L VCs

	Value added of firm i (in logs) for a given production chain			Relative contribution of a given stage of production to the total va of a production chain		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Upstreamness (in logs)	-3.594***	-3.556***	-1.746***			
	(0.009)	(0.011)	(0.020)			
Stage of production (1 to 6)	-	-	-	-0.117***	-	-
				(0.000)		
2nd stage of production	-	-	-	-	-0.468***	-
					(0.001)	
3rd stage of production	-	-	-	-	-0.597***	-0.129***
					(0.001)	(0.001)
4th stage of production	-	-	-	-	-0.657***	-0.189***
					(0.001)	(0.001)
5th stage of production	-	-	-	-	-0.674***	-0.206***
					(0.001)	(0.001)
6th and subsequent stages	-	-	-	-	-0.677***	-0.209***
					(0.001)	(0.001)
Observations	145,040	72,691	58,051	86,675	86,675	72,036
R-squared	0.514	0.586	0.115	0.552	0.808	0.490

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

(1) Estimated using only the 10 largest va contributors of each production chain.

(2) Estimated using only the 5 largest va contributors of each production chain.

(3) Idem as (2) excluding the largest contributor of each production chain.

(4) to (6): stage of production varies from 1 to 6 according to the firm upstreamness. A firm is in the 1st stage of production if its upstreamness is <= to 1,5. A firm is in the ith stage of production if its upstreamn is in the (i-0,5 ; i+0,5] interval.

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Concluding remarks

- Purpose of the paper : bring a theoretical model of organization of the production chains to the Belgian production network
- Mixed evidence on productivity ranking along the value chain
- The position of the firm affects its contribution to the value added embodied in the final good. More value is added in the most downstream segments of production
- The position of the firm on the domestic segment of production chains affect its survival. The most fragile domestic firms operate at the most upstream segments of the domestic production chain.
- To survive at the “RoW-Domestic” border, firms have to be very productive