The effects of carbon pricing along the production network

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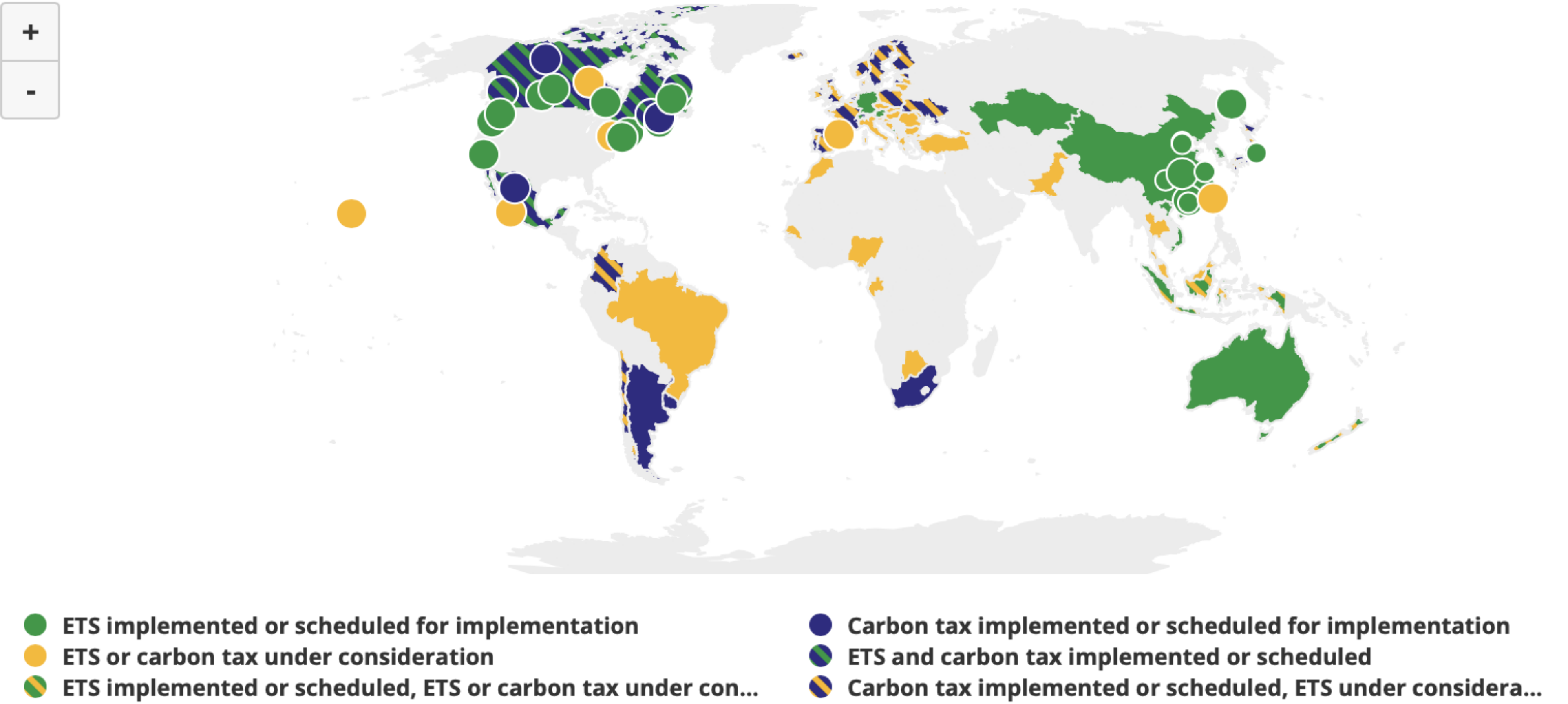
This work represents only the views of the authors and not necessarily those of the National Bank of Belgium or the Eurosystem.

Motivation

- Emissions trading is a key and central policy needed to achieve the transition to climate neutrality, growing worldwide

Summary map of regional, national and subnational carbon pricing initiatives



Source: World Bank, 2023

Motivation

- Emissions trading is a key and central policy needed to achieve the transition to climate neutrality, growing worldwide
- Yet, many GHG emissions are not covered by carbon pricing
- What are the economic implications of incomplete carbon pricing?
  - Could it be that the reach of existing ETSs is larger than the number of regulated firms or emissions covered would suggest?
  - Do emissions leak to non-regulated sectors/firms? (cf. Fowlie and Reguant 2022)
  - Are there important innovation effects not accounted for?
  - Who bears the cost of the policy? Are regulated firms just passing through its carbon cost?
  - Could there be better or worse ways of having ETS with limited scope? (only regulate “central” firms?)
- Understanding supply chains better will also help with designing new policies such as CBAM

Research question

Having better data on firms' operations, such as production network data, allows progress on these issues

As first step in larger research project:

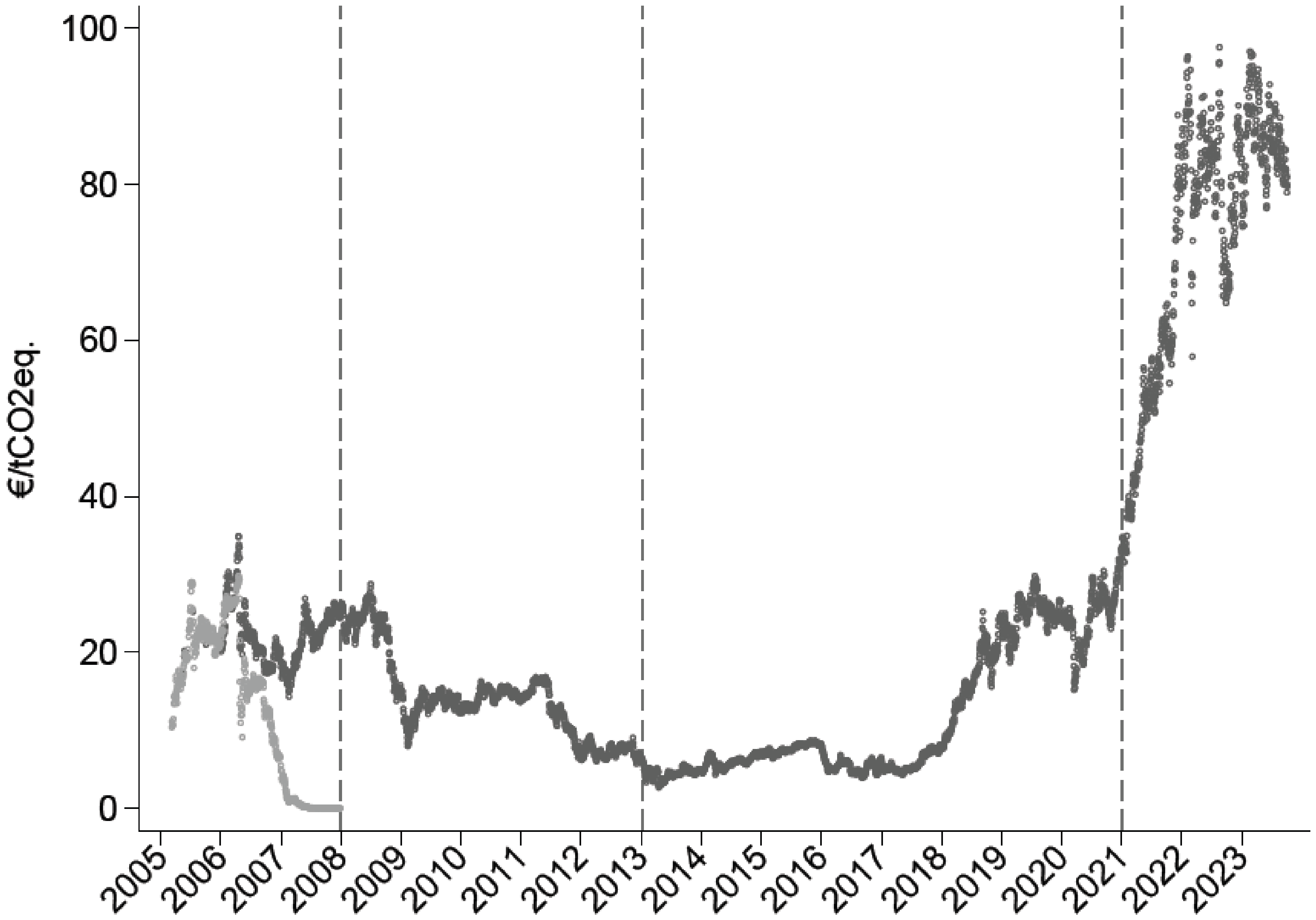
What are the effects on a firm of

- having firms in its supply chain subject to carbon pricing?
- having clients or other downstream firms subject to carbon pricing?

Our setting: European Union Emissions Trading System (EU ETS)

- Created in 2005, still the largest carbon market today
- Regulates >10,000 power plants, manufacturing installations and airplane operators in 31 countries
- 36% of the EU's greenhouse gas emissions (initially: ca. 50%)
- Upcoming legislated changes (*Fit for 55*)*:*
  - Scope expansion to include buildings and road transport: ca. 75% of EU greenhouse gas emissions priced as of 2027
  - Cap for industry, power sector and aviation will decline to zero prior to 2040
  - Low-hanging power sector fruit picked, expectation of future price increases

The carbon price in the EU ETS over its four phases



Policy relevance for industrial decarbonization

Hard-to-abate emissions in industry (large fixed-cost investments, negative opex implications) → abatement cost bite

Theory provides hope for untapped cost savings:

- Indirect effects of carbon pricing could be quantitatively relevant (King, Tarbush and Teytelboym, 2019)
- If amplification mechanisms exist along the supply side of the production network for industrial firms, climate targets can be met at lower cost (van der Ploeg and Venables, 2022; Mealy et al. 2023)
- Insights so far only from model calibrations. We are the first to provide empirical evidence about the magnitude of the effects of carbon pricing along the production network

Contribution to the wider research literature

Large empirical literature on the firm-level effects of carbon pricing, mostly based on the EU ETS (Colmer et al. forthcoming, Dechezleprêtre et al. 2018, many more)

- Mixed effects on emissions reductions + no competitiveness effects for firm-level outcomes
- Channels to explain the effects only recently being explored
- Potential SUTVA violation if control group affected by treatment (Barrows, Calel, Jégard and Ollivier, 2023)

Network amplification of carbon pricing effectiveness

- Supply side production effects affect effectiveness of carbon pricing (King, Tarbush and Teytelboym, 2019)
- Positive social network effects lower the carbon tax required to achieve a given emissions target to 38% below the Pigouvian carbon tax (Konc, Savin and van den Bergh, 2021)

Data

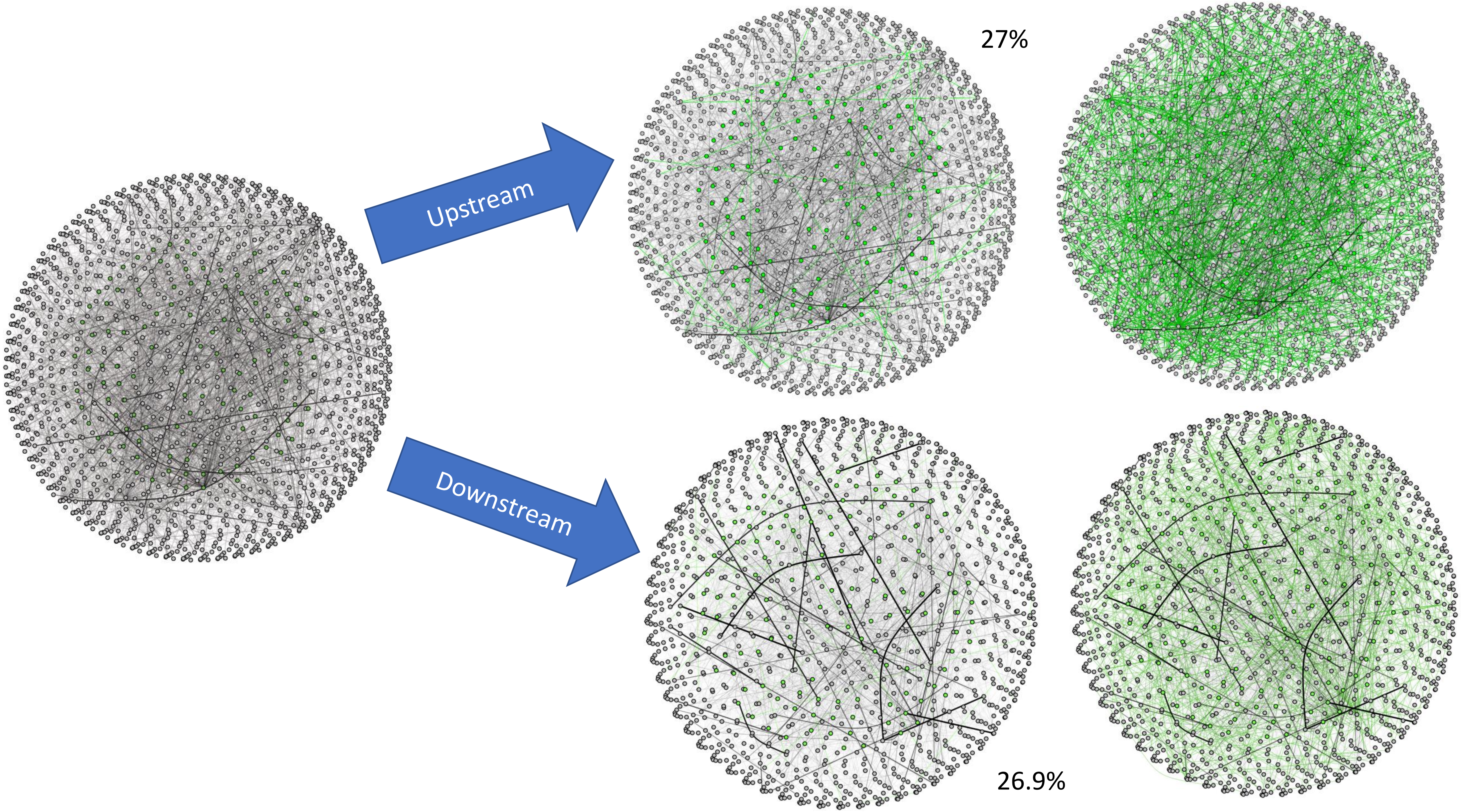
Data: Belgium as ideal case study thanks to frontier data

- Annual accounts: revenue, capital stock, employees, productivity, pricing
- PATSTAT: patenting, including green vs. brown
- Structural Business Survey: energy shares in input cost ; share of green turnover ; green investments.
- Carbon market data (European Union Transaction Log)
  - Treatment status and treatment intensity
  - Greenhouse gas emissions for regulated installations (not unregulated ones)

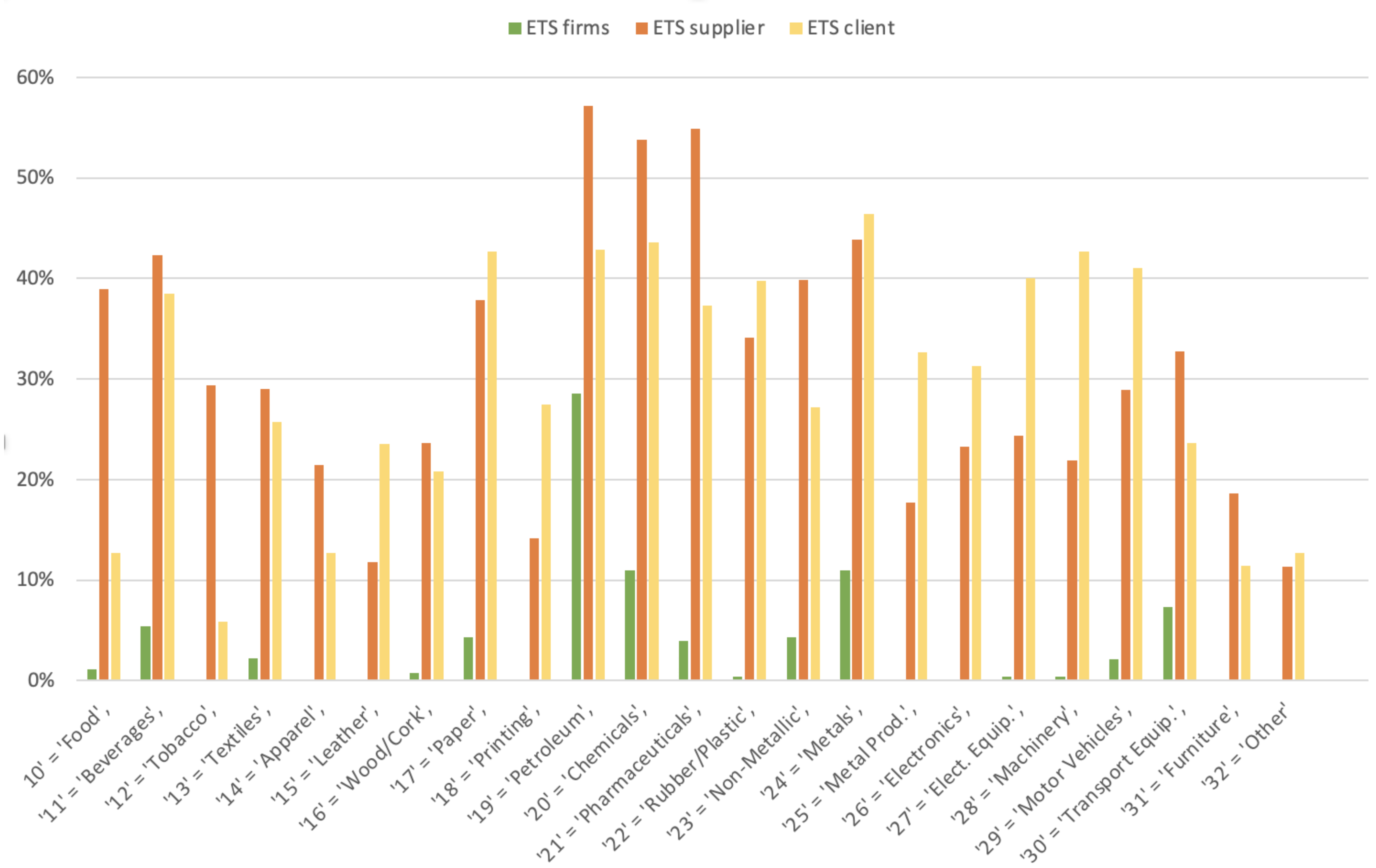
- Production network: B2B data (Dhyne, Duprez and Komatsu, 2023) identify upstream suppliers and downstream buyers, and quantitative importance of relationship

Data: Descriptive statistics

	Non-ETS	ETS
Sales (in thousands)	9,953.7	623,446.9
	(213,072.8)	(1,650,141)
Employment	20.32	687.69
	(172.5123)	(1,228.321)
Value Added (in thousands)	9.242	10.295
	(1.047)	(1.361)
Total number of patents	0.036	3.599
	(1.502)	(16.115)
Total clean of patents	0.020	0.357
	(0.131)	(2.068)
Green investors	0.031	0.790
	(0.173)	(0.408)
Number of firms in year 2018	54,666	171

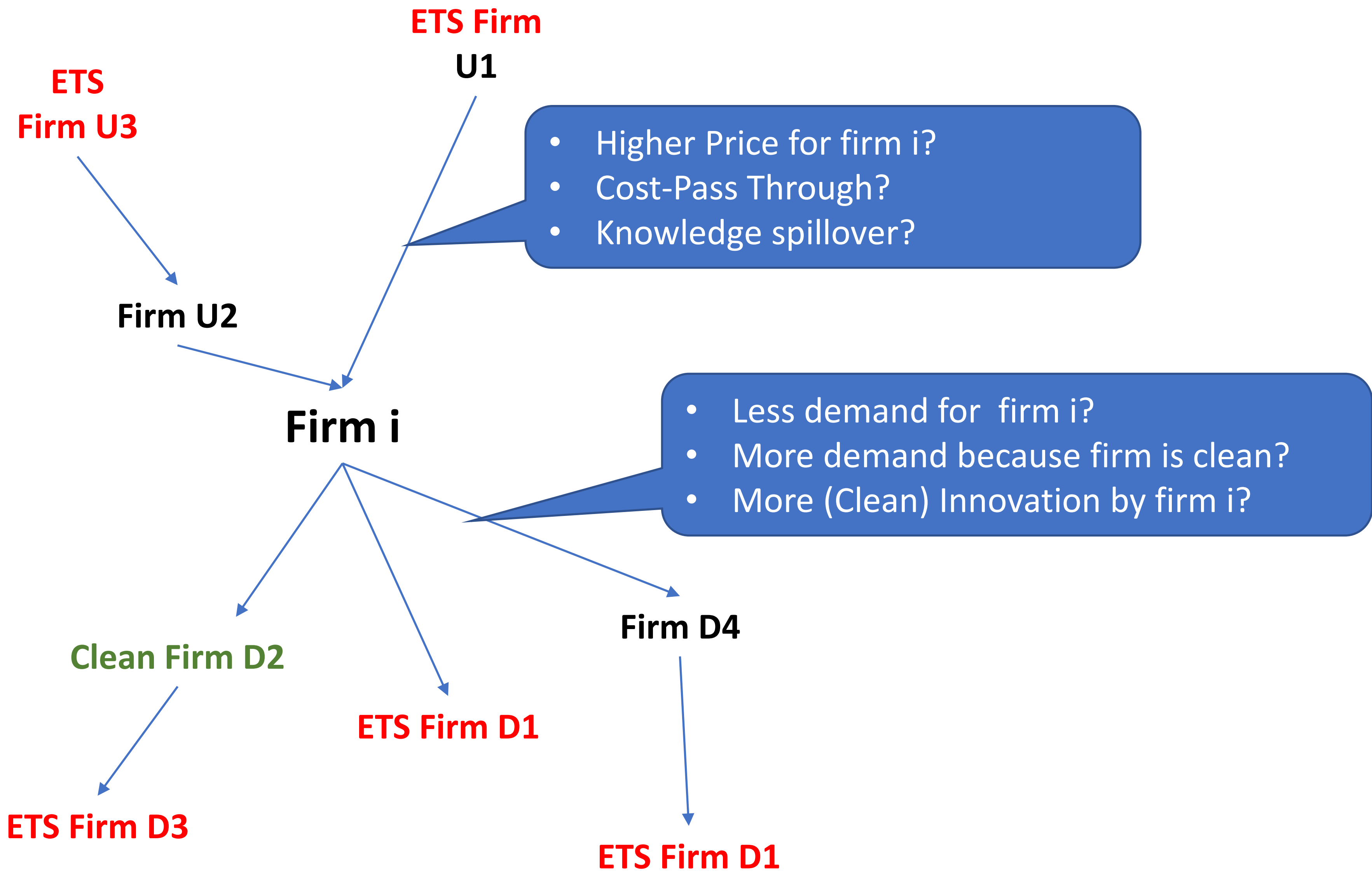

Upstream
Downstream
27%
26.9%

Data: EU ETS exposure across industry



Empirical approach

Possible mechanisms



Shift Share approach

Shift: change of ETS price

$$Y_{it} - Y_{it-1} = \beta \omega_{i0}(X_{it} - X_{it-1}) + \epsilon_{it} - \epsilon_{it-1}$$

Share: computed on pre-sample production network to be plausibly exogeneous
exposure to ETS firm

How could exogeneity be violated?

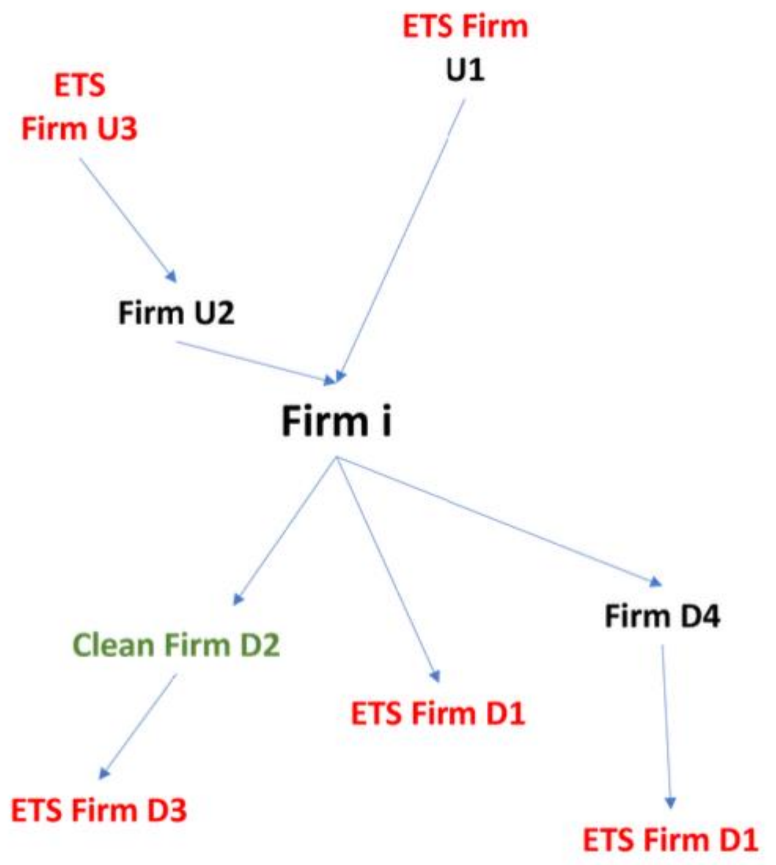
- Long run sectoral or regional trends
- Firm characteristics such as MNE

Upstream weights/exposure (push of ETS firms)

Exposure of firm i to upstream carbon pricing:

$$\Delta p_i^{Up} = ETS_i + \sum_u S_{u,i} \Delta p_d^{Up}$$

Input purchases from u by i in revenue of i



Recursive page rank algorithm

$$\Delta p_i^{Up(0)} = 0$$

$$\Delta p_i^{Up(r+1)} = ETS_i + \sum_u S_{u,i} \Delta p_u^{UP(r)}$$

where r indexes a recursion step.

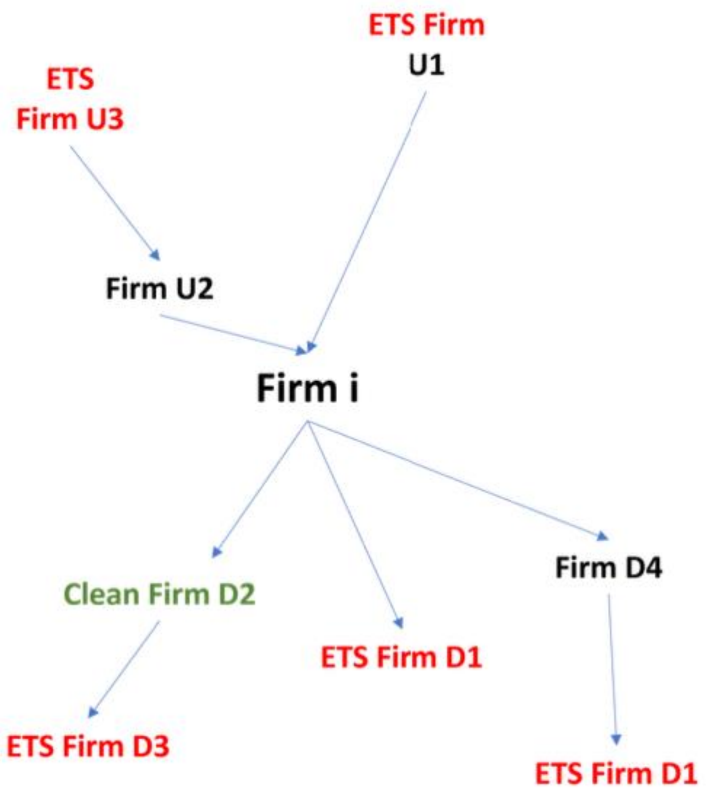
Recursion steps represent closeness to ETS firms

Downstream weights/exposure (pull of ETS firms)

Similar approach for downstream linkages:

$$\Delta p_i^{Down} = ETS_i + \sum_d S_{d,i} \Delta p_d^{Down}$$

Sales to *d* by *i* over revenue of *i*

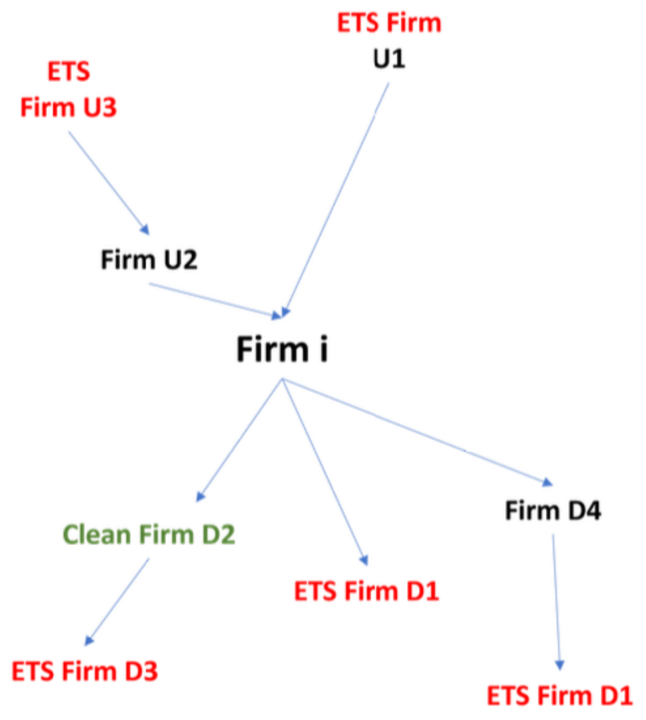


Indirect clean connections

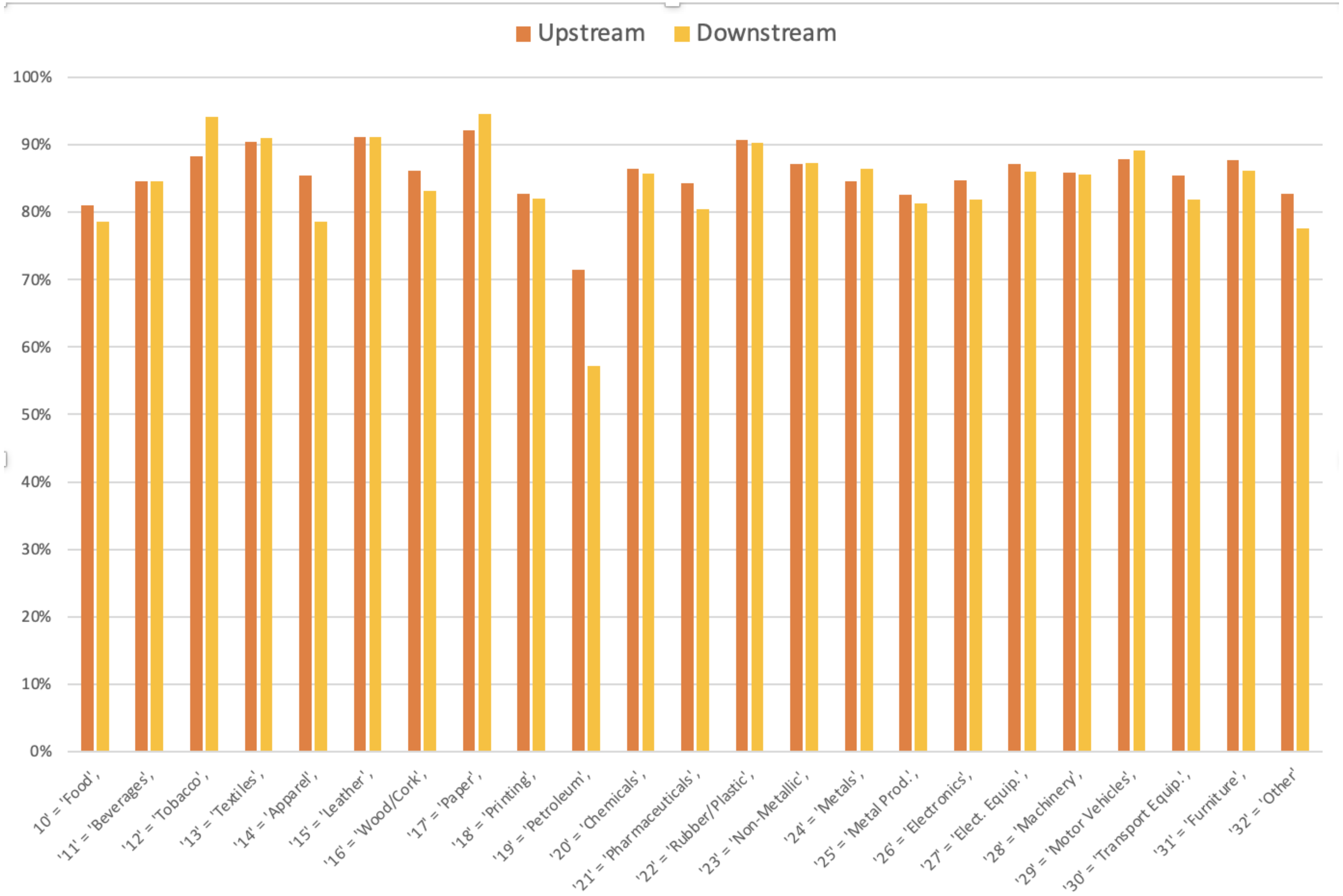
To capture the increased value for decarbonised innovation channel, we construct an additional upstream measure only for linkages with firms with clean innovation:

$$\Delta p_i^{Down \times Clean} = ETS_i +$$

$$\sum_d S_{d,i} \times Clean_d \times \Delta p_d^{Down \times Clean}$$

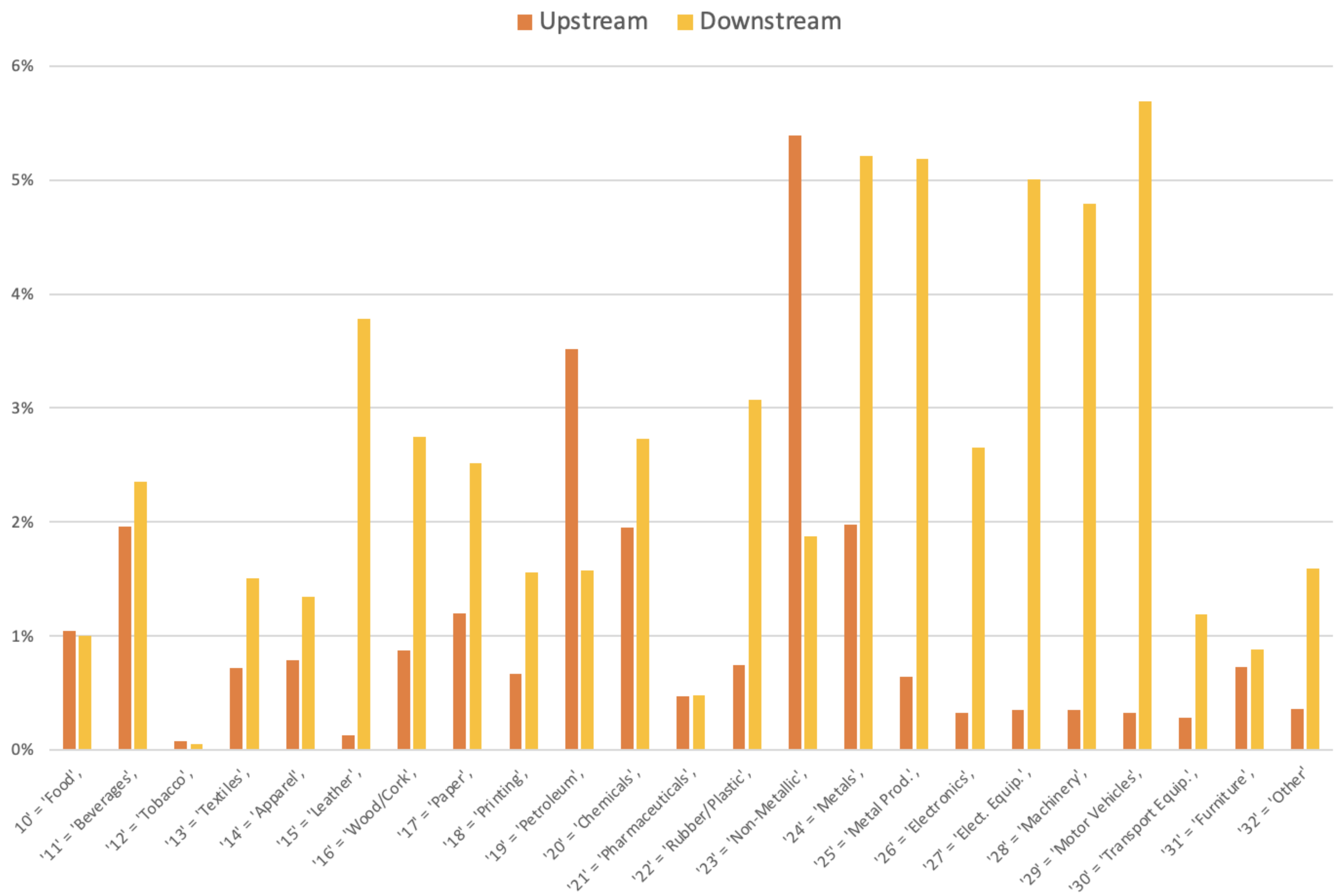


Resulting exposure (share of firms exposed)

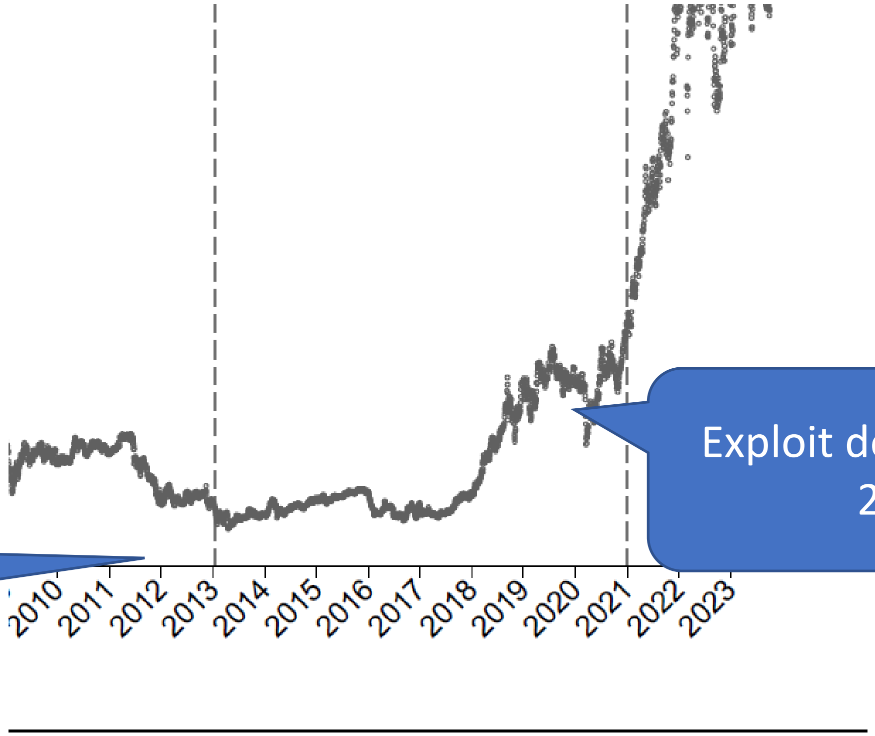


% of firms in each sector that have a non-zero exposure to ETS upstream or downstream

Resulting exposure (exposure share in revenue)



Current design



Exploit doubling of ETS price between 2013 and 2017/18/19

Compute exposure based on 2012 data

$$Y_{i2019} - Y_{i2013} = \beta_{ETS} ETS_i + \beta_{up} \Delta p^{up}_{i2012} +$$

$$\beta_{up} \Delta p^{down}_{i2012} + \beta_{up \times clean} CLEAN_i \times \Delta p^{down}_{i2012} + \epsilon_{it} - \epsilon_{it-1}$$

(First) Results

Price elasticity of
~-0.2

The Effect on Sales Δ log(Sales) - 2016-2019

	(1)	(2)	(3)	(4)
ETS (Direct)	0.013	0.019	0.019	0.008
	(0.041)	(0.042)	(0.042)	(0.023)
Upstream		-0.156***	-0.158***	-0.103***
		(0.046)	(0.046)	(0.038)
Downstream			0.033	0.022
			(0.021)	(0.018)
Year and 2-digit Sector Controls	Yes	Yes	Yes	Yes
Manufacturing only?	Yes	Yes	Yes	No
Observations	137,560	137,560	137,560	201,568
Firms	41,823	41,823	41,823	61,497

(First) Results

	(1) Δ Total Patents	(2) Δ Total Patents	(3) Δ Clean Patents	(4) Δ Clean Patents
ETS (Direct)	0.104 (0.066)	0.104 (0.066)	0.028 (0.020)	0.028 (0.020)
Upstream	0.006 (0.006)	0.006 (0.006)	-0.000 (0.002)	-0.000 (0.002)
Downstream	-0.004 (0.007)	-0.004 (0.007)	-0.003 (0.003)	-0.004 (0.003)
Downstream X Clean		-0.321 (0.830)		0.270 (0.483)
Year and 2-digit Sector Controls	Yes	Yes	Yes	Yes
Manufacturing only?	Yes	Yes	Yes	Yes
Observations	137,560	137,560	137,560	137,560
Firms	41,823	41,823	41,823	41,823

Need to identify better clean tech relevant for ETS firms?

Conclusion

- To understand the full impact of emissions trading we need to look beyond the regulated firms
- The production network is a key dimension in this respect
- First paper to explore this
- First results suggest evidence for **cost pass through** down the supply chain
- No innovation effects (Yet?)

The Road ahead

- **Wider variety of indicators representing more nuanced aspects of the production network (+Lasso perhaps)**
- **More outcomes: more nuanced innovation measures**
- **Impact on production network structure: Changing to clean suppliers?**
- **Heterogeneity of effects further**
- **Deal with non-domestic part of network**

Thanks

Extra slides

Computing elasticities

We want to know the price elasticity β but what we have is $\tilde{\beta} = \beta \Delta P$

Hence we need to divide the coefficients by the log change in ETS price…

Let’s assume price went from 15 to 30 i.e. log change = .7

Therefore elasticity = -0.15/.7= .21

Regression sample upstream and downstream totals

	Whole sample	Industrial firms
Delta log(Sales)	0.09615	0.0823
	(0.3249)	(0.3227)
ETS Direct (0 or 1)	0.0006	0.0027
	(0.0247)	(0.0517)
Upstream	0.0086	0.0094
	(0.0282)	(0.0284)
Downstream	0.02023	0.0207
	(0.0753)	(0.0772)
Number of observations	201,568	137,560
Number of Firms	61,497	41,823