The role of granularity in propagation of a micro demand shocks in Slovenia

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Motivation

- Previous macroeconomic theory argues that firm-level idiosyncratic shocks do not affect aggregate fluctuations as firm-level shocks average out (Lucas, 1984)
- This result holds under conditions of equal weight of all firms in an economy and absence of inter-linkages between firms
- However, modern economies rely on complex ("intertwined") interactions between upstream and downstream firms, banks and other financial institutions, etc.
- Can networks serve as origins of aggregate fluctuations? (Acemoglu et al, 2012)

Lucas vs. Acemoglu

- Aggregate vs. individual volatility:
- Aggregate output (log GDP) is given by summing up all the firms' outputs y:

$$y \equiv log(GDP) \equiv v'\epsilon$$

- where ϵ is the vector of sectoral shocks and v is the influence vector
- Hence, aggregate volatility is a function of individual / sectoral shocks and of their specific weights

Lucas vs. Acemoglu

- Aggregate volatility is equal to:

$$\sigma_{agg} = \sqrt{var(y)} = \sqrt{\sum_{i=1}^{n} \sigma_i^2 v_i^2}$$

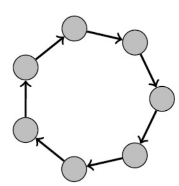
- If v_i = 1/n and $\sigma_i = \sigma$, then Lucas (1984) applies:

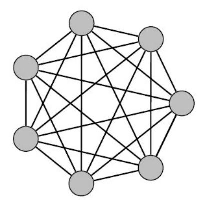
$$\sigma_{agg} = \frac{\sigma}{\sqrt{n}}$$

- Therefore, $\sigma_{agg} \to 0$ when n $\to \infty$: no aggregate fluctuations without aggregate shocks.
- v_i = 1/n is crucial in Lucas' theory. In the framework of networks, this argument is relevant when the network is **regular**,
  - i.e. if each sector has a **similar degree of importance** as a supplier to other sectors.

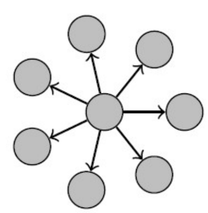
Lucas vs. Acemoglu

- Examples of regular networks:
  - **Rings** : each sector draws all of its inputs from a single other sector.
  - **Complete graphs** : each sector equally draws inputs from all other sectors.





- Lucas' argument fails when v_i is not equal to 1/n, which happens when the network is **asymmetric**.
- The extreme example is the **star network** when one sector is a supplier to all other sectors, but not vice versa.



Motivation

- Bernanke et al (1996): "*small shocks, large cycles puzzle*"
  - interaction between the input-output structure and the shape of the distribution of microeconomic shocks is important
- If the firm size distribution is sufficiently heavy-tailed (the largest firms contribute disproportionally to aggregate output), firm-level idiosyncratic shocks may translate into fluctuations at the aggregate level (Gabaix (2011)
- Acemoglu et al (2015) show for sizable fluctuations to arise,
  - either input-output linkages within the economy have to be extremely unbalanced,
  - or microeconomic shocks need to have thicker tails than the normal distribution.

Motivation

- In case of asymmetric networks the networks amplify the propagation of shocks in the economy.
- Firm heterogeneity matters for understanding the impact of idiosyncratic shocks for the overall economy
  - firm-level shocks do not average out at the macro level when the size distribution of firms is fat-tailed
  - an idiosyncratic shock to one particular large firm may become important through its central role in the supply chain and hence the interlinkages between firms can amplify such shocks
- It is essential to study firms that serve as hubs of economics activity

Outline

- A case of a network company
- Applying the network analysis for studying the propagation of 2009 shocks using the whole population of Slovenian firms
  - Data
  - Input-output linkages
  - Empirical model
  - First results
- Conclusions

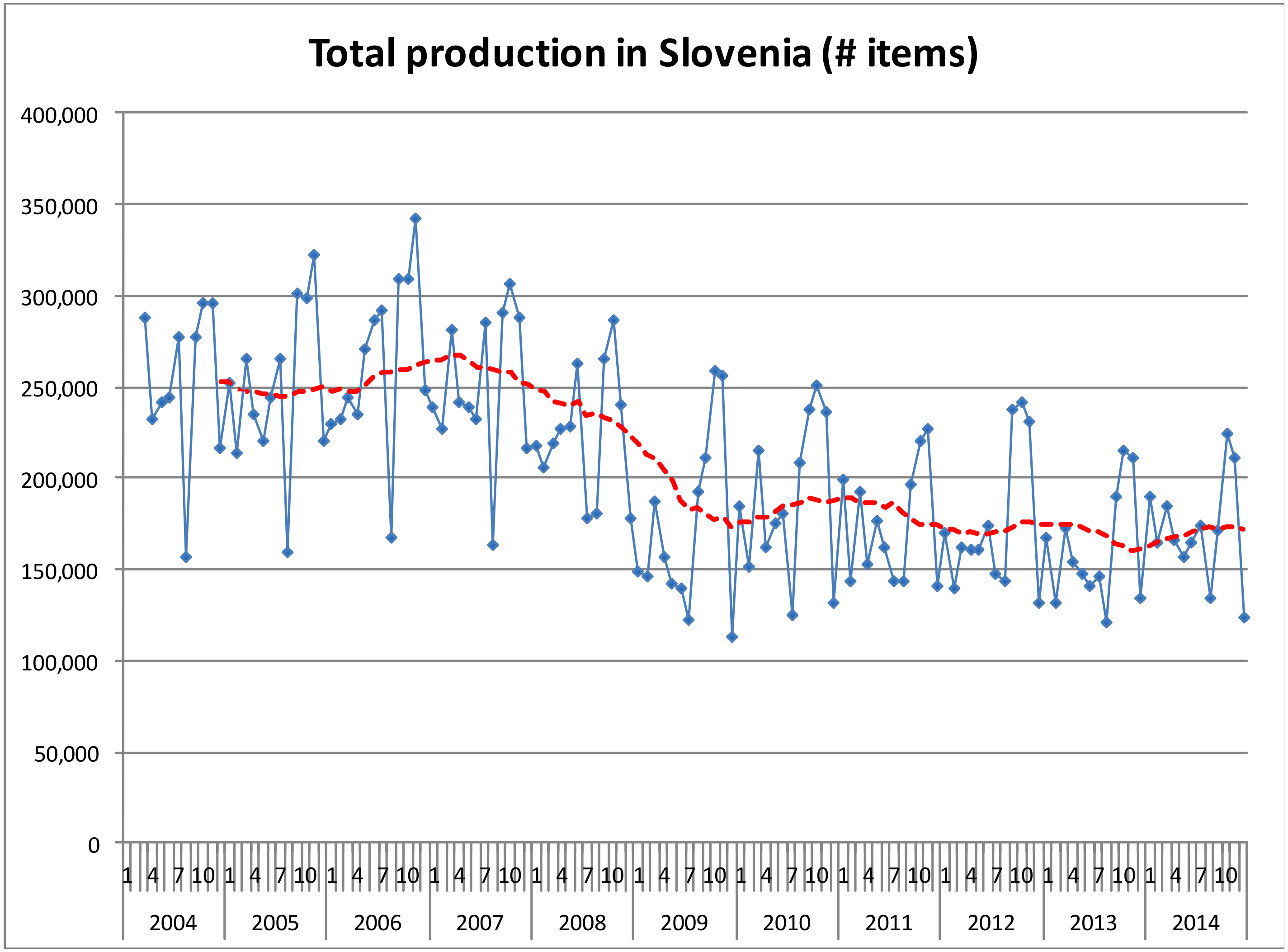
Case of a hub firm

- Biggest regional producer of home appliances
  - 5,500 employees in 2008
  - Production facilities in 3 countries
  - 1,800 suppliers in Slovenia, 3,000+ suppliers worldwide (2008)
  - Sales branches in 90+ countries
  - €1.3 bn consolidated turnover in 2018

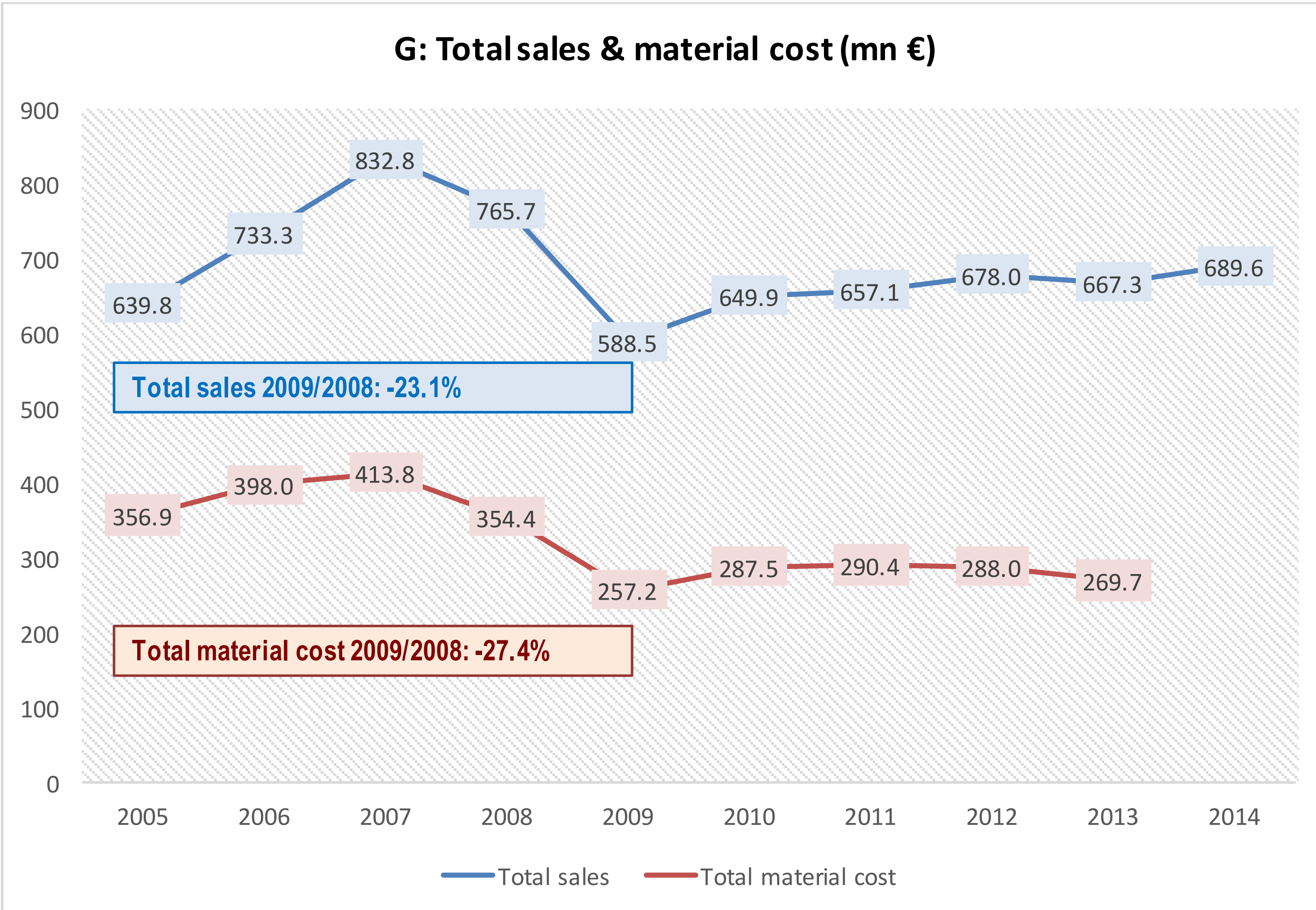
- Hit by adverse demand shock in 2008-09
  - Sales down by 21% in 2009

- The shock was propagated across the network

Initial shock

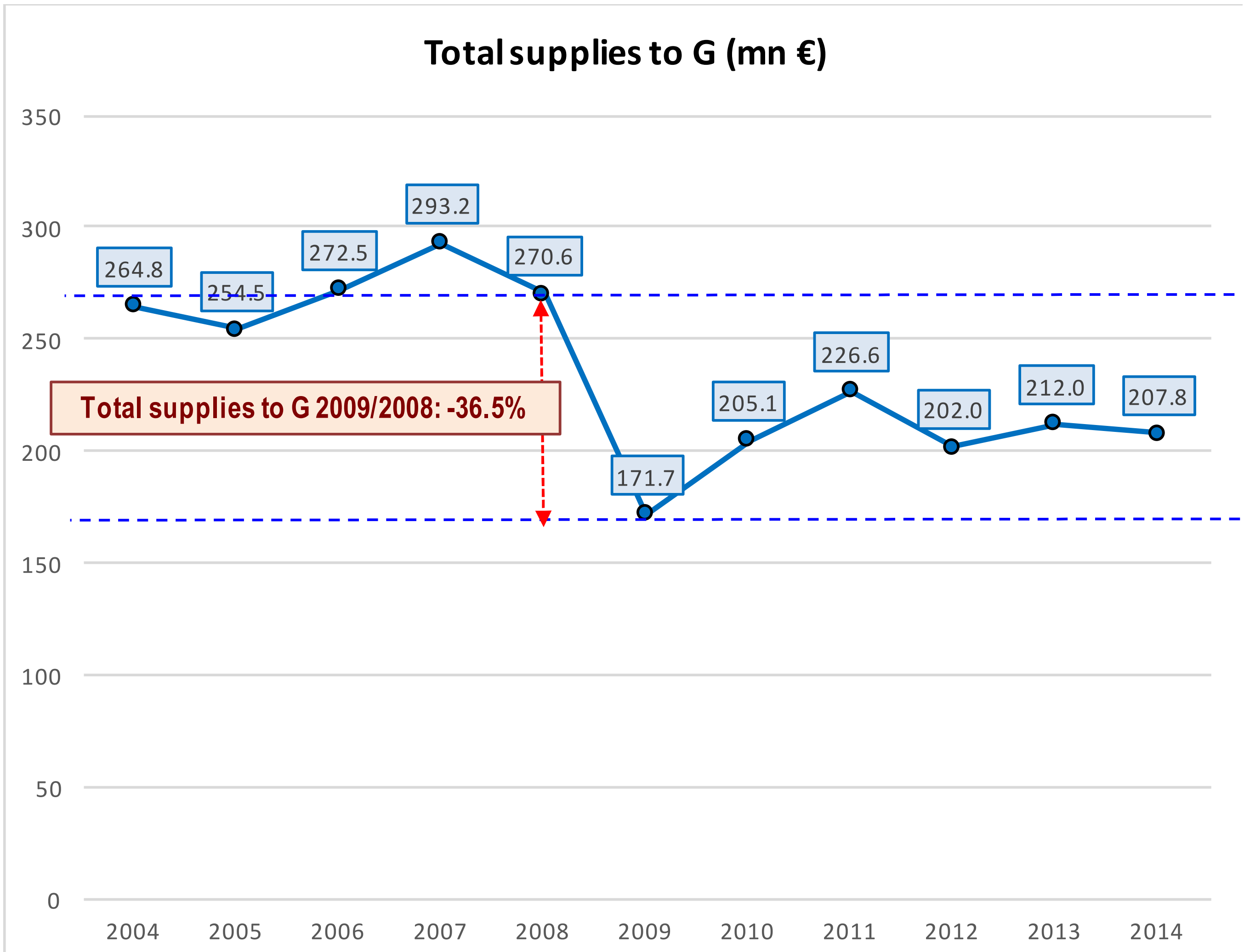


Initial shock

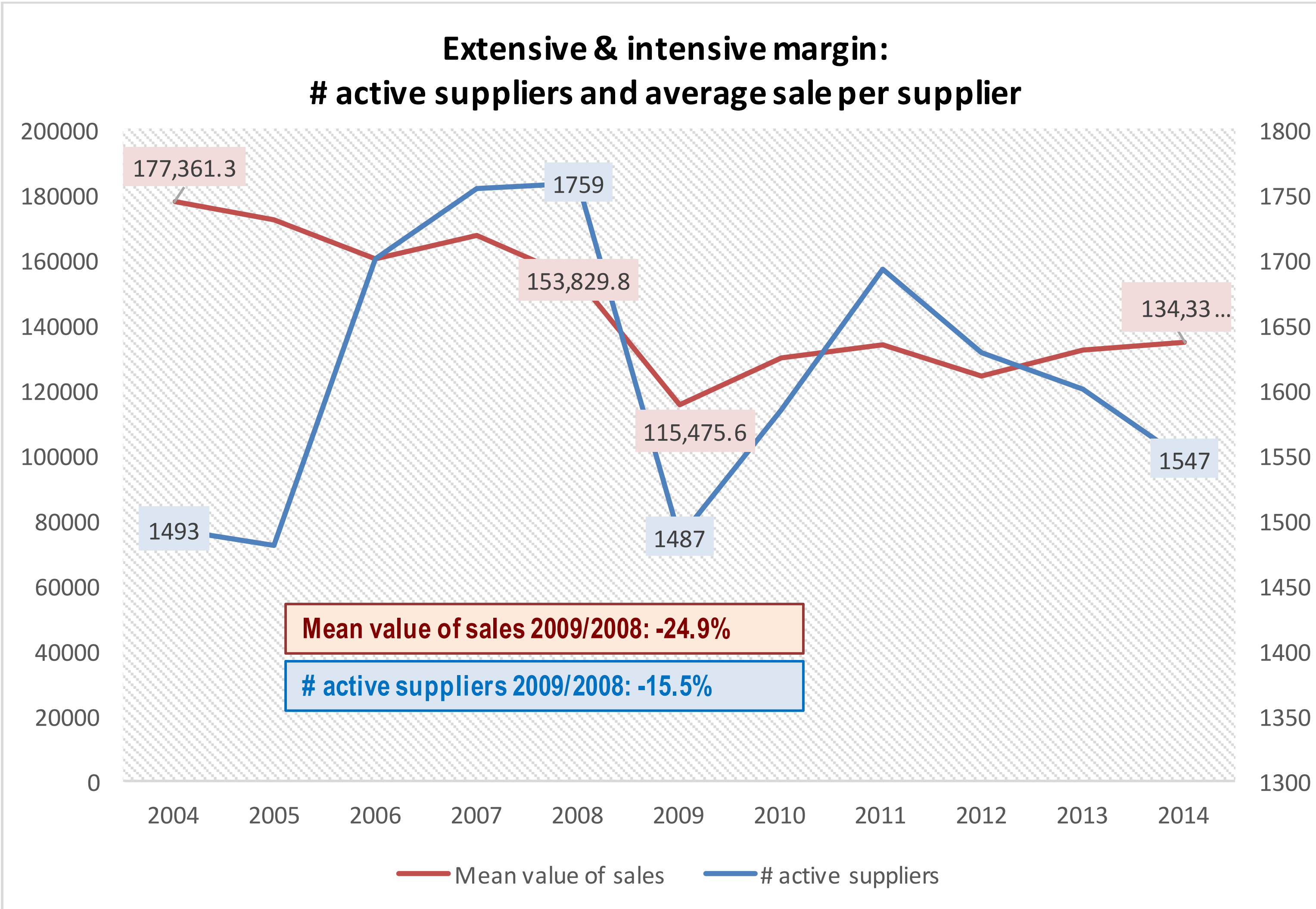


Note: Sales of products produced in Slovenia and corresponding material cost

First-order effect on local suppliers



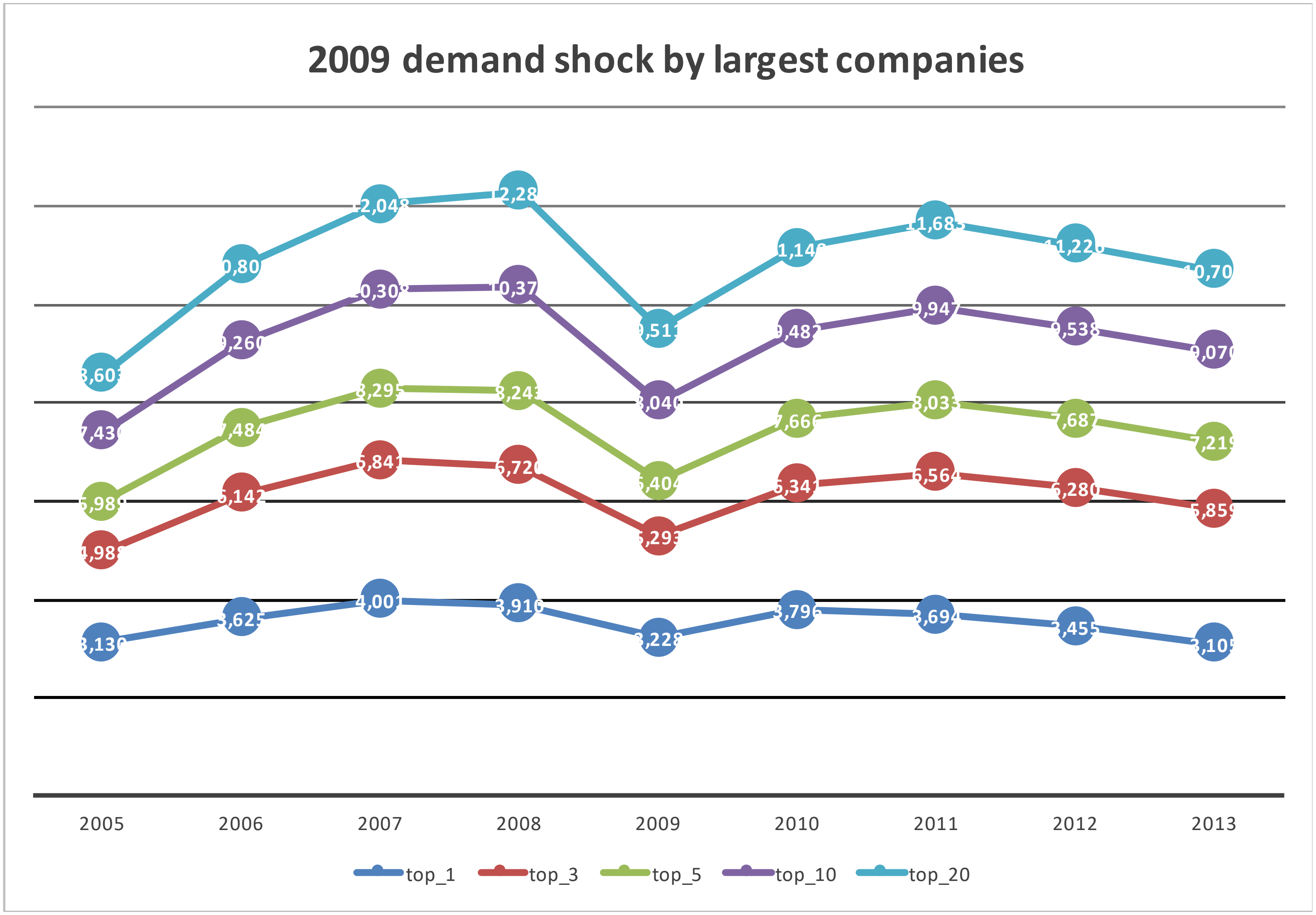
Adjustments via intensive & extensive margins



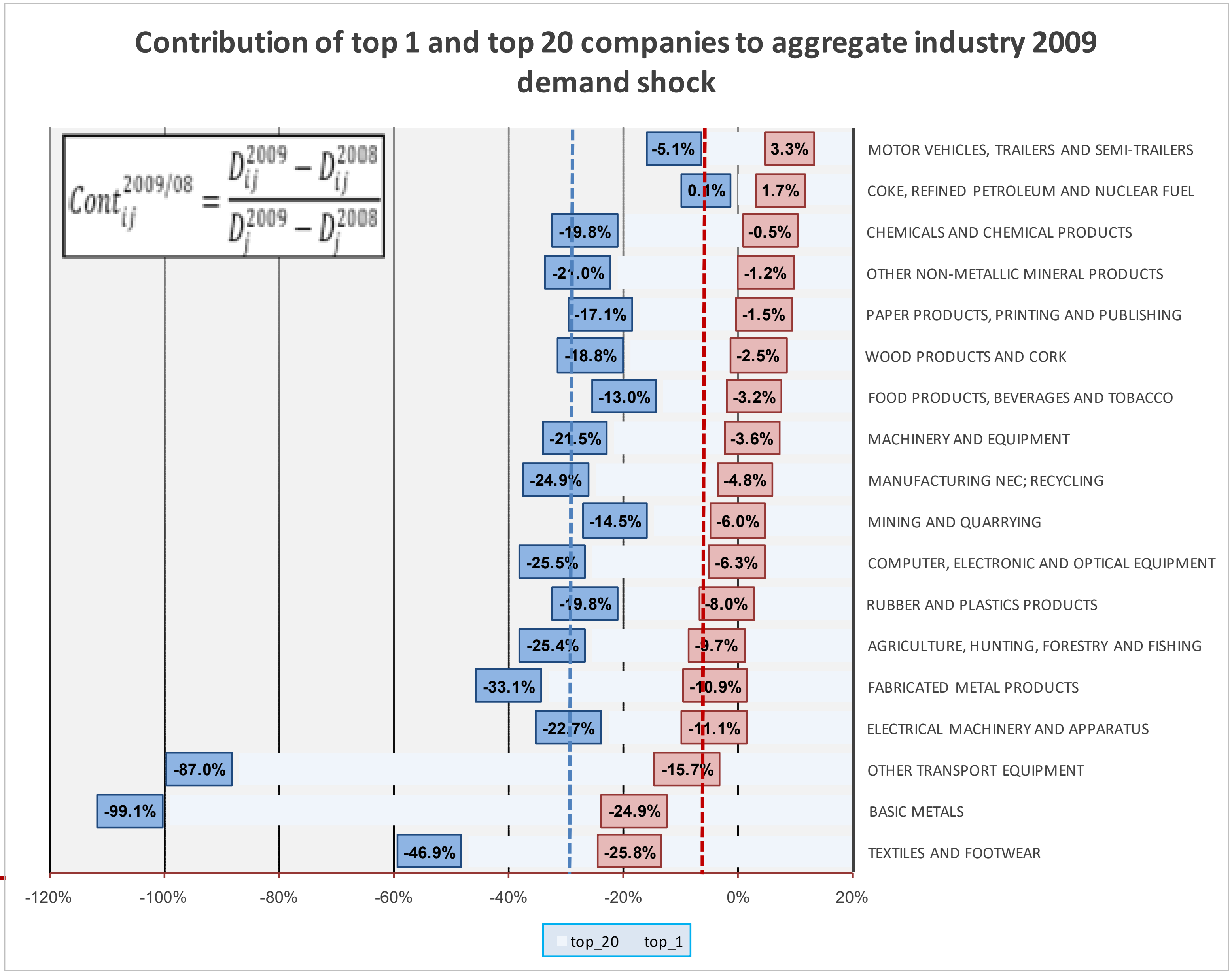
Second-order effects

- Suppliers to G hit by the adverse shock adjust
  - Reduce production, employment
- But also cut purchases of inputs
  - The shocks spreads further down the upstream industries network
- However, difficult to disentangle the effects due to demand shock originated at G and the effects of the overall demand shock due to 2008-09 crisis
- Need to take into account simultaneous shocks from various hubs

Demand shocks



Contribution to demand shocks

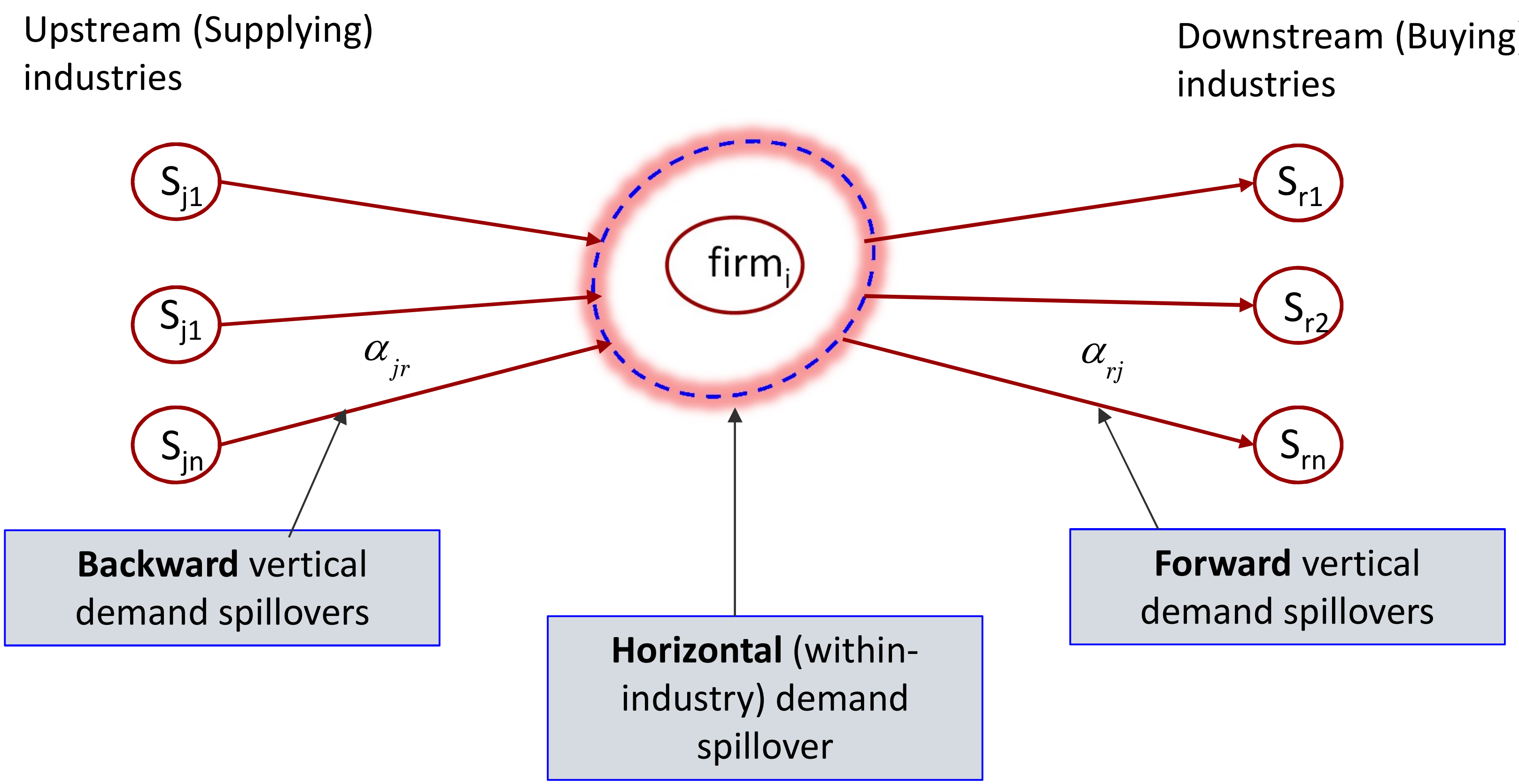


Aims

- Using a population of Slovenian firms to show the importance of hub firms for for propagation of demand shocks
  - Taking 2008-09 demand shock as a natural experiment
  - Studying how the first-order demand shock by top-1, top-3, top-5, top-10 & top-20 largest firms in an industry affects activity of firms in the same and in upstream industries
  - First-order demand shock measured as the decline in domestic sourcing (material cost)
  - Using 2-digit IO tables to calculate horizontal and backward vertical demand spillovers
  - Estimating impact of demand spillovers on overall activity and on individual firms’ performance

Conceptual framework

- Direct and spillover effects of idiosyncratic demand shock



Empirical approach

- Demand shock spillover defined as reduction in volume of material cost
- Identifying top-1, top-3, top-5, top-10 & top-20 largest firms in an industry
  - ranked by their volume of material cost
- Summing up material cost of these top firms by industries
- Linking demand shocks across industries using backward I-O coefficients
- Regressing firm sales on these vertical linkages variables (and a set of firm-level variables)

Empirical approach

Empirical model (in logs):

$$Y_{it} = \alpha + \beta_1 C_t + \beta_2 \mathrm{M}_{it} + \beta_3 \mathrm{Exp}_{it} + \beta_4 D\_Over_{it}$$
$$+\beta_5 HL_{kt} + \beta_6 C_t * HL_{kt} + \beta_7 BL_{kt} + \beta_8 C_t * BL_{kt}$$
$$+\gamma \sum_{t=2}^{T} time_t + \phi \sum ind^k + \eta_i + \varepsilon_{it}$$

Where:

Y_{it} – log firm i's sales

M $_{it}$ – vector of production function inputs (logs of labor, capital, mat. cost)

C – crisis dummy (2009)

Exp_{it} – log exports

D_Over_{it} – log debt overhang

HL_{kt} – horizontal spillover in industry *k*

BL_{kt} – backward spillover in industry *k*

Empirical approach

Demans linkages:

- Horizontal demand spillovers

$HL_{ijt} = \sum MC_{ijt}$ *HL* is an industry sum of demand (mat.cost) by largest sourcing firms (top-1 to top-20)

- Backward demand spillovers

$BL_t^{jk} = \sum_{r,j=1}^{n} \left(\alpha_{jr} * HL_t^{jk} \right)$ *BL* is weighted share of demand made available for upstream (supplying) industries by largest sourcing firms

- α_{jr} is input–output coefficient between industries *j* and *r*
- Model includes also interactions of HL & BL with the crisis dummy

Data

- Firm-level data:
  - Whole population of Slovenian firms (AJPES)
  - Period: 2005 – 2014
  - Includes JSC, LLC and large sole-proprietors
  - About 50,000 observations per year
  - Data trimming (for outliers)

- Input-output tables from OECD
  - for 2005-2011 (latest available)
  - Nace Rev.1 (64 2-digit sectors)
  - Matched to firm-level data

Empirical outline

- Panel data structure for 1995-2014
- All data in logs
- Fixed effects estimator
  - Robustness check: dep.variables in first differences

- A number of specifications estimated:
  - Model 1: total sample, top-20 demand spillovers
  - Model 2: All top demand spillover groups
  - Model 3: splitted sample into small, medium & large firms (<50,<250,>250)

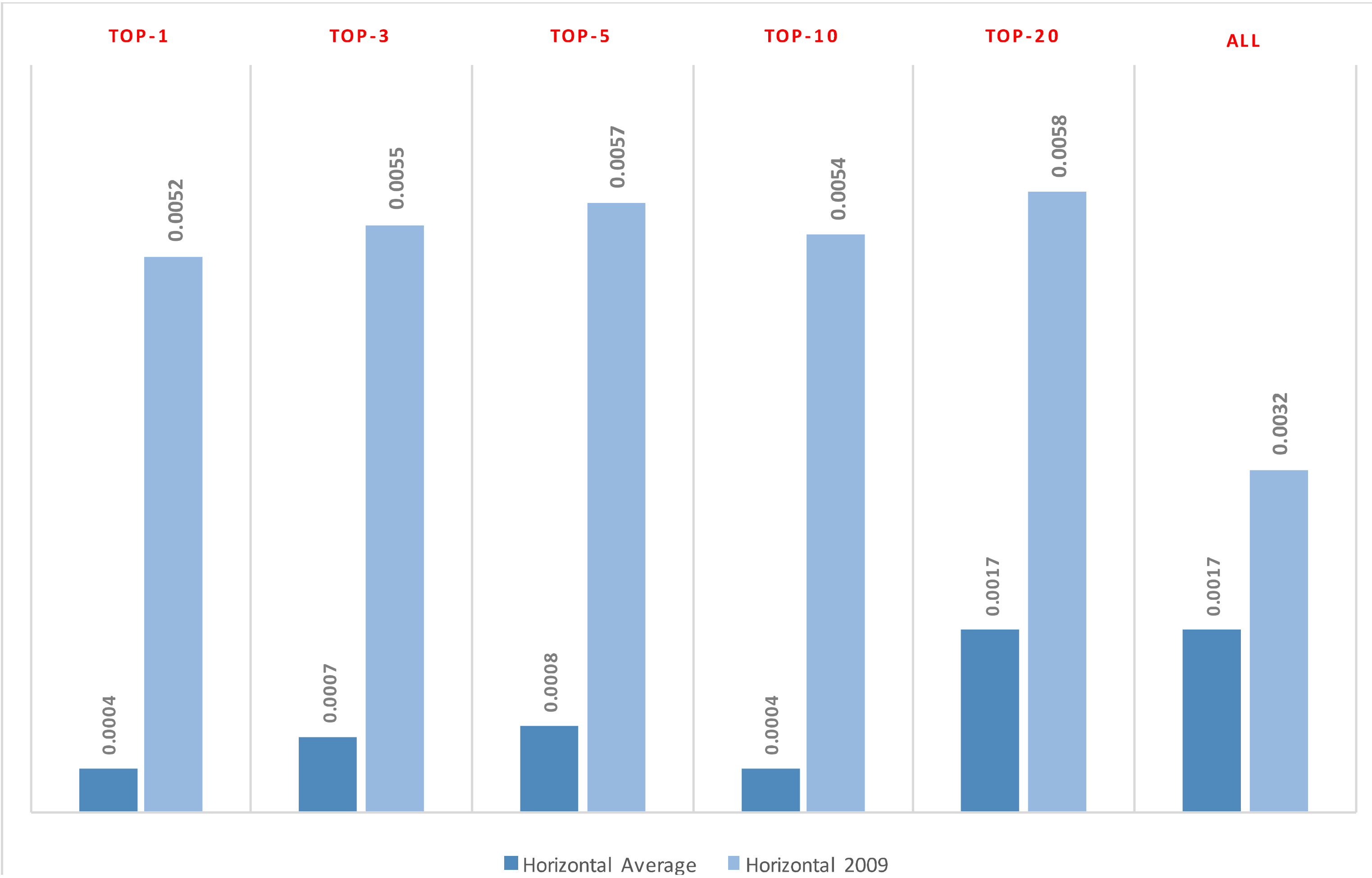
Results

	1	2	3	4
	FE	FE	FE	FE
2009 dummy				0.4368
				[3.71]***
Log Capital	0.2085	0.2078	0.2108	0.2108
	[438.79]***	[439.59]***	[445.87]***	[445.65]***
Log Labor	0.3241	0.321	0.3215	0.3217
	[133.06]***	[132.71]***	[134.13]***	[134.08]***
Log Mat.cost	0.2778	0.2754	0.2726	0.2725
	[144.03]***	[143.49]***	[143.61]***	[143.26]***
Exporter dummy		0.1546	0.1528	0.1525
		[35.31]***	[35.32]***	[35.21]***
Debt-to-assets			0	0
			[5.73]***	[5.72]***
Log Debt overhang			-0.0199	-0.0199
			[-66.38]***	[-66.36]***
Hor. spillover (Top-20)	0.0003	0.0003	0.0002	0.0002
	[6.00]***	[6.22]***	[4.58]***	[3.34]***
Hor. spillover (Top-20)*Crisis				0.0006
				[3.91]***
Backward spillover (Top-20)	0.001	0.0011	0.0009	0.0009
	[19.43]***	[20.71]***	[17.33]***	[14.87]***
Backward spill. (Top-20)*Crisis				0.0247
				[3.68]***
Constant	6.7668	5.6205	6.7007	6.7027
	[427.38]***	[215.32]***	[426.03]***	[424.16]***
Observations	383,919	383,919	383,919	383,919
R-squared	0.948	0.949	95%	95%

Robust t-statistics in brackets
*** p<0.01, ** p<0.05, * p<0.1

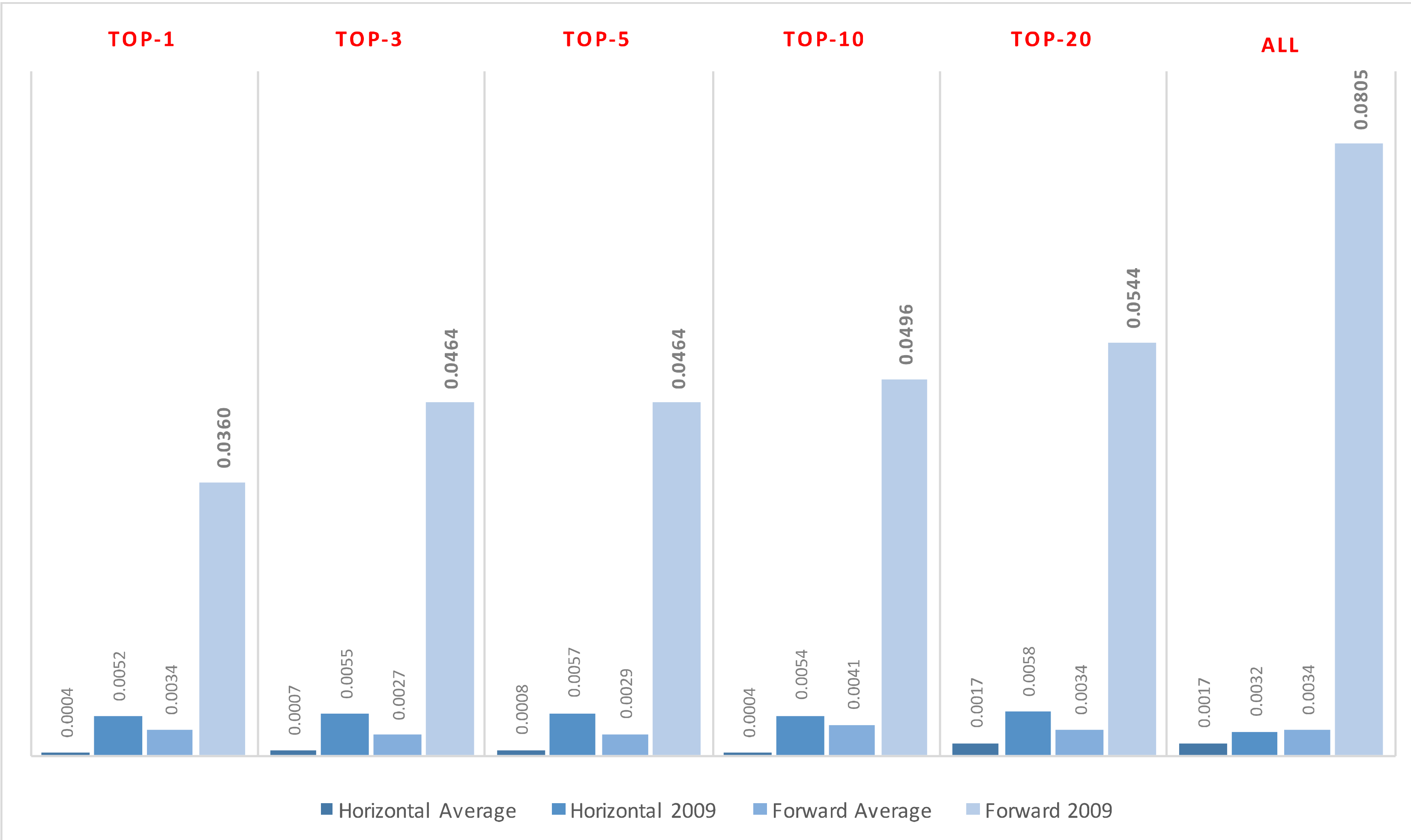
- Average Hor. spillover effect quite low
- But triples in the crisis year
- Backward demand shock spillovers more important
- And increase by a factor of 30 during the crisis year

Results – Horizontal spillovers



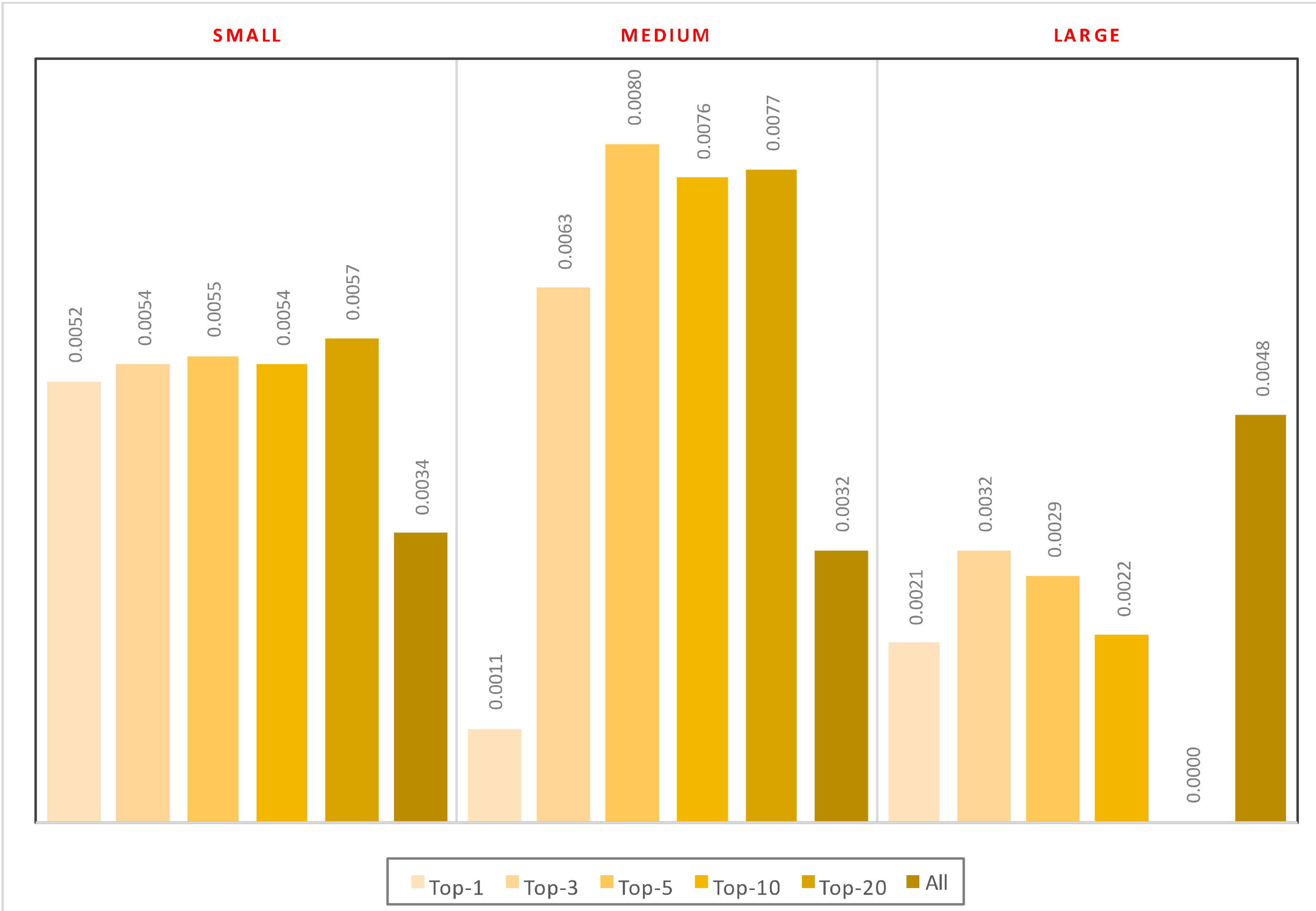
- Intra-industry demand effects quite low, but quadruple during the crisis year
- A demand shock in the same sector during the crisis by 10%, reduces firms' sales by 0.05%

Results – Backward spillovers



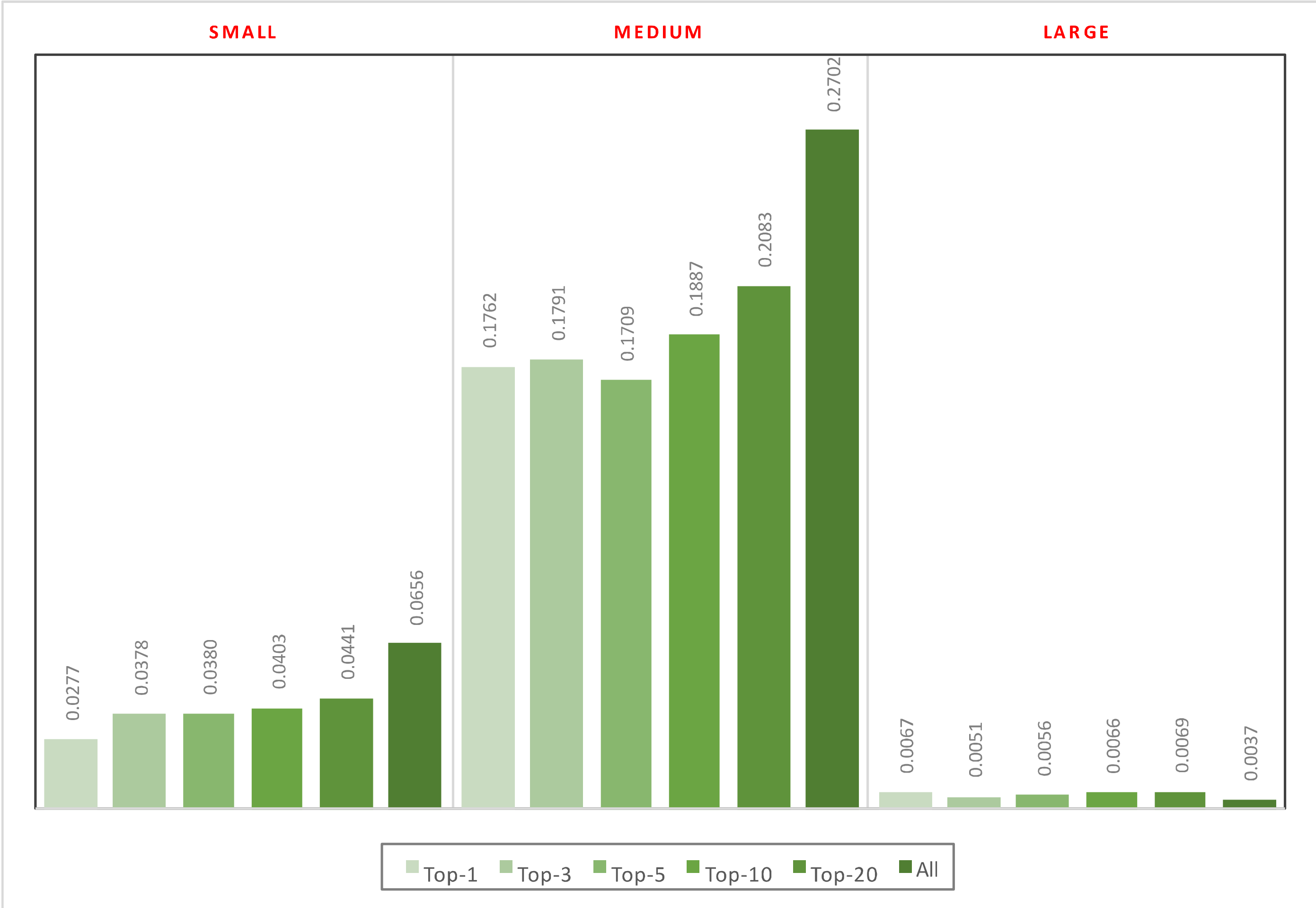
- Backward demand effects become substantial during the crisis year
- A demand shock in downstream buying sectors during the crisis by 10%, reduces firms' sales by 0.4 – 0.8%

Horizontal spillovers – by size classes



- Medium-sized firms most affected by horizontal demand effects
- A demand shock in the same sector during the crisis by 10% reduces firms' sales by up to 0.8%

Backward spillovers – by size classes



- Medium-sized firms most affected by Backward demand spillovers
- A demand shock in downstream buying sectors during the crisis by 10%, reduces sales of medium-sized firms by 2% - 3% and of small firms by 0.2 – 0.6%

Key findings

- Micro shocks to network firms **<u>can</u>** produce large aggregate shocks

- Within-industry demand shocks posed by large firms have little effect
- Backward linkages are more important and become substantial during the crisis
- Effects amplify during the crisis by a factor 3 to 30
- Small & medium-sized firms are hit the most by demand shock spillovers
- However, we need to account for aggregate effects instead of average effects