Credit Supply Shocks, Network Effects, and the Real Economy

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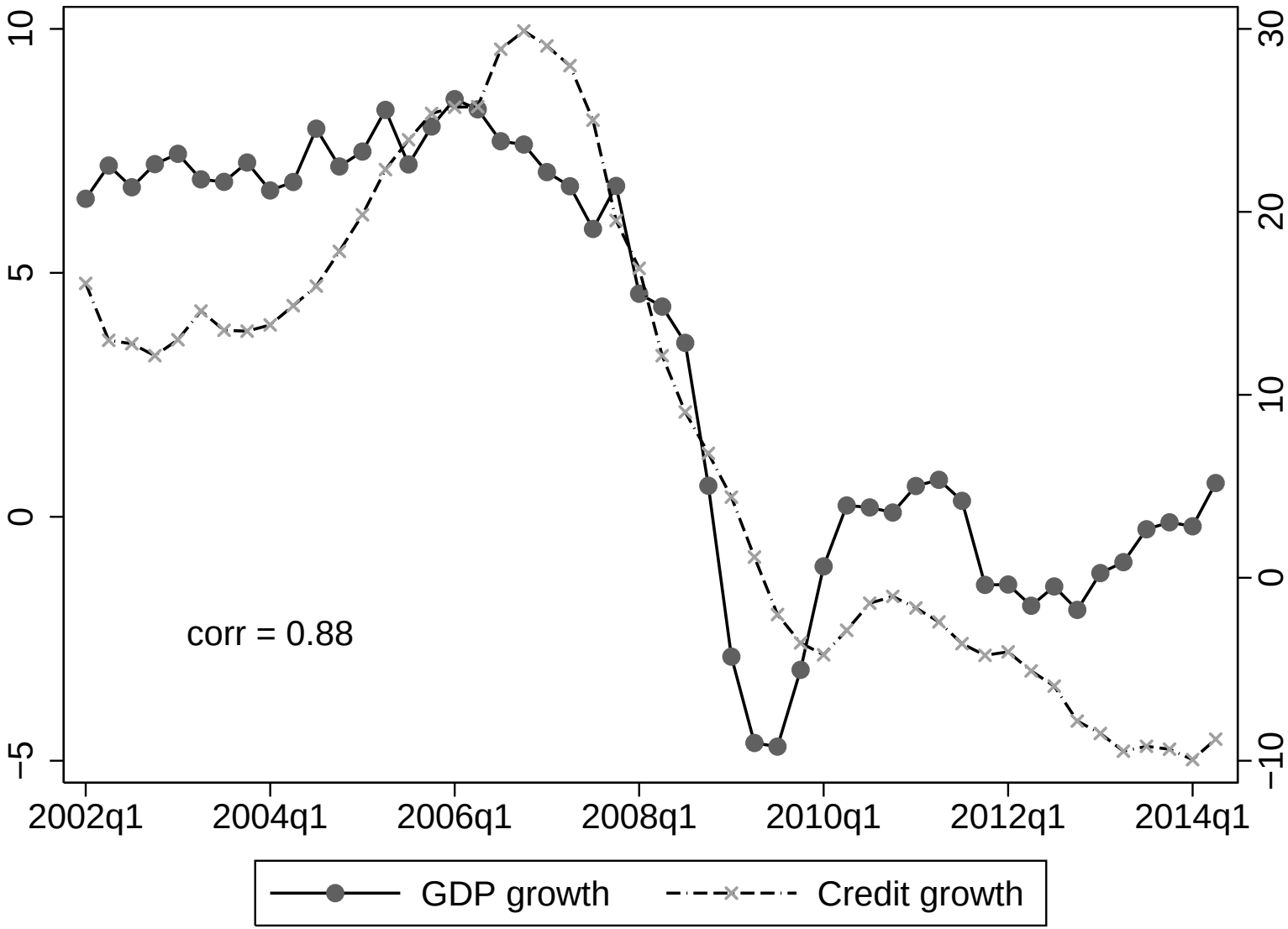
Credit and output growth in Spain



Challenges and proposed solutions

- Investigating the link between credit shocks and real variables poses different challenges:

(A) Identifying credit supply shocks.

(B) Quantifying aggregate real effects.

(C) Data requirements.

Challenges and proposed solutions

- Investigating the link between credit shocks and real variables poses different challenges:

  (A) Identifying credit supply shocks.

  (B) Quantifying aggregate real effects.

  (C) Data requirements.

- To overcome these challenges, we proceed in several ways:

  (A) We disentangle the bank lending channel from the firm borrowing channel using bank-firm level data together with matched employer-employee techniques.

  (B) We formulate a general equilibrium economy with buyer-supplier relations based on Acemoglu et al (2012).

  (C) We exploit a novel database covering the quasi-census of Spanish firms and documenting their credit relations over 2002-2013.

In a nutshell

- We explore the macroeconomic real effects of credit supply shocks (bank lending channel) in Spain over the 2004-2010 period.
- We investigate how bank-lending shocks permeate the economy through input-output linkages.
- We find that this propagation effect is of the same magnitude as the direct effect typically estimated in the literature:
  - Around 1.6 percentage points of annual output growth during 2004-2007 were due to positive credit supply.
    - **0.9 pp. from direct effects** and **0.7 pp. from propagation effects**.
  - Around -1.7 percentage points of annual output growth during 2008-2010 were due to negative credit supply.
    - **-1.0 pp. from direct effects** and **-0.7 pp. from propagation effects**.

Related literature

- Bank lending channel literature:
  - Mostly empirical.
  - e.g. Khwaja and Mian (2008); Amiti and Weinstein (2013); Chodorow-Reich (2014); Jiménez, Mian, Peydró and Saurina (2014); Cingano, Manaresi and Sette (2015); Bentolila, Hansen and Jiménez (2016).
- Networks literature:
  - Mostly theoretical.
  - e.g. Acemoglu, Carvalho, Ozdaglar and Tahbaz-Salehi (2012); Acemoglu, Akcigit, Kerr (2015); Carvalho (2014); Bigio and La'O (2016).
- This paper aims to bring them together.

Roadmap

- **Data**.
- Identification and validation of credit supply shocks.
- Direct effects of credit supply on real outcomes.
- Network propagation of the credit supply shocks. [PRELIMINARY]

Data (I) — CIR

- The Central Credit Register (CIR) is maintained by the Bank of Spain in its role as primary banking supervisory agency.
- It contains detailed monthly information on all outstanding loans over 6,000 euros to non-financial firms granted by all banks operating in Spain.
- Annual bank-firm credit exposure is computed as the average value of monthly loans between bank i and firm j.
- We end up with a bank-firm-year database covering 9 years from 2002 to 2010, 235 banks, 1,555,806 firms, and 18,346,144 bank-firm-year pairs (our so-called loans).

Data (II) — SABI-CBI

[Firm size distribution][Coverage]

- We use administrative data on firm-level characteristics taken from the Spanish Commercial Registry and constructed by Almunia, López-Rodríguez and Moral-Benito (2016).
- The so-called SABI-CBI data set combines two different samples taken from the Commercial Registry raw data:
  - The Central de Balances Integrada (CBI) from the Bank of Spain.
  - The Informa dataset commercialized by Bureau van Dijk under the denomination of SABI, the Portuguese and Spanish input for the Amadeus and Orbis datasets.
- We end up with a firm-year database covering 9 years from 2002 to 2010, 1,580,586 firms, and 8,883,184 firm-year observations.

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Identification of bank-specific credit supply shocks

Khwaja and Mian (2008) meet Abowd, Kramarz, and Margolis (1999)

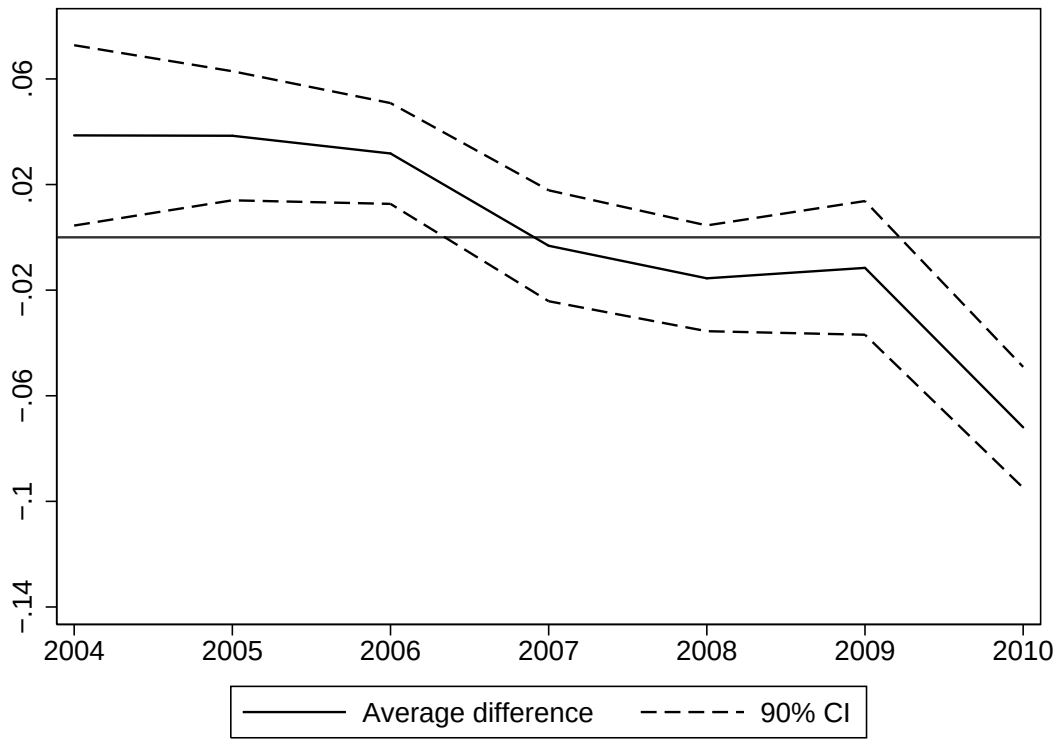
- We consider the following decomposition of credit growth between **bank** i and **firm** j in year t:

$$\Delta \ln c_{ijt} = \delta_{it} + \lambda_{jt} + \epsilon_{ijt} \tag{1}$$

- δ_{it} and λ_{jt} refer to the bank-lending channel (supply) and the firm-borrowing channel (demand).
- δ_{it} captures bank-specific effects that are identified through differences in credit growth between banks lending to the same firm.
- In order to estimate and identify δ_{it} we resort to matched employer-employee techniques advanced by Abowd, Kramarz, and Margolis (1999). [Details]

Validation 1: Weak banks

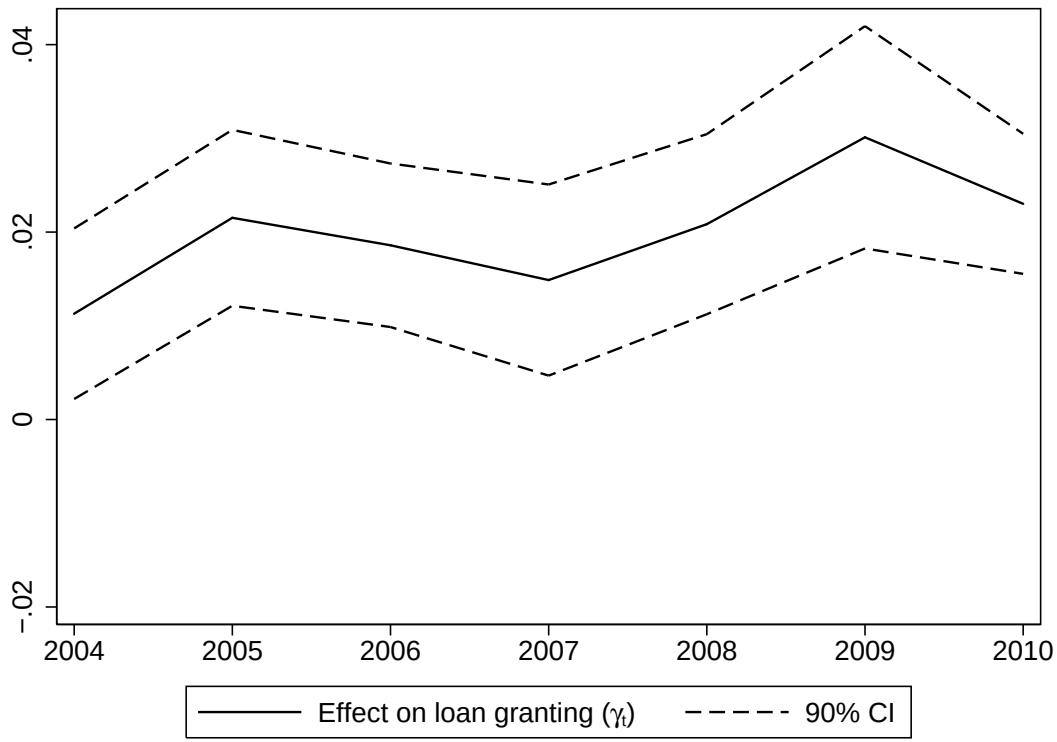
Figure: Average difference in bank supply shocks (weak - healthy)



Notes. This plot is based on year-by-year regressions of the bank-level dummies on a constant and a dummy for weak banks as identified in Bentolila et al 2016. For each year we plot the coefficient on the weak bank dummy, which estimates the average difference in supply shocks by type of bank (weak or healthy).

Validation 2: Loan granting

Figure: Effect of the bank shocks on loan granting



Notes. This plot is based on year-by-year regressions of the loan granted dummy on the bank-level dummies and a set of firm fixed effects: $Loan\_granted_{ij} = \gamma\hat{\delta}_i + \lambda_j + \epsilon_{ij}$. In particular, the γ parameter plotted here estimates the effect of the bank dummies on the probability of acceptance of a loan request. Standard errors are clustered at the bank level.

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Real effects of credit supply shocks

[BLC loan level][BLC firm level]

- Reduced-form effects on firm growth (OLS):

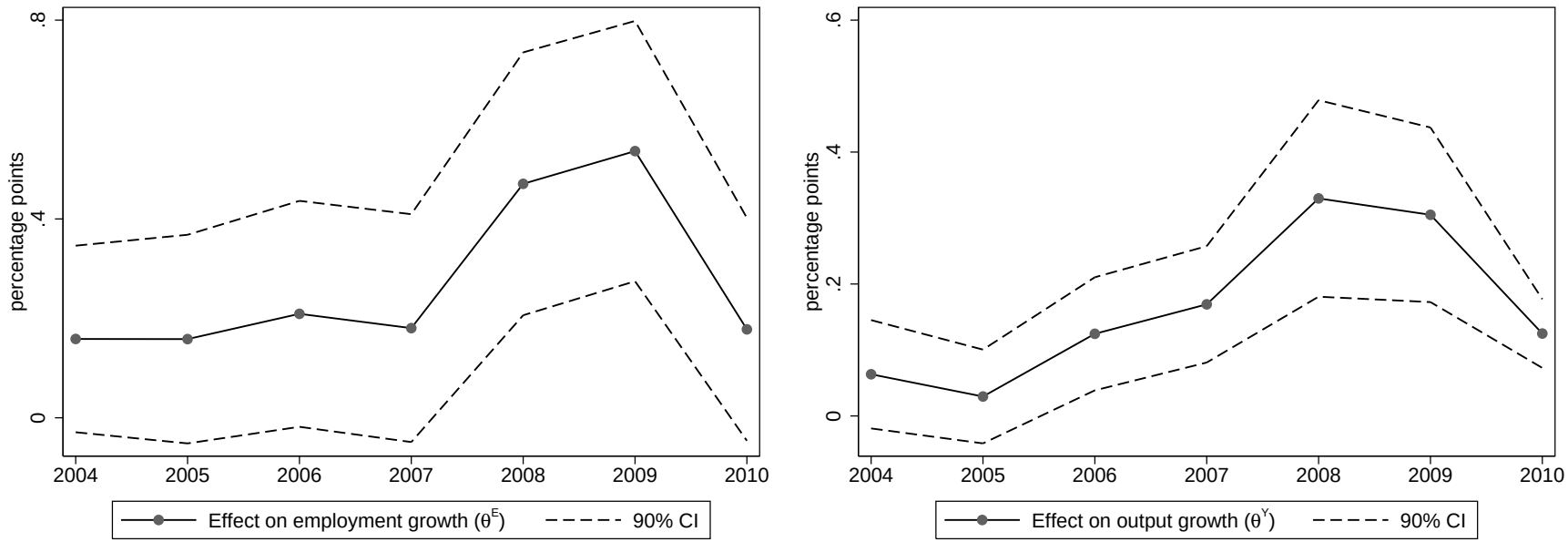
$$\Delta \ln y_j = \theta^y \overline{\delta}_j + \pi^y X_j + \nu_j^y \tag{2}$$

- Credit-driven effects on firm growth (IV):

$$\begin{aligned} \Delta \ln y_j &= \phi^y \Delta \ln c_j + \pi_{IV}^y X_j + u_j^y \\ \Delta \ln c_j &= \psi \overline{\delta}_j + \Phi X_j + v_j \end{aligned} \tag{3}$$

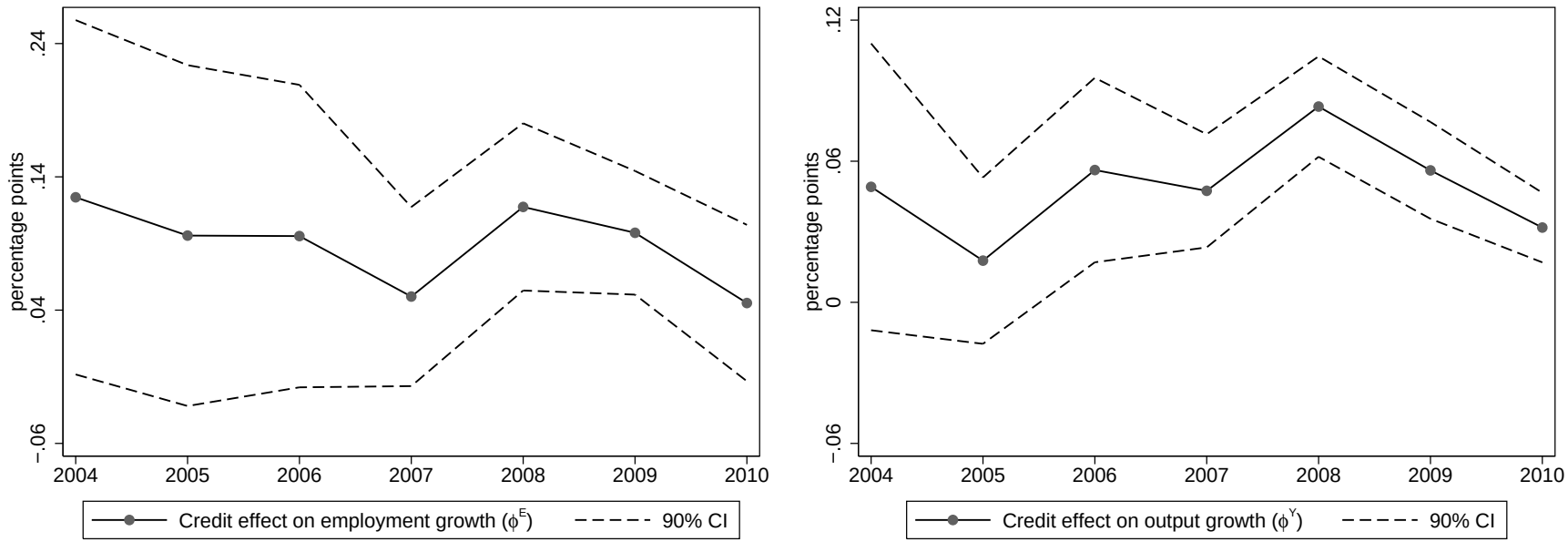
where $y_j = \{E_j, Y_j\}$ refers to either employment or output of firm j.
$\overline{\delta}_j$ is the firm-specific credit supply shock ($\overline{\delta}_j = \sum_i \frac{c_{ij(-1)}}{\sum_i c_{ij(-1)}} \hat{\delta}_i$).
The vector X_j includes the firm-specific credit demand shocks ($\hat{\lambda}_j$) as well as other firm covariates, namely, size, sector of activity, lagged investment, lagged loan-to-assets ratio, and lagged productivity.

Reduced-form effects of the BLC on firm growth



Notes. This figure plots the θ^E and θ^Y estimates from year-by-year regressions given by equation (2), which identify the reduced-form effect of the bank lending channel on employment and output growth at the firm level. In particular, the figure plots the effect of a one SD increase in the credit supply shock on annual employment and output growth in percentage points. The estimation samples comprise, on average, 354,029 and 344,908 firms in each year. Standard errors used to construct the confidence bands are multi-clustered at the main bank and industry level.

Credit-driven effects of the BLC on firm growth



Notes. This figure plots the ϕ^E and ϕ^Y estimates from year-by-year IV regressions given by (3), which identify the effect of credit supply on employment and output growth at the firm level through the access to credit. In particular, the figure plots the effect of a one percentage point increase in credit growth on annual employment and output growth in percentage points. The estimation samples comprise, on average, 354,029 and 344,908 firms in each year. Standard errors used to construct the confidence bands are multi-clustered at the main bank and industry level

From firms to industries

- We estimate the counterfactual employment and output growth that we would have observed in the absence of credit supply shocks as follows:

$$\widetilde{\Delta \ln y_j} = \Delta \ln y_j - \hat{\phi}^y \overline{\Delta \ln c_j} \tag{4}$$

where $\overline{\Delta \ln c_j} = \hat{\psi}\bar{\delta}_j$ is the credit growth induced by supply factors.

- Firm-specific figures can be aggregated as follows:

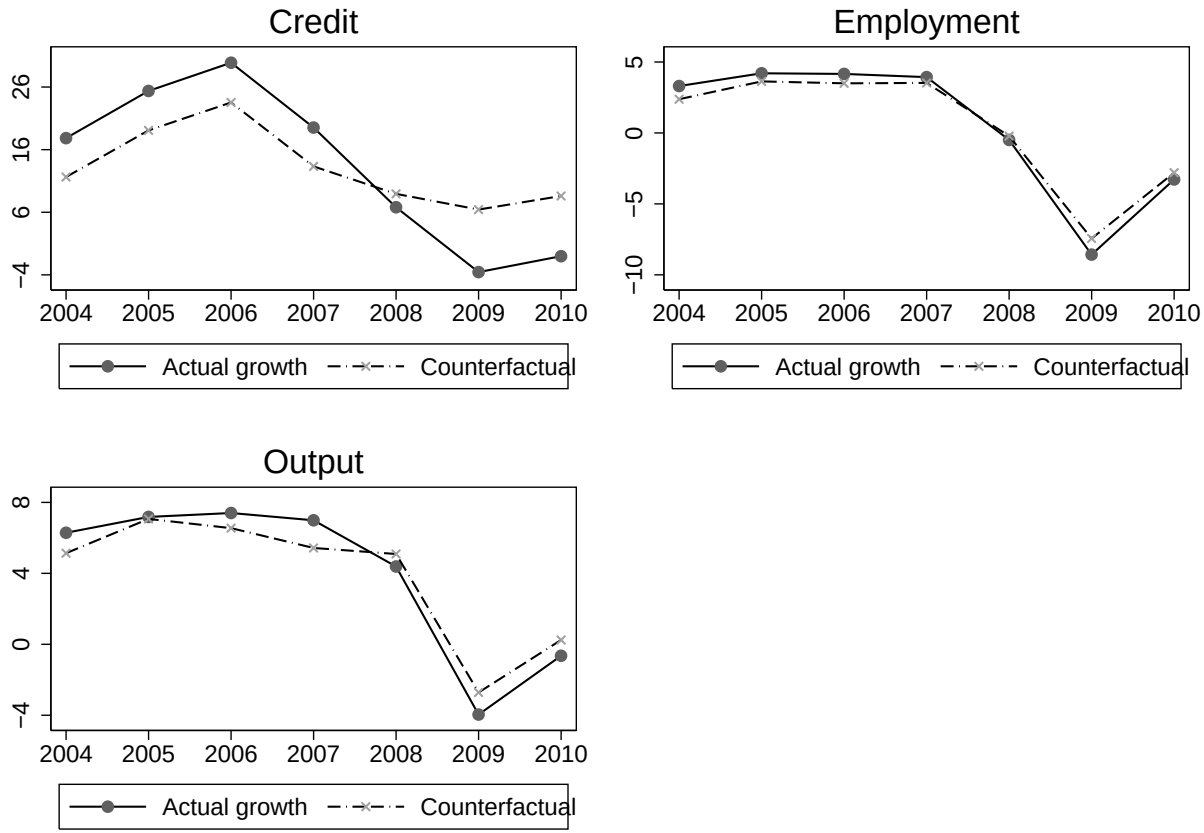
$$\widetilde{\Delta \ln y} = \sum_i \varphi_i \widetilde{\Delta \ln y_i} \tag{5}$$

$$\Delta \ln y = \sum_i \varphi_i \Delta \ln y_i \tag{6}$$

where φ_i refers to the employment (or output) weight of firm i in the previous year ($\varphi_i = \frac{y_{i(-1)}}{\sum_j y_{j(-1)}}$).

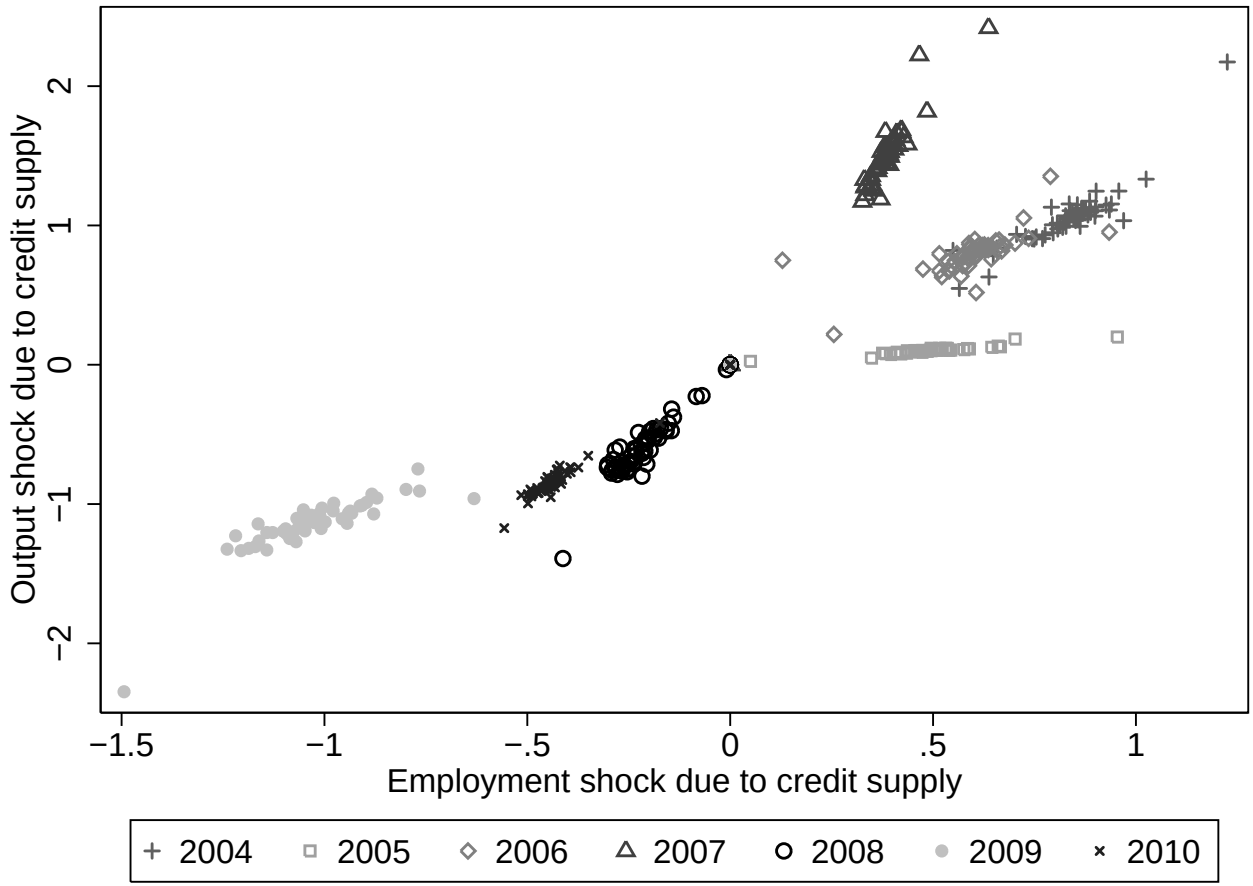
Aggregate direct effects

[Figures][A time-varying credit supply indicator]



Notes. This figure plots aggregate credit, employment and output growth rates. Actual refers to National Accounts figures for employment and output, and Banco de España figures for credit. Counterfactual refers to the estimated growth rates in the absence of credit supply shocks ($\widetilde{\Delta \ln E}$, $\widetilde{\Delta \ln Y}$, and $\widetilde{\Delta \ln C}$).

Direct effects by industry



Notes. This figure plots the industry-specific shocks in terms of employment (x axis) and output (y axis) due to credit supply. These shocks are constructed from the aggregation of the firm-level shocks $\hat{\phi}^y \overline{\Delta \ln c_j}$.

Roadmap

- Data.
- Identification and validation of credit supply shocks.
- Direct effects of credit supply on real outcomes.
- **Network propagation of the credit supply shocks**. [PRELIMINARY]

Network propagation of the credit supply shocks

- A recent strand of the literature emphasizes the role of input-output linkages in propagating shocks:
  - e.g. Acemoglu, Carvalho, Ozdaglar and Tahbaz-Salehi (2012), Carvalho (2014), Acemoglu, Akcigit, Kerr (2015), Bigio and La'O (2016).

- We consider this type of models to quantify the propagation of our estimated credit supply shocks.
  - The model is close to Acemoglu, Carvalho, Ozdaglar and Tahbaz-Salehi (2012).
  - We include financial frictions through working capital as in Bigio and La'O (2016).
  - So far we focus on a simple version of the model:
    - e.g. labor is inelastically supplied by the household.

The model (I)

Technology and market structure

- There are n industries operating in the economy

  - Given the level of disaggregation in INE IO tables ($n = 64$)

- One perfectly competitive firm operates in each industry $i = 1, ..., n...$

- ...using the following production function:

$$y_i = l_i^{\alpha_i^l} \prod_{j=1}^{n} y_{ij}^{a_{ij}}$$

  where:

  - y_i is the amount of units produced in industry i
  - y_{ij} is the amount of goods produced in industry j used as inputs by industry i
  - l_i is the amount of labor used by industry i
  - We assume: $\alpha_i^l + \sum_{j=1}^{n} a_{ij} = 1, \quad \alpha_i^l > 0 \quad \text{and} \quad a_{ij} \geq 0$

The model (II)

Financial Constraints

- We assume the existence of working capital
  - Wages and the cost of intermediate goods must be paid in advance
  - Firms want to borrow to afford this cost before production takes place
- Firms can borrow just up to a fraction ϕ of their revenue

$$l_i + \sum_{j=1}^{n} p_j y_{ij} \leq \phi_i p_i y_i$$

- Under CRS, the firm would always like to borrow an amount equal to $p_i y_i$
  - The constraint binds whenever $\phi < 1$

The model (III)

Firms' maximization problem

- Firm operating in industry i solves the following maximization problem:

$$\max_{l_i, x_{ij}, \forall j} \left\{ p_i y_i - l_i - \sum_{j=1}^{n} p_j y_{ij} \right\}$$

$$\text{subject to:} \quad y_i = l_i^{\alpha_i^l} \prod_{j=1}^{n} y_{ij}^{a_{ij}}$$

$$l_i + \sum_{j=1}^{n} p_j y_{ij} \leq \phi_i p_i y_i$$

- This problem is solved in two stages
  1. Given level of expenditure E_i, the firm decides how much to spend in each factor
  2. The level of expenditure E_i is pinned down by:

$$E_i = \min\{1, \phi_i\} p_i y_i$$

The model (IV)

Households

- Don't do much in this model (supply L units of labor inelastically)
- They maximize

$$u(c_1, ..., c_n,) = \prod_{i=1}^{n} c_{ij}^{\beta_i}$$

subject to:

$$\sum_{i}^{n} p_i c_i = wL$$

- FOC yield to:

$$p_i c_i = \beta_i wL$$

The model (V)

Equilibrium

An equilibrium in this economy is defined as a set of prices $\{p_1, ..., p_n\}$ and allocations $\{l_1, ...; l_n\}$, $\{y_1, ..., y_n\}$, $\{c_1, ..., c_n\}$ and $\{y_{i1}, ..., y_{in}\}$, $\forall i$, such that:

1. Firms solve their maximization problem
2. Households solve their optimization problem
3. Markets clear

The model (VI)

Network effects

- It can be shown that all type of supply shocks have the same effect:

$$dlny_i = \underbrace{dln\phi_i}_{\text{direct effect}} + \underbrace{\sum_{j=1}^{n} (h_{ij} - \mathbf{1}_{i=j}) \times dln\phi_j}_{\text{network effect}}$$

- This model predicts downstream effects only

  - Imagine j is a supplier of i
  - $\phi_j \downarrow \Rightarrow y_j \downarrow \Rightarrow p_j \uparrow \Rightarrow y_{ij} \downarrow \Rightarrow y_i \downarrow$

- No upstream effects:

  - Imagine z is a customer of i
  - $\phi_z \downarrow \Rightarrow y_z \downarrow \Rightarrow p_z \uparrow \Rightarrow p_z y_z$ remains constant (CD assu.) $\Rightarrow y_{zi}$ remains constant

The model (VII)

IO structure

- Firms' FOC imply:

$$a_{ij} = \frac{p_j y_{ij}}{R_i}$$

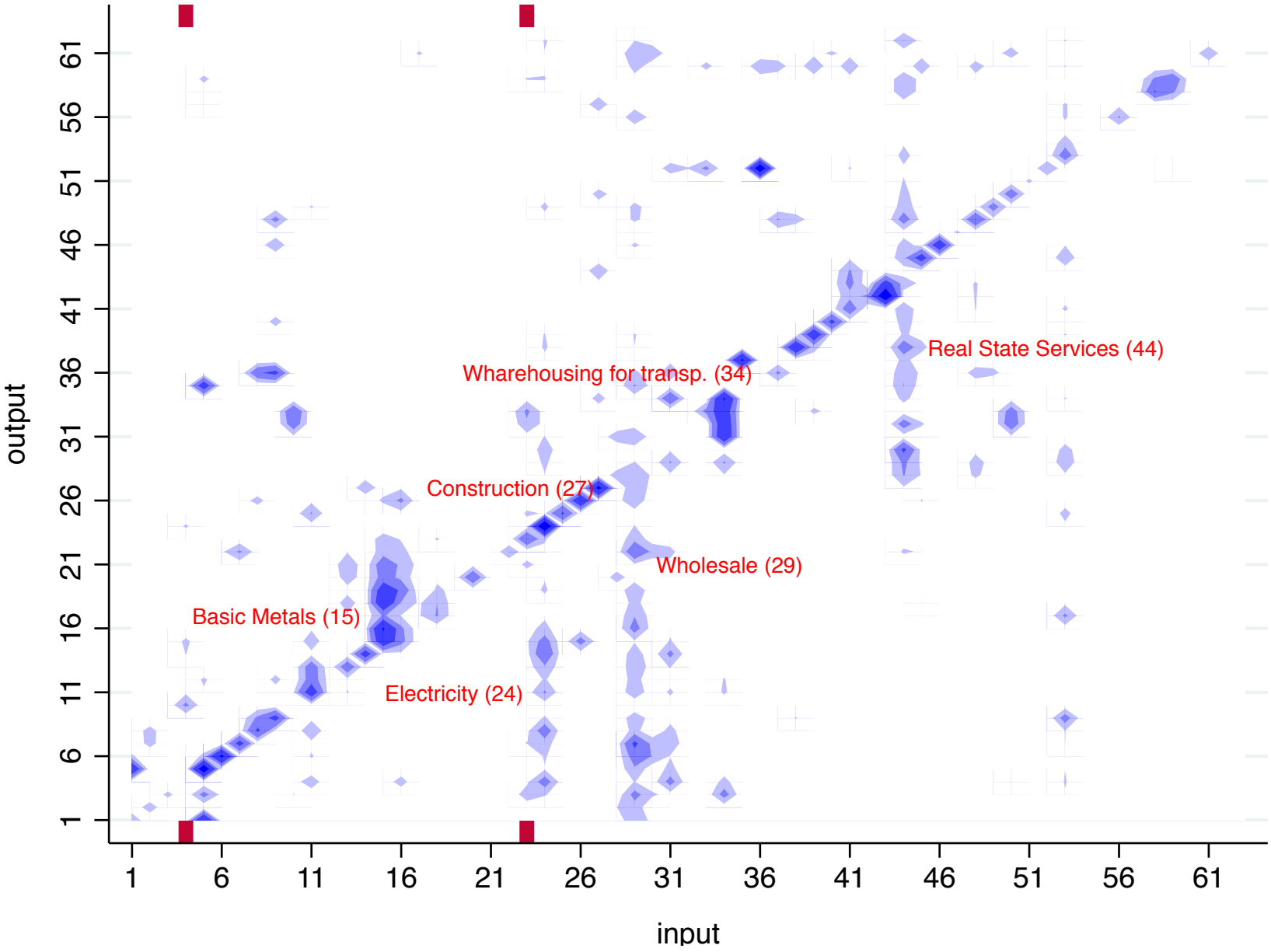
- When $R_i = 1$:

  $a_{ij} =$ "euros spent in industry j by industry i to produce 1 euro of revenue"

- INE provides this matrix (direct requirement matrix):

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix}$$

The Spanish IO structure

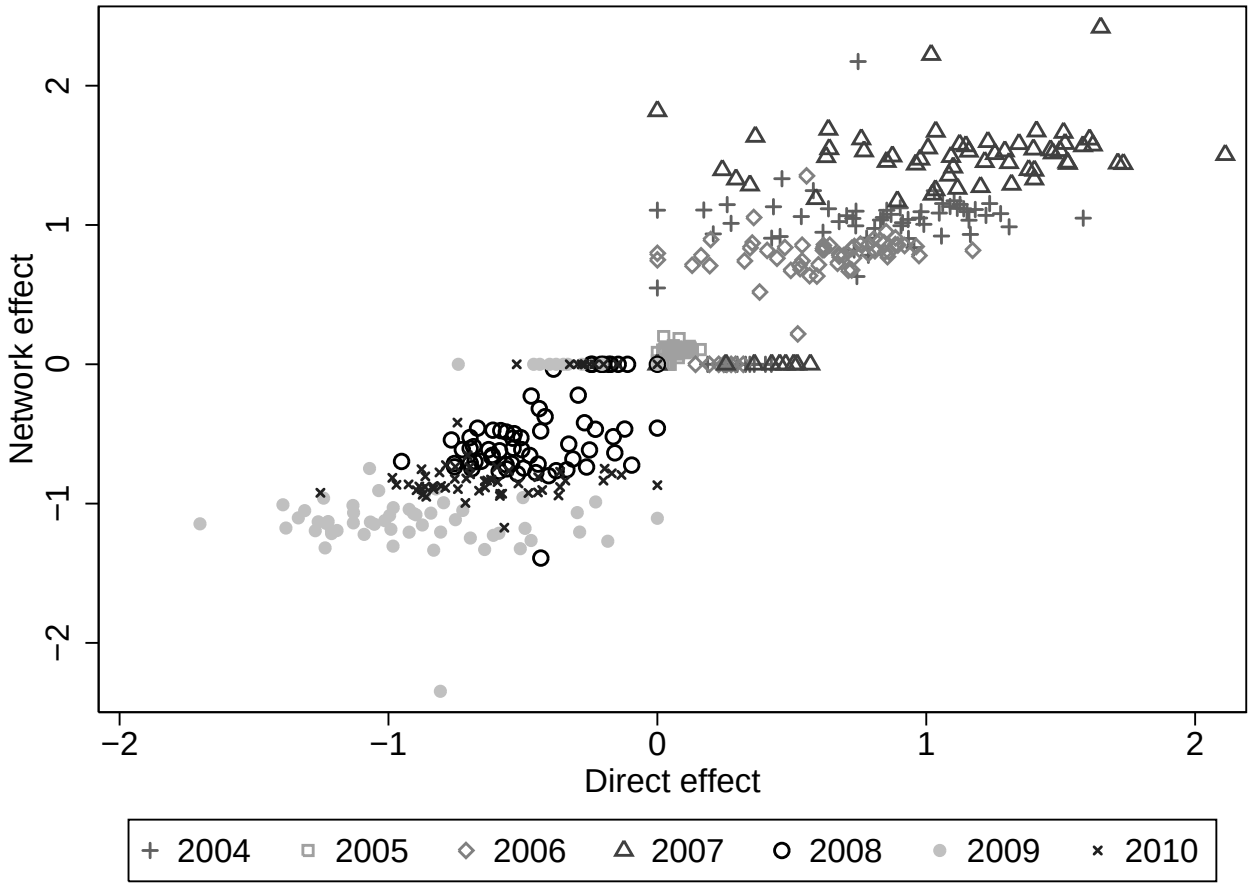


Quantitative experiment

Experiment

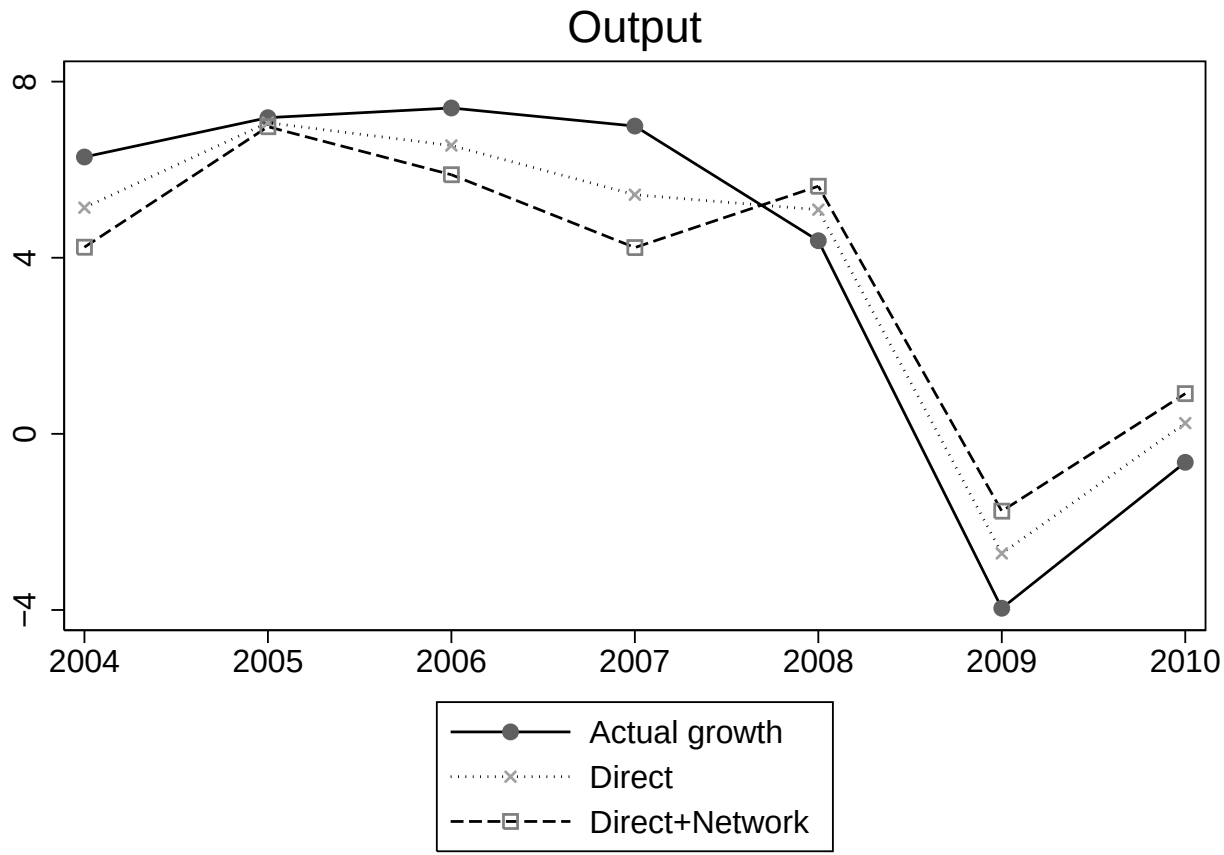
- We are interested in changes of value added (not about the levels).
- For each year, we set ϕ in each industry such that the model generates the same "direct effect" as the one that we observe in the data
- Example:
  - Imagine that we estimate that value added would have been 10% higher in the absence of negative financial shock due to the direct effect in a given industry.
  - Then we fix ϕ in that industry so the model generates the same 10% from the direct effect.
  - The model also tells us what is the network effect and the total effect.
  - Imagine that, given a direct effect of a 10%, the model predicts a network effect of 5%:
    - We would conclude that the network effect accounts for 1/3 of the total effect.

Direct and network effects by industry



Notes. This figure plots the industry-specific effects (in percentage points) on output due to credit supply shocks.

Aggregate (direct+network) effects — total economy



Notes. This figure plots aggregate output growth. Actual refers to National Accounts figures. Direct and network refer to the estimated growth rates in the absence of credit supply shocks.

Final remarks

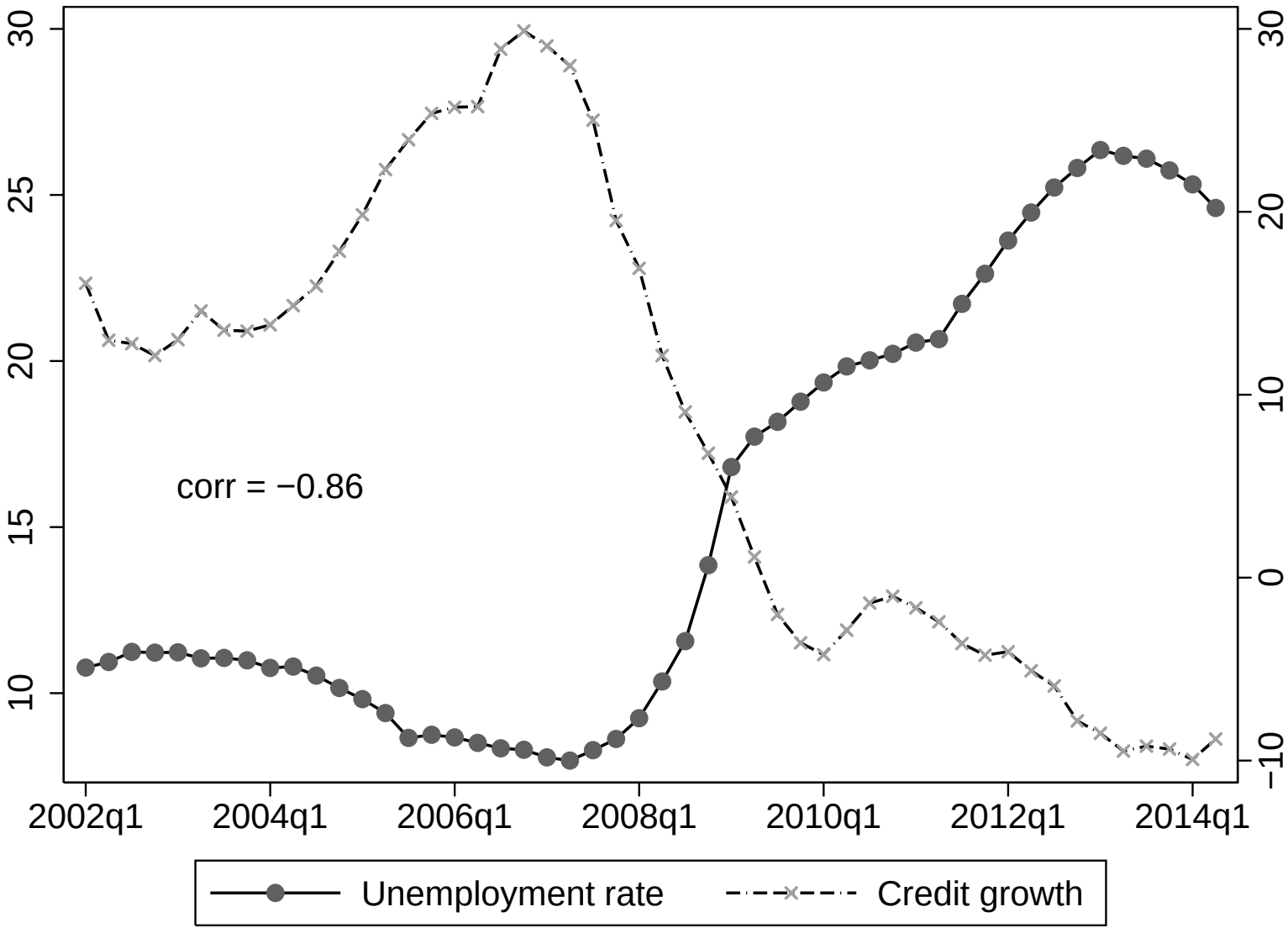
Summary

- According to our estimates, credit supply might explain around 20% of output growth during 2004-2007 and 55% of the output fall in 2009.
- Propagation through industry linkages explain around 40% of these effects.

Work ahead

- Incorporate endogenous labor supply to the model in order to quantify the propagation of employment effects from the bank-lending channel.

Credit growth and unemployment in Spain



SABI-CBI dataset

Table: Firm size distribution in terms of turnover (million euros).

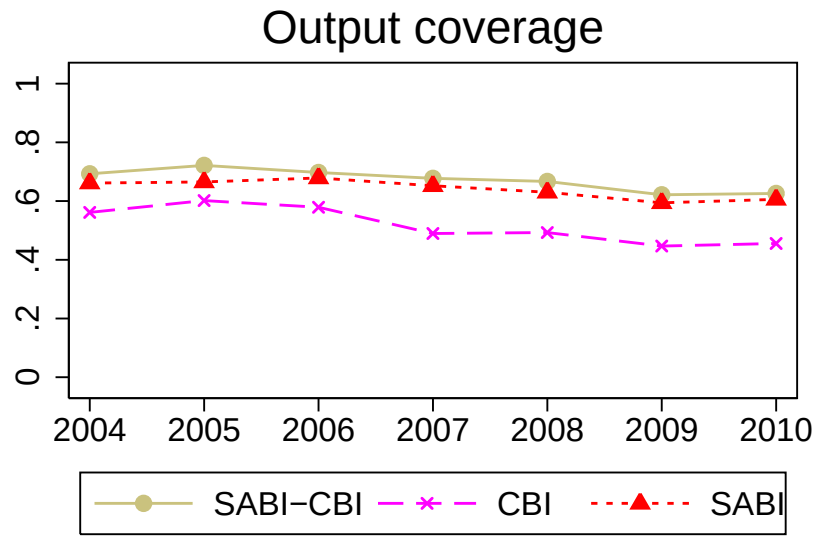
	0-0.06	0.06-0.6	0.6-1.5	1.5-6.0	6.0-30	+30
SABI-CBI	91%	79%	90%	92%	86%	82%
CBI	90%	73%	81%	81%	60%	59%
SABI	19%	63%	84%	90%	85%	79%

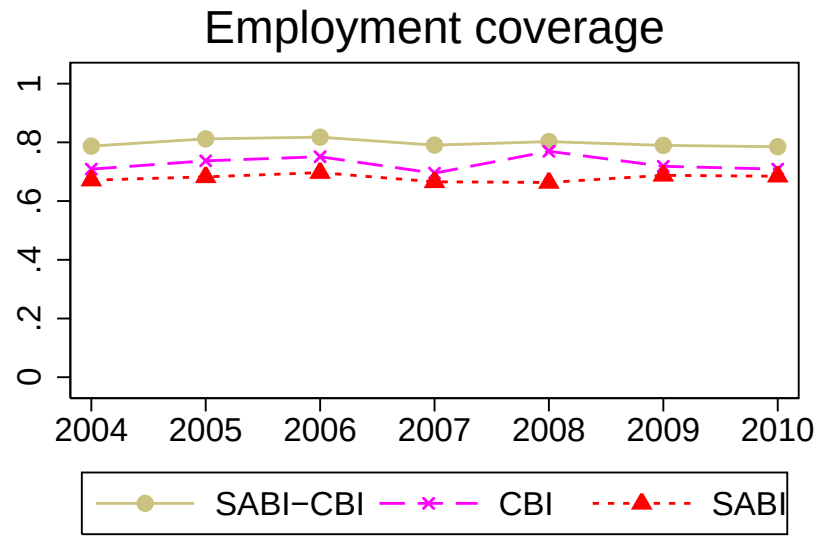
Table: Firm size distribution in terms of number of employees.

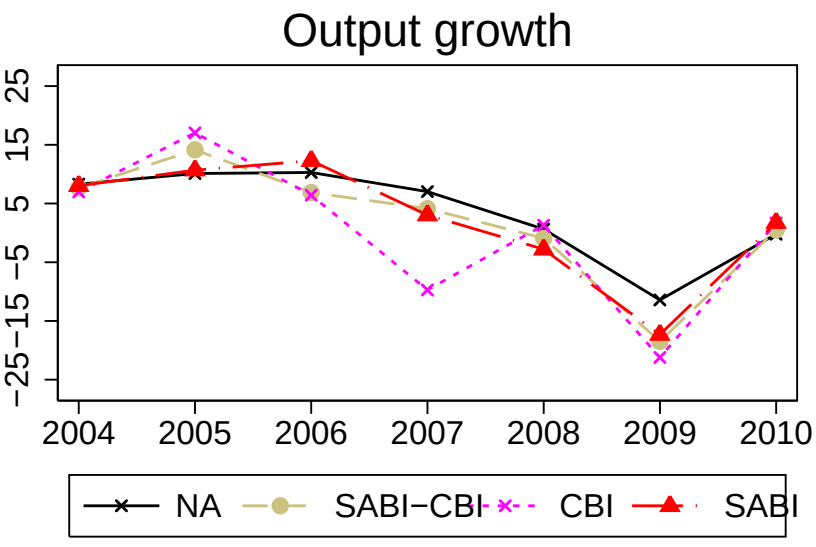
	0 to 9	10 to 19	20 to 49	50 to 200	+200
SABI-CBI	81%	108%	106%	95%	93%
CBI	77%	98%	93%	73%	76%
SABI	38%	99%	99%	89%	86%

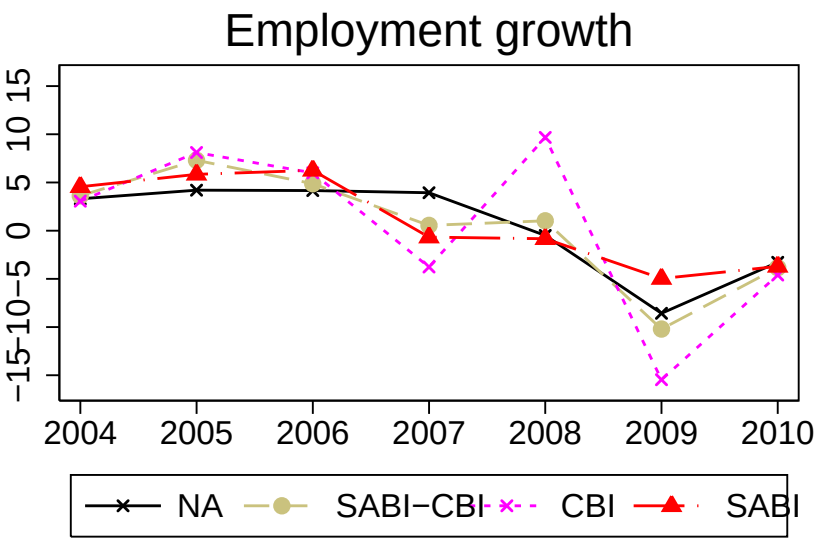
Notes. Each cell corresponds to the number of firms in total economy from each database relative to the number of firms in the AEAT statistics (tax authority census) for turnover and in the DIRCE statistics (census from the National Statistics Institute) for employment. All figures refer to the average over the 2004-2010 period.

SABI-CBI dataset

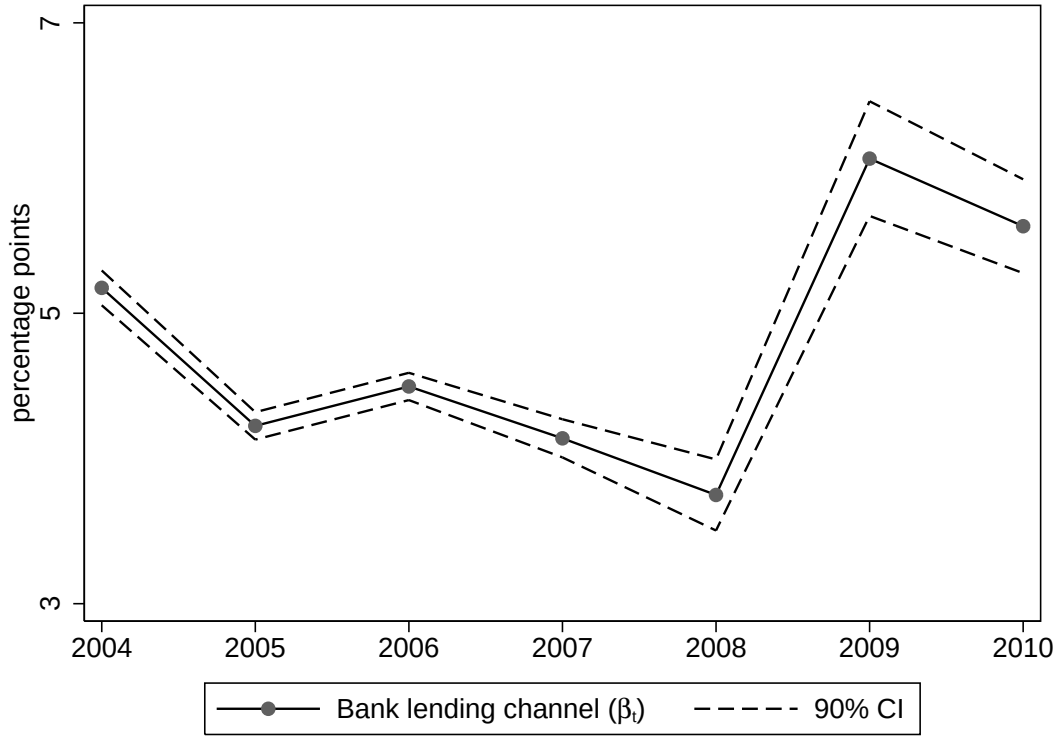






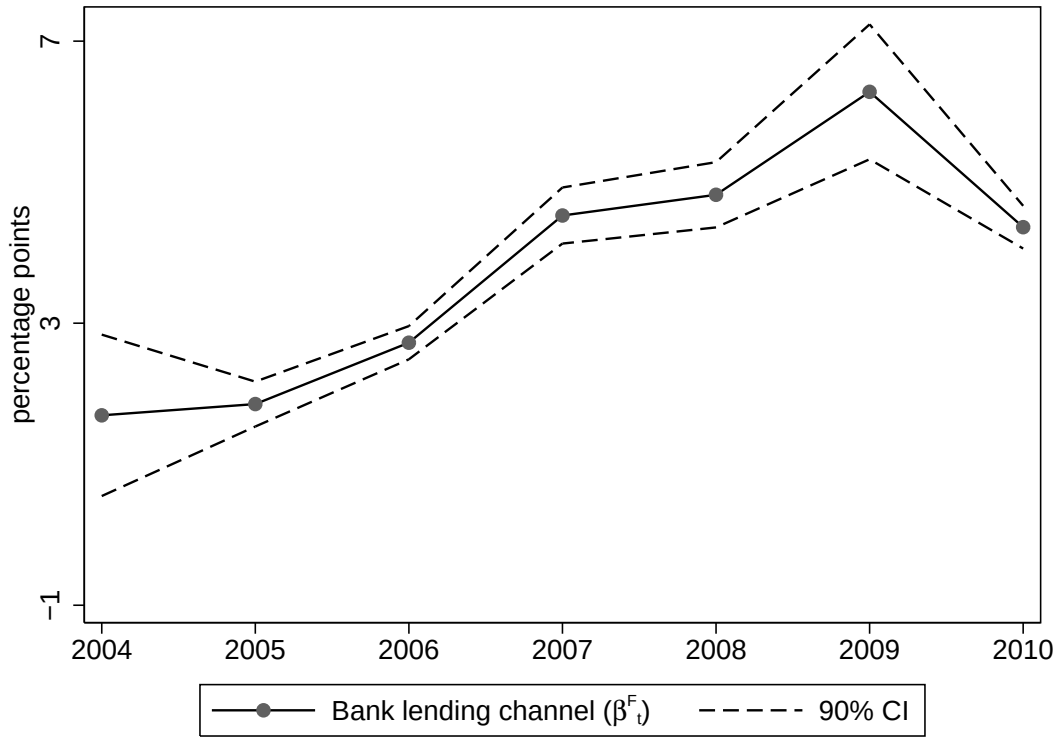


The bank lending channel at the loan level



Notes. This figure plots the β estimates from year-by-year regressions given by equation $\Delta \ln c_{ij} = \alpha + \beta\hat{\delta}_i + \eta_j + v_{ij}$. The estimation sample comprises, on average, 1,667,718 loans and 887,992 firms in each year. Standard errors used to construct the confidence bands are multi-clustered at the bank and firm level.

The bank lending channel at the firm level



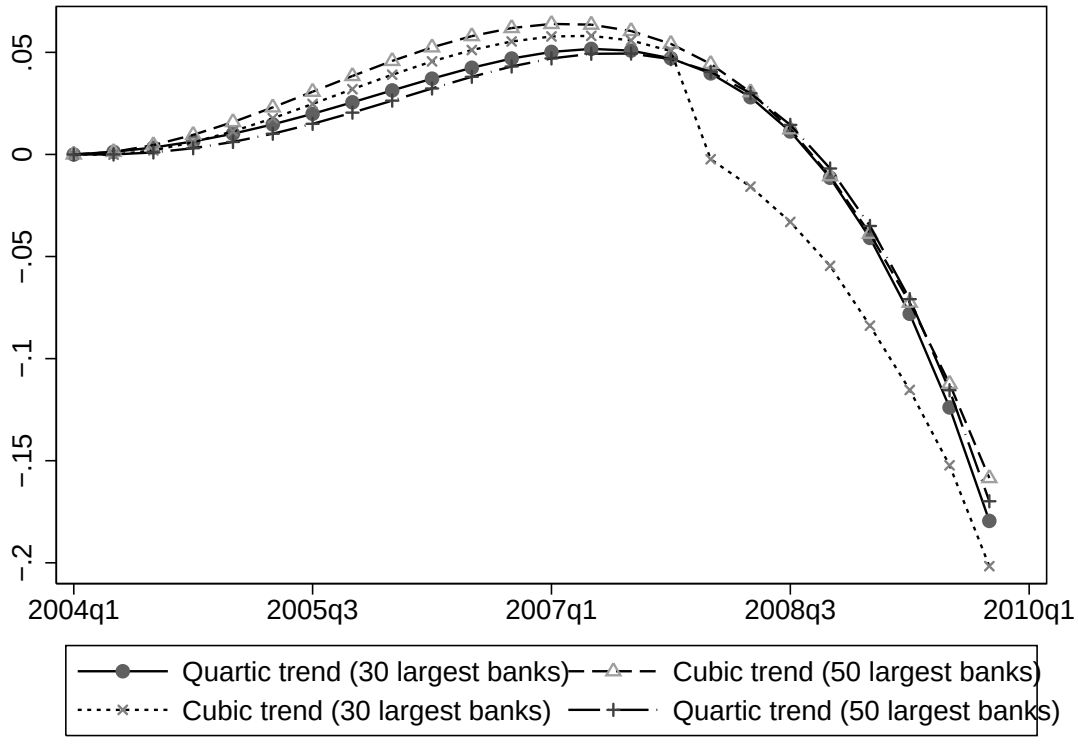
Notes. This figure plots the β^F estimates from year-by-year regressions given by $\Delta \ln c_j = \alpha^F + \beta^F \overline{\delta}_j + \gamma^F \hat{\lambda}_j + u_j$, which identify the bank lending channel at the firm level. The estimation sample comprises, on average, 841,911 firms in each year. Standard errors used to construct the confidence bands are clustered at the main bank level, i.e., the largest lender for a firm.

Aggregate direct effects

Year	Employment growth due to BLC	Actual employment growth	Output growth due to BLC	Actual output growth	Credit growth due to BLC	Actual credit growth
2004	0.93	3.31	1.15	6.29	6.21	17.84
2005	0.57	4.20	0.11	7.18	6.31	25.38
2006	0.66	4.16	0.85	7.40	6.35	29.89
2007	0.41	3.93	1.56	6.99	6.20	19.53
2008	-0.27	-0.49	-0.71	4.39	-2.14	6.80
2009	-1.14	-8.57	-1.25	-3.96	-9.99	-3.56
2010	-0.48	-3.28	-0.89	-0.65	-9.61	-1.02
2004-2007	0.64	3.90	0.92	6.97	6.27	23.16
2008-2010	-0.63	-4.11	-0.95	-0.07	-7.25	0.74

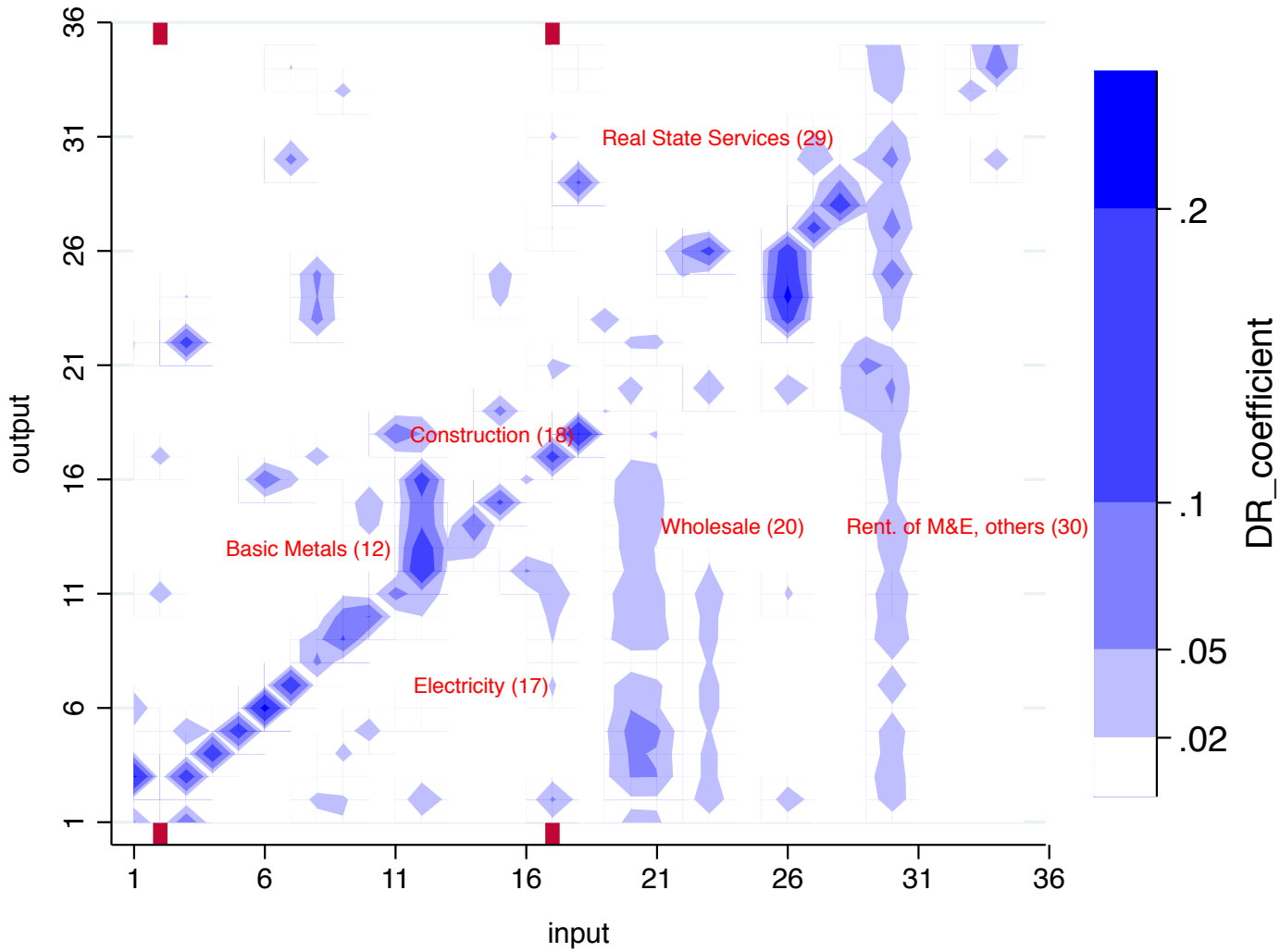
Notes. All figures refer to annual growth rates. Actual refers to National Accounts figures for employment and output, and Banco de España figures for credit. The estimated direct effects are computed as the weighted average of industry-specific figures.

Aggregate credit supply over time



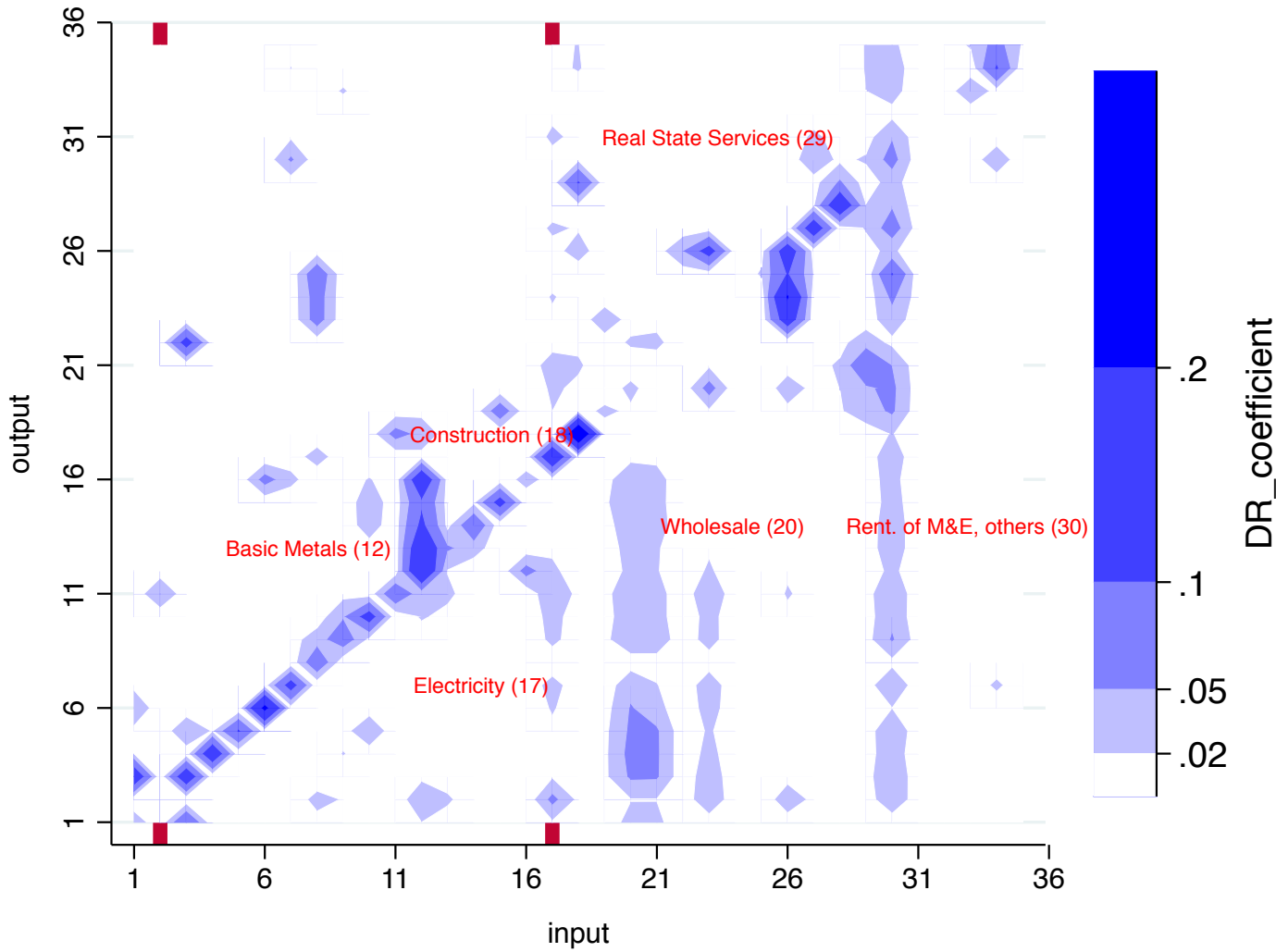
Notes. This figure plots the aggregate credit supply indicator resulting from averaging the bank-specific credit supply trends estimated in the following equation $\Delta \ln c_{ijt} = \mu_{jt} + \zeta_i + K_i' \times T + \xi_{ijt}$ where $\Delta \ln c_{ijt}$ refers to credit growth between bank i and firm j in quarter t.

The Spanish Input-Output structure 2000



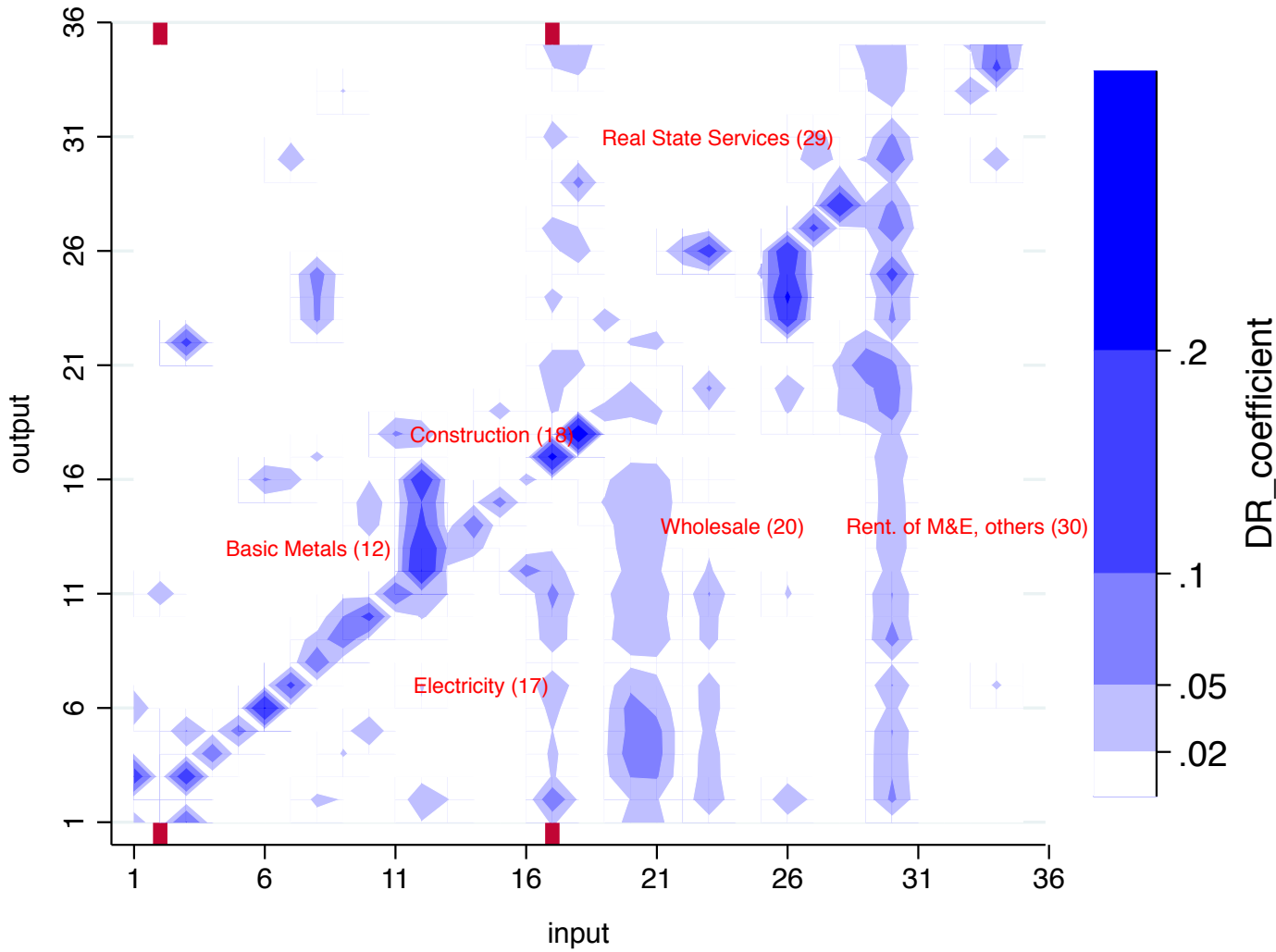
Notes. This figure shows the IO structure of the Spanish economy for the year 2000. Source: World Input-Output Database.

The Spanish Input-Output structure 2005



Notes. This figure shows the IO structure of the Spanish economy for the year 2005. Source: World Input-Output Database.

The Spanish Input-Output structure 2010



Notes. This figure shows the IO structure of the Spanish economy for the year 2010. Source: World Input-Output Database.

List of industries (I)

Number	Industry
1	Crop and animal production, hunting and related service activities
2	Forestry and logging
3	Fishing and aquaculture
4	Mining and quarrying
5	Manufacture of food products, beverages and tobacco products
6	Manufacture of textiles, wearing apparel and leather products
7	Manufacture of wood and of products of wood and cork, except furniture;
8	Manufacture of paper and paper products
9	Printing and reproduction of recorded media
10	Manufacture of coke and refined petroleum products
11	Manufacture of chemicals and chemical products
12	Manufacture of basic pharmaceutical products and pharmaceutical preparations
13	Manufacture of rubber and plastic products
14	Manufacture of other non-metallic mineral products
15	Manufacture of basic metals
16	Manufacture of fabricated metal products, except machinery and equipment
17	Manufacture of computer, electronic and optical products
18	Manufacture of electrical equipment
19	Manufacture of machinery and equipment n.e.c
20	Manufacture of motor vehicles, trailers and semi-trailers
21	Manufacture of other transport equipment
22	Manufacture of furniture; other manufacturing
23	Repair and installation of machinery and equipment
24	Electricity, gas, steam and air conditioning supply
25	Water collection, treatment and supply
26	Sewerage; waste collection, treatment and disposal activities; materials recovery;
27	Construction
28	Wholesale and retail trade and repair of motor vehicles and motorcycles
29	Wholesale trade, except of motor vehicles and motorcycles
30	Retail trade, except of motor vehicles and motorcycles
31	Land transport and transport via pipelines
32	Water transport
33	Air transport
34	Warehousing and support activities for transportation

List of industries (II)

Number	Industry
35	Postal and courier activities
36	Accommodation; food and beverage service activities
37	Publishing activities
38	Motion picture, video and television programme production, sound recording and music publishing activities;
39	Telecommunications
40	Computer programming, consultancy and related activities; information service activities
41	Financial service activities, except insurance and pension funding
42	Insurance, reinsurance and pension funding, except compulsory social security
43	Activities auxiliary to financial services and insurance activities
44	Real estate activities
45	Legal and accounting activities; activities of head offices; management consultancy activities
46	Architectural and engineering activities; technical testing and analysis
47	Scientific research and development
48	Advertising and market research
49	Other professional, scientific and technical activities; veterinary activities
50	Rental and leasing activities
51	Employment activities
52	Travel agency, tour operator reservation service and related activities
53	Security and investigation activities; services to buildings and landscape activities; business support activities
54	Public administration and defence; compulsory social security
55	Education
56	Human health activities
57	Social work activities
58	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling activities
59	Sports activities and amusement and recreation activities
60	Activities of membership organisations
61	Repair of computers and personal and household goods
62	Other personal service activities
63	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
64	Activities of extraterritorial organisations and bodies

Aggregate (direct+network) effects — total economy

Year	Direct Effect due to BLC	Network Effect due to BLC	Total Effect due to BLC	Actual growth
2004	1.15	0.90	2.05	6.29
2005	0.11	0.09	0.20	7.18
2006	0.85	0.66	1.52	7.40
2007	1.56	1.20	2.76	6.99
2008	-0.71	-0.53	-1.24	4.39
2009	-1.25	-0.96	-2.20	-3.96
2010	-0.89	-0.67	-1.56	-0.65
2004-2007	0.92	0.71	1.63	6.97
2008-2010	-0.95	-0.72	-1.67	-0.07

Notes. All figures refer to annual output growth in nominal terms. Actual is taken from National Accounts. The estimated direct and network effects are computed as the output-weighted average of industry-specific figures. Total refers to the sum of the direct plus the network effect.

Matched employer-employee techniques

Identification

- Bank- and firm-effects are identified only in relative terms within each group (Abowd et al. 2002).
- A group is a set of bank and firms that are connected: all the firms that have a credit relationship with any of the banks in the group, and all the banks that provide credit to at least one firm from the group.
- We identify 9 groups (one per year): all firms and banks are connected within a year but there are neither banks nor firms connected across years.

Estimation

- Cornelissen (2008) shows how to efficiently store the sparse matrices involved in FEiLSDVj estimation.