Identifying Financial Constraints from Production Data

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Link to the paper:
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3278938

Motivation

- Resolving FC is a major policy concern
  - FC impact firms' investments (Amiti and Weinstein, forthcoming JPE)
  - FC impact firms' employment decisions (Chodorow-Reich, 2014 QJE)

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  - FC impact firms' employment decisions (Chodorow-Reich, 2014 QJE)
- Having an adequate measure of the level and evolution of FC
  - is crucial for the design of policy interventions
  - is crucial to enhance academic knowledge
- Unfortunately, Farre-Mensa and Ljungqvist (2016 RFS) show:
  - **Existing FC measures: inadequate & fail to capture FC**

Motivation

- Existing FC measures based on *observable* proxy variables:
  - Kaplan and Zingales (1997 QJE): observables chosen based on the CEO's financial statements
  - Whited and Wu (2006 RFS): observables chosen based on an economic investment model
  - Hadlock and Pierce (2010 RFS): index based on size and age
  - Dividend payout
  - Credit rating
- *Unobservables* also matter a lot!!
  - e.g. trust in management, customer dependence, banks' internal approval models/lending standards,...

This paper

- [*What*?] we propose a new methodology
  - to recover firm-year level financial constraints
  - from the production behavior of profit maximizing firms
  - starting idea:
    - for homogeneous sets of firms, firm growth constraints have predominantly a financial nature (Beck, Demirgüç-Kunt and Maksimovic, 2005 JF)
    - binding input cost constraints reflect a highly inelastic supply of external finance within narrowly defined sets of firms

This paper

- [*How*?] we model financial constraints as
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  - due to binding constraints on input costs
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- [*Intuition* :] FC as obstacle to profit maximization of firms:
  - relaxing FC opens the door to production possibilities that go together with higher profitability.

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- [*Intuition* :] FC as obstacle to profit maximization of firms:
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Preview: what our measure picks up ↪

Preview: what our measure does not pick up ↪

Identifying Financial Constraints

- Optimization problem:

$$(OP) \qquad \max_{\mathbf{X},\Omega} PF(\mathbf{X}, \Omega) - \mathbf{WX} - \Omega \text{ s.t. } \mathbf{WX} \leq C.$$

Identifying Financial Constraints

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- Operationalization via Linear Programming:

$$\min_{\Omega_i \in \mathbb{R}_+} \sum_i \frac{\Omega_i}{\mathbf{W}_i\mathbf{X}_i + \Omega_i}$$

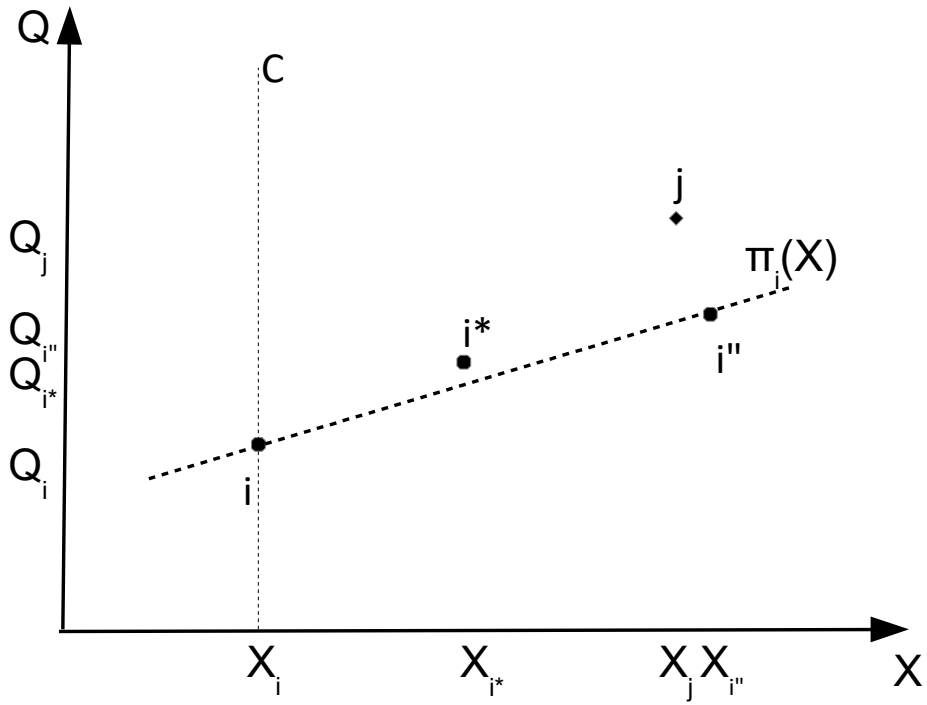
s.t.

$$\forall i \in \{1,\ldots,N\} : \theta P_i Q_i - \mathbf{W}_i\mathbf{X}_i - \Omega_i \geq P_i Q_j - (\mathbf{W}_i\mathbf{X}_j) - \Omega_j \text{ for all } j \in \hat{\boldsymbol{T}}_i^{FC},$$

$$\text{with } \hat{\boldsymbol{T}}_i^{FC} = \{j | \mathbf{W}_i\mathbf{X}_i \geq \mathbf{W}_i\mathbf{X}_j\}.$$

Identifying Financial Constraints

- when all inputs are observed

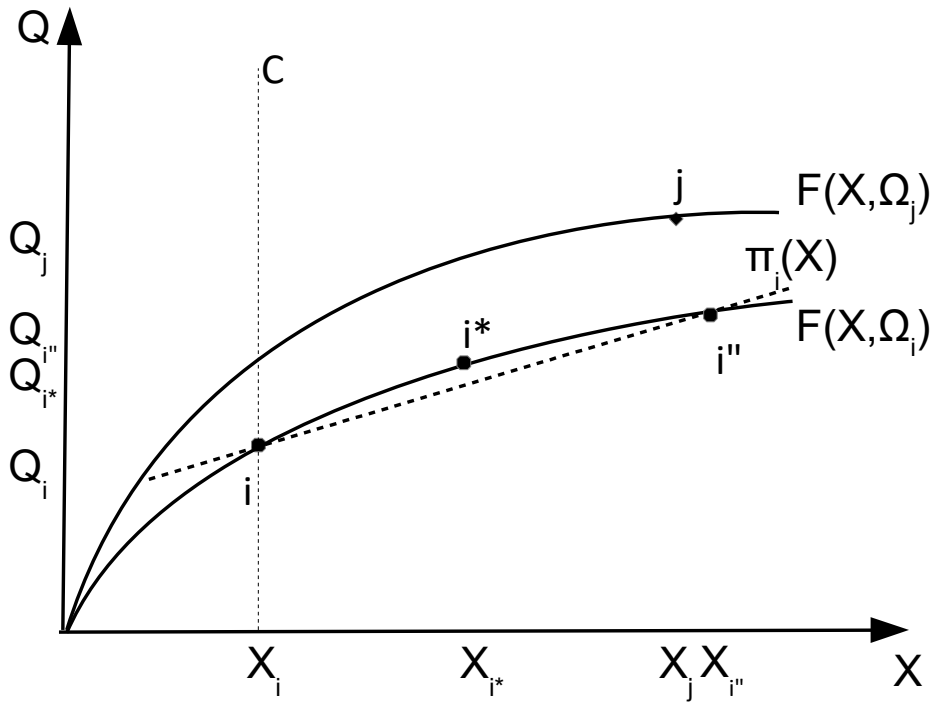


Revealing FC :
$\pi_i(X,\Omega) \neq \pi_i(X)$

- $FC_i^{***} = \frac{P_i Q_j - \mathbf{W}_i \mathbf{X}_j}{P_i Q_j} - \frac{P_i Q_i - \mathbf{W}_i \mathbf{X}_i}{P_i Q_i}$

Identifying Financial Constraints

- when productivity (Ω) is heterogeneous and unobserved



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$\pi_i(X_{i"},\Omega_i) = \pi_i(X_i,\Omega_i)$

$\pi_i(X_{i*},\Omega_i) > \pi_i(X_i,\Omega_i)$

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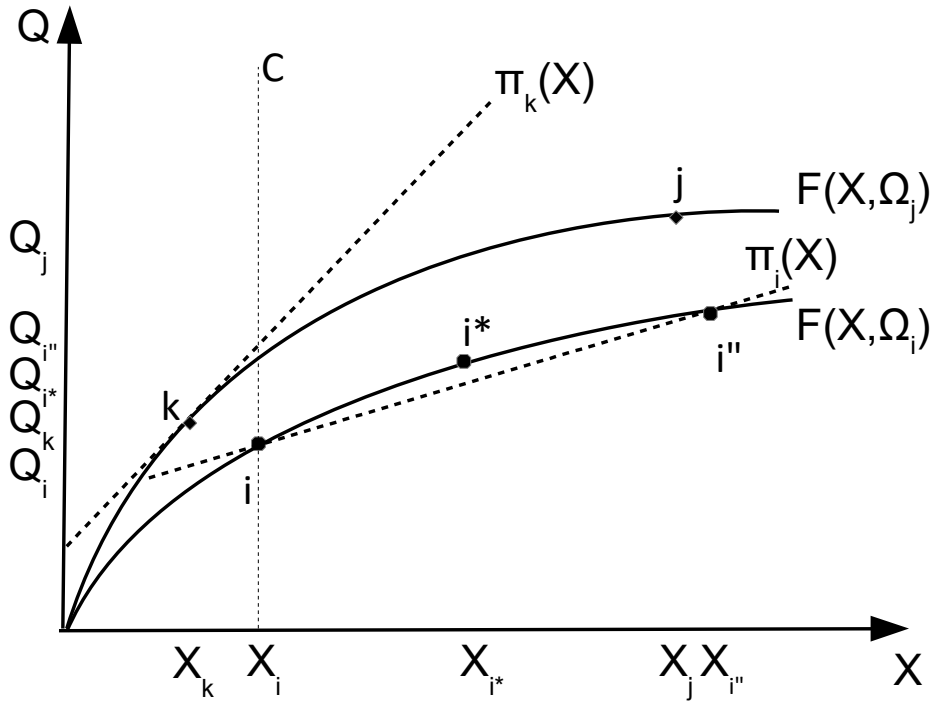

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For this example:

$\Omega_k = \Omega_j$

Revealing Ω :

$\pi_i(X_i,\Omega_i) \geq \pi_i(X_k,\Omega_k)$

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Identifying Financial Constraints

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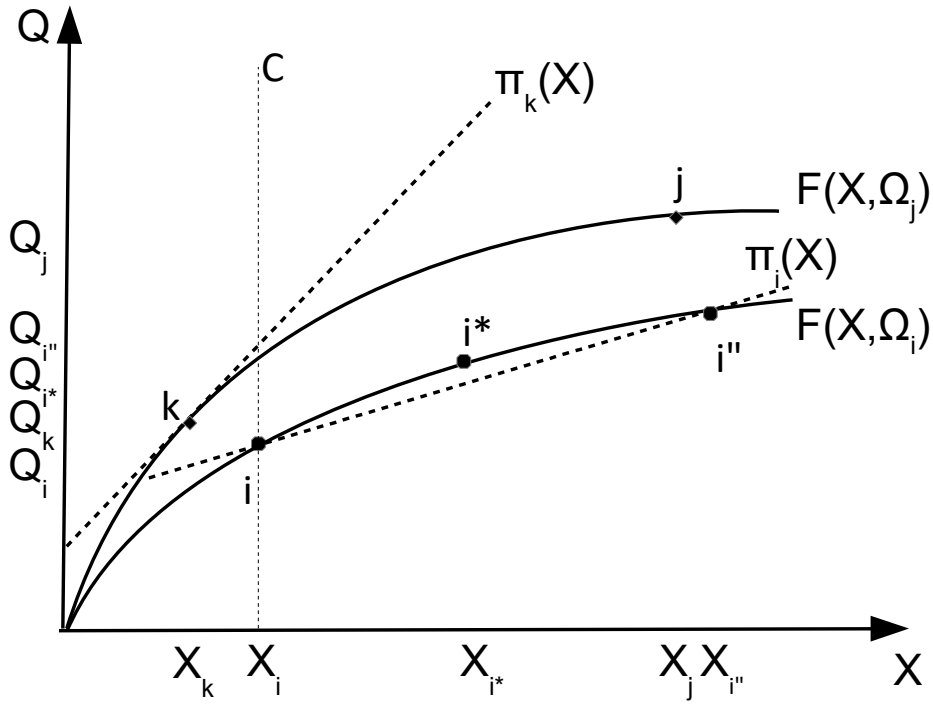

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$\pi_k(X_k,\Omega_k) \geq \pi_k(X_i,\Omega_i)$

- $FC_i^* = \frac{P_i Q_j - \mathbf{W}_i \mathbf{X}_j - \Omega_j}{P_i Q_j} - \frac{P_i Q_i - \mathbf{W}_i \mathbf{X}_i - \Omega_i}{P_i Q_i}$

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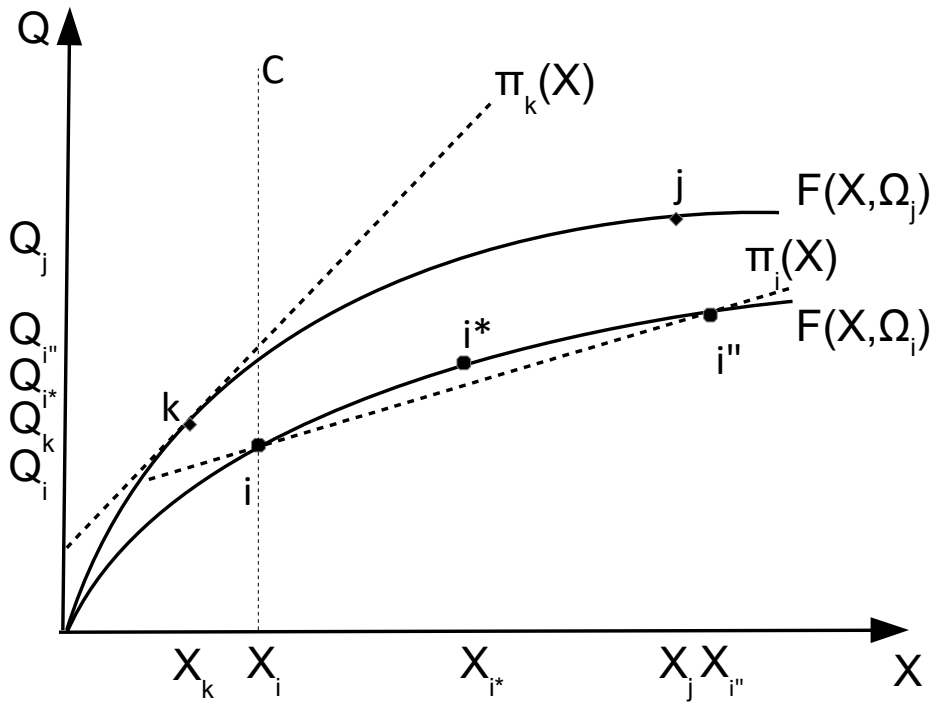

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For this example:
$\Omega_k = \Omega_j$

Revealing Ω :
$\pi_i(X_i,\Omega_i) \geq \pi_i(X_k,\Omega_k)$
$\pi_k(X_k,\Omega_k) \geq \pi_k(X_i,\Omega_i)$

- $FC_i = median_{j \in T_i^{beyond}} \left(\frac{P_i Q_j - \mathbf{W}_i \mathbf{X}_j - \Omega_j}{P_i Q_j} \right) - \frac{P_i Q_i - \mathbf{W}_i \mathbf{X}_i - \Omega_i}{P_i Q_i}$

Estimation procedure

- We measure Ω and FC at the country x nace 4 digit x firm size group level
- 7 firm size groups (+- based on EC definition):
  - 2 groups of large firms: very large (FTE>1000) & large (250<FTE<1000)
  - 2 groups of medium sized firms: cat 1 (100<FTE<250) & cat 2 (50<FTE<100)
  - 2 groups of small firms: small (25<FTE<50) & very small (10<FTE<25)
  - micro firms (5<FTE<10)
- Only firms with labor cost/capital cost ratio higher (lower) than 0.25 (1.75) times the respective ratio of firm in question are potential comparison partners
- Allow for moderate levels of noise in the data by setting the goodness-of-fit parameter $1 < \theta < 1.1$
- Only include country-sector-size groups for which data are close-to-rationalizable
- On average 986 comparison observations in each country-sector-size cluster

Data

- Financial statements and survey data
  - Orbis Europe (2005-2015): $\pm$ 150,000 manufacturing firms
  - SAFE (waves 3-14, 2010-2015): $\pm$ 3,200 manufacturing firms
  - 5 countries (BE, DE, ES, IT, FR)
  - Output measure: operating Value Added (instead of sales revenue)

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  - 5 countries (BE, DE, ES, IT, FR)
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Table: Summary statistics

	Obs.	Mean	St.Dev.
Panel A			
Deflated value added (mln)$_{it}$	728,642	5.4	114.8
Labor (FTE)$_{it}$	728,642	76.3	1,177
Deflated capital (mln)$_{it}$	728,642	3.9	90.8
Panel B			
Latent Input (mln)$_{it}$	728,642	3.9	30.2
Financial constraints$_{it}$	728,642	0.55	0.52

Data

Table: Summary statistics (continued)

	Obs.	Mean	St.Dev.
Panel C			
Rejection or discouragement:			
Bank loan$_{it}$	2,315	0.25	0.43
Credit line$_{it}$	1,710	0.29	0.45
Trade credit$_{it}$	1,684	0.21	0.41
Other financing$_{it}$	899	0.25	0.43
Most pressing problem:			
Access to finance$_{it}$	6,582	0.12	0.33
Panel D			
Financial pressure$_{it}$	728,642	0.51	0.64
Leverage$_{it}$	728,642	0.55	0.31
Age$_{it}$	728,642	23.2	17.6
Total Assets$_{it}$	728,642	9.43	29.8
Panel E			
DSO$_{it}$-DPO$_{it}$	488,099	-61.8	127
(AR$_{it}$-AP$_{it}$)/TA$_{it}$	488,099	12.3	18.2
Δln(Cash$_{it}$)	488,099	0.02	1.15
Cash$_{it}$/TA$_{it}$	488,099	10.3	12.9
Δln(Fixed Assets$_{it}$)	488,099	-0.01	0.23
Δln(Employees$_{it}$)	488,099	0.01	0.10

Relation between our FC measure and self-reported financial constraints

$$Y_{i,c,s,t} = g(\alpha FC_{i,c,s,t}, \beta X_{i,c,s,t-1}, \nu_t, \mu_c, \lambda_s, u_{i,c,s,t})$$

	(1)	(2)	(3)	(4)	(5)
	pressing problem:	rejection or discouragement:			
	Access to Finance$_{it}$	**Bank Loan**$_{it}$	**Credit Line**$_{it}$	**Trade Credit**$_{it}$	**Other Financing**$_{it}$
Panel A					
FC$_{it}$	0.036***	0.125***	0.100***	0.118***	0.035
	(0.008)	(0.019)	(0.023)	(0.020)	(0.030)
ROC-AUC	0.55	0.58	0.57	0.58	0.53
Control variables	No	No	No	No	No
Country FE	No	No	No	No	No
Sector FE	No	No	No	No	No
Year FE	No	No	No	No	No
Panel B					
FC$_{it}$	0.015**	0.115***	0.097***	0.099***	0.016
	(0.007)	(0.020)	(0.025)	(0.021)	(0.032)
ROC-AUC	0.77	0.77	0.75	0.78	0.76
Control variables	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	6,582	2,315	1,710	1,684	899

↩ ↪

Determinants of Financial Constraints

$$Y_{i,c,s,t} = g(\beta X_{i,c,s,t-1}, \nu_t, \mu_c, \lambda_s, u_{i,c,s,t})$$

	(1)	(2)	(3)	(4)	(5)	(6)
		pressing problem:	rejection or discouragement:			
	FC_{it}	**Access to Finance**$_{it}$	**Bank Loan**$_{it}$	**Credit Line**$_{it}$	**Trade Credit**$_{it}$	**Other Financing**$_{it}$
Financial Pressure$_{it-1}$	0.095***	0.027***	0.053***	0.072***	0.041***	0.060***
	(0.001)	(0.004)	(0.012)	(0.019)	(0.012)	(0.022)
Leverage$_{it-1}$	0.030***	0.221***	0.347***	0.429***	0.257***	0.215***
	(0.002)	(0.014)	(0.051)	(0.067)	(0.050)	(0.071)
ln(age)$_{it-1}$	-0.018***	0.003	-0.014	0.013	-0.025*	0.024
	(0.001)	(0.005)	(0.014)	(0.018)	(0.014)	(0.022)
ln(total assets)$_{it-1}$	-0.098***	-0.003	-0.019***	-0.030***	-0.015**	-0.041***
	(0.001)	(0.002)	(0.007)	(0.009)	(0.007)	(0.014)
Observations	728,641	6,582	2,315	1,710	1,684	899
R-squared	0.141	0.146	0.153	0.136	0.153	0.151
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

Financial constraints and non-financial obstacles

$$Y_{i,c,s,t} = g(\alpha FC_{i,c,s,t}, \beta X_{i,c,s,t-1}, \nu_i, \mu_c, \lambda_j, u_{i,c,s,t})$$

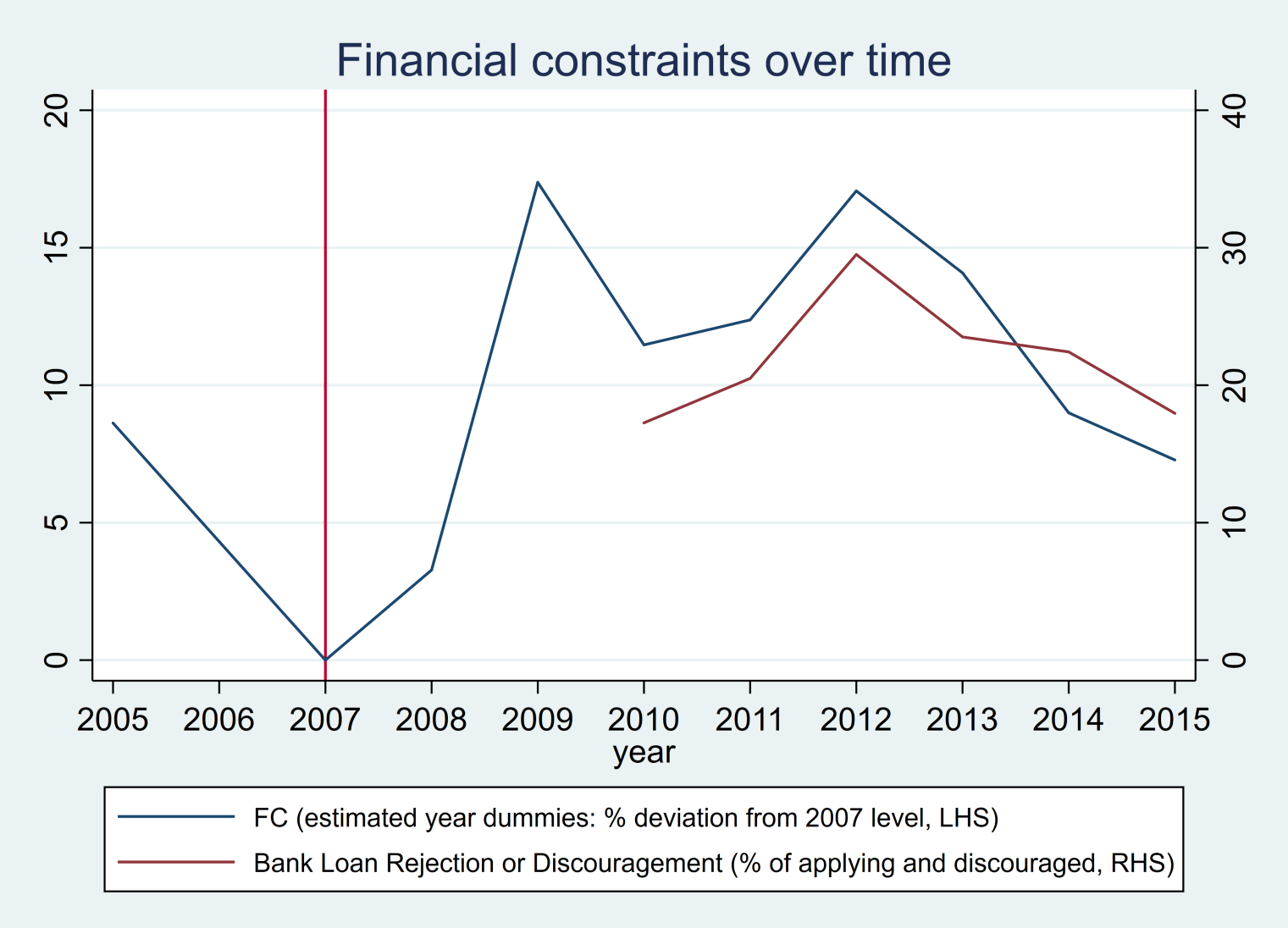
	The firm perceives the following as its most pressing problem:				
	(1) **Finding customers**$_{it}$	(2) **Competition**$_{it}$	(3) **Costs of production or labor**$_{it}$	(4) **Availability of skilled staff**$_{it}$	(5) **Regulation**$_{it}$
Panel A					
FC$_{it}$	0.020	0.018*	-0.020	-0.035***	0.001
	(0.013)	(0.011)	(0.013)	(0.011)	(0.009)
ROC-AUC	0.51	0.51	0.51	0.54	0.50
Control variables	No	No	No	No	No
Country FE	No	No	No	No	No
Sector FE	No	No	No	No	No
Year FE	No	No	No	No	No
Panel B					
FC$_{it}$	0.009	0.013	-0.028**	-0.012	0.005
	(0.014)	(0.012)	(0.014)	(0.010)	(0.007)
ROC-AUC	0.64	0.66	0.67	0.75	0.75
Control variables	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	5,438	5,238	5,328	4,998	5,029

↩

Financial constraints and price-setting power

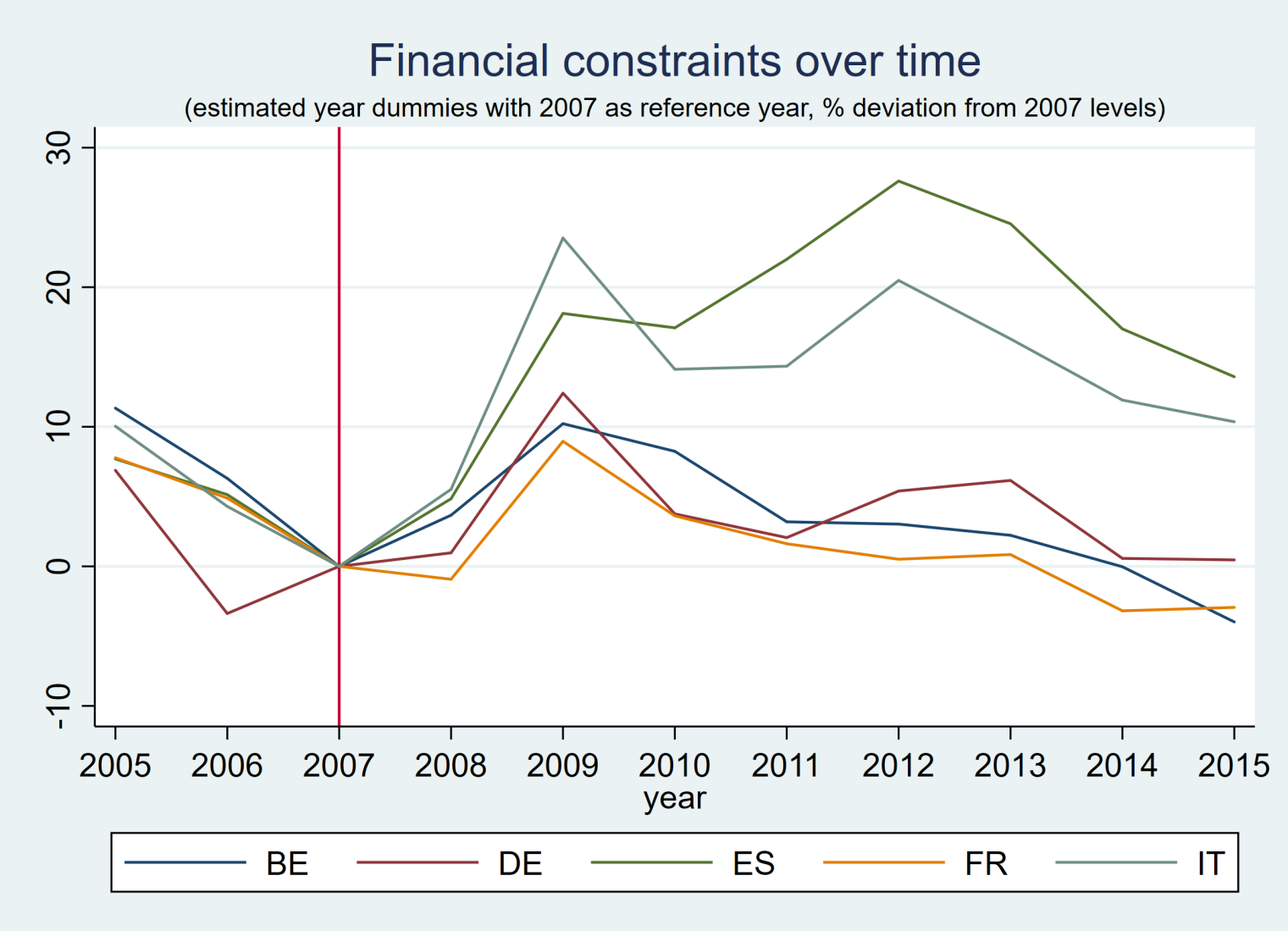
	Rejection or discouragement: Bank Loan$_{it}$				
	(1)	(2)	(3)	(4)	(5)
	full sample	domestic sectoral MS<Q4	sectoral MS<Q4	domestic HHI<Q4	HHI<Q4
Panel A					
FC$_{it}$	0.125***	0.123***	0.129***	0.125***	0.107***
	(0.019)	(0.023)	(0.023)	(0.023)	(0.021)
Wald-test (p-value)		0.93	0.88	0.99	0.40
ROC-AUC	0.58	0.57	0.58	0.58	0.56
Control variables	No	No	No	No	No
Country FE	No	No	No	No	No
Sector FE	No	No	No	No	No
Year FE	No	No	No	No	No
Panel B					
FC$_{it}$	0.115***	0.101***	0.109***	0.099***	0.090***
	(0.020)	(0.026)	(0.026)	(0.025)	(0.023)
Wald-test (p-value)		0.59	0.81	0.51	0.26
ROC-AUC	0.77	0.79	0.78	0.77	0.78
Control variables	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	2,315	1,638	1,644	1,781	1,779

Time variation in financial constraints



Notes. $FC_{i,c,s,t} = \nu_t + \beta X_{i,c,s,t-1} + \gamma_i + \mu_c + \lambda_s + u_{i,c,s,t}$

Time and country variation in financial constraints



Notes. For each country: $FC_{i,s,t} = \nu_t + \beta X_{i,s,t-1} + \gamma_i + \lambda_s + u_{i,s,t}$

Our FC measure and real effects

$$Y_{i,c,s,t} = \alpha FC_{i,c,s,t-1} + \beta X_{i,c,s,t-1} + \gamma_i + \nu_t + \mu_c + \lambda_s + u_{i,c,s,t}$$

	(1) DSO_{it}-DPO_{it}	(2) $\frac{AR_{it}-AP_{it}}{TA_{it}}$	(3) $\Delta\ln(Cash_{it})$	(4) $\frac{Cash_{it}}{TA_{it}}$	(5) $\Delta\ln(Fix.\ Ass._{it})$	(6) $\Delta\ln(Emp_{it})$
Panel A						
FC_{it-1}	-7.89***	-0.62***	-0.01***	-0.62***	-0.02***	-0.01***
	(0.36)	(0.05)	(0.00)	(0.04)	(0.00)	(0.00)
R-squared	0.14	0.04	0.01	0.05	0.01	0.01
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	No	No	No	No	No	No
Year FE	No	No	No	No	No	No
Firm FE	No	No	No	No	No	No
Control variables	No	No	No	No	No	No
Panel B						
FC_{it-1}	-3.99***	-0.46***	-0.13***	-0.47***	-0.03***	-0.03***
	(0.44)	(0.06)	(0.01)	(0.04)	(0.00)	(0.00)
R-squared	0.78	0.76	0.41	0.82	0.36	0.37
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	488,099	488,099	488,099	488,099	488,099	488,099

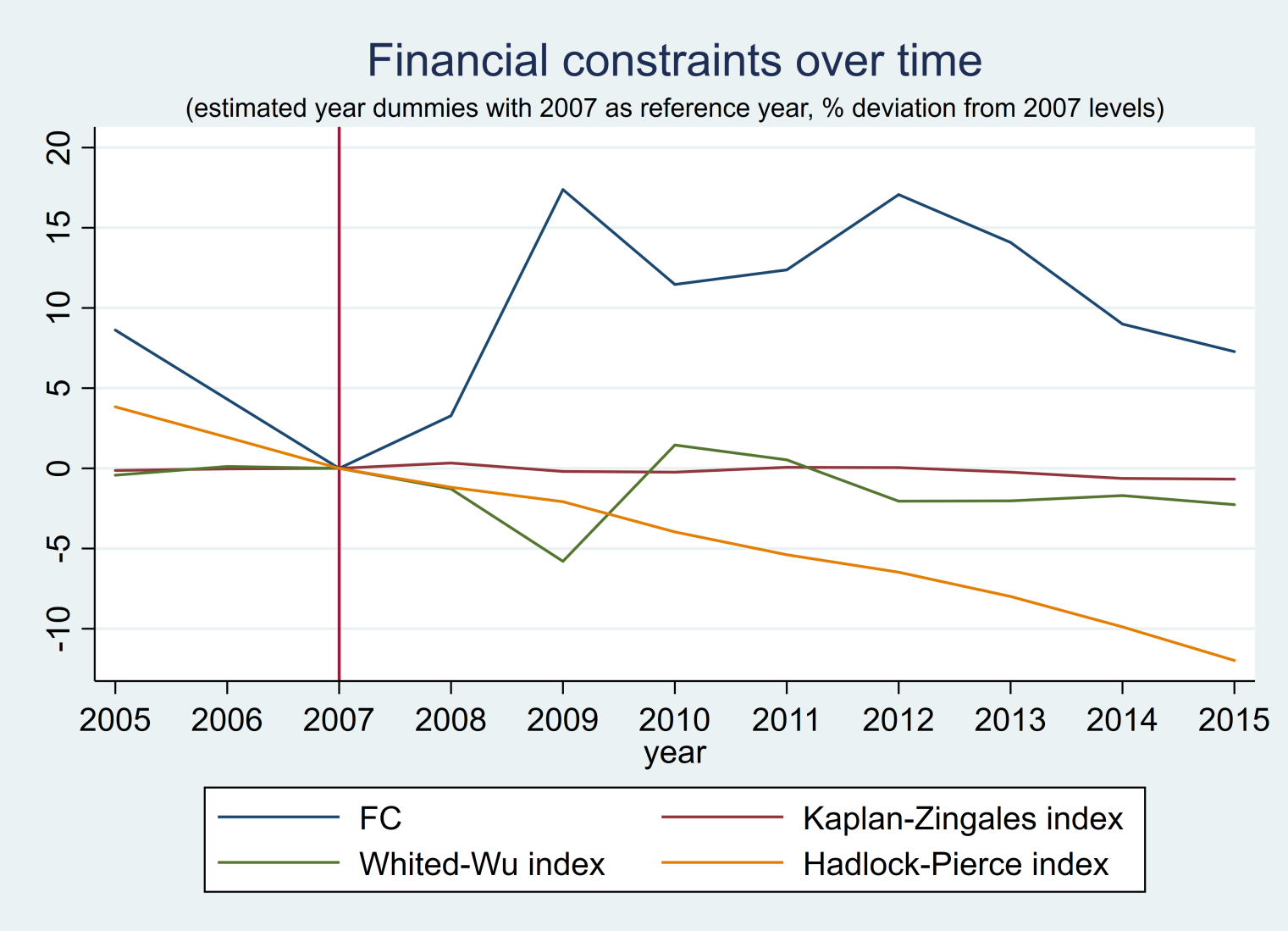
Comparison with existing financial constraints indices

Panel A: private firms (n=653,419)	**FC$_{it}$**	Kaplan-Zingales$_{it}$	Whited-Wu$_{it}$
Kaplan-Zingales$_{it}$	0.067		
Whited-Wu$_{it}$	0.314	0.006	
Hadlock-Pierce$_{it}$	0.257	-0.019	0.777
Panel B: public firms (n=1,902)	FC$_{it}$	Kaplan-Zingales$_{it}$	Whited-Wu$_{it}$
Kaplan-Zingales$_{it}$	0.046		
Whited-Wu$_{it}$	0.266	0.220	
Hadlock-Pierce$_{it}$	0.134	0.026	0.673

Comparison with existing financial constraints indices

	pressing problem:	rejection or discouragement:			
	Access to Finance$_{it}$	**Bank Loan**$_{it}$	**Credit Line**$_{it}$	**Trade Credit**$_{it}$	**Other Financing**$_{it}$
Panel A					
FC$_{it}$	0.022**	0.116***	0.089***	0.113***	0.027
	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)
Kaplan-Zingales index$_{it}$	0.003***	0.001	-0.001	-0.001	0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Whited-Wu index$_{it}$	0.251**	0.359	0.744**	0.021	0.768*
	(0.12)	(0.25)	(0.30)	(0.27)	(0.41)
Hadlock-Pierce index$_{it}$	0.008	0.037**	0.007	0.051***	-0.010
	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)
ROC-AUC	0.63	0.61	0.60	0.62	0.58
Control vars, C FE, S FE, Y FE	No	No	No	No	No
Panel B					
FC$_{it}$	0.012*	0.117***	0.094***	0.098***	0.026
	(0.01)	(0.02)	(0.03)	(0.02)	(0.04)
Kaplan-Zingales index$_{it}$	0.001**	-0.003**	-0.004***	-0.002	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Whited-Wu index$_{it}$	0.202	0.520	0.499	0.260	1.225
	(0.16)	(0.45)	(0.56)	(0.47)	(0.78)
Hadlock-Pierce index$_{it}$	-0.014	-0.021	-0.008	0.025	-0.038
	(0.02)	(0.04)	(0.05)	(0.04)	(0.07)
ROC-AUC	0.77	0.77	0.76	0.79	0.76
Control vars, C FE, S FE, Y FE	Yes	Yes	Yes	Yes	Yes
Observations	6,076	2,145	1,616	1,624	810

Time variation in financial constraints indices



Notes. For each index: $Index_{i,c,s,t} = \nu_t + \gamma_i + \mu_c + \lambda_s + u_{i,c,s,t}$

Conclusion

1. New methodology to identify financial constraints:
   - profitability that firms forgo because they cannot produce on the optimal scale, due to binding input cost constraints
   - $\Rightarrow$ for homogeneous sets of firms, firm growth constraints have predominantly a financial nature (see e.g. Beck et al. JF 2005)

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2. Our methodology has strong micro-economic foundations
3. Our methodology provides an accurate picture of FC
   - across firms
   - across countries
   - over time

Thank you for your attention