Dynamics of Investment and Firm Performance : Comparative evidence in manufacturing industries

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Motivation

Against economic intuition on selection processes, no link between firm performance and growth found in Italy and France (Bottazzi et al, 2009)

Can it be explained by the role mediated by investment ?

$$\text{PERFORMANCE} \Longleftrightarrow \text{INVESTMENT} \Longleftrightarrow \text{GROWTH}$$

Is there a channel linking investment to firm performance ?

$\Rightarrow$ Do we get investment right? How to define relevant investment episodes?

$\Rightarrow$ Previous evidence (Power, 1998) suggests there is no effect on productivity ; if that were true, what is the point of investing?

Research questions

UNDERSTANDING THE INVESTMENT DECISION REQUIRES :

- *Data* : "The great unknown" (observed investment).
- *Identification of investment episodes*
  "a theoretical rather than a numeric or algebraic concept, [which] lacks an unambiguous real-world analogue" (Power 1998)
- *Time and sectoral heterogeneity* : What is the within-firm timing pattern of investment?
  "In particular [...] what happens to a plant before a spike and, more importantly, what happens to a plant after a spike." (Doms and Dunne 1998)

$\Rightarrow$ What is the differentiated interrelation between investment episodes and profitability, sales, employment, or productivity at the firm level?

Related literature

Traditional investment theory

- Aggregate level of investment ; Optimal capital stock ; Convex adjustment costs
  $\rightarrow$ *marginal and smooth adjustments*

Eisner & Strotz (1963); Jorgenson (1963); Lucas (1967)

Recent empirical evidence

- Firm behavior ; Non convex costs
  $\rightarrow$ Lumpy nature of investment

Doms & Dunne (1998) for US; Duhautois & Jamet (2001) for France; Nilsen et al (2003; 2009) for Norway; Carlsson & Laséen (2005) for Sweden

The link between investment and productivity or employment

- Negative effects on productivity growth in the short run, *no effect in the long?*
- Learning by doing effect: *theory, no evidence*
- Interrelation between investment and employment spikes

Power (1998); Bessen et al. (1999) ; Huggett & Ospina (2001); Sakellaris (2004) ; Licandro et al. (2004); Nilsen et al. (2009); Shima (2010) ; Asphjell et al. (2010)

What we do :

1. Compare observed investment patterns in the French and Italian manufacturing sector

2. Introduce a new way to measure spikes without size dependence

3. Evaluate the dynamic interrelation between spikes and a set of firm performance variables

Results

$\Rightarrow$ Determinants of investment similar in both countries, but weaker effects on the performance of Italian firms

$\Rightarrow$ The costs and gains from investment differ by sector

The French and Italian datasets

The Italian Micro.3 database (Istat)

- (open) panel combining information from census and corporate annual reports about all the firms with 20 employees or more operating in any sector of activity over 1996-2006.

The French EAE database (SESSI/INSEE)

- Longitudinal data on a virtually exhaustive panel of industrial French firms located on the national territory with 20 employees or more over 1996-2007.

$\Rightarrow$ Focus on the manufacturing industry i.e. ISIC (rev.3.1) 171 to 366

$\Rightarrow$ We also perform the analysis at the Pavitt sectoral level (Pavitt, 2004)

$\Rightarrow$ Exclude firms experiencing a radical restructuration during the period

'Observed' investment: acquisitions of tangible fixed assets

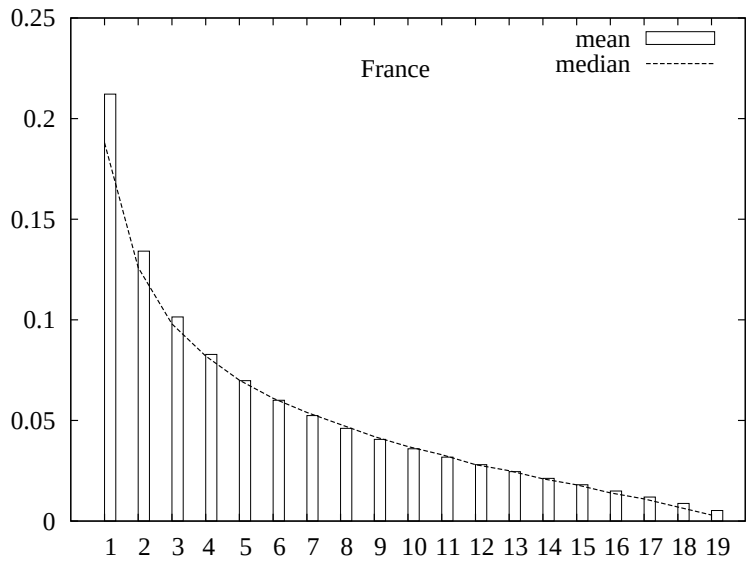
Let's look at it!

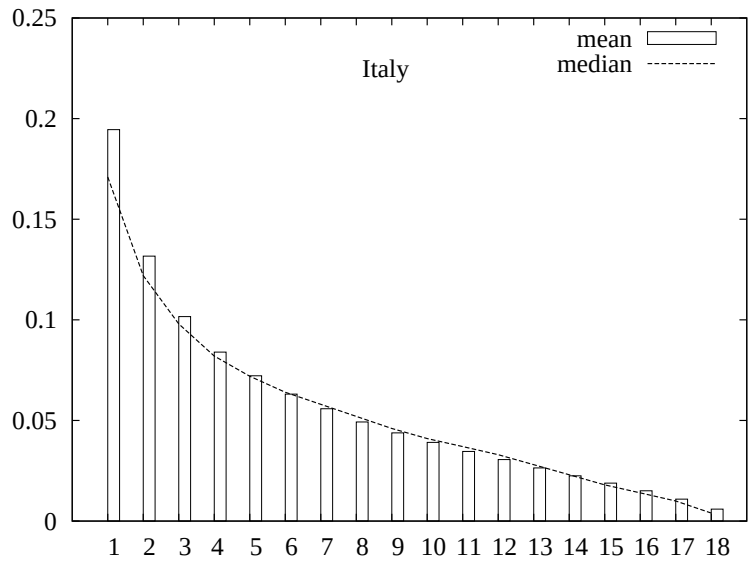
The variables

Investment rate:	I_t / K_{t-1}
Number of employees:	$Empl_t$
Growth of employment:	$Empl.Growth_t = log(Empl_t) - log(Empl_{t-1})$
Labour productivity:	$Prod_t = VA_t / Empl_t$
Growth of labour productivity:	$Prod.Growth_t = log(Prod_t) - log(Prod_{t-1})$
Total sales:	$Sales_t$
Growth of total sales:	$Sales.Growth_t = log(Sales_t) - log(Sales_{t-1})$
Profit rate:	$Profit_t = GOM_t / Sales_t$

Investment lumpiness

Figure : **Left**: Investment shares by rank from 1989 to 2007 in France ; **Right**: in Italy (1990- 2006).





- Biggest three episodes account for 1/2
- Most episodes of small scale

What is an investment spike?

1. An investment spike is an irregular investment episode at the firm level and a rare event

   $\Rightarrow$ Thus spikes must account for a disproportionate share of total industry investments.

   $\Rightarrow$ The firm is not simply "adjusting" or replacing its capital stock

2. Several ways to define a spike with respect to the history of investment of a firm

   - **Absolute threshold**: Investment rate higher than a fixed threshold 20%, 35% Cooper et al (1995)
   - **Relative threshold**: Investment rate higher than the median (times a constant) Power (1998)
   - Adjusted measure to account for the size dependency of the investment rate Nilsen et al (2009), this paper

The size bias issue

From the Gibrat law (firm growth is independent of its size) we would expect investment rates to be independent of firm size. BUT small firms are more likely to display high investment rates

$\Rightarrow$ the probability that a small firm has an investment ratio above a fixed threshold, is much larger than for a large firm (under-represent big firms)

$\Rightarrow$ This motivates that the threshold for an investment spike should also be decreasing in $K_{i,t-1}$

- **The linear fit** (Nilsen et al. 2009) sets a threshold rule that is negatively related with firm size according to a *log-linear function* in size ($K_{i,t-1}$):

$$E[(I_{i,t}/K_{i,t-1})|K_{i,t-1}] = \hat{\gamma}_0 + \hat{\gamma}_1 \ln K_{i,t-1}$$

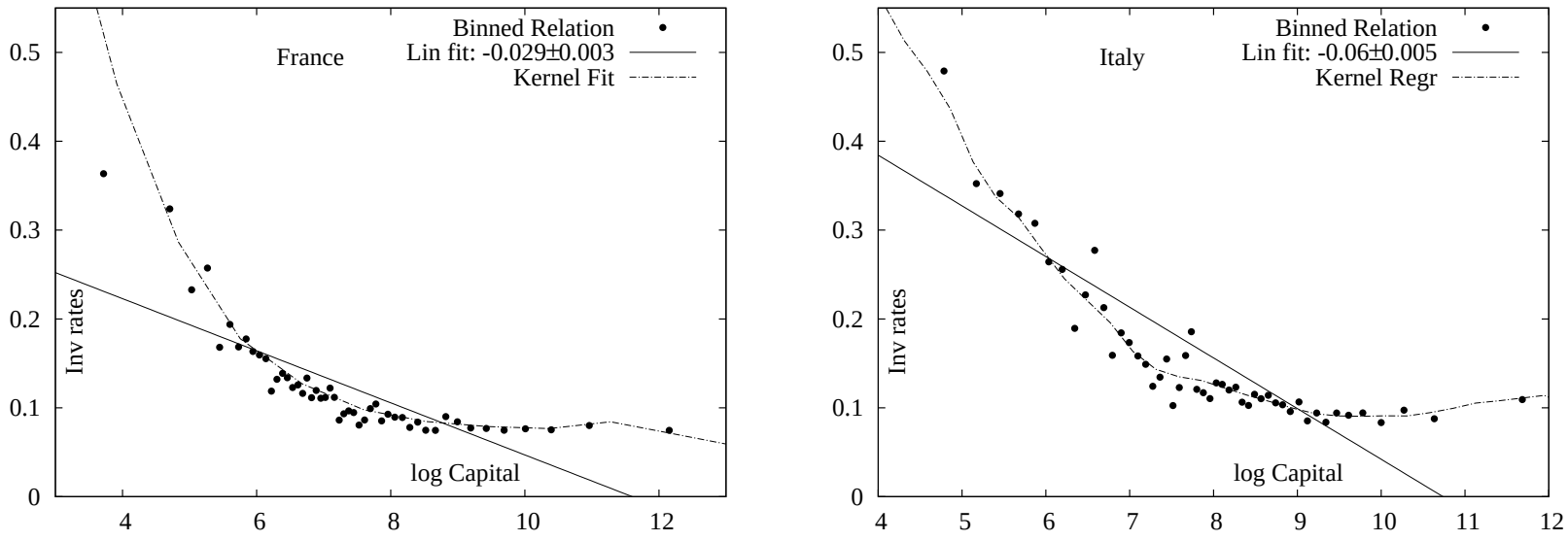
$$I_t/K_{i,t-1} > \max[\alpha E[(I_{i,t}/K_{i,t-1})|K_{i,t-1}], 0.20]$$

Note : the parameters are computed for each Pavitt sector and each year

- **The exponential fit** : same with an exponential relation

The size bias issue II

Figure : Linear vs kernel fit and spike threshold, 2003



- **The kernel fit** : no premises on the shape of the relationship, no minimum threshold:

$$I_t/K_{i,t-1} > \alpha E[(I_{i,t}/K_{i,t-1})|K_{i,t-1}]$$

Note : We estimate the kernel density function f :$I_t/K_{i,t-1} = f(\ln K_{i,t-1}) + e_{i,t}$

Comparing spike rules

	Absolute	Relative	Linear	Exponential	Kernel
France					
Mean investment rate (all sample : 0.14)	0.47	0.54	0.60	0.57	0.53
% of spikes in nb of obs.	18.28	13.18	11.58	12.22	13.45
% of total investment accounted by spikes	28.36	20.69	27.07	27.51	34.67
Italy					
Mean investment rate (all sample : 0.12)	0.53	0.58	0.59	0.59	0.53
% of spikes in nb of obs.	15.07	11.89	12.39	10.74	13.14
% of total investment accounted by spikes	36.56	31.20	35.70	32.90	41.50

$\Rightarrow$ All rules select rare and highest investment episodes

Table : Share of observations across size classes, comparing rules

Size class	**All sample**	Absolute	Relative	Linear	Exponential	Kernel
France						
Small	**17.51**	32.33	31.52	25.15	21.09	18.35
Medium	**67.78**	60.81	61.85	64.11	68.66	67.64
Large	**14.71**	6.86	6.63	10.73	10.25	14.01
Italy						
Small	**8.56**	13.5	13.77	11.05	10.48	6.20
Medium	**65.53**	69.2	68.90	68.24	68.00	65.00
Large	**25.09**	17.2	17.33	20.71	21.00	28.00

Note: Here we compare the share of observations in each size class for the French sample and for the observations considered as a spike according to each rule. “Small” stands for $lnK < 6$, “Medium” for $6 \leq lnK < 9$ and “Large” for $lnK \geq 9$.

$\Rightarrow$ Under-representation of large firms

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Size class	**All sample**	Absolute	Relative	Linear	Exponential	Kernel
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Large	**25.09**	17.2	17.33	20.71	21.00	28.00

$\Rightarrow$ The kernel rule removes the size bias best

Investment and Firm performance

The first part of our analysis has adressed the dynamics of the investment variable, and confirmed its lumpy pattern.

In a second step, we consider the interrelation between the investment spike and firm performance (sales, size, growth, productivity and profitability).

1. First we test which (and how) variables affect the probability to have a spike
2. Then we focus on the effect of investment spikes on firm performance.

Determinants of the probability to have a spike

Econometric method (kernel measure)

Random Effects logistic regression

Binary dep. var : taking $y_{it} = 1$ if there is a spike and 0 if not

$$y_{i,t} = \beta X_{i,t-1} + \gamma D_{i,t} + v_i + u_{i,t}$$

- where $X_{i,t-1}$ is a vector of observed exogenous variables (lagged firm characteristics such as corporate performance variables),
- $D_{i,t}$ is a vector of duration dummies (time since last spike),
- and v_i is a firm-specific unobserved random-effect.
- $u_{i,t}$ is a serially uncorrelated logistic disturbance term.
- Time (year) and sectoral (2-digit) dummies are also included in the regressions.

Table : Determinants of Investment (France)

	(1)	(2)	(3)	(4)	(5)	(6)
$Sales_{t-1}$	0.015***			0.013***		
$Empl_{t-1}$		0.011***			0.010***	
$Plant_{t-1}$			0.008***			0.008***
$Profit_{t-1}$	0.262***	0.220***	0.225***	0.221***	0.184***	0.189***
$Prod_{t-1}$	-0.011***	0.008***	0.007***	-0.007***	0.010***	0.009***
D1 (d)	0.161***	0.164***	0.164***	0.156***	0.159***	0.158***
D2 (d)	0.062***	0.064***	0.064***	0.062***	0.064***	0.064***
D3 (d)	0.050***	0.051***	0.051***	0.050***	0.051***	0.051***
$Prod.Growth_{t-1}$				0.009**	0.004	0.004
$Sales.Growth_{t-1}$				0.036***	0.042***	0.041***
$Empl.Growth_{t-1}$				0.071***	0.070***	0.073***
D_{export} (d)				-0.002	0.0012	0.004**
Time & sector	Yes	Yes	Yes	Yes	Yes	Yes
Observations	122405	122405	122371	122191	122191	122157

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
$* \ p < 0.10$, $** \ p < 0.05$, $*** \ p < 0.01$

Table : Determinants of Investment (France)

	(1)	(2)	(3)	(4)	(5)	(6)
$Sales_{t-1}$	0.015***			0.013***		
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Observations	122405	122405	122371	122191	122191	122157

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
$* \ p < 0.10$, $** \ p < 0.05$, $*** \ p < 0.01$

Table : Determinants of Investment (Italy)

	(1)	(2)	(3)	(4)
$Sales_{t-1}$	0.012***		0.012***	
$Empl_{t-1}$		0.013***		0.013***
$Profit_{t-1}$	0.183***	0.129***	0.183***	0.130***
$Prod_{t-1}$	0.016*	0.033***	0.012	0.029***
D1 (d)	0.132***	0.132***	0.128***	0.128***
D2 (d)	0.078***	0.078***	0.077***	0.077***
D3 (d)	0.051***	0.051***	0.051***	0.051***
$Prod.Growth_{t-1}$			0.006	0.001
$Sales.Growth_{t-1}$			0.038**	0.043**
$Empl.Growth_{t-1}$			0.019	0.016
D_{export} (d)			0.007	0.008
Time & sector	Yes	Yes	Yes	Yes
Observations	15877	15877	15746	15746

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table : Determinants of Investment (Italy)

	(1)	(2)	(3)	(4)
$Sales_{t-1}$	0.012***		0.012***	
$Empl_{t-1}$		0.013***		0.013***
$Profit_{t-1}$	0.183***	0.129***	0.183***	0.130***
$Prod_{t-1}$	0.016*	0.033***	0.012	0.029***
D1 (d)	0.132***	0.132***	0.128***	0.128***
D2 (d)	0.078***	0.078***	0.077***	0.077***
D3 (d)	0.051***	0.051***	0.051***	0.051***
$Prod.Growth_{t-1}$			0.006	0.001
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$Empl.Growth_{t-1}$			0.019	0.016
D_{export} (d)			0.007	0.008
Time & sector	Yes	Yes	Yes	Yes
Observations	15877	15877	15746	15746

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Determinants of the probability to have a spike - Results

- In both countries, profitability and investment opportunities (sales growth) have a strong positive effect

  $\Rightarrow$ The availability of cash increases the proba to invest

- Having had a spike recently increases the probability of spike, but the hazard function is decreasing

  $\Rightarrow$ Spikes span over several years

National and sectoral differences

- In France, growing firms invest more ; in Italy, more productive firms invest more
- Results are robust at the sectoral level, except for productivity and exports
  - productivity is positively associated to investment spikes in the Supplier dominated sector, and in France it is negatively associated to spikes in the Scale Intensive sector
  - The export dummy is negatively associated with spikes in the French Supplier dominated sector (low export shares) and positively in the Scale intensive sector (high export shares)

$\Rightarrow$ MORE PERFORMING AND DYNAMIC FIRMS HAVE A HIGHER PROBABILITY TO INVEST

Effects of spikes on firm performance

ECONOMETRIC METHOD (KERNEL MEASURE)

- Dependent vars : the profitability rate, productivity and prod. growth, sales and sales growth , the number of employees and empl. growth.
- Each performance variable is regressed on a group of spike dummy variables using a random effects model.

$$X_{i,t} = \beta D_{i,t} + \gamma_1 D_{before,i,t} + \gamma_2 D_{least,i} + v_i + \epsilon_{i,t}$$

- where $D_{i,t}$: dummies for spike in t, $t-1$, $t-2$
  $\Rightarrow$ short term effect
- D_{before} : dummies for spike before $t-2$
  $\Rightarrow$ long term effect
- D_{least} : dummy for having invested at least once in the period
  $\Rightarrow$ comparison of investing vs non investing firms

For french firms, we isolate strictly expansionary investment events as the spikes associated with an increase in the nb of plants
$\Rightarrow$ Specification with $Dt_{i,plant}$

Table : Effect of Investment on Profitability

	France		Italy
	Profit (7)	Profit (8)	Profit (7)
Dt0 (d)	0.008***	0.009**	0.005**
Dt1 (d)	0.004	0.007***	0.003
Dt2 (d)	-0.004	0.004**	0.000
D_{before} (d)	0.000	0.000	-0.001
D_{least} (d)	0.018***	0.019***	0.087
$Dt0_{plant}$ (d)		-0.008**	
$Dt1_{plant}$ (d)		-0.017***	
$Dt2_{plant}$ (d)		-0.008	
Time & sector	Yes	Yes	Yes
Observations	133773	123615	21665

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table : Effect of Investment on Productivity

	France				Italy	
	Prod (7)	Prod (8)	Prod. Gr (7)	Prod. Gr (8)	Prod (7)	Prod. Gr (7)
Dt0 (d)	0.013***	0.014***	-0.019***	-0.018***	0.019**	-0.000
Dt1 (d)	0.011***	0.015***	-0.002	0.000	0.005	0.005
Dt2 (d)	0.009***	0.011***	-0.003	-0.005	-0.005	-0.005
D_{before} (d)	0.008**	0.008**	-0.008***	-0.006**	-0.002	-0.003
D_{least} (d)	0.085***	0.086***	0.012***	0.012***	0.039***	0.002
$Dt0_{plant}$ (d)		-0.004		-0.010		
$Dt1_{plant}$ (d)		-0.028***		-0.007		
$Dt2_{plant}$ (d)		-0.010		0.017		
Time & sector	Yes	Yes	Yes	Yes	Yes	Yes
Observations	133163	123091	132901	122870	21892	21695

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table : Effect of Investment on Productivity

	France				Italy	
	Prod (7)	Prod (8)	Prod. Gr (7)	Prod. Gr (8)	Prod (7)	Prod. Gr (7)
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Dt2 (d)	0.009***	0.011***	-0.003	-0.005	-0.005	-0.005
D_{before} (d)	0.008**	0.008**	-0.008***	-0.006**	-0.002	-0.003
D_{least} (d)	0.085***	0.086***	0.012***	0.012***	0.039***	0.002
$Dt0_{plant}$ (d)		-0.004		-0.010		
$Dt1_{plant}$ (d)		-0.028***		-0.007		
$Dt2_{plant}$ (d)		-0.010		0.017		
Time & sector	Yes	Yes	Yes	Yes	Yes	Yes
Observations	133163	123091	132901	122870	21892	21695

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table : Effect of Investment on Sales

	France				Italy	
	Sales (7)	Sales (8)	Sales Gr. (7)	Sales Gr.(8)	Sales (8)	Sales Gr. (7)
Dt0 (d)	0.097***	0.094***	0.036***	0.032***	0.028***	0.020***
Dt1 (d)	0.090***	0.086***	-0.004	-0.004	0.007	-0.003
Dt2 (d)	0.075***	0.074***	-0.014***	-0.014***	0.010	0.005
D_{before} (d)	0.057***	0.054***	-0.018***	-0.017***	0.003	-0.004
D_{least} (d)	0.255***	0.258***	0.032***	0.032***	0.347***	0.013*
$Dt0_{plant}$ (d)		0.012		0.019***		
$Dt1_{plant}$ (d)		0.012*		0.000		
$Dt2_{plant}$ (d)		0.003		-0.001		
Time & sector	Yes	Yes	Yes	Yes	Yes	Yes
Observations	133761	123605	133760	123604	22157	22085

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table : Effect of Investment on Sales

	France				Italy	
	Sales (7)	Sales (8)	Sales Gr. (7)	Sales Gr.(8)	Sales (8)	Sales Gr. (7)
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D_{least} (d)	0.255***	0.258***	0.032***	0.032***	0.347***	0.013*
$Dt0_{plant}$ (d)		0.012		0.019***		
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Time & sector	Yes	Yes	Yes	Yes	Yes	Yes
Observations	133761	123605	133760	123604	22157	22085

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table : Effect of Investment on Employment

	France				Italy	
	Empl (7)	Empl (8)	Empl. Gr. (7)	Empl. Gr. (8)	Empl (8)	Empl. Gr. (7)
Dt0 (d)	0.072***	0.068***	0.037***	0.034***	0.021***	0.017***
Dt1 (d)	0.073***	0.068***	0.004**	0.003	0.023***	0.004
Dt2 (d)	0.061***	0.058***	-0.010***	-0.009***	0.020***	-0.004
D_{before} (d)	0.046***	0.043***	-0.012***	-0.010***	0.005	-0.010**
D_{least} (d)	0.117***	0.116***	0.023***	0.023***	0.311***	0.009**
$Dt0_{plant}$ (d)		0.013**		0.012***		
$Dt1_{plant}$ (d)		0.019**		0.002		
$Dt2_{plant}$ (d)		0.009		0.004		
Time & sector	Yes	Yes	Yes	Yes	Yes	Yes
Observations	133738	123584	133715	123564	22879	22879

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table : Effect of Investment on Employment

	France				Italy	
	Empl (7)	Empl (8)	Empl. Gr. (7)	Empl. Gr. (8)	Empl (8)	Empl. Gr. (7)
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Dt2 (d)	0.061***	0.058***	-0.010***	-0.009***	0.020***	-0.004
D_{before} (d)	0.046***	0.043***	-0.012***	-0.010***	0.005	-0.010**
D_{least} (d)	0.117***	0.116***	0.023***	0.023***	0.311***	0.009**
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$Dt1_{plant}$ (d)		0.019**		0.002		
$Dt2_{plant}$ (d)		0.009		0.004		
Time & sector	Yes	Yes	Yes	Yes	Yes	Yes
Observations	133738	123584	133715	123564	22879	22879

Marginal effects
(d) for discrete change of dummy variable from 0 to 1
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Effects of spikes on firm performance - Results

- *Contemporaneous effect*: positive shock on sales and employment growth but negative shock on productivity growth.
- *Persistent effect* : positive effect of investment spikes on employment levels in both countries, and on sales in France
- *Selection effect* : investing firms are more profitable, more productive and bigger than non investing firms

National and sectoral differences :

- In general, effects of investment are weaker and less persistent in Italy:

  $\Rightarrow$ to be related to the italian productivity growth stagnation?

- In France, setting up a new plant is higly disruptive : negative shock on profitability and productivity; requires additional hiring

  $\Rightarrow$ Replication is costly (Winter and Szulanski, 2001)

- Results mostly robust at the sectoral level, but the effect on productivity is driven by the Supplier dominated sector

  $\Rightarrow$ purchase of new intermediate inputs which incorporate a higher technology level

Thanks for your attention!