What happens when firms invest?
Investment events and firm performance

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Motivation - the nature of investments

- At the macroeconomic level the relation between equipment investment and economic growth is well established in the literature (see e.g. Long and Summers, 1991),
  - the evidence for the impact of firm-level investment on the ability of firms to grow or to increase efficiency is much more scant
  - the link is important, as e.g. Foster et.al (2001) show that aggregate labor productivity growth is largely driven by within-firm changes
- Investments lumpiness
  - Doms and Dunne (1998): years of inactivity or repair and maintenance are followed by one or several years of heavy investment
  - Gourio and Kashyap (2007): most of the variation in aggregate investment can be explained by changes in the number of establishments undergoing investments spikes
- We focus on episodes of investment spikes and try to look what happens after a spike
  - they have potential to change firm behavior
  - important element of total variation
  - relatively easy to filter out

Investments and firm performance - theory

- Literature on embodied technical change (Cooley et al., 1997; Jensen et al., 2001)
  - investments means technological upgrading (new capital embodies more recent technology)
  - following an investment episode we should observe a productivity increase.
- Jovanovic and Nyarko (1996) "learning-by-doing" model
  - technology switch may temporarily reduce firm expertise
  - short-run costs of investments
  - positive productivity effects might appear in the medium-to-long-run
- Productivity costs seem also to arise also from destroying a particular organization of production
  - Rebuilding a new one is time-consuming
- Firm level relation between investment and efficiency is, to a large extent, an empirical question

Investments and firm performance - econometrics

- The literature is not particularly deep and is far from consensus
  - No effect:
    - Power (1998), first paper, finds no evidence of investment and productivity or productivity growth
  - Positive effect, but…
    - Grazzi, et. al, (2016): investment spikes are associated with higher productivity, sales and employment (in France, but not in Italy),
    - Nilsen et al. (2009) finds evidence of a positive and significant, but only contemporaneous effect
    - Geylani, Stefanou (2013) finds that productivity growth increases after investment spikes over time and then trails off
  - Negative impact effect, with "learning-by-doing"effect
    - Hugget, Ospina (2001) observe a fall in productivity after an investment spike with a subsequent slow recovery thereafter
    - Sakellaris (2003) shows that TFP drops after spikes in investment or bursts in job destruction and recovers slowly afterward
- Results are for different countries, definitions, industries
  - suggest that relation between investments and performance is complex

Value added of this study and data sources

- The study contributes to the stream of literature in various dimensions
  - We employ a new definition of investment spike, better suited to our data
  - We employ an econometric techniques (matching and multi-event diff-in-diff) to the question at hand
  - Our results augment the literature and stress the importance of the firm size
  - Sectoral coverage (most of the literature covers specific sector and is mainly concentrated on manufacturing, whereas we present results for all sectors)
- Data sources:
  - Firm data
    - Individual census data on Polish enterprises, with employment over 9 (complete for 50+)
    - Annual database, covers years 2002-2015
    - Total 565k observations (after initial cleaning), increasing from 26k in 2002 to 47k in 2015
    - Financial statements: balance sheets and profit and loss accounts
  - Price data (for TFP calculation)
    - Annual national accounts deflators of value added, GFCF, global output and intermediate consumption for main sectors of the economy: Eurostat
    - Annual data on current and previous period replacement costs of fixed assets main classification (assets and sectors): Eurostat

Data properties

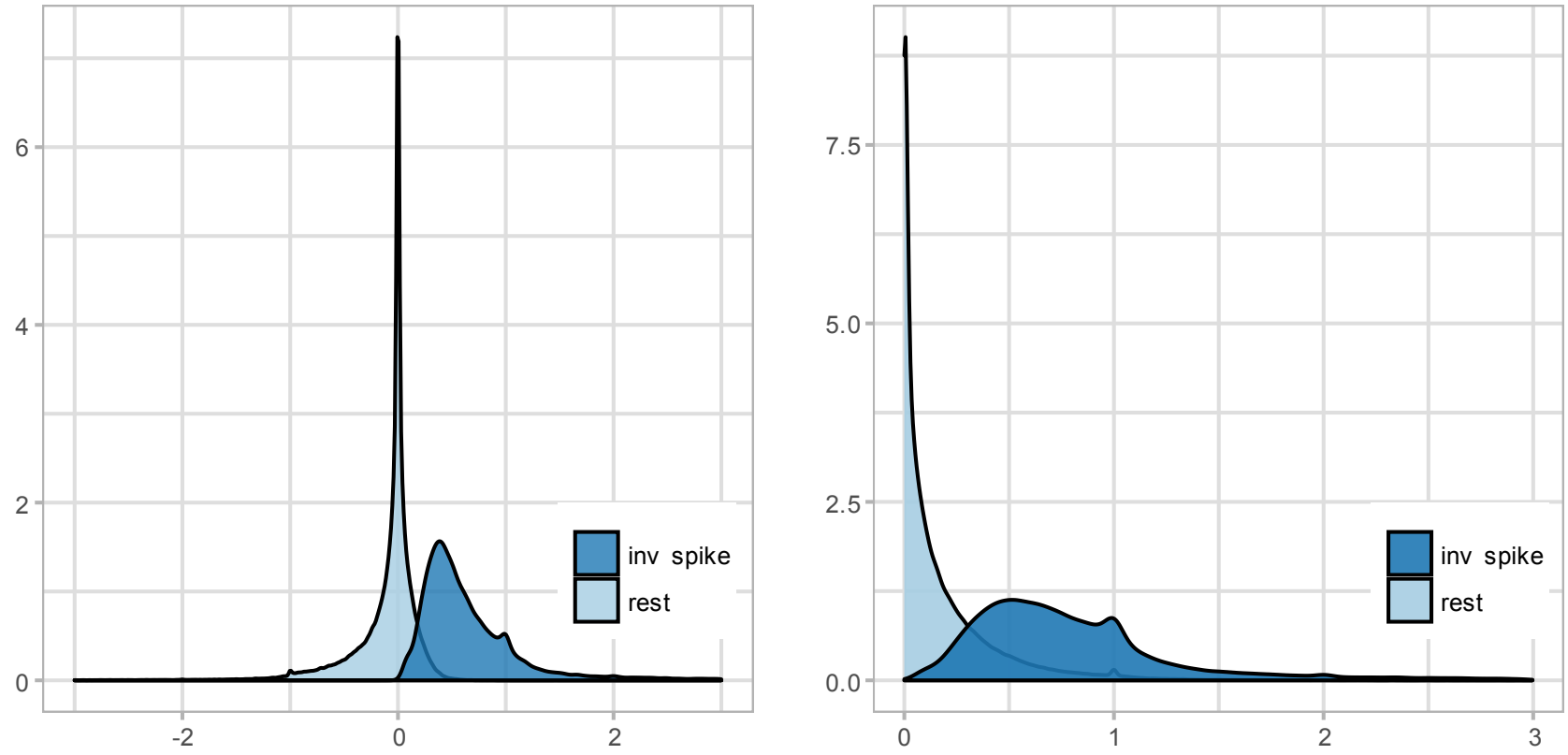
	2002	*2005*	*2008*	*2011*	*2015*
No. of firms	26136	33611	45056	46320	46980
Employment share	0.641	0.785	0.878	0.847	0.849
Average Employment	120.0	111.5	105.0	100.8	101.0
Capital/ Employment	133.9	139.8	142.2	169.9	198.3
Return on assets	0.015	0.052	0.043	0.054	0.039
Debt to assets	0.157	0.125	0.122	0.138	0.158
Liquidity	0.22	0.34	0.35	0.40	0.41
Productivity (Sales / Employment)	274.8	361.1	434.6	550.8	594.8
Productivity (Value added / Employment)	74.9	89.5	102.2	124.2	139.5
Export share	0.156	0.182	0.181	0.216	0.252
No. of exporters	0.208	0.226	0.214	0.243	0.274

Definition of investment spike

- Investment lumpiness does not translate into bimodal distribution of changes of I/K and measuring spikes is not straightforward (see Grazzi, et, al, 2016)
- Usual approach, e.g. Power (1998)
  - Measuring spikes on a firm level using some firm-specific threshold
  - Drawback: in firms with relatively flat investment path this methods select as spikes also episodes with mild changes in I/K.
- Our definition is based on the whole distribution of I/K, taking account of industry and time idiosyncrasy
  - We assume there is some normal investment intensity in each industry and it may evolve over time
  - Sizable departures from this pattern are treated as a spike
- Investment spike is defined as 12.5% of highest positive $\Delta\left(\frac{I}{K}\right)$
  - Absent changes of magnitude higher, in absolute terms, than 3 (1% of observations, irrelevant for the main results)
  - Calculated separately for each year and NACE2 sector
- It selects about 5500 incidents of big investments
  - About 10% of effective observations
  - Number of spikes corresponds to results of Power (1998) with restrictive definition of a spike: I_{it}/K_{it} higher than 3.25 of its median
  - this choice offers a relatively good trade-off between the sample size and separation of investment distributions between investors and non-investors

Distribution of big investments in the population

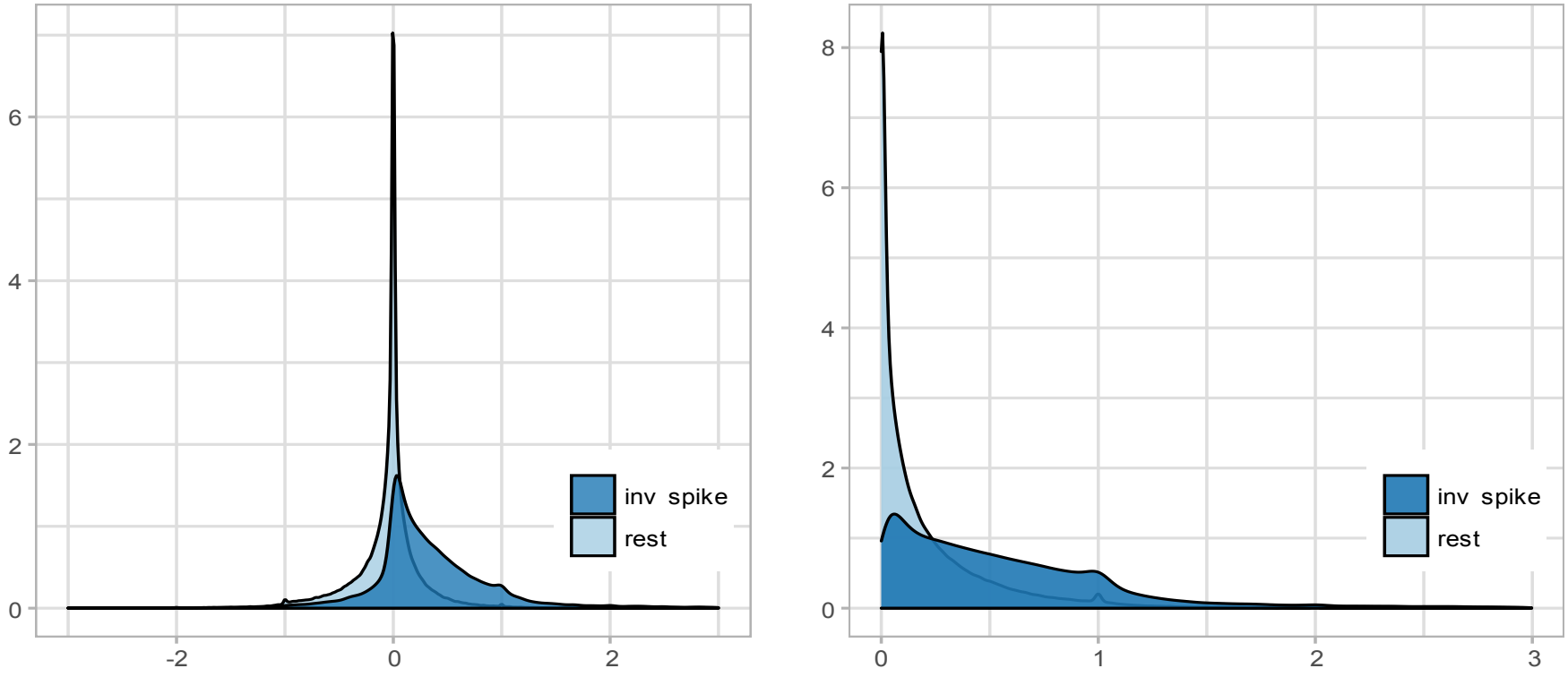
Distribution of changes (left panel) and levels (right panel) of investment/capital rate in firms engaged in big investments (inv spikes) and the rest of firms



- Nilsen, et al. (2009): any meaningful spike measure should select episodes of investment that are larger than the unconditional investment rates
  - mean investment rate is 0.5 during investment spikes and 0.13 otherwise

Problem with a firm-level definition of a spike

Distribution of changes (left panel) and levels (right panel) of investment/capital rate

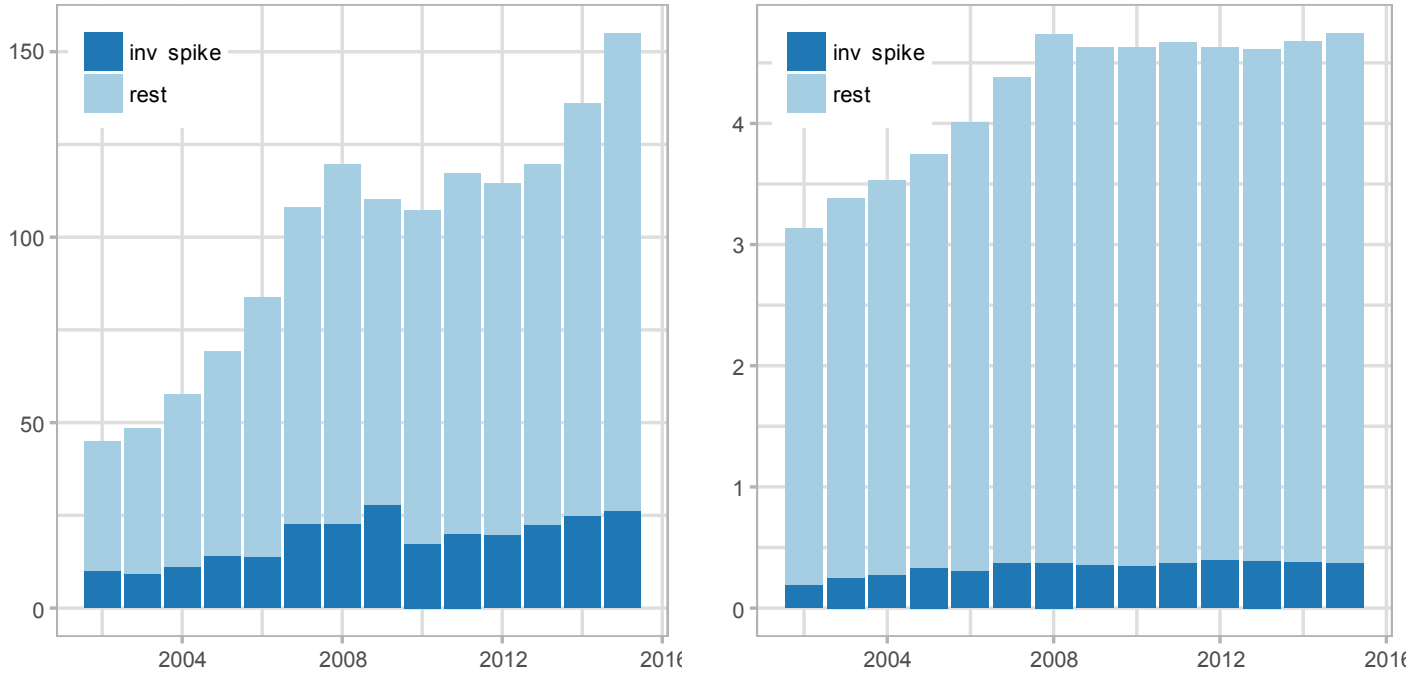


Selection rule, as in Power (1998):

$$\frac{I_{it}}{K_{it}} > 3.25 \times median_i\left(\frac{I_{it}}{K_{it}}\right),$$

How important are identified cases for total investments?

Investment outlays (left panel in bln PLN) and employment (right panel in mln) of big investors (inv spikes) and the rest of firms

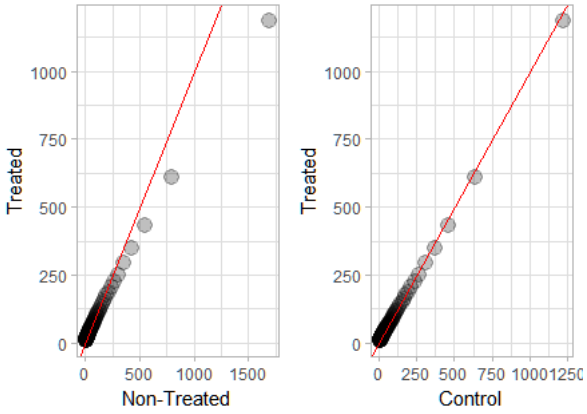


- Parsimony is another criterion for selection among spike rules
  - the share of big investors is ca. 10% in each period (by construction)
  - the share in employment is less than 8%
  - investment due to spikes account for almost 19% of total investments

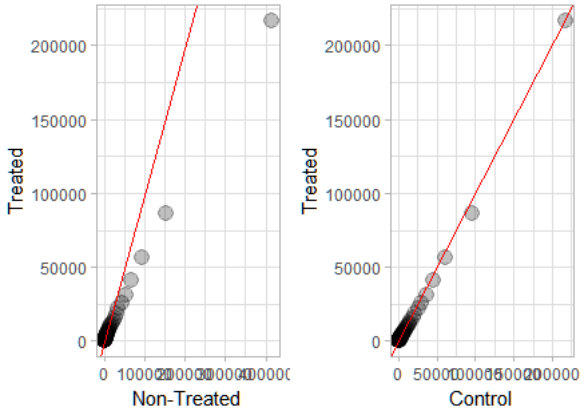
Construction of a control group

- Pooling spikes from different periods makes time comparison not a bad identification strategy
  - additional comparison to some control firms (similar, but not investing at that time) make the comparison more robust
- Matching on propensity score
  - Using logit to estimate $Pr\ (d = 1|X) = CEF\ E[d|X]$ - the distance between firms
  - Using nearest neighbor matching and single best match (the least biased but also least precise estimate of counterfactual)
- Covariates (size, market, technology, performance and financing):
  - Size: labor (average employment), capital (book value of fixed assets), sales (of products and goods)
  - Market: export share (of products)
  - Technology: labor share (in total costs)
  - Performance: productivity (VA/L) and ROA
  - Financing: liquidity (short-term assets/short-term liabilities) and debt-to-assets ratio
- Exact matching for NACE2 and ownership status (state, foreign and domestic private)
- Separate matching for each year in the sample (we do not have a structural model of investment probability)

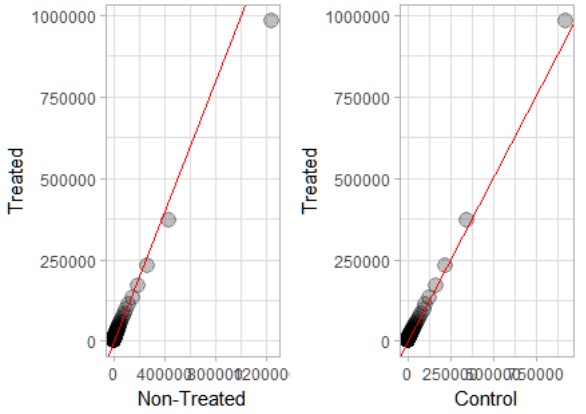
Labour



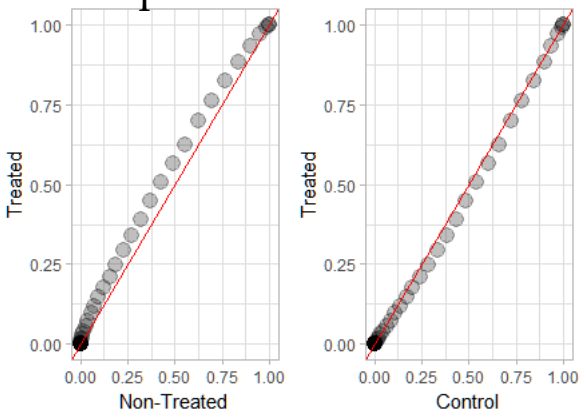
Capital



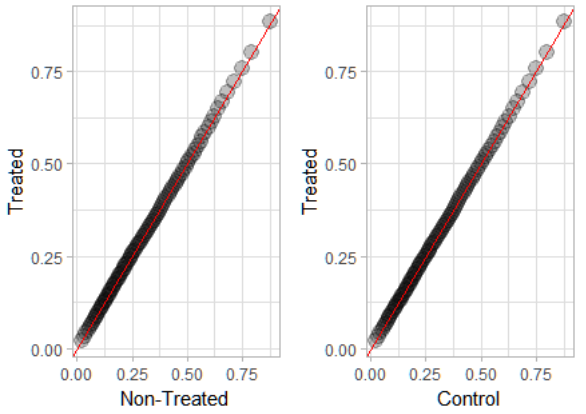
Sales



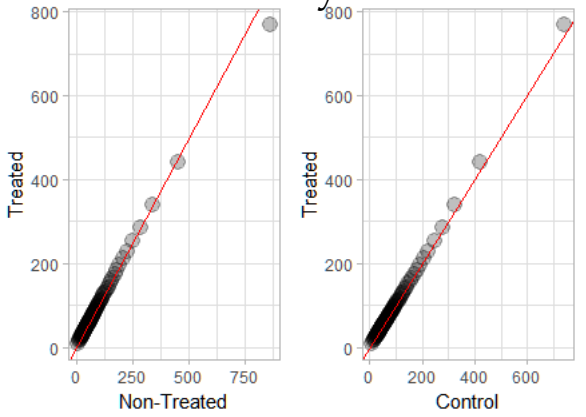
Export share



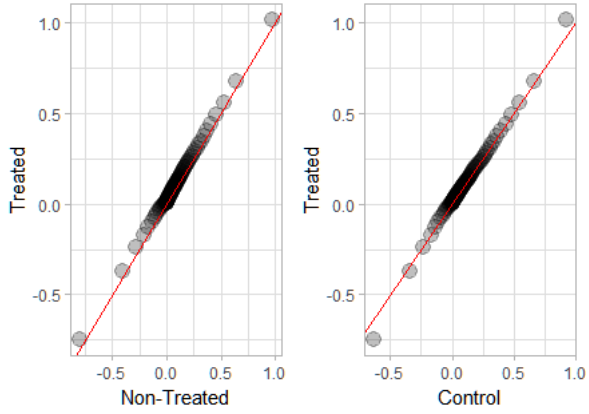
Labour share



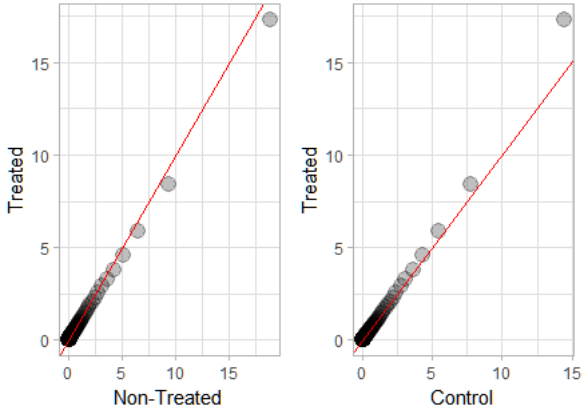
Productivity



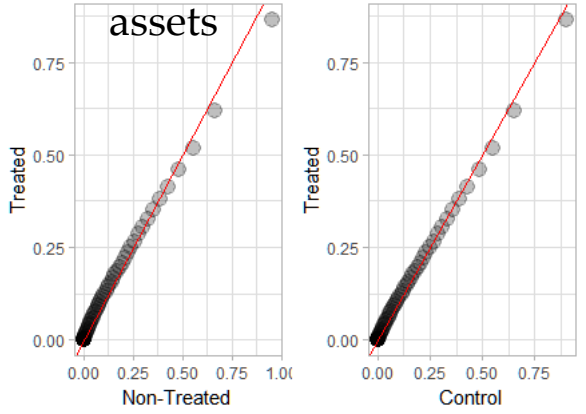
ROA



Liquidity



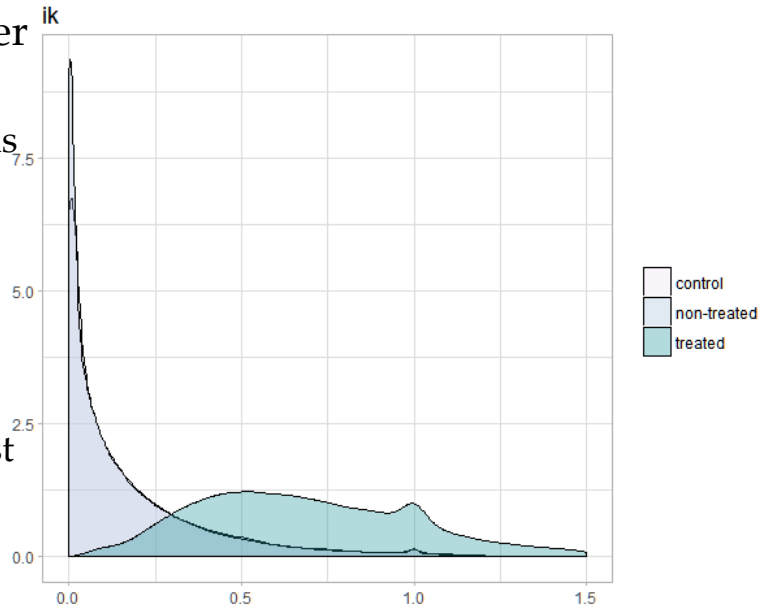
Debt-to-assets



Properties of treated (investors) and control group

names	labour	capital	sales	export share	labour share	productivity	roa	liquidity	debt over assets
full sample	105	16767	49221	0.113	0.317	94.5	0.077	1.09	0.087
treated	86	9447	44580	0.125	0.318	95.2	0.099	0.93	0.090
non-treated	107	17557	49722	0.112	0.317	94.4	0.074	1.11	0.086
matched	86	9897	38790	0.130	0.318	91.8	0.094	0.84	0.086
reduction	0.20	0.44	0.22	-0.16	-0.003	0.0	-0.27	0.25	0.00
non-treated vs treated	0.25	0.86	0.12	0.10	0.004	0.01	0.25	0.19	0.04
matched vs treated	0.00	0.05	0.13	0.04	0.002	0.04	0.05	0.11	0.05
t-stat. (treated vs. non-treated)	**11.94**	**15.34**	**2.36**	**-10.27**	-1.62	-0.83	**-18.58**	**4.85**	**-2.55**
p.value	**0.00**	**0.00**	**0.02**	**0.00**	0.11	0.40	**0.00**	**0.00**	**0.01**
t-stat. (treated vs. control)	-0.23	0.76	**-2.54**	**3.195**	-0.449	**-3.15**	**-3.572**	**-3.26**	**-2.379**
p.value	0.82	0.45	**0.01**	**0.001**	0.653	**0.00**	**0.000**	**0.00**	**0.017**

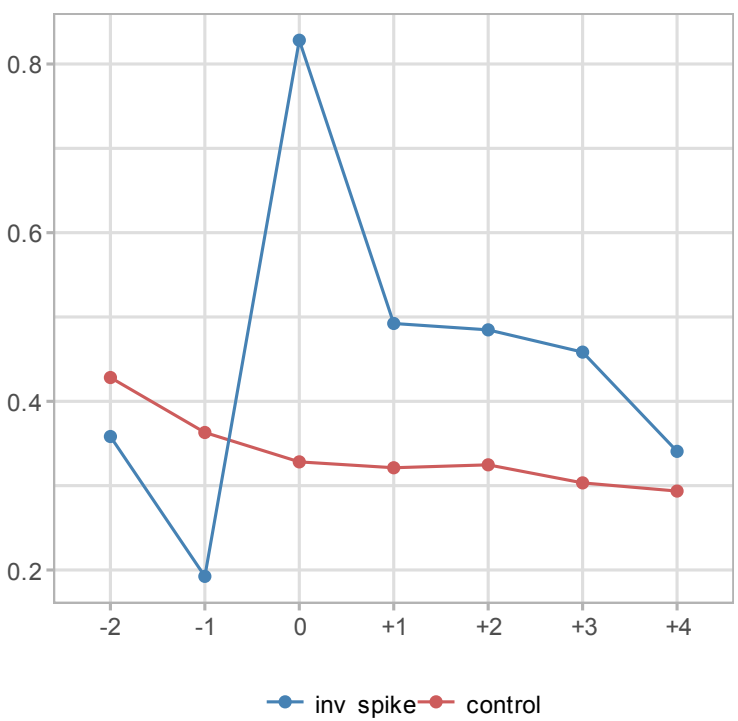
- Treated population (investment spikes) is much closer to control group than to non-treated population
  - In almost all cases, except sales and productivity, means of control are closer to treated
- T-tests of means differences between treated and control (for the whole sample) show:
  - Statistically insignificant differences (between treated and control) only for labour, capital and labour share
  - In other cases distributions are so wide that Welch t-test still sees differences
- Kolmogorov-Smirnoff tests: only export share and labor share distributions indistinguishable

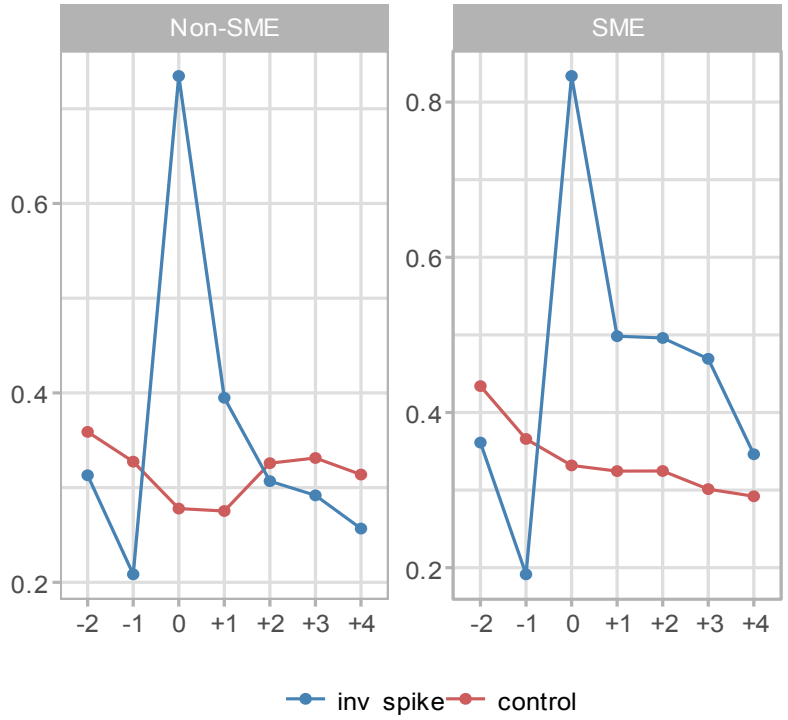


Investment spike at a glance

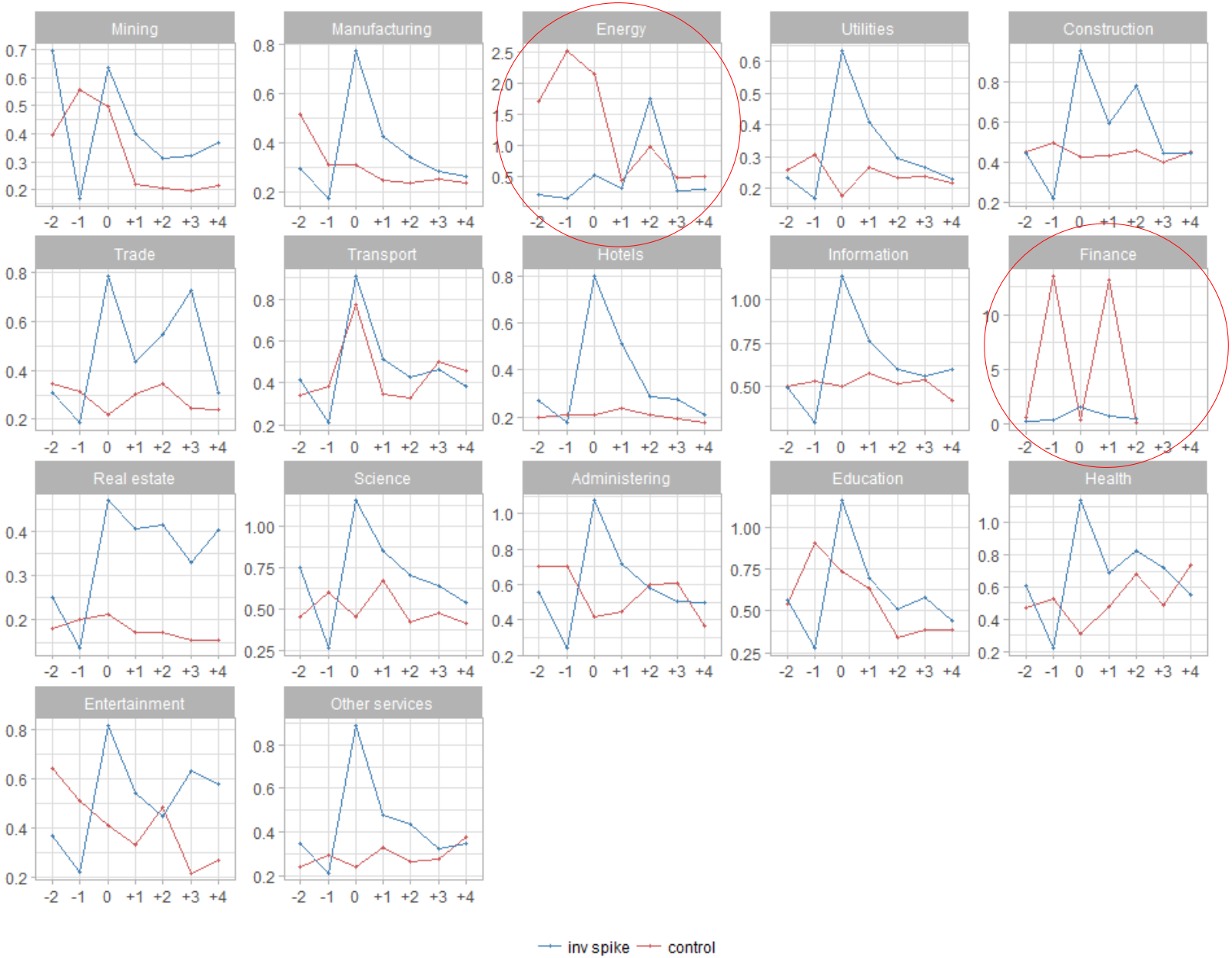
- The moment of investment spike is of course interesting, but more important is what happens to firms in the neighbor of the investment decision
- We will look at the window of -2/+4 years around a spike
  - periods before allow to check for common trends (and possible expectations effects)
  - periods after allow to measure the effects of big investments
- We excluded energy and finance from the further analysis
- One of the desirable feature of properly specified control group is the absence of investment spike at the time of interest

I/K close to investment spike





Investment spikes in sectors



Estimation strategy - intuition

- To find effects of investment spikes on firm performance we used the approach of Gormley and Matsa (RFS, 2011)
  - Big investment is not an natural experiment so it is not straightforward to interpret the results in terms of causality
  - But still the methods are quite helpful in our context
- Spikes (treatment cases) occur in different years (cohorts)
- Consider estimating generalized diff-in-diff for some cohort:

$$y_{it} = \beta(d_i \times p_t) + \alpha_i + \delta_t + \epsilon_{it}$$

Where:

  - y_{it} - performance indicator
  - d_i - indicator of firm i being treated (having big investments) in this event (cohort)
  - p_t - indicator of treatment occurring before period t
  - unit i and period t FE control for independent effects of d_i and p_t
- Here, contrary to standard diff-in-diff, we need to account for cohorts
  - Sample is restricted to a window of -2/+ 4 years pre- and post- event
  - Control firms for some cohorts that become later treated firms within the observation windows are dropped
- Samples for those cohorts are pooled (with cohort tracking)

Measurement of dynamic effects

- Parallel trend is an important assumption allowing for the interpretation of divergence of post treatment developments to the (causal) effect of treatment
  - Possibility of divergence in trends before treatment
- Moreover, it is worth to allow for the treatment post effects to have different magnitude
  - Possibility to disentangle short-term and longer term effects (learning-by-doing in our case)
- Autor (2003) suggested the simplest solution
  - Instead of $d_i \times p_t$ in the model specification using $\sum_{j\in\{-2,-1,1,2,3,4\}} \beta_j d_i \times \tau_j$, where $\tau_j = 1$ when the difference between current date and treatment date is j
  - Due to collinearity we excluded $j = 0$
  - β_j measure changes of performance indicators relative to base period, so accounting for any possible difference of these indicators in the moment of treatment
- Ideally:
  - Estimates for periods before treatment dates should be insignificant
  - Estimated for the post treatment dates should be significant

Estimation strategy

- Summing up, our estimation is a multiple events generalized diff-in-diff:

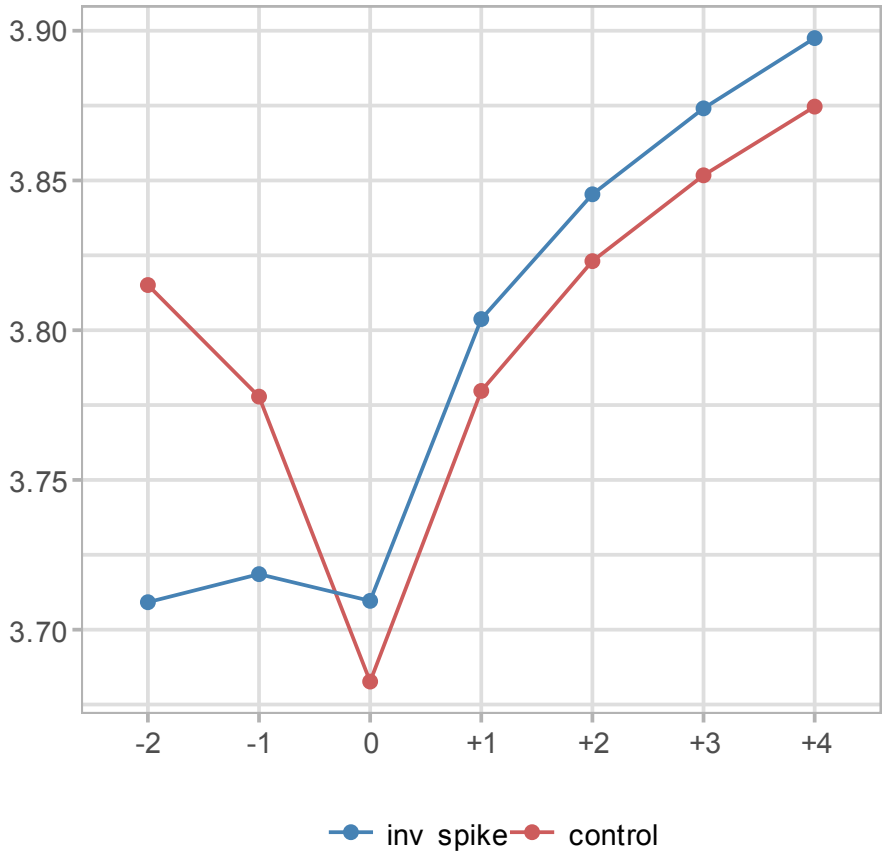
$$y_{ict} = \sum_{j \in \{-2,-1,1,2,3,4\}} \beta_j d_{ict} \times \tau_j + \alpha_{ic} + \delta_{ct} + \epsilon_{ict}$$

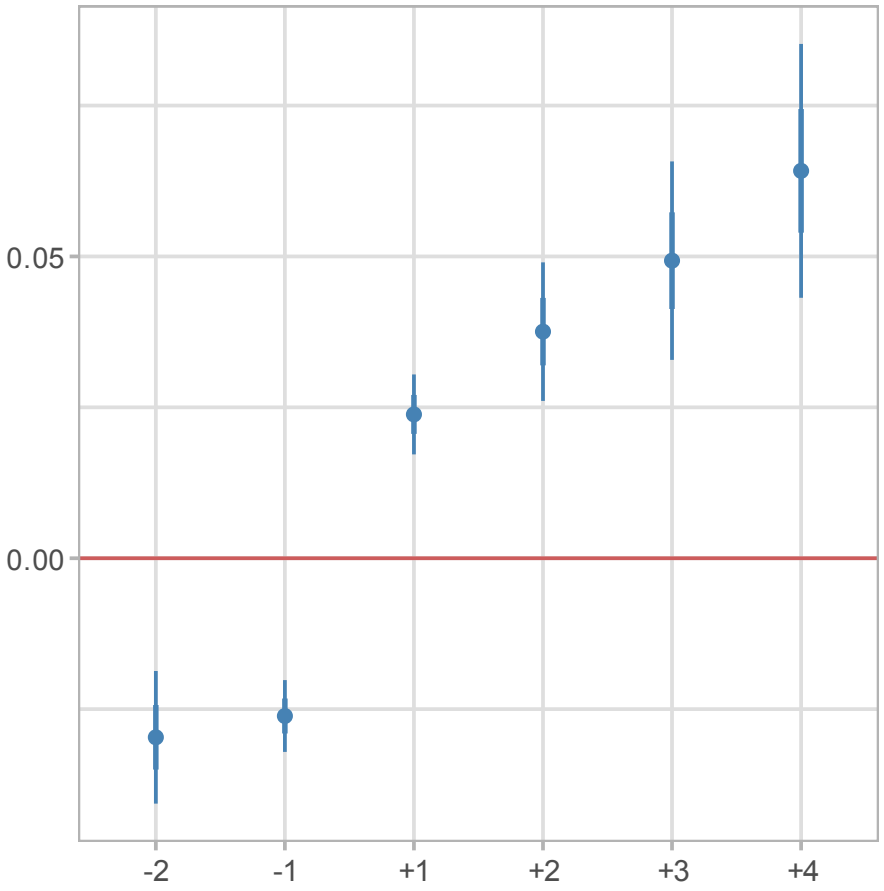
Where:

  - d_{ict} - indicator of firm i in period t being treated in cohort c
  - τ_j - indicator of current period t being j periods post or before (negative j) treatment
  - α_{ic} - unit-cohort FE, controlling for the fact of treatment (big investment) dummy in each cohort
  - δ_{ct} - time-cohort FE, controlling for dummy indicating the post period in each cohort
- Clustering at industry (NACE02) level
  - allows for within industry correlation (firms within industries have more in common than firms from different industries)
  - allows within industries error autocorrelation, as industry shocks are usually persistent
- Pooling and direct accounting for cohorts makes the results more robust, as:
  - results should not be driven by particularities of any period
  - results should not be driven by a particular set of firms (in 57% of firms with spikes the spike occur only once per sample, in 27% it occurs twice)
- Estimated using FELM package in R, utilizing the method of alternating projections to sweep out multiple group effects from the normal equations before estimating the remaining coefficients with OLS

Employment effects

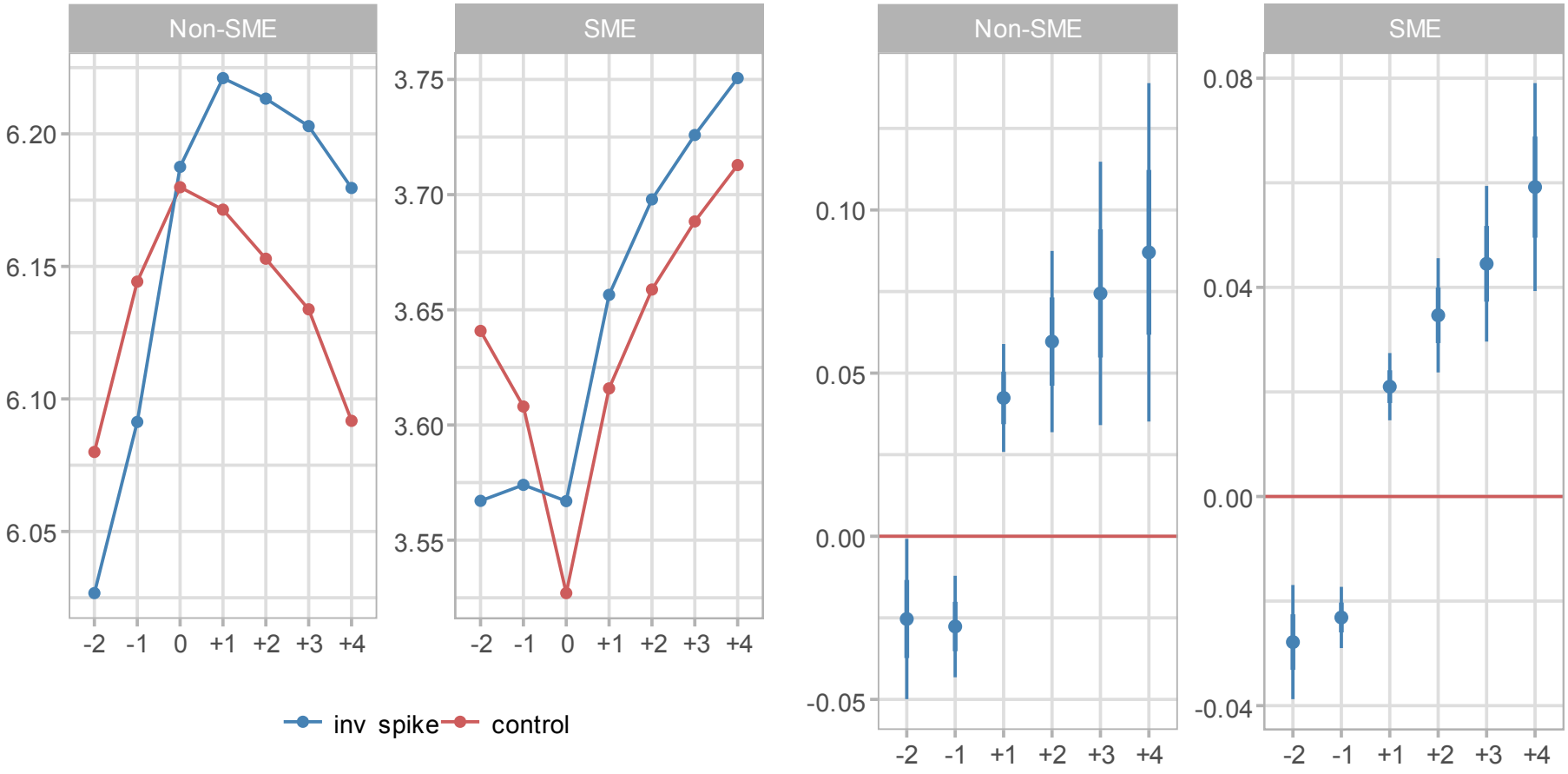
Log employment close to an investment spike (left panel) and estimation coefficients (right panel)





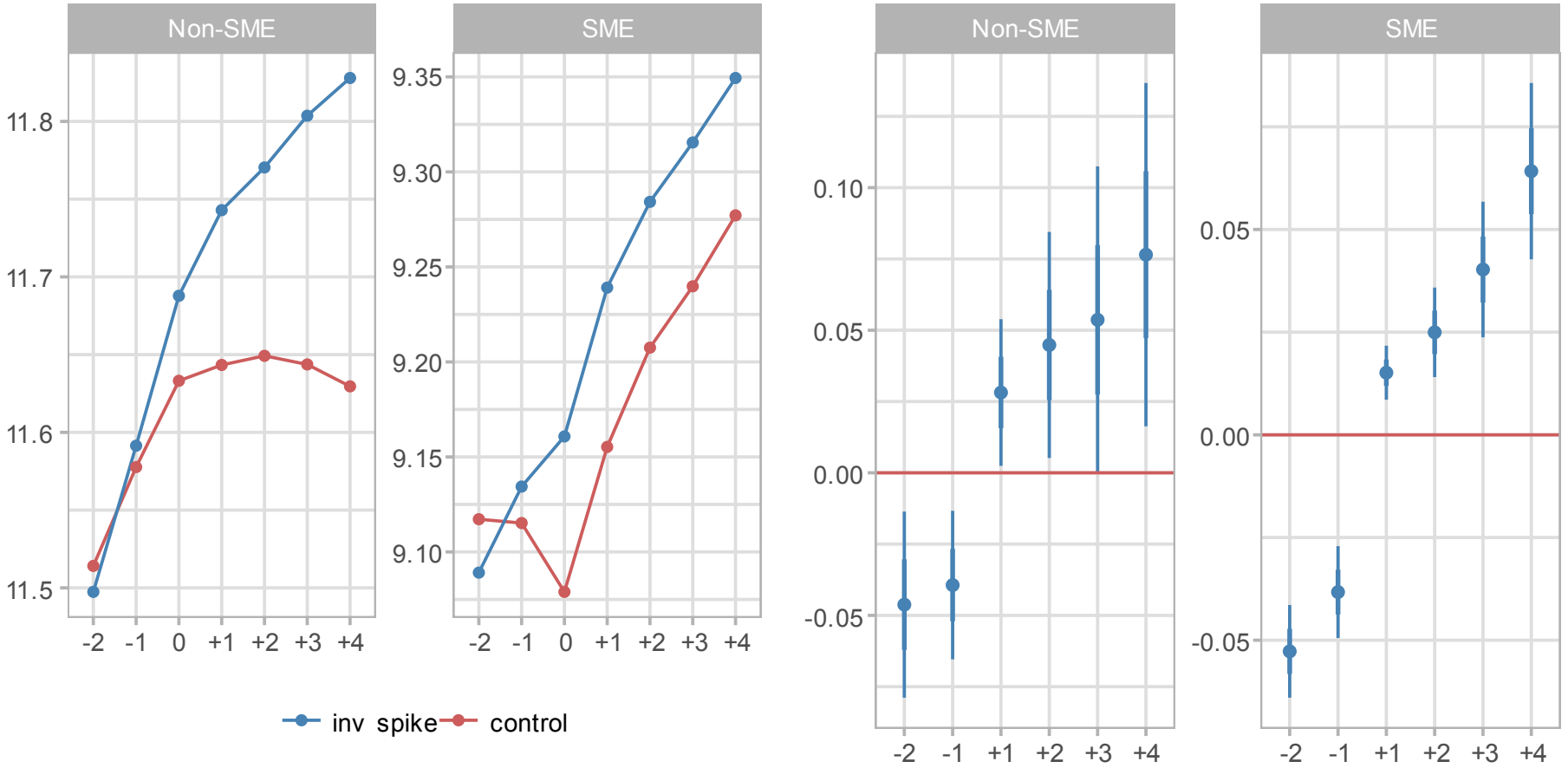
Employment effects in size classes

Log employment close to an investment spike (left panel) and estimation coefficients (right panel), both for size classes



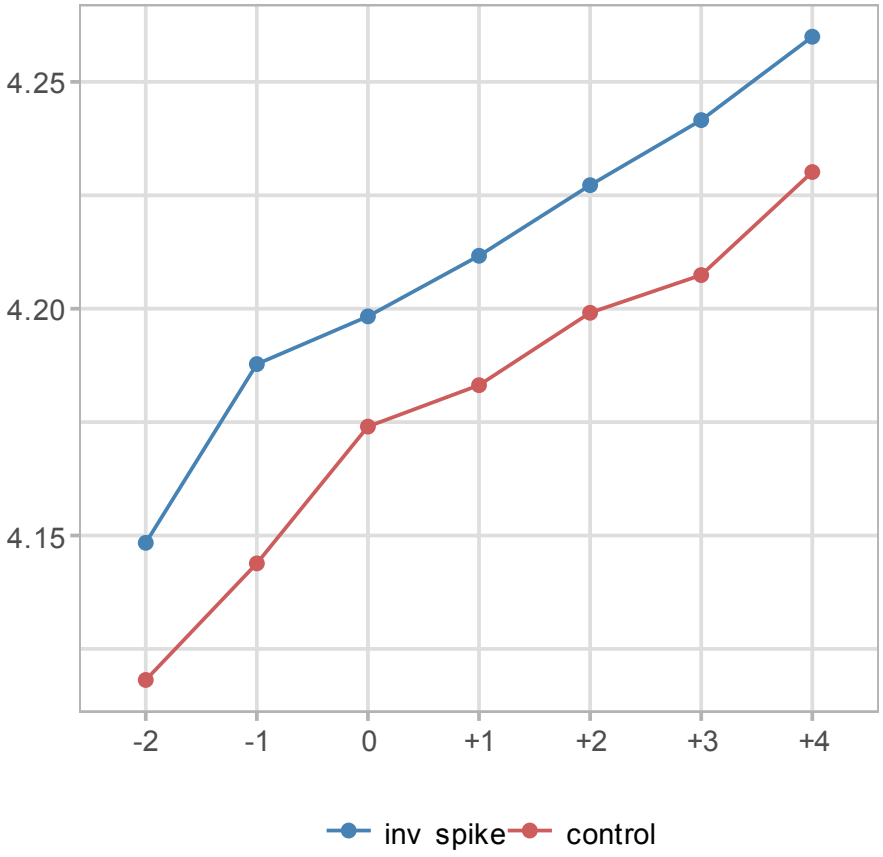
The results indicate that after investment spike employment in smaller firms rises faster than in the control group, but in larger firms it falls slower than the fall in the control group

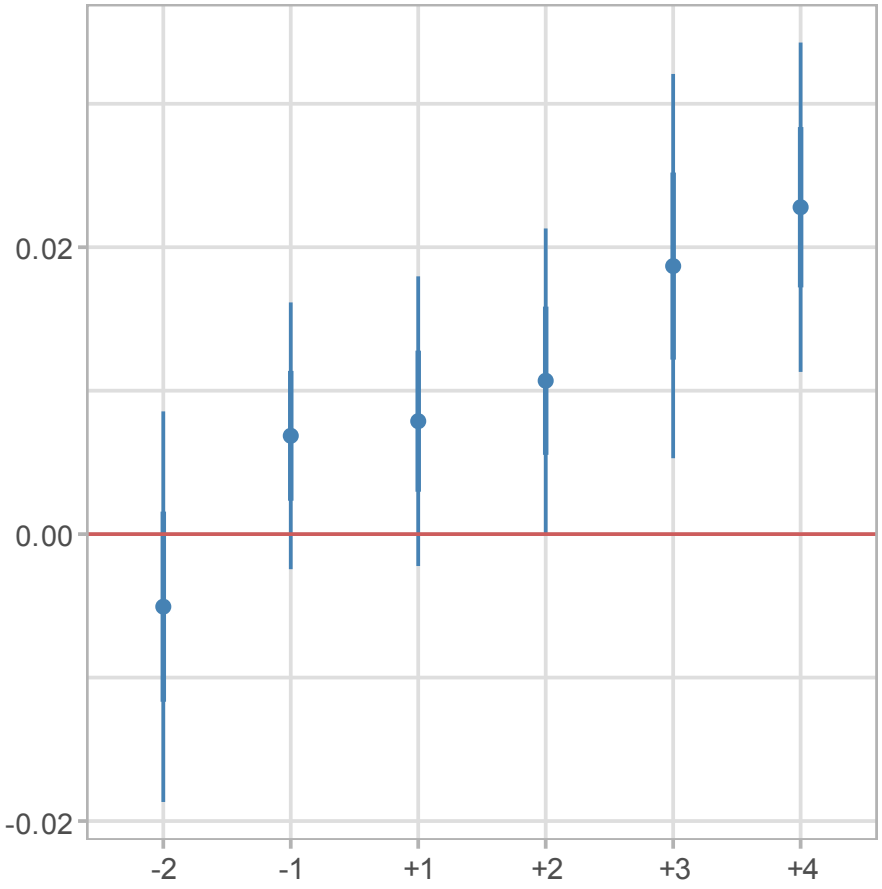
Sales effects in size classes



- Smaller firms tend to be more dynamic and tend to grow regardless of investments, but investment outlays translate into higher growth.
- Sales growth of larger firms seems to be conditioned on investment outlays, with sales in control group staying flat.

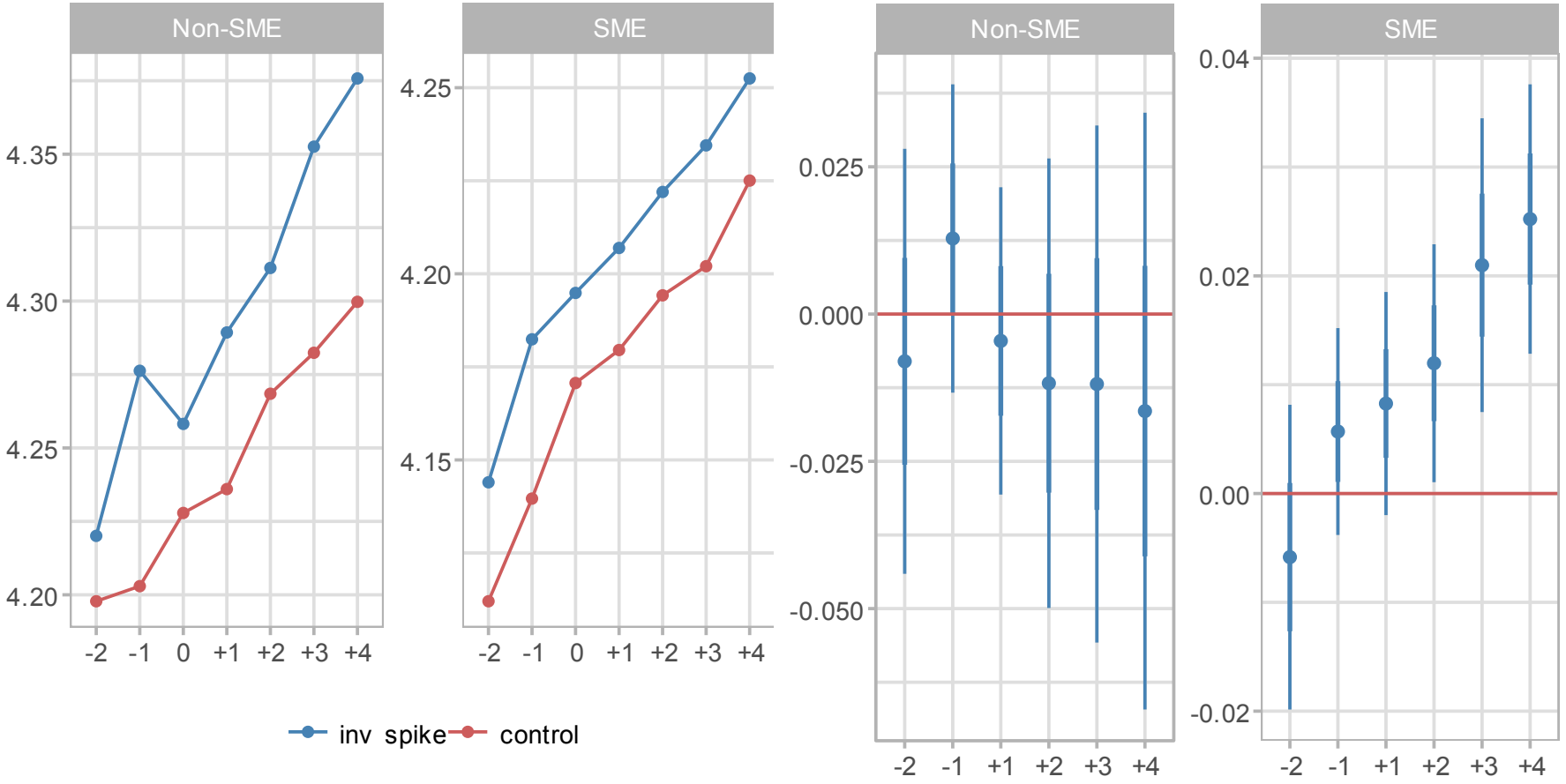
Labor productivity (VA/L) effects





- Labor productivity tends to be higher in investing firms, also after the spike, so the increase of sales and value added dominates the rise of employment.
- Longer term productivity effect of investment spike is positive and significant, with an average labor productivity gain of 2%.
- This fade-in of productivity gain is consistent with a learning-by-doing model of Jovanovic and Nyarko (1996).

Labor productivity in size classes



- In smaller firms the results are roughly the same as in the aggregate case – productivity gain 3-4 years after the spike is ca. 2-3% and is significant
- In larger firms, the productivity level also increases after a spike, but this effect is insignificant
- There is no learning-by-doing effect in case of larger firms

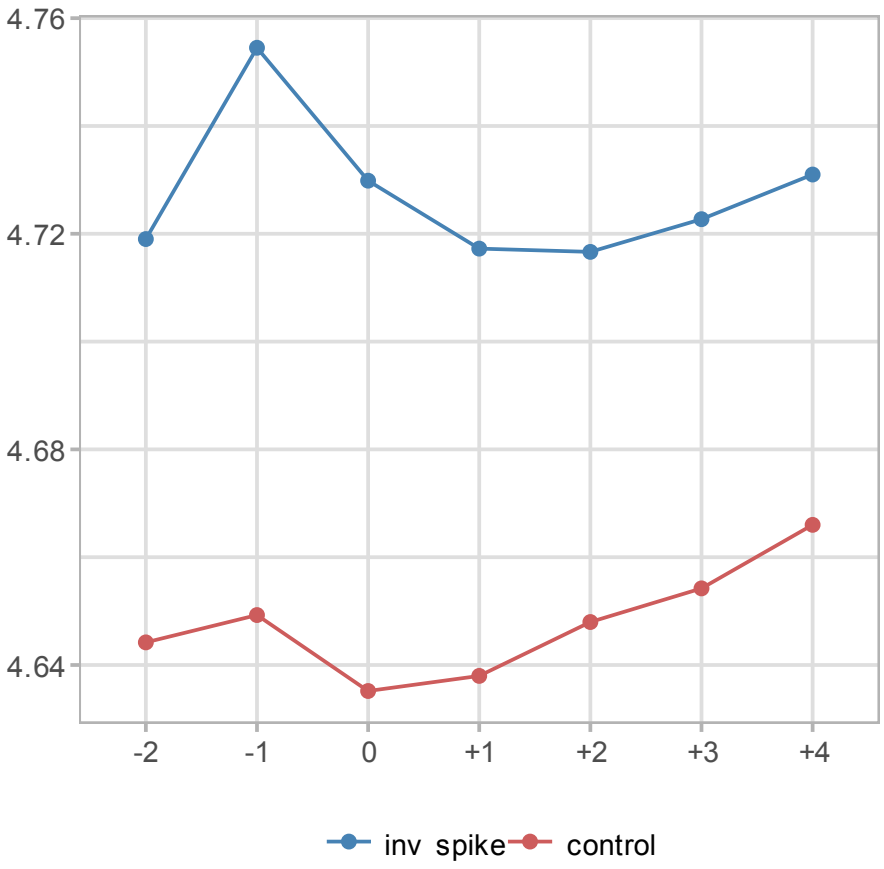
TFP measurement

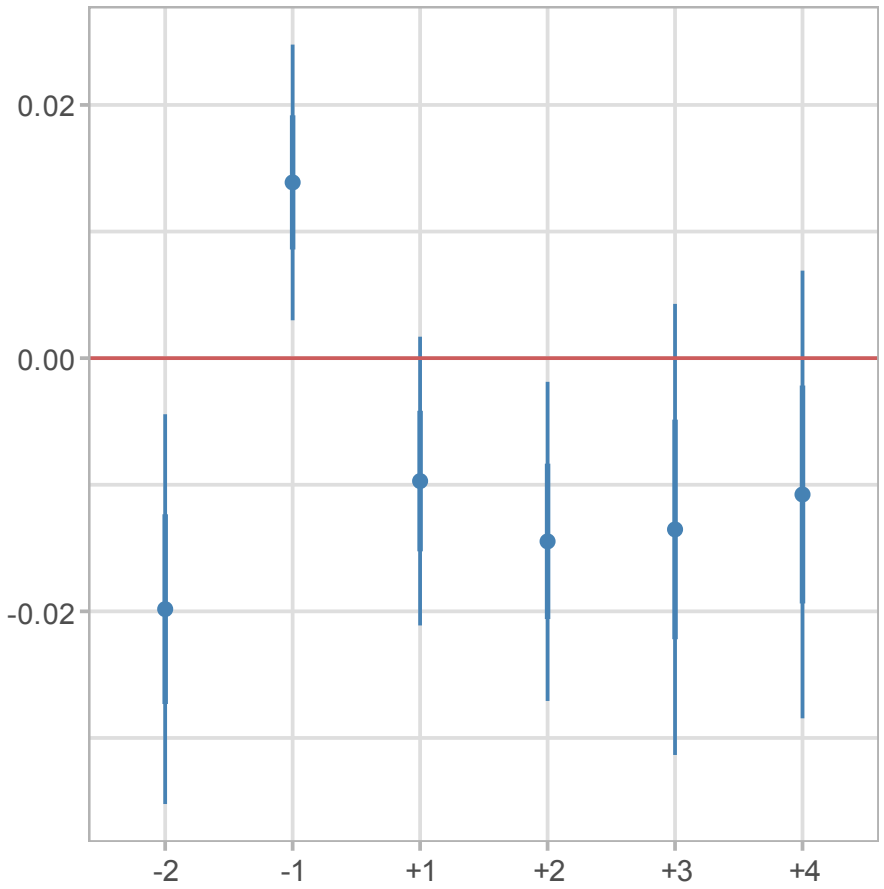
- Labor productivity is not a perfect measure of firm performance and efficiency
  - it is simple, but measures the efficiency of labor only
  - it is affected by capital deepening - for a broad category of production functions

$$\frac{Y}{L} = f(\frac{K}{L}, TFP) \text{ with } \frac{\partial f}{\partial K/L} > 0, \frac{\partial f}{\partial TFP} > 0.$$

- TFP measurement is subject to many problems, Marschak and Andrews (1944)
  - Endogeneity due to simultaneous impact of TFP on output and input factors
- Problem was addresses e.g. by
  - Olley Pakes (1996) use investment to account for correlation between input levels and the unobserved firm-specific productivity
  - Levinsohn, Petrin (2003) utilizes materials as a control variable, as in practice investments are frequently zero
- We used LP method
  - Intermediate consumption used as proxy variable
  - OP TFP estimates exhibit a sudden, one period drop in big investors TFP in the period of big investments, apparent especially in SMEs
  - We account for firm exit in the productivity estimation step
  - All variables were deflated using sectoral deflators of value added (used for value added and intermediate consumption) and capital price index (for different kinds of assets)

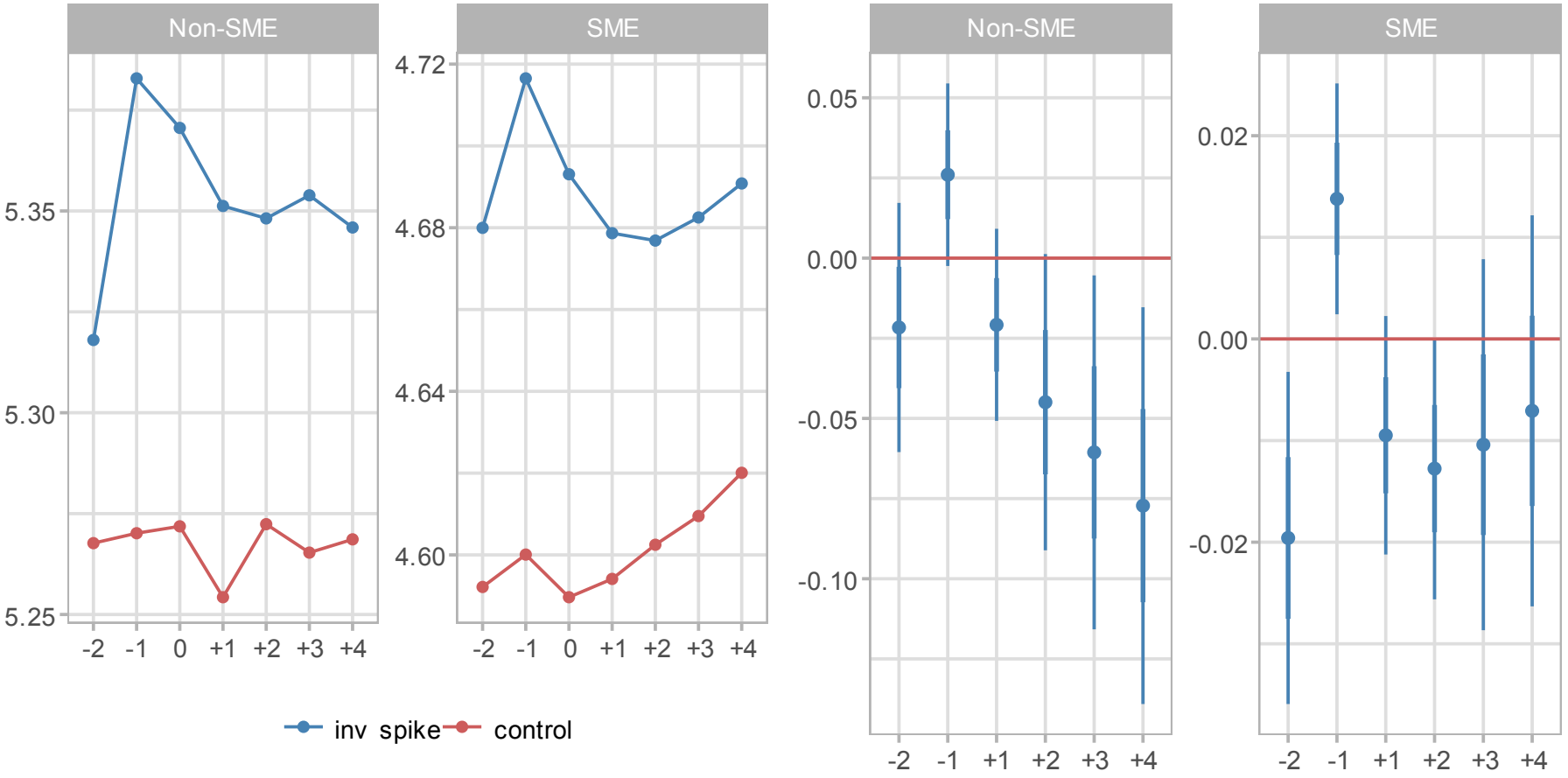
TFP





- Big investors are on average more productive than firms in the control group (0.095 log-difference in the moment of spike and persists within the window of observation
- TFP seems to deteriorate in absolute terms just after an investment spike and rise only gradually more than 2 years after the spike (still insignificant)
- It follows that the positive labor productivity effect is due to capital deepening and no TFP improvement

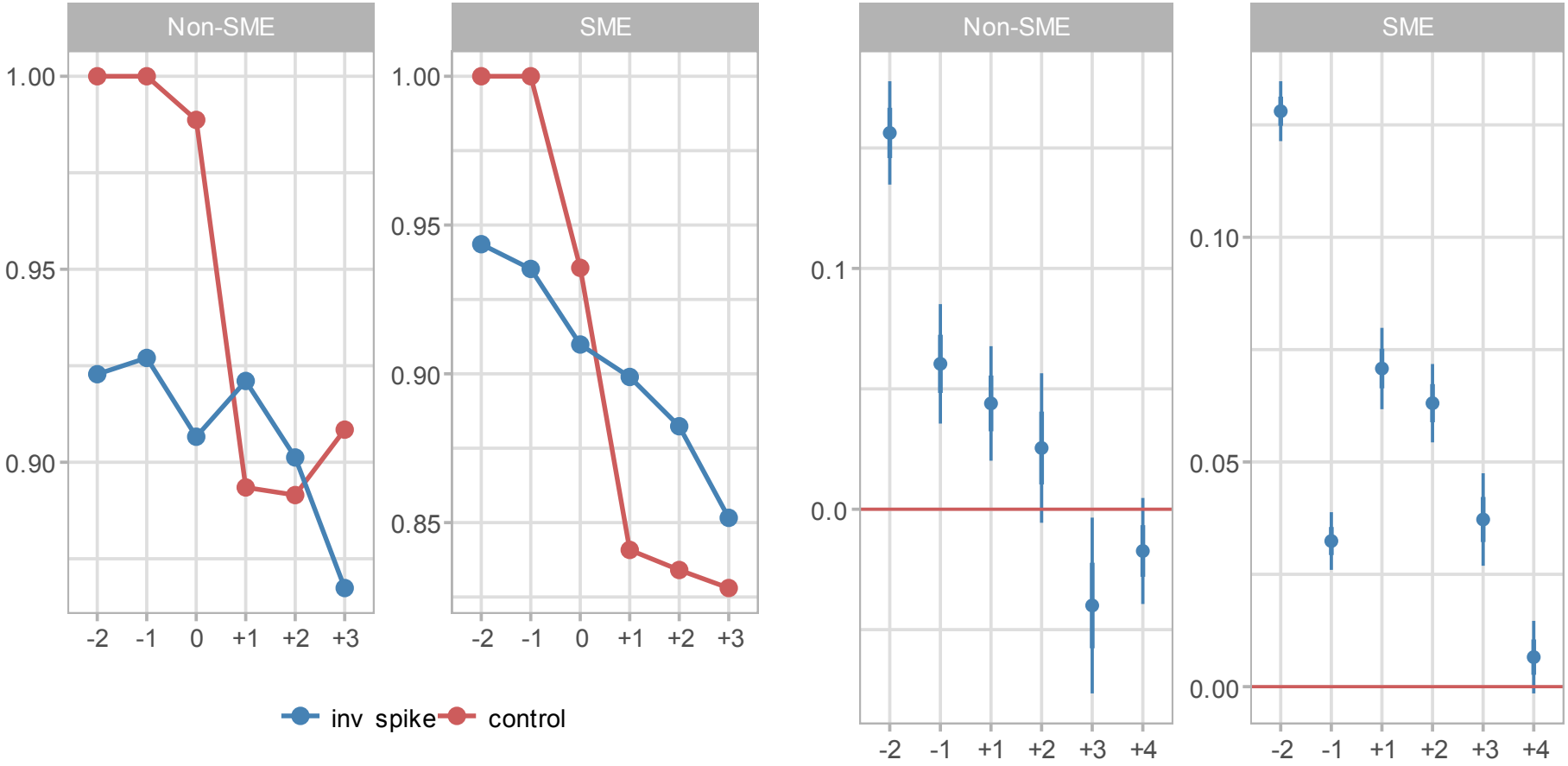
TFP in size classes



- SMEs: no significant effect of investment spike on subsequent TFP, There is some indication of learning-by-doing effect at the end of the observation window but it is small and statistically insignificant, so the whole rise of labor productivity seems to be driven by capital deepening
- Larger companies: no change of labor productivity after a spike is accompanied by a fall of TFP, with no indication of a learning-by-doing effect.

Survival probability in size classes

To check the effects of investment spike for survival probability we calculated the binary variable I_{ict} indicating if the firm *i* from a cohort *c* was observed both in period *t* and period *t+1*, corrected for "dropping" effect due to the end of sample in cohorts near sample end.



A decision to invest in larger firms seems to be, apart from expansion of market share, a way to avoid bankruptcy

Robustness

- Definition of investment spike. We followed more conventional approach of Power (1998) and defined investment spike as all events where $\frac{I_{it}}{K_{it}} > \alpha \times median_t \left(\frac{I_{it}}{K_{it}}\right)$, calculated for each firm. α was set at 3.25, which is a conservative choice, coherent with number of firms in baseline parametrization.
- No date grouping in the definition of investment spike (relatively more investment spikes are observed in the first years of the sample, especially in the period of high investment growth before the crisis of 2008/2009)
- Omission of the most problematic variable in the matching procedure (exclusionof productivity from variables to match on, the difference on productivity became insignificant and it have not affected significantly other tests)

- In all cases main results of the paper are unchanged

Conclusions

- We used diff-in-diff estimation on a large sample of Polish companies from all sectors to show what are the consequences of investment spikes for efficiency
- In smaller firms:
  - investment spike is associated with subsequent sales expansion and employment increase
  - labor productivity rises (with short learning-by-doing period) mostly due to capital deepening, as TFP drops directly after a spike and only gradually rises thereafter.
  - big investments seem to aim at higher market share at the cost of temporarily lower productivity
- In larger firms
  - spike results in sales expansion, but also employment drop
  - labor productivity is unaffected, as capital deepening is accompanied by significantly lower TFP, both in absolute and relative terms.
  - investment seems to be, apart from expansion of market share, a way to avoid bankruptcy
  - may be driven by agency problems – managerial ability results of Bromiley (1991)
- Our results also suggest that:
  - the strength of macroeconomic relation between investment activity and productivity may change in time and may be heavily affected by the composition of investment growth
  - the relation between investments and labor productivity may substantially differ than the relation of investment and TFP.
  - the positive relation between investments and various measures of efficiency observed at the macroeconomic level could be to a large extend driven by improvement of allocative efficiency as despite the within firms efficiency development resources are attracted to more effective firms after an investment spike