How (not) to measure Competition

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Introduction

- Conventional ways of measuring competition (concentration (H) and price cost margin (PCM)) are not robust from a theoretical point of view
  - see, for instance, Amir and Lambson (2000), Bulow and Klemperer (2002) and Stiglitz (1987) for cases where competition goes up and PCM goes up as well
- We introduce a new measure based on the intuition that *in a more competitive market, firms are punished more harshly for being inefficient*
- In particular, we estimate for an industry the following *elasticity*: percentage increase in profits due to a 1 percent increase in efficiency
- We do this estimation for 119 Dutch industries in both manufacturing and services using firm level data (on average 87.000 firms per year)
- On average this elasticity equals 7 for the Dutch industries in the data

How do we know which measure is better?

- Theory suggests that PCM and H can point in the wrong direction due to the reallocation effect
- *Reallocation effect:* as competition intensifies (more aggressive conduct), market shares of efficient firms increase at the expense of inefficient firms
- This implies that H goes up; (incorrectly) indicating a fall in competition
- This shifts market share from firms with low PCM to firms with high PCM which can lead to an increase in industry average PCM; (incorrectly) indicating a fall in competition
- We would expect the reallocation effect to be strong in (sub) markets where concentration is high and where our measure of the reallocation

effect is big

- Empirically we can identify these cases and show that the probability that PCM and PE deviate (over time) increases with concentration and the size of the reallocation effect

Intuition profits elasticity

- In a more competitive market, firms are punished more harshly for being inefficient
- Hence a 1% increase in (marginal) costs, leads to a bigger percentage fall in profits (in a more competitive market)
- Roughly speaking, we estimate the following relation for each market and time period

$$\ln(\pi_i) = \alpha - \beta \ln(c_i)$$

  where π_i equals variable profits and c_i marginal costs of firm i
- The slope β of this relation is the profit elasticity, PE, we are interested in

- To interpret PE, consider a monopolist who faces demand curve of the form $x = p^{-\varepsilon}$ (where $\varepsilon > 1$) and produces with constant marginal costs c
- monopolist solves $\pi = \max_p \{px(p) - cx(p)\}$
- Then we can write

$$\ln(\pi) = \ln\left(\frac{(\varepsilon - 1)^{\varepsilon - 1}}{\varepsilon^{\varepsilon}}\right) - (\varepsilon - 1)\ln(c)$$

- Hence PE$= \varepsilon - 1 > 0$
- Similarly for oligopoly where ε is firm's own price elasticity
- If firm faces more elastic demand, it is in a more competitive situation and β is higher

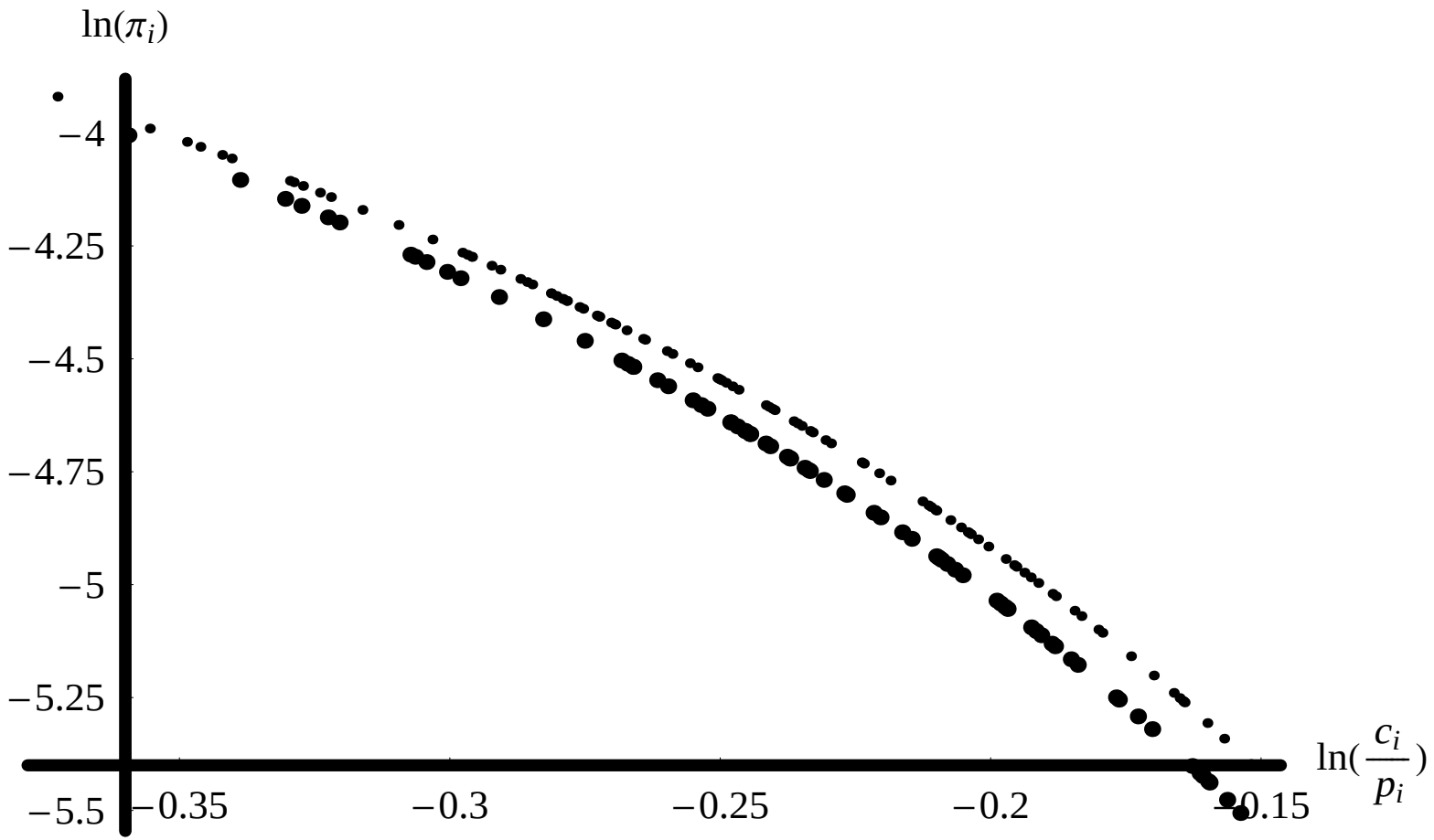
A simple Cournot model

- Firm i faces a demand curve of the form $p(x_i, x_{-i}) = a - bx_i - d\sum_{j \neq i} x_j$
- i chooses output x_i which solves $\max_{x \geq 0}\{(a - bx - d\sum_{j \neq i} x_j)x - c_i x\}$
- Cournot output for firm i is given by

$$x(c_i, c_{-i}, n) = \frac{(\frac{2b}{d} - 1)a - (\frac{2b}{d} + n - 1)c_i + \sum_{j=1}^{n} c_j}{(2b + d(n-1))(\frac{2b}{d} - 1)}$$

- variable profits are given by $\pi_i = (b + \lambda d)x(c_i, c_{-i}, n)^2$
- Firm i enters if $\pi_i \geq f$
- Simulations with $a = 40, b = 30, d = 20, f = 0.004$ and 110 c_i's are drawn from a lognormal distribution with mean 0.7 and standard deviation 0.08
- we increase competition by raising $d = 20$ to $d = 30$ (goods closer substitutes)
- we are interested in the relation between $\ln(\pi_i)$ and $\ln(\frac{c_i x_i}{p_i x_i})$ since we cannot observe c_i directly in the data

Relation with $d = 20$ (small dots) and $d = 30$ (large dots)



Outcome

- After increase in competition, the relation becomes steeper: PE increases from 6.78 to 7.50
- Number of active firms falls from 101 to 74: under the more competitive regime, inefficient firms can no longer enter and concentration goes up
- price cost margin falls from 0.22 to 0.21 where

$$PCM = \frac{\sum_{i=1}^{n}(p_i x_i - x_i c_i)}{\sum_{i=1}^{n} p_i x_i} = \sum_{i=1}^{n} \frac{p_i x_i}{\sum_j p_j x_j} pcm_i$$

  where $pcm_i = \frac{p_i - c_i}{p_i}$ is the price cost margin of firm i.
- Hence PE and PCM correctly indicate that competition has increased after d goes up.

Robustness

- The slope between (log) profits and (log) costs also becomes steeper in models with other parameterizations of competition (like the model above with lower entry barriers or 'more aggressive' conjectures (like Bertrand); an Hotelling beach with lower travel costs; demand based on a CES utility function where goods become closer substitutes; models with foreign competition where import tariffs are reduced etc.)
- We focus on situations where competition becomes more intense due to more aggressive conduct by firms, since reductions in entry costs are picked up correctly by all three measures PE, PCM and H
- to estimate the slope we only need to observe a sample of firms out of the industry, not all of them (as one needs with PCM and H)

Simulations

- With the model above we do the following simulations:
  - for each parameter constellation we draw (110) firms out of the log normal distribution, calculate the Cournot equilibrium and derive $PE_0, PCM_0,$
  - we raise d by 10 and derive PE_1, PCM_1
  - we repeat this 100 times and calculate the fraction of times where $PE_1 > PE_0$, the fraction where $PCM_1 < PCM_0$, the average (over the 100 iterations) H_0 and the average reallocation effect (see below)
  - we do these steps for different parameter values where $d = 15, 20$, $f = 0.004, 0.008, 0.012$, $stdev = 0.08, 0.16, 0.24, 0.32$

Empirical measure of the reallocation effect with PCM

- Suppose competition changes from $t = 0$ to $t = 1$, then we can write

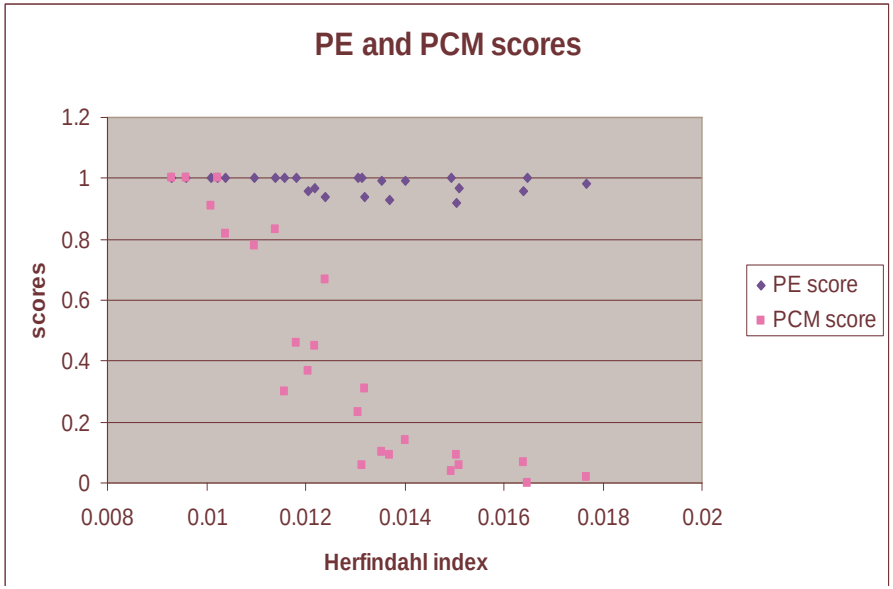
$$PCM_1 - PCM_0 = \sum_{i \in I_1} ms_{i1} pcm_{i1} - \sum_{i \in I_0} ms_{i0} pcm_{i0} =$$

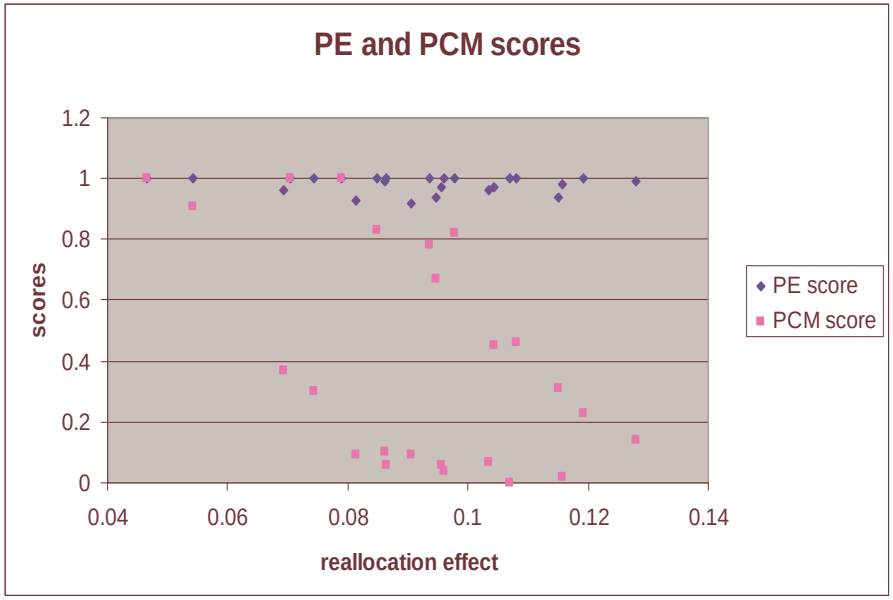
$$\sum_{i \in I} \{ \underbrace{ms_{i0}(pcm_{i1} - pcm_{i0})}_{\text{within effect}} + \underbrace{pcm_{i0}(ms_{i1} - ms_{i0})}_{\text{reallocation effect}} + \underbrace{(pcm_{i1} - pcm_{i0})(ms_{i1} - ms_{i0})}_{\text{interaction effect}} \}$$

$$+ \underbrace{\sum_{i \in I_1 \setminus I} ms_{i1} pcm_{i1} - \sum_{i \in I_0 \setminus I} ms_{i0} pcm_{i0}}_{\text{change in active firms effect}}$$

where $I_0(I_1)$ is number of active firms before (after) change in competition, $I = I_0 \bigcap I_1$ and $i \in I_1 \setminus I$ if both $i \in I_1$ and $i \notin I$.

- Fraction of cases in which PE and PCM correctly indicate an increase in competition as a function of the average Herfindahl index and of the value of the reallocation effect:


PE and PCM scores
1.2
1
0.8
0.6
0.4
0.2
0
scores
0.008
0.01
0.012
0.014
0.016
0.018
0.02
Herfindahl index
PE score
PCM score


PE and PCM scores
1.2
1
0.8
0.6
0.4
0.2
0
scores
0.04
0.06
0.08
0.1
0.12
0.14
reallocation effect
PE score
PCM score

(Firm fixed effects and time fixed effects)

- Theory shows that an increase in competition raises the profits of a firm relative to a less efficient firm (for all such combinations of firms)
- Hence we want to estimate the elasticity β given by

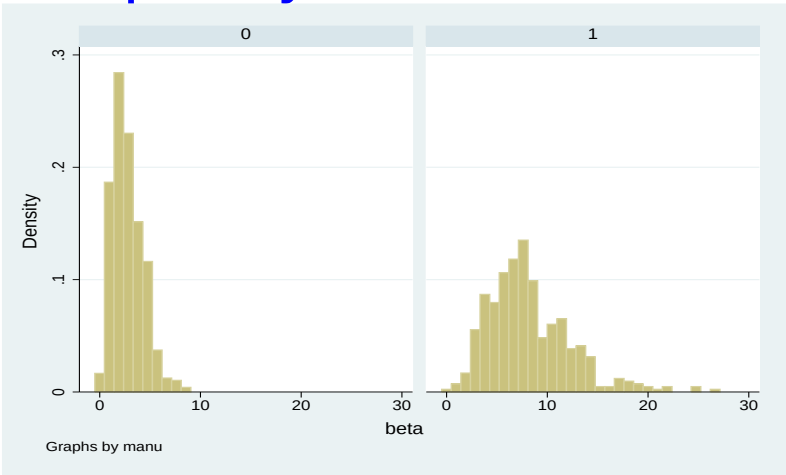
$$\ln(\frac{\pi_{it}}{\pi_{1t}}) = \alpha - \beta \ln(\frac{c_{it}}{c_{1t}}) + \varepsilon_{it}$$

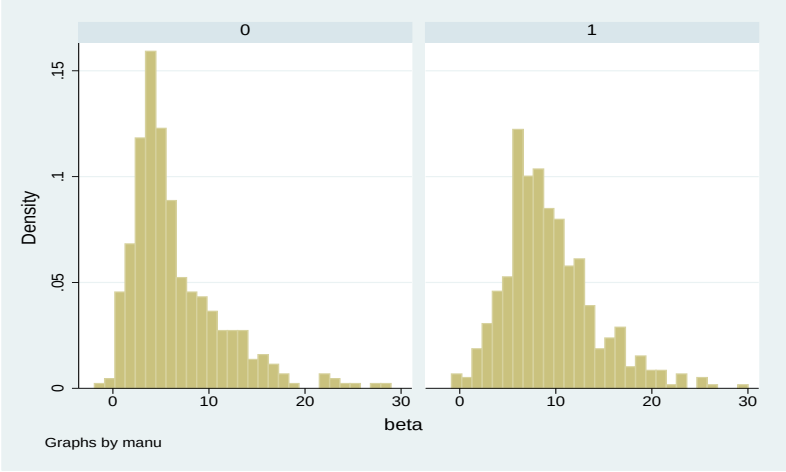
- However, we only observe the relative profits and marginal costs with some error denoted by u_i and v_i resp. which can vary by firm
- The equation to be estimated becomes
  $\ln(\frac{\pi_{it}u_i}{\pi_{1t}}) = \alpha - \beta \ln(\frac{c_{it}v_i}{c_{1t}}) + \varepsilon_{it}$ or equivalently
- $\ln(\pi_{it}) = \alpha_i + \alpha_t - \beta \ln(c_{it}) + \varepsilon_{it}$ where
  $\alpha_i = \alpha - \beta \ln(v_i) - \ln(u_i)$ and $\alpha_t = \ln(\pi_{1t}) + \beta \ln(c_{1t})$

Data

- We use firm level data from Statistics Netherlands (CBS)
- Data covers 1993-2002
- number of industries is 119 and roughly speaking we have on average 87.000/120 = 725 firms per year per industry
- variable profits π_i are defined as: $revenues_i$ minus $variable\ costs_i$ where
- $variable\ costs_i$ =
  $labor\ costs_i + energy\ costs_i + intermediate\ inputs_i$
- average variable costs c_i are defined as: $variable\ costs_i / revenue_i$
- We focus on subsample where PE is estimated at (at least) 10% significance level

Frequency distributions PE





Left: services, right: manufacturing; top: SME, bottom: BE

Properties of competition measures (cross-section)

- We first regress PE, PCM, H, Average Labor Productivity and Variance Average Variable Costs on the following explanatory variables: Labor Income Share, Import Share, Manufacturing and Big Enterprize dummies
- This yields for PE, PCM, H:

	PE	PCM	H
All observations			
Labor income share	1.32 (8.7)**	-0.49 (17.4)**	-0.14 (3.4)**
Import share	0.19 (2.0)**	-0.03 (1.6)	0.10 (2.7)**
Manufacturing dummy	0.33 (6.8)**	-0.06 (5.5)**	0.00 (0.1)
Big enterprize dummy	0.25 (7.5)**	-0.02 (2.8)**	0.07 (6.8)**
R^2	0.470	0.694	0.251

- Then we take the residuals of these regressions to calculate the following partial correlation coefficients

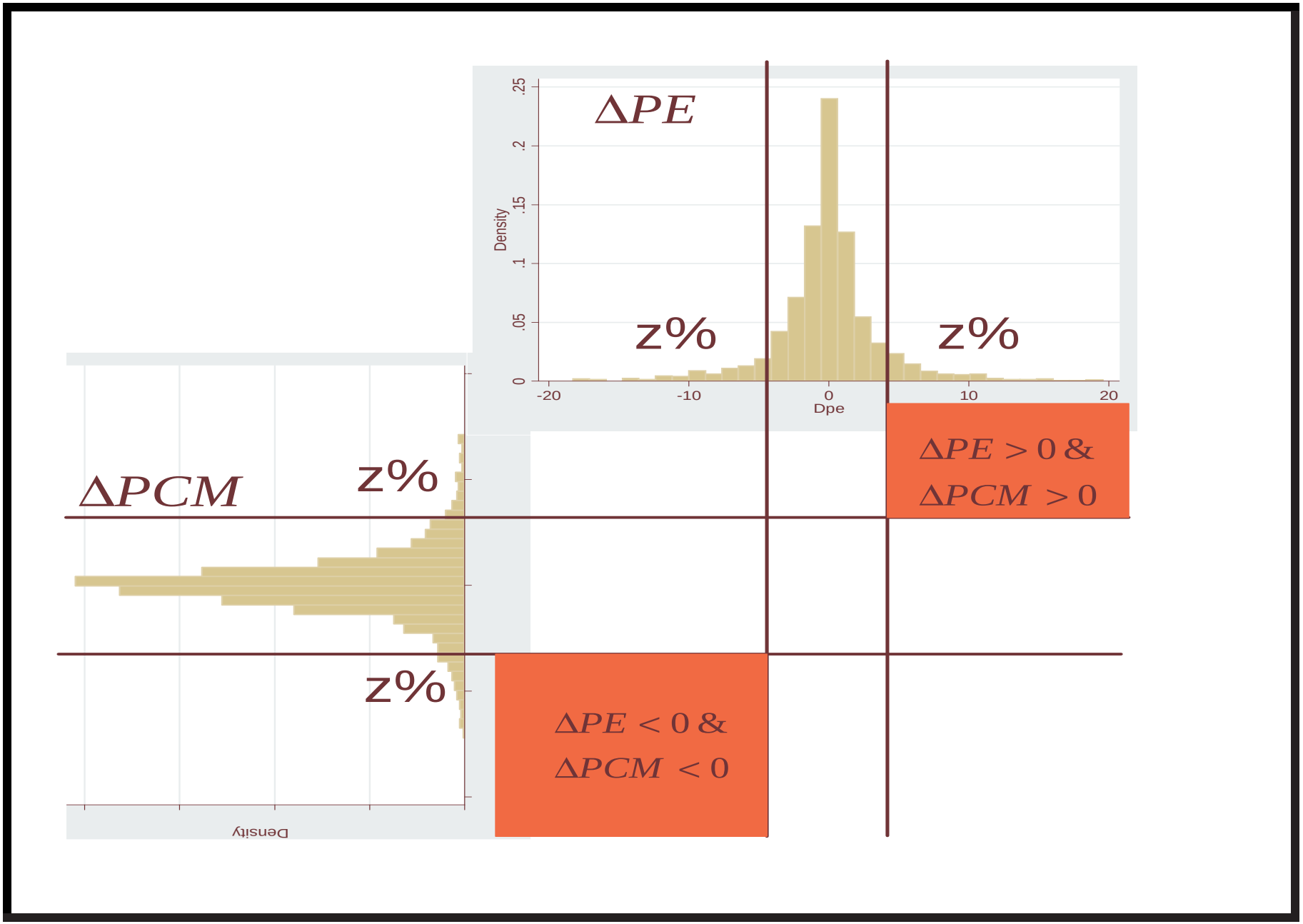
	PE	PCM	H	Labor prod.	Var. AVC
PE	–	-0.171**	0.182**	0.120**	-0.046**
PCM		–	-0.009	0.072**	0.236**
H			–	0.108**	-0.013

Interpretation

- A high labor share in value added indicates low capital costs and hence it is easier to enter the industry; high labor income share leads to high PE and low PCM
- industries that face more competition from abroad are more competitive
- manufacturing industries are more competitive than service industries
- big firms operate on a more competitive (probably national) market segment than small and medium sized firms.
- PE and PCM show similar correlations and H is odd one out; *e.g.*H is larger with bigger enterprizes, suggesting less intense competition while PE and PCM suggest opposite
- More intense competition in terms of PE weeds out inefficient firms and hence average labor productivity goes up (see also effect on variance AVC: lower variance as competition more intense)
- This effect goes in opposite direction for PCM: conditional on price, higher efficiency leads to higher PCM
- partial correlation coefficient PE and H is positive; suggesting that more intense competition (higher PE) can increase H by removing inefficient firms

Comparing PCM and PE in the data

- Although PCM and PE are consistent on the aggregate data (partial correlation coefficient PE and PCM is negative)
- there are sectors where over time PCM suggests that competition went up, while PE indicates that it went down and the other way around
- We claim that this happens due to the reallocation effect (and that therefore PCM points in the wrong direction)
- Problem is the noise in the data where PCM and PE change (a little) over time while actually there is no underlying change in competition
- To filter out this noise, we focus on cases where ΔPCM and ΔPE are in the top/bottom z% of their distributions: in the red areas PE and PCM contradict each other “strongly”


ΔPE
Density
.25
.2
.15
.1
.05
0
-20
-10
0
10
20
Dpe
z%
z%
ΔPCM
z%
z%
ΔPE > 0 &
ΔPCM > 0
ΔPE < 0 &
ΔPCM < 0
Density

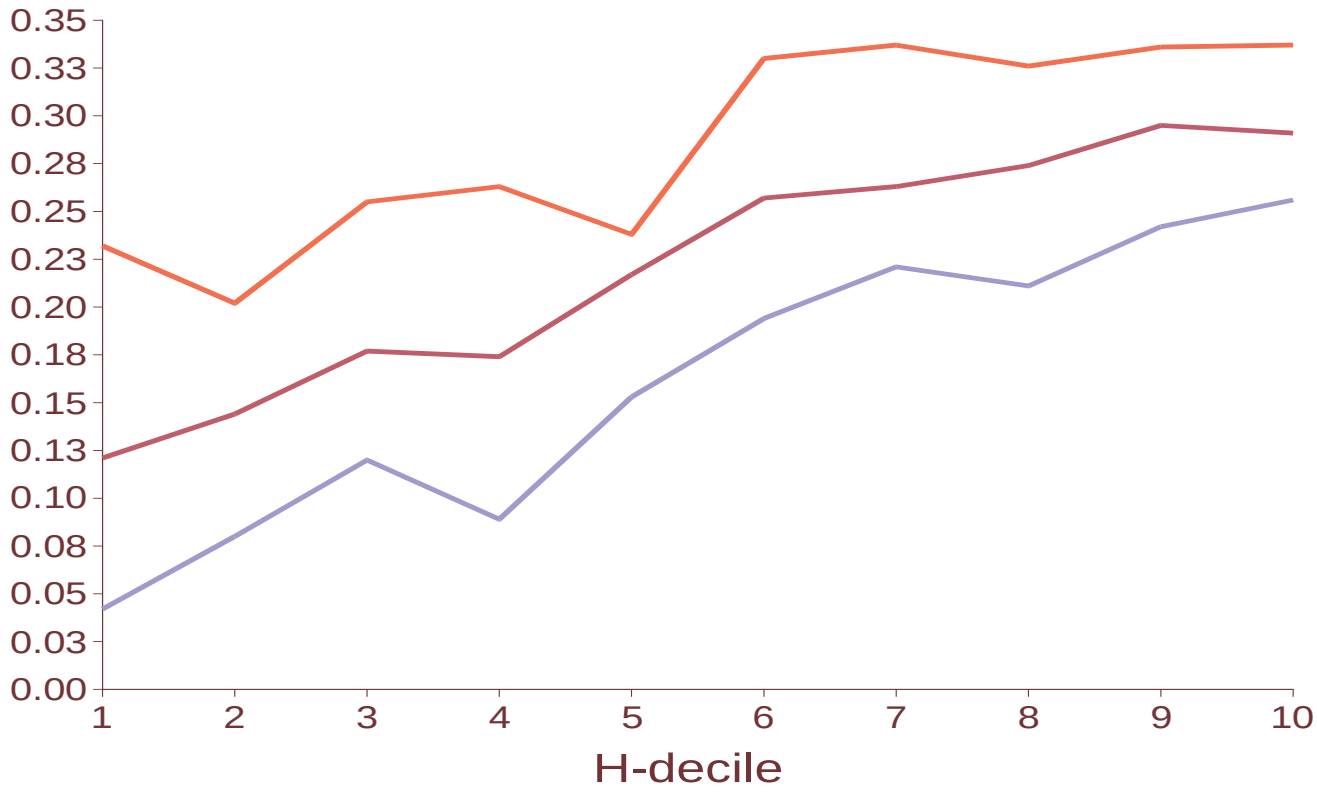
Reallocation effect

- We want to explain/predict when industries end up in the red areas using the intuition from the simulations that concentration and our measure of the reallocation effect are important
- We use a dummy for the empirical measure of the reallocation effect when it is big relative to PCM (below 25th or above 75th percentile)
- We estimate a fixed effects logit model explaining the probability that an industry ends up in the red areas (for different values of z)
- Higher H implies higher probability of inconsistency; intuitively, with low concentration, reallocation effect is small as well
- The dummy for the reallocation effect is significant at 5% level if $z = 35$

- Probability of inconsistency between ΔPE and ΔPCM; parameter estimates fixed effects logit model:

	z=45	z=40	z=35
H	6.87 (3.6)**	7.68 (3.8)**	8.16 (3.8)**
Reallocation big	0.14 (1.1)	0.27 (1.8)*	0.34 (2.0)**
Observations	1355	1243	1013
Markets	185	169	140

- Hence the reallocation effect is responsible for the inconsistency between changes in PCM and PE. Effect of H is strongest and there is weaker direct evidence using the empirical measure of the reallocation effect



Probability of inconsistency by H deciles for $z = 45, 40, 35$

Conclusion

- In this paper we consider a new measure of competition
- we estimate for an industry the following elasticity: *percentage fall in variable profits due to a one percent increase in marginal costs*
- The higher this elasticity, the more competitive the industry: firms are punished more harshly for being inefficient
- On average this elasticity equals 9.5 (8.2) for big (small) firms in manufacturing and 6.5 (2.8) for big (small) firms in services
- This elasticity varies with industry characteristics in a sensible way and in a way comparable to PCM
- When PCM and PE point in different directions for the development of competition over time, this is due to the reallocation effect which tends to raise PCM after an increase in competition