Characterizing the Production Process: A Disaggregated Analysis of Italian Manufacturing Firms

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A Foreword

- Describing the production technlogy is a relevant issue in economics
- Early applications have suffered from aggragate nature of the data
- Available database allow to recover a detailed picture of economic phenomena (i.e. production).

Purpose for the present work

- A theoretical model which describes how production is carried out and is consistent with empirical evidence is badly needed.
- We investigate relations between inputs and output.
- We are interested in exploring and *recovering a ground* on which shaping a theoretical framework.

1. Outline

Non-Parametric Analysis :

- Inputs/output relation
- 2D kernel regression

Parametric Analysis : Cobb-Douglas with two inputs

- Inputs/output relation
  - A testable framework for the hypothesis of independency of output Vs. input ratio
  - Empirical evidence
- Production Function estimates
  - OLS estimates
  - Panel Data estiamates

2. The Data

- MICRO.1 (Italian Statistical Office).
- Longitudinal data for about 8000 firms with number of employees greater than 19. Period 1989 – 1997.
- Possibility of keeping track of the same firm during the interval
- Firms are classified according to their sector of principal activity $\Rightarrow$ ISIC code - 2 digit
- **Variables** :

  Output $\Rightarrow$ Total Sales (accounting for differences in initial/final stock)

  Inputs

  - Labor $\Rightarrow$ Number of employees
  - Capital $\Rightarrow$ Fixed tangible assets

3. Non-parametric analysis – Kernel regression

- Problem: Estimating $g(x)$ without imposing a functional form

$$y = g(x) + \epsilon$$

Common non-parametric estimator $\Rightarrow$ Kernel estimator

- $g(x)$ is the conditional expectation of y given x:

$$g(x) = E(y|x) = \int y\, f(y|x)\, dy$$

By Bayes' rule

$$\int y\, f(y|x)\, dy = \int \frac{y\, f(y,x)}{f(x)}\, dy = \frac{\int y\, f(y,x)\, dy}{f(x)}$$

- The kernel estimator replaces $f(y,x)$ and $f(x)$ by their empirical estimates:

$$\hat{g}(x) = \frac{\int y\, \hat{f}(y,x)\, dy}{\hat{f}(x)} \tag{1}$$

- Denominator $\Rightarrow$ $$\hat{f}(x) = \frac{1}{Nh}\sum_{i=1}^{N} K(\frac{x - x_i}{h_x}) \tag{2}$$

- Nominator $\Rightarrow$ $$\hat{f}(y, x) = \frac{1}{N}\sum_{i=1}^{N} \frac{1}{h_x h_y} K(\frac{x - x_i}{h_x}; \frac{y - y_i}{h_y}) \tag{3}$$

Where h_x and h_y are the bandwidths and $K(.)$ integrates to 1. This yields:

$$\hat{g}(x) = \frac{\sum_{i=1}^{N} y_i K(\frac{x-x_i}{h_x})}{\sum_{i=1}^{N} K(\frac{x-x_i}{h_x})} \tag{4}$$

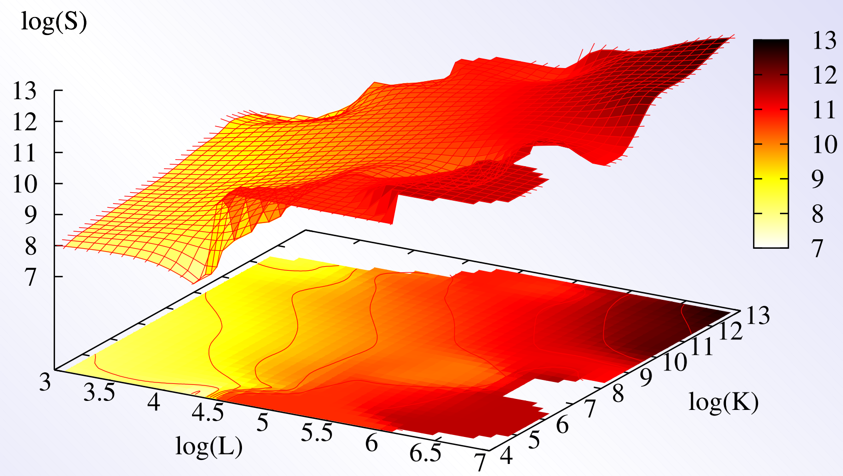

Figure 1: ISIC 29 Industrial Machinery - Output levels (Log S) for different combinations of labor (Log L) and capital (Log K) in year **1994**.

Same level of output is attainable with much different mix of inputs

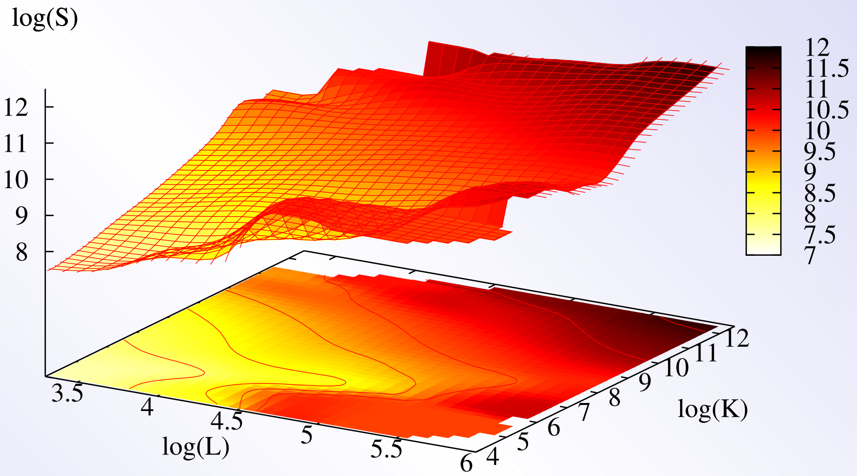

Figure 2: ISIC 28 Metal Products - Output levels (Log S) for different combinations of labor (Log L) and capital (Log K) in year **1994**.

Tolerance to inefficiencies is higher at lower level of output

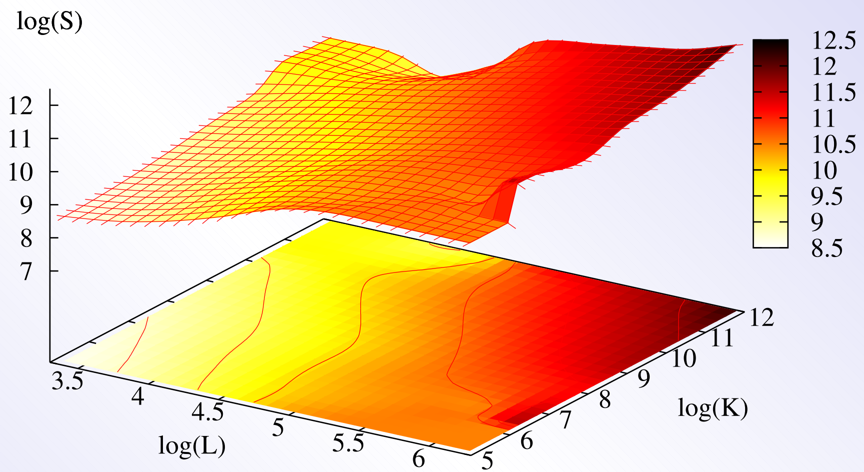

Figure 3: ISIC 29 Industrial Machinery - Output levels (Log S) for different combinations of labor (Log L) and capital (Log K) in year **1997**.

Heterogeneity in the mix of inputs is persistent over time

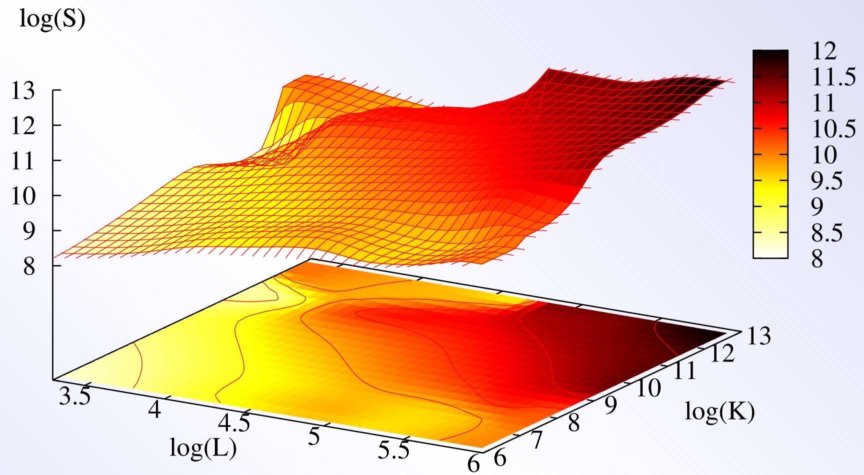

Figure 4: ISIC 28 Metal Products - Output levels (Log S) for different combinations of labor (Log L) and capital (Log K) in year **1997**.

Heterogeneity in the mix of inputs is persistent over time

4. Parametric Analysis

Input Ratio in a Cobb-Douglas framework

- Cost Minimization Problem

$$\min_{L,K}\{L\, p_L + K\, p_K\} \qquad \text{such that} \qquad c\, L^{\alpha}\, K^{\beta} = S$$

- Solving for K and L we get factor demand equations.
- Input Ratio, r, as capital over labor, is:

$$r = \frac{K}{L} = \frac{\beta}{\alpha}\frac{p_L}{p_K}$$

$\Rightarrow$ In the Cobb-Douglas the input ratio does not depend on size

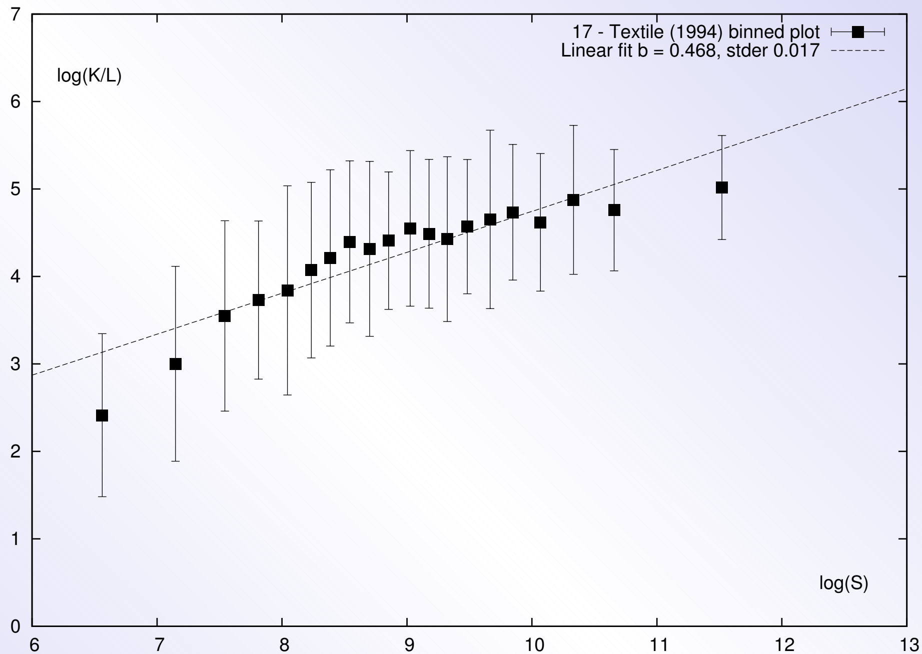

Figure 5: ISIC 17 Textile - Relation b/w input ratio, k/l and sales in year **1994**. Errorbars display one standard error.

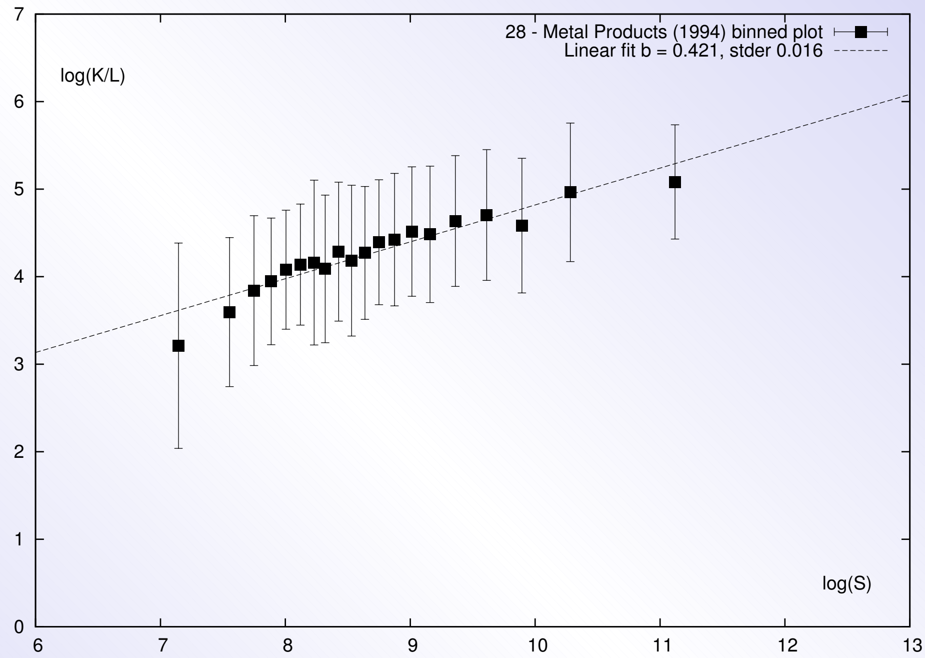

Figure 6: ISIC 28 Metal Products - Relation b/w input ratio, k/l and sales in year **1994**. Errorbars display one standard error.

Panel Data Analysis

Fixed Effects model

$$(s_{it} - \bar{s}_i) = \alpha_L(l_{it} - \bar{l}_i) + \beta_K(k_{it} - \bar{k}_i) + (e_i - \bar{e}_i) \tag{5}$$

- Unobserved variable is correlated with regressors

SECTOR	ISIC Code	Total Obs.	Fixed Effects (Within-group)			Random Effects (ML)		
			c	α	β	c	α	β
Food and Beverages	15	11715	5.817	0.432	0.268	5.114	0.568	0.282
			(0.064)	(0.014)	(0.005)	(0.053)	(0.012)	(0.005)
Textiles	17	15423	5.534	0.565	0.149	4.821	0.654	0.185
			(0.057)	(0.013)	(0.005)	(0.049)	(0.011)	(0.005)
Rubber Plastics	25	8950	4.575	0.737	0.193	4.368	0.724	0.243
			(0.074)	(0.017)	(0.007)	(0.054)	(0.013)	(0.006)
Basic Metals	27	5190	4.734	0.692	0.191	4.140	0.792	0.255
			(0.125)	(0.026)	(0.010)	(0.082)	(0.018)	(0.009)
Metal Products	28	20591	4.331	0.858	0.155	4.009	0.881	0.184
			(0.052)	(0.012)	(0.004)	(0.036)	(0.009)	(0.004)
Indust. Machinery	29	21965	4.632	0.875	0.142	4.552	0.901	0.140
			(0.054)	(0.012)	(0.005)	(0.033)	(0.008)	(0.004)
Electr. Machinery	31	8409	5.182	0.718	0.133	4.250	0.815	0.1901
			(0.077)	(0.017)	(0.007)	(0.050)	(0.013)	(0.007)
Furniture Manufact.	36	13061	4.936	0.704	0.16 4.386	0.803	0.186	
			(0.062)	(0.015)	(0.005)	(0.050)	(0.012)	(0.005)

Table 1: Estimated coefficients for the Fixed Effects, Between-group and Random effects model (both Maximum Likelihood and GLS Estimates). Standard Errors in brackets.

Essential References

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