On the Ubiquitous Heterogeneity in Corporate Characteristics and Performances: A Bird's Eye Assessment of the Evidence and Some Interpretative Conjecture[1]

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[1] More on the subject in G. Dosi Statistical Regularities in the Evolution of Industries. A Guide through some Evidence and Challenges for the Theory, in F. Malerba and S. Brusoni (eds.) Perspectives on Innovation, Cambridge, Cambridge University Press, 2007

1. Outline

2. Firm Sizes, Growth Rates and Profitabilities
   - Size Distribution
   - Growth Rates
   - Profitability
   - Persistently different characteristics and performance

3. Technological Characteristics of firms
   - Innovativeness
   - Labor Productivities

4. An interpretative framework

Major questions

- Fundamental drivers of the evolution of contemporary economies are the activities of search, discovery and economic exploitation of new products, new production processes, new organizational arrangements within and amongst business firms.
- Given that, what are the statistical properties that such processes might possibly display?

Basic Question

- *First*, are there distinct characteristics of the micro-entities (in primis, business firms) and their distributions which systematically persist over time?
- *Second*, how do such possible heterogeneous characteristics within the population of competing firms affect their relative evolutionary success over time? And in particular what are the ultimate outcomes in terms of growth and profitability performances?
- *Third*, amongst the foregoing statistical properties and relations between them, which ones are invariant across industries, and, conversely, which ones depend on the technological and market characteristics of particular sectors?

- Size distribution

i) *Generic properties which hold across levels of aggregation and across countries:*

   a) wide variability of firm sizes (hence ruling out any naive notion of “optimal size”)
   b) skewed distributions, stable over time (cf. from Ijiri and Simon, 1977 and Steindl, 1965 all the way to Bottazzi and Secchi, 2003, Dosi, 2007 and Bottazzi et al., 2007)

⇒ see Figures 1, 2 and 3 on Italian manufacturing

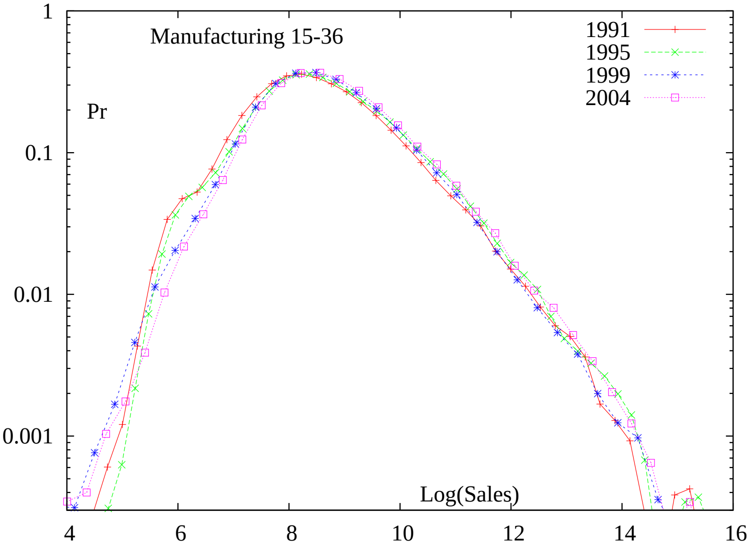

Figure 1: Empirical Densities of $\log(S_i)$ in different years. Size measured in terms of sales. Thousands of euro, deflated with production price index.

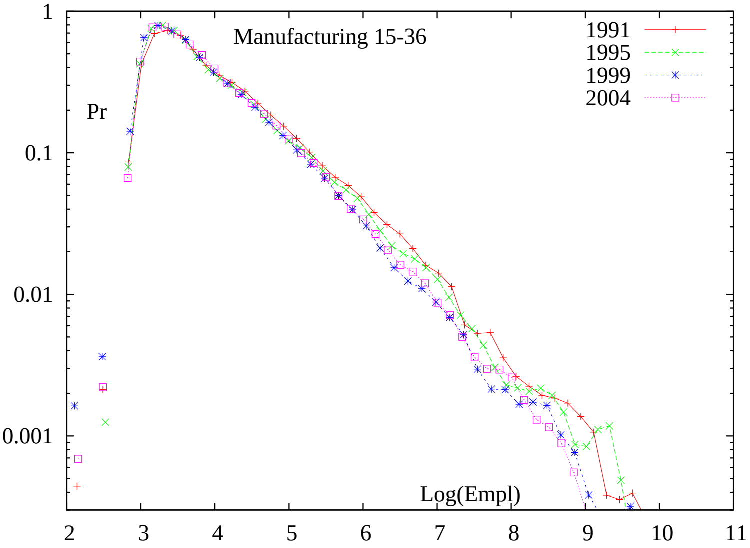

Figure 2: Empirical Densities of $\log(L_i)$ in different years. Size measured in terms of number of employees.

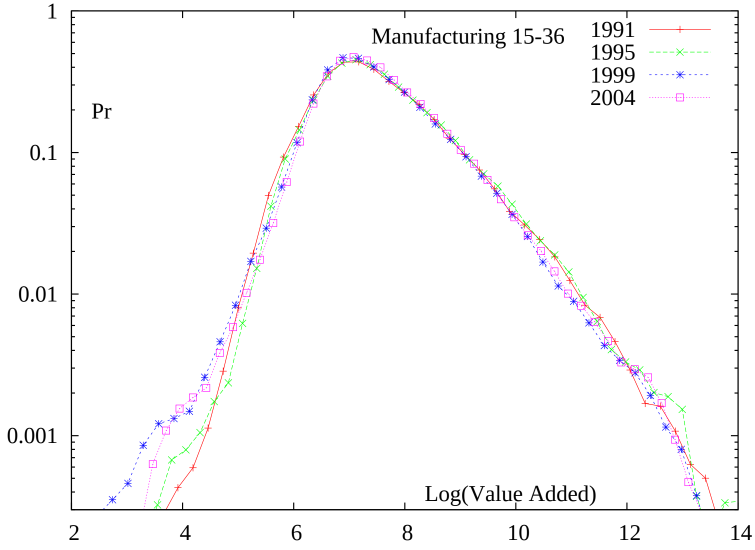

Figure 3: Empirical Densities of $\log(VA_i)$ in different years. Size measured in terms of Value Added. Thousands of euro, deflated with production price index.

But

ii) *Very different sector-specific distribution:*
   a) different shapes;
   b) different degrees of concentration;
   c) possible bimodality, no log-normality;
   d) evidence of separation core-fringe in several sectors

For some examples on distribution regarding some Italian sectors, see Figure 4 to 7. Proxies of concentration over 3-digit sectors are reported in Fig. 8. The concentration measure is:

$$d_{20}^{4} = \frac{C_4}{C_2 0} \qquad t = 1989, ..., 1996 \tag{1}$$

where C_4 C_{20} are the sum of market shares of the top 4 and 20 firms in a sector, respectively.

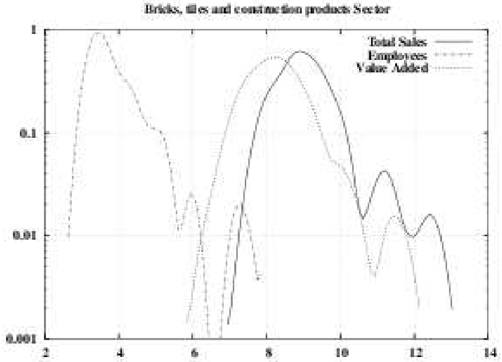

Figure 4: Densities of $\log(S_i)$, $\log(L_i)$ and $\log(VA_i)$ for the Construction Materials (NACE 264). Source Bottazzi et al. (2003).

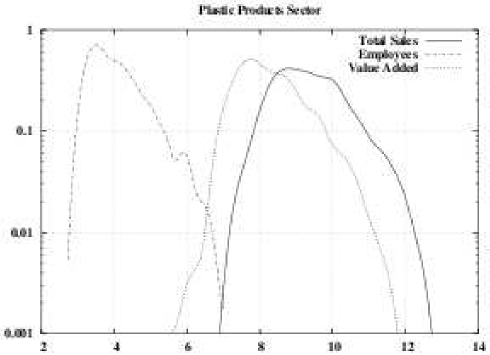

Figure 5: Densities of $\log(S_i)$, $\log(L_i)$ and $\log(VA_i)$ for Plastic Products (NACE 252). Source Bottazzi et al. (2003).

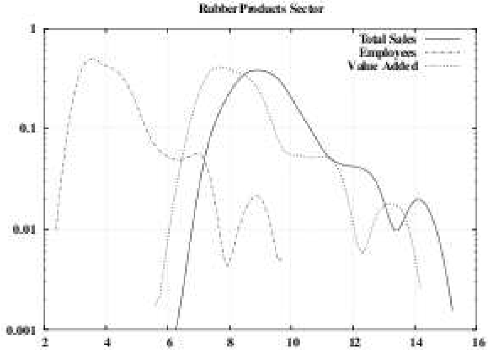

Figure 6: Densities of $\log(S_i)$, $\log(L_i)$ and $\log(VA_i)$ for Rubber Products (NACE 251). Source Bottazzi et al. (2003).

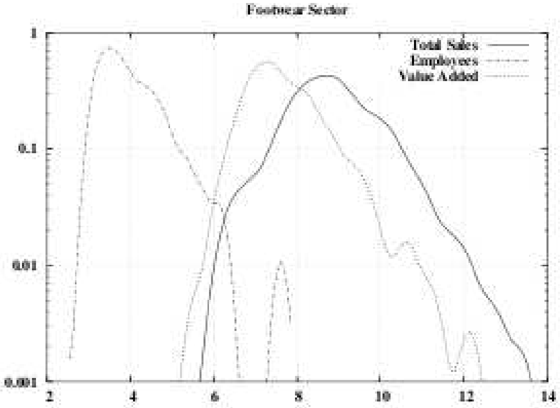

Figure 7: Densities of $\log(S_i)$, $\log(L_i)$ and $\log(VA_i)$ for the Footware (NACE 193). Source Bottazzi et al. (2003).

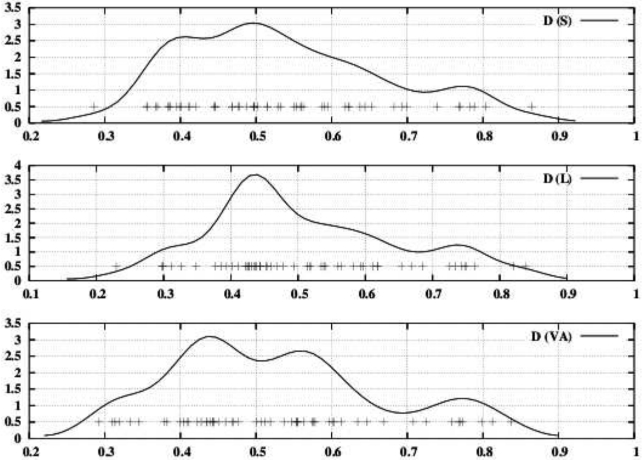

Figure 8: Probability densities (kernel estimates) of the concentration index D^4_{20} in terms of Total Sales, Number of Employees and Value Added. The support of these densities is [0.2 1]. Source Bottazzi et al. (2007).

iii) *For aggregate manufacturing only:*

(possibly) Pareto upper tail of the distribution.
See: Figure 9 and 10 from Axtell (2001) whose estimates regards however the whole population of US firms.
Other estimates on the Fortune 500 firms for different years seem to display increasing departures from a Pareto distribution: see Fig. 11.
The estimated models are

$$\log S_i = \alpha + \beta \log r_i \tag{2}$$

$$\log S_i = \alpha + \beta \log r_i + \gamma (\log r_i)^2 \tag{3}$$

where $s_i = \log S_i$ is the size of firm i (in current dollar sales) and r_i is its rank in terms of sales themselves.
[More on the conjecture that Pareto distributions are a (puzzling) outcome of aggregation among sectors characterized by diverse regimes of technological learning, which do not display Paretian size distributions, is in Dosi et al. (1995) and Marsili (2001).]

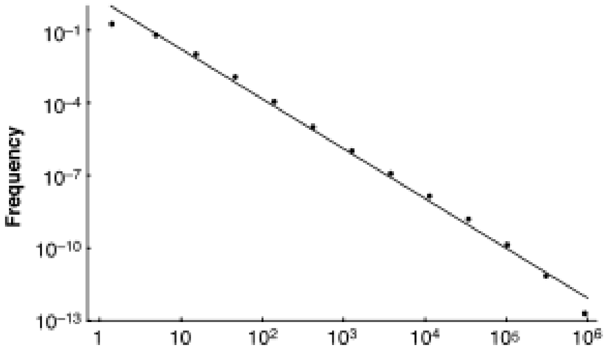

Figure 9: Firm Size (employees). Source Axtell (2001).

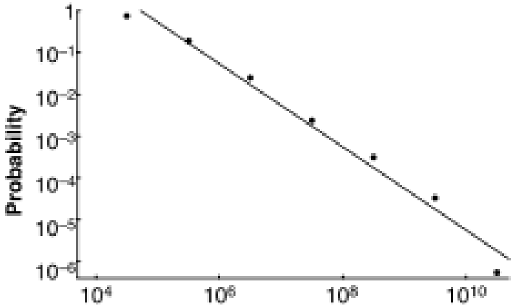

Figure 10: Firm Size (receipts). Source Axtell (2001).

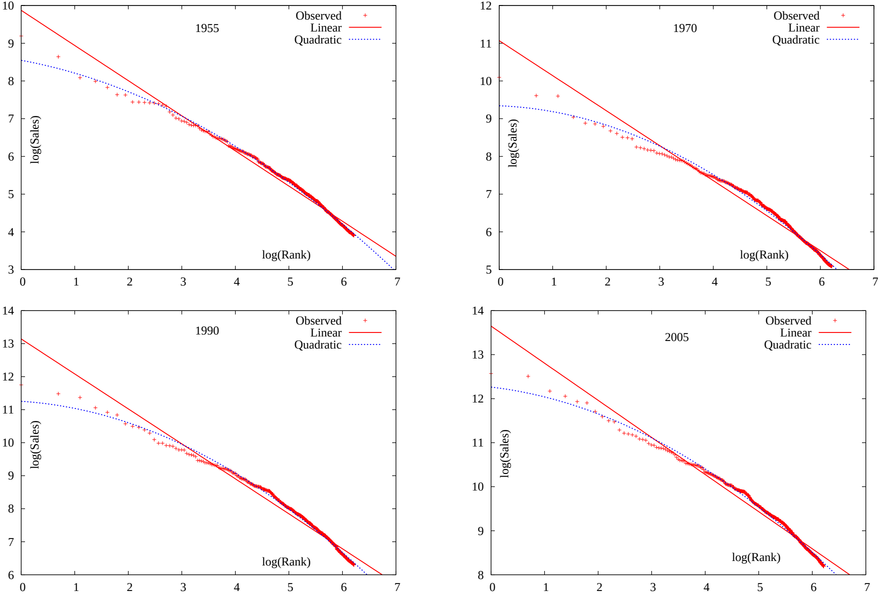

Figure 11: Zipf fit of Sales distribution for Fortune 500 firms, various years. Source Dosi et al. (2008).

Year	Linear Model		Quadratic Model		
	α	β	α	β	γ
1955	**9.871**	**-0.931**	**8.548**	**-0.263**	**-0.077**
	(0.083)	(0.015)	(0.204)	(0.089)	(0.009)
1970	**11.069**	**-0.928**	**9.342**	-0.056	**-0.100**
	(0.103)	(0.019)	(0.249)	(0.124)	(0.011)
1980	**12.506**	**-0.997**	**10.704**	-0.087	**-0.104**
	(0.106)	(0.019)	(0.499)	(0.149)	(0.010)
1990	**13.143**	**-1.059**	**11.254**	-0.105	**-0.109**
	(0.119)	(0.118)	(0.181)	(0.077)	(0.008)
2000	**13.254**	**-0.809**	**11.727**	-0.038	**-0.088**
	(0.096)	(0.017)	(0.185)	(0.078)	(0.008)
2005	**13.649**	**-0.843**	**12.264**	**-0.143**	**-0.080**
	(0.087)	(0.016)	(0.130)	(0.056)	(0.005)

Table 1: Fortune 500; Zipf fit. Linear and Quadratic Models. 5% statistically significant coefficients are in bold. Source Dosi et al. (2008).

Growth Rates

- Given the foregoing diversity in size distributions, what are the properties of *growth rates*?

$$s_i(t) = \log S_i(t) - < \log S_i(t) >$$

where $< \log S_i(t) >$ is the mean (log) size, ($\equiv 1/N \sum S_i(t)$)

- The variable under study is then the first difference:

$$g_i(t) = s_i(t+1) - s_i(t)$$

Setting the “strawman hypothesis”: ‘Gibrat Law’

$$S_i(t+1) = \alpha + \theta_i S_i(t) + \varepsilon_i(t) \qquad (4)$$

where α is the sector-wide component of growth (both “nominal” and “real”).

- **Strong Gibrat hypothesis:**

a) $\theta = 1$ for every i that is the “Law of Proportionate Effects”: *multiplicative growth is an average independent of initial conditions*, i.e. no systematic scale effects

Note:
$\theta < 1$ would be evidence corroborating regression-to-the-mean, and, indirectly, some underlying “optimal size” attractor;
$\theta > 1$ ought to capture persistent tendency toward monopoly.

b) is i.i.d., normally distributed

N.B.: Corroboration of HP b) would turn out to be quite *damaging* for evolutionary theories of industrial change. After all, basic building-blocks of evolutionary theories are the twin notions of

i) persistent heterogeneous characteristics among agents;
ii) systematic processes of competitive selection among them.

The “strong version” of Gibrat, indeed is a falsification as good as one might get of evolutionary theories: multiples small, “atomless”, uncorrelated shocks to micro growth.

Under “normalized” sizes (as from above definitions) one studies the properties of the distributions of the $g_i(t)$ and of

$$g_i(t+1) = \beta g_i(t) + \varepsilon_i(t) \tag{5}$$

The properties of growth-size relation

Overall, the evidence is mixed:

a) most often, smaller firms - on average - grow faster (caveat: small surviving firms...);
b) otherwise, no strikingly robust relation size $\Leftrightarrow$ average rates of growth

[For a summary of quite a few econometric results see the table with the review of the literature in Lotti et al. (2003); conversely, on the relationship between size and growth and its lack of size dependency, above some size thresholds, cf. Bottazzi et al. (2001) on the international pharmaceutical industry; Bottazzi et al. (2007) on Italian firms; Bottazzi and Secchi (2003) on U.S. Compustat data; for discussions, cf. Ijiri and Simon (1977) and Sutton (1997)]

c) the relationship size-growth is modulated by the age of firms themselves (broadly speaking, exerting *negative* effects on growth rates, but *positive* effects on survival probabilities, at least after some post-infancy threshold ...) (see among others Evans, 1987a,b)

The cross-sectional and longitudinal properties of growth rate distributions

- *What “structure” do they display, if any?*

After all, the θ_i coefficients ought to be considered just as proximate coefficients for “static” returns to scale (or, at least as likely, spuriously correlated to “deeper” initial technological and organizational conditions). Conversely, the statistical properties of the “error term” in equation 2 and 3 offer precious clues on the basic characteristics of the processes of market competition and corporate growth over time.

i) Growth rates, growth variability and size

Since the early insight from Hymer and Pashigian (1962), a quite robust evidence suggests that the variance of firms’ growth rates fall as firms’ size increases.

An interpretation of the variance-scale relation is that it depends in fact on the diversification-size relation. See Figure 12 and 13 from Bottazzi et al. (2001) on the international pharmaceutical industry.

In turn, the evidence of Figure 13 can be accounted for by a *branching process* in diversification activities (Bottazzi et al., 2001).

N.B. Such a process of diversification is well in tune with *capability-driven* patterns of diversification, as capability-based theories of the firm would predict, with new activities incrementally building upon existing ones (cf. also the remarks in Teece et al., 1994).

Growth Variability / Firm Size Relations

- "Scaling Law": $\sigma(g|s) \approx S^{\beta}$

$\Rightarrow$ Aggregate Manufacturing, U.S. data:

- Amaral et al. (1997): $\beta \approx -.2 \pm .03$
- Bottazzi and Secchi (2003): $\beta \approx -.19 \pm .01$

$\Rightarrow$ International Pharmaceutical Industry:

- Bottazzi et al. (2001): $\beta \approx -.2 \pm .03$

$\Rightarrow$ Aggregate Sectoral Manufacturing, Italian data:

- Bottazzi et al. (2002): $\beta \approx 0$
- ... as such a puzzling piece of evidence

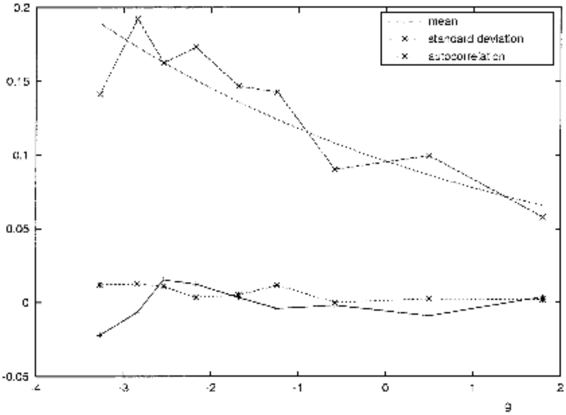

Figure 12: Mean, standard deviation and autocorrelation of growth h computed for different size bins plotted against the average size in the bin. The exponential fit to the standard deviation ($\sigma(h) = e^{\beta g}$) gives a value $\beta = -.2 \pm .03$. (log-log scale) Source Bottazzi et al. (2001).

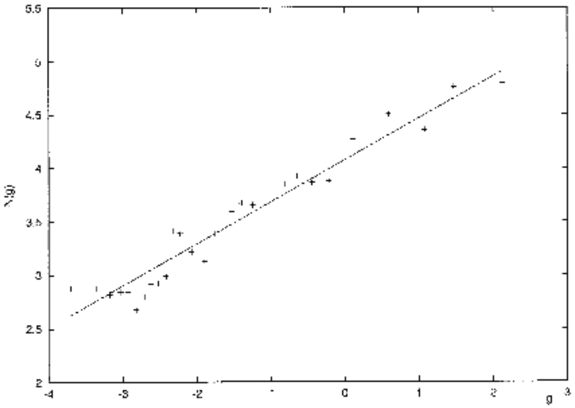

Figure 13: Number of submarkets a firm operates in vs. firm size. Source Bottazzi et al. (2001).

ii) Growth rates distributions

Studies include Stanley et al. (1996) and Bottazzi and Secchi (2003) on U.S. data; Bottazzi et al. (2001) on the international pharmaceutical industry; Bottazzi et al. (2002) and Bottazzi et al. (2007) on the Italian industry.

Here the objects of the study are the distributions of $g_i(t)$, normalized by their size-conditional variance, when appropriate. See Figure 14 for the estimating method common to the Bottazzi et al. works.

The Subbotin distribution

$$f(x) = \frac{1}{2ab^{1/b}\Gamma(1/b+1)} e^{-\frac{1}{b}\left|\frac{x-\mu}{a}\right|^{b}}$$

$\Gamma(x)$ is the Gamma function. The parameter a is a scale parameter which basically captures the “width” of the central part of the distribution; under the “normalization” of our data μ is washed away; the shape parameter b captures the fatness of the tails: the lower its value, the fatter they are. For $b = 2$ the density corresponds to a Gaussian distribution and for $b = 1$ to a Laplace (exponential) one; conversely as $b \to \infty$, the distribution tends to a uniform one. Note that under the log transformation an exponential density displays a linear “tent” shape.

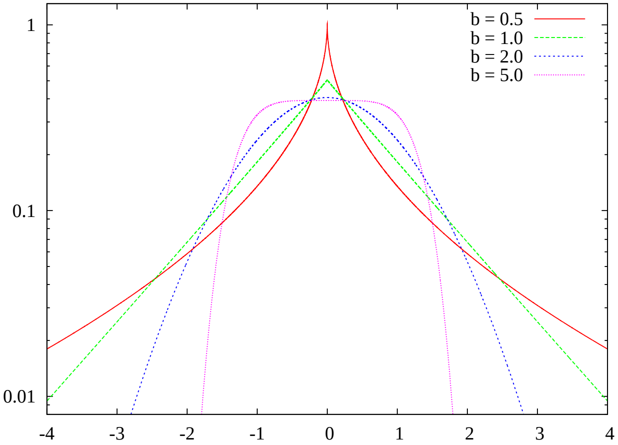

Figure 14: Subbotin distribution for different values of b. See also Bottazzi and Secchi (2006).

Properties of growth rates distributions

[cf. Figures 15 to 17 on the Aggregate Manufacturing, and Figures 18 and 19 for some sectoral examples]

a) Exponential (Laplace) distribution as a very robust property which holds:
   - across levels of aggregation
   - across countries
   - across different measures of size (e.g. sales, employees, value added)

b) some (moderate) heterogeneity across different sectors with respect to the distribution parameters b (cf. Figure 20)

c) stability over time

Major interpretative question: what are the underlying correlating mechanisms which generically yield the observed fat-tails in the distributions? [some hypotheses on underlying increasing-returns dynamics is in Bottazzi and Secchi, 2006; other possibly complementary ones draw on Dosi et al., 1995.]

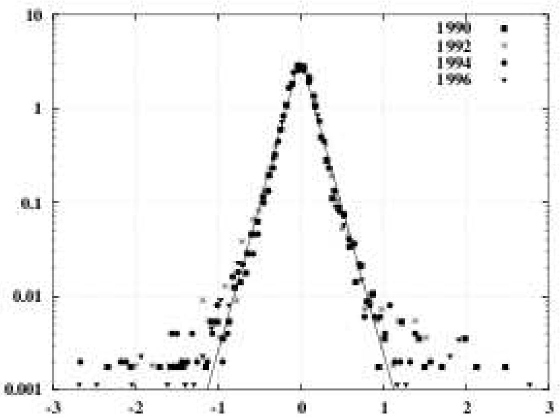

Figure 15: Growth rates distributions in different years. Size measured in terms of sales. Italian Aggregate Manufacturing. Source Bottazzi et al. (2003).

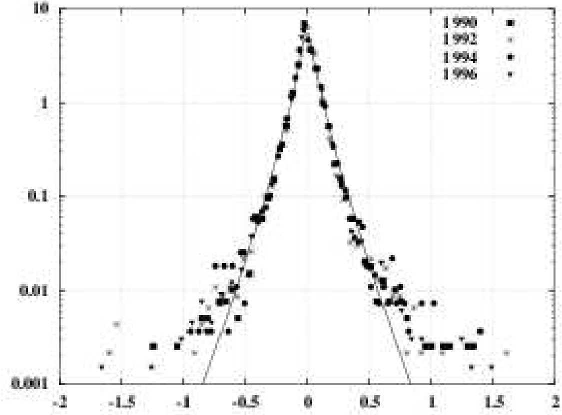

Figure 16: Growth rates distributions in different years. Size measured in terms of employees. Italian Aggregate Manufacturing. Source Bottazzi et al. (2003).

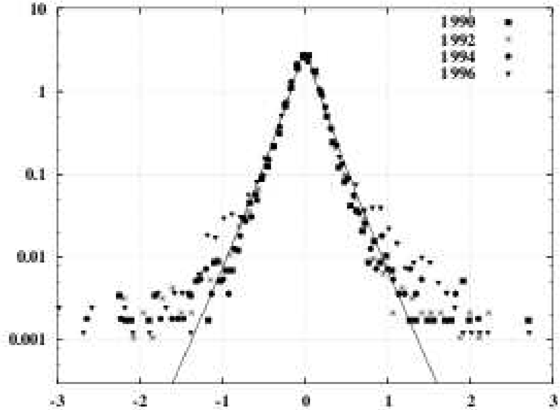

Figure 17: Growth rates distributions in different years. Size measured in terms of Value Added. Italian Aggregate Manufacturing. Source Bottazzi et al. (2003).

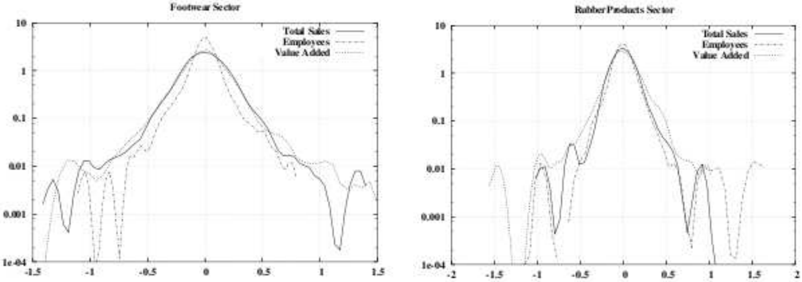

Figure 18: Kernel estimation of total sales, number of employees and value added growth rates for Footware (Left) and Rubber Products (Right). Source Bottazzi et al. (2003).

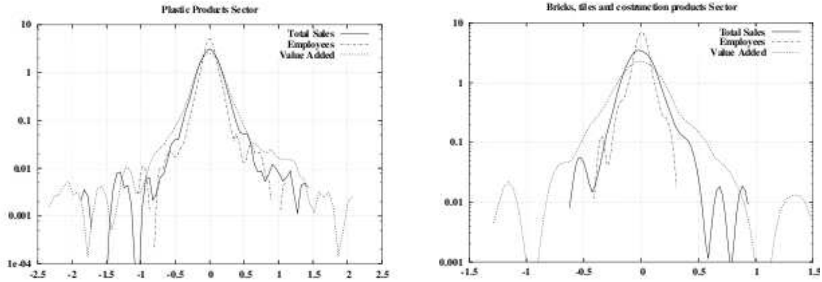

Figure 19: Kernel estimation of total sales, number of employees and value added growth rates for Plastic Products (Left) and Construction Materials (Right). Source Bottazzi et al. (2003).

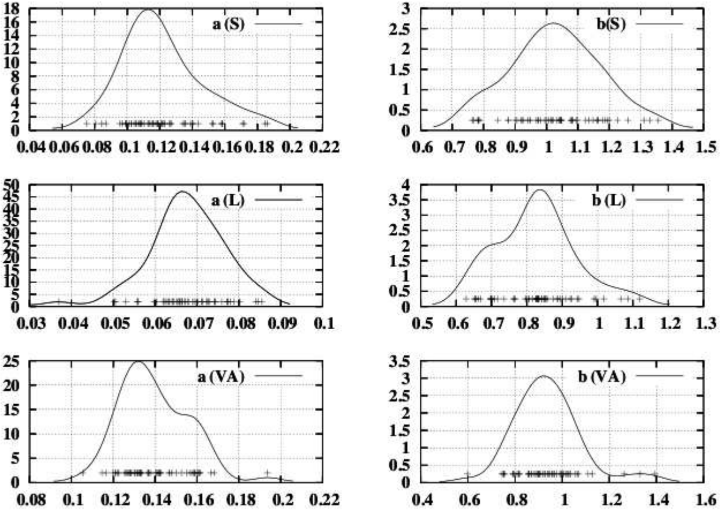

Figure 20: Probability densities (kernel estimations) of the Subbotin parameters a and b estimated in all the 55 sectors analyzed and for all the three size proxies used. Source Bottazzi et al. (2003).

iii) Autocorrelation in growth rates

The variable under study become the first difference

a) In the international drug industry:

- long-lasting positive autocorrelation (up to the 7th lag), see Fig. 21
- autocorrelation for each firm within specific markets present but lower than for the firm as a whole (cf. Fig. 22) [N.B.: This should be taken as evidence that firms cannot be considered as aggregations on independent lines of business. Rather, the "competitiveness" of whole firms is revealed over time in the entire ensembles of market in which it operates]

b) U.S. evidence

- relatively weak autoregressive structure (generally one-lag only) with a good deal of inter-sectoral variability [this is a puzzle: could it be due to the fact that one still studies even at sectoral levels, aggregates which are too broad, actually comprising many industries?]

c) Italian evidence

- average autocorrelation in most sectors nearly zero;
- ... but heterogeneous profiles across firms with the same sector (cf. Fig. 23 and 24) [N.B.: systematic micro heterogeneity is confirmed by comparing the actual firm-specific distribution with "artificial ones" obtained via random bootstrapping of growth rates...]

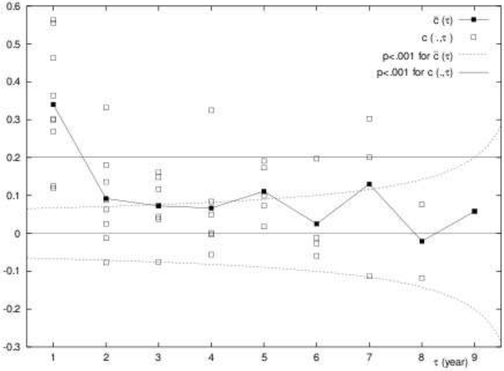

Figure 21: Time autocorrelation of the firm growth. The points are the values $c(t, \tau)$ for different time t plotted against τ. The line is the mean $\bar{c}_j(\tau)$. The significance line for $p = .001$ (about 2.64 std. devs) is plotted for both the single points and the average. Source Bottazzi et al. (2001).

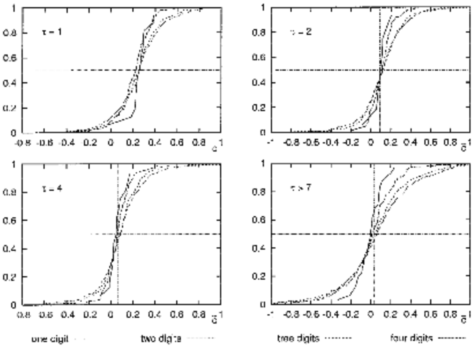

Figure 22: Distribution function of the autocorrelation coefficients $\bar{c}_j(\tau)$. Different aggregation levels and time lags τ are plotted. The vertical lines correspond to “aggregate” values at the firm-level. The horizontal line is centered at 0.5. Source Bottazzi et al. (2001).

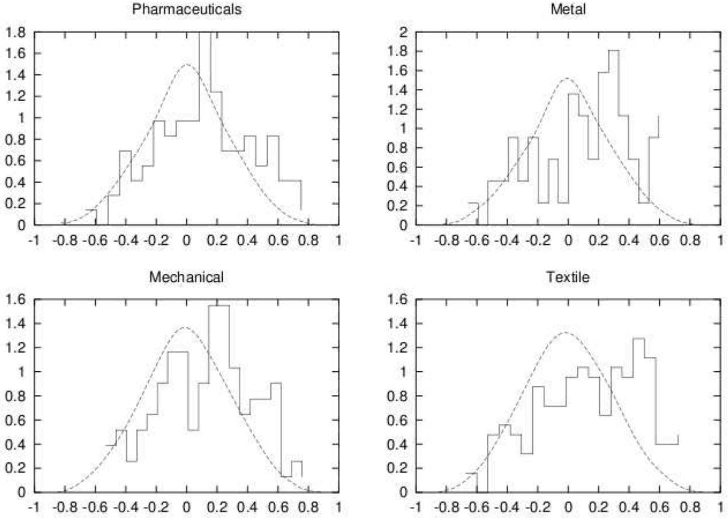

Figure 23: Autocorrelation in Sales Growth rates. Italian Data. Source Bottazzi et al. (2002).

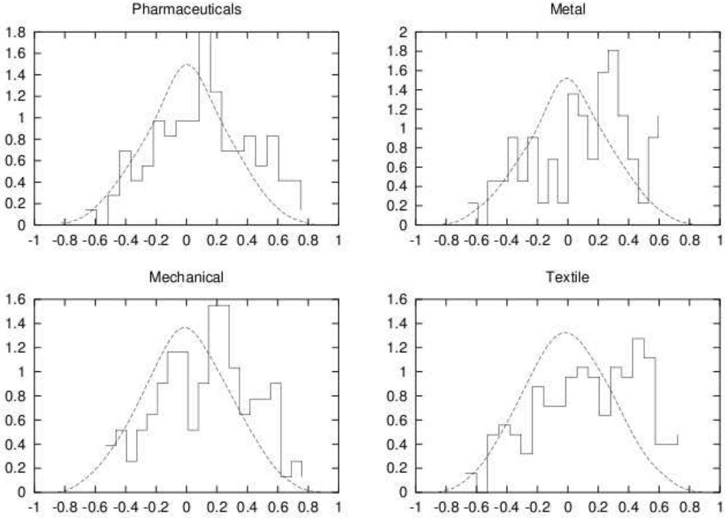

Figure 24: Autocorrelation in Sales Growth rates. Italian Data. Source Bottazzi et al. (2002).

Together with growth, profitability is another crucial measure of performance.
Building on the background literature on persistence in profitability differences across firms including Mueller (1986), Mueller (1990), Cubbin and Geroski (1987), Geroski and Jacquemin (1988), Gschwandter (2004), here we consider the distribution of gross margins within Italian manufacturing sectors and their persistence over time.
Consider the variable

$$GM_i(t) = (VA_i(t) - W_i(t))/VA_i(t)$$

where GM_i is gross operating margins; VA_i is value added; W_i is the total wage cost.

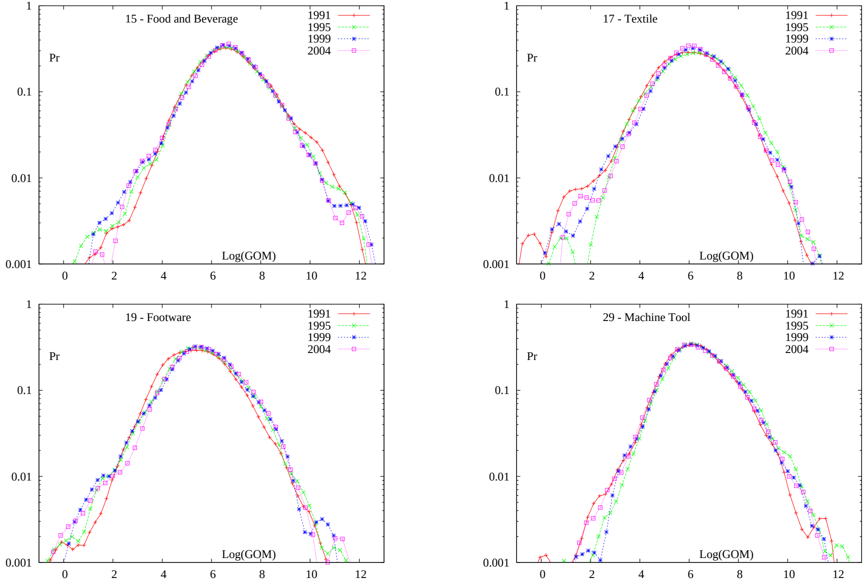

Figure 25: Empirical densities of (log) Gross Margin by sector. Thousands of euro, deflated with production price index. Our elaboration on Micro.3.

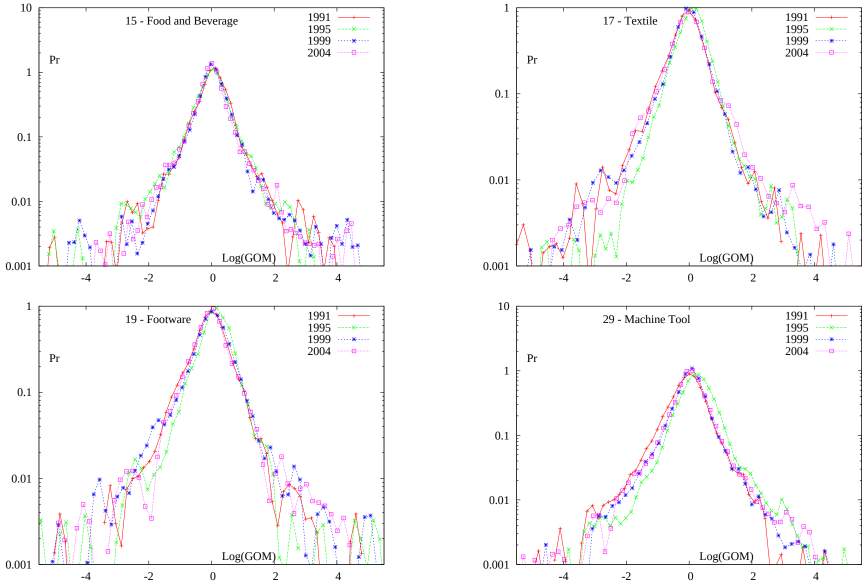

Figure 26: Empirical densities of (log) Gross Margin growth rates, by sector. Our elaboration on Micro.3.

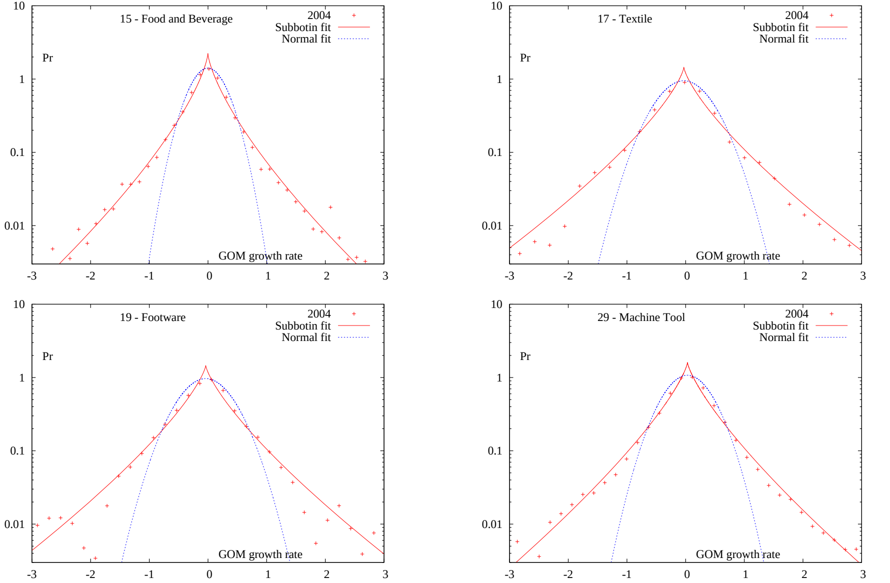

Figure 27: Empirical densities of (log) Gross Margin growth rates 03-04, by sector. Subbotin and Normal fit. Our elaboration on Micro.3.

NACE SECTOR	Levels AR(1)	Levels std err	Differences AR(1)	Differences std err
15 Food products and beverages	0.9516	0.0060	-0.3424	0.0190
17 Manufacture of textiles	0.9117	0.0067	-0.2953	0.0163
18 Wearing apparel; dyeing of fur	0.9328	0.0087	-0.3992	0.0254
19 Tanning, dressing of leather manuf. of luggage, footwear	0.8781	0.0144	-0.2984	0.0307
20 Manuf. of wood &cork prod	0.9430	0.0115	-0.3658	0.0332
21 Manuf. of pulp & paper prod	0.9432	0.0104	-0.2935	0.0298
22 Recorded media	0.9471	0.0098	-0.3917	0.0293
24 Manuf. of chemicals products	0.9370	0.0081	-0.3315	0.0216
25 Rubber and plastic products	0.9203	0.0085	-0.2917	0.0208
26 Other non-metallic mineral prod	0.9430	0.0067	-0.3337	0.0190
27 Basic metals	0.9149	0.0101	-0.3245	0.0248
28 Fabricated metal products	0.9213	0.0064	-0.2957	0.0155
29 Machinery and equipment n.e.c.	0.9207	0.0055	-0.3215	0.0137
31 Electrical machinery n.e.c.	0.9649	0.0086	-0.2382	0.0265
35 Other transport equipment no cars	0.9200	0.0175	-0.1824	0.0461

Table 2: Autocorrelation of Gross Margins Levels and Growth Rates. Our elaborations on Italian data (1989-1997).

Major findings

i) wide distributions of probabilities across firms characterize all sectors

ii) stability over time

iii) some (mild) regression to the mean tendencies

Summing up

i) More structure in the growth process than generally assumed:
   - ubiquitous fat-tailed distribution suggesting underlying correlation mechanisms
   - (some) autocorrelation over time

ii) Wide variability in profitabilities, quite stable over time

These indicators, capturing two central aspects of firms performances reveal widespread and persistent heterogeneity. What about underlying differences in production efficiencies and degrees of innovativeness?

Technological Characteristics of firms

Innovativeness

i) A lot of qualitative evidence from the economics of innovation suggests deeply asymmetric innovative capabilities (Freeman and Soete, 1997; Dosi, 1988; Dosi et al., 2005).
ii) Moreover, differential innovativeness is often persistent over time (Cefis, 2003a).

Regarding more specifically the international pharmaceutical industry:

iii) Rare arrival of major innovations: process of arrival by firm well described by a Bose-Einstein statistics[2] (cf. Fig. 28).

N.B.: This possibility of correlated arrival is well in tune with an evolutionary notion of high-capability, persistent, innovators

iv) Heterogeneity across firms in innovative content of product portfolios

[2] $P(x;N,M) = \binom{N+M-x-2}{N-2} / \binom{N+M-1}{N-1}$. See also Bottazzi and Secchi (2006)

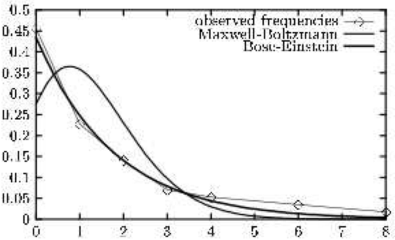

Figure 28: The frequencies of total New Chemicals Entities over the firms populations in the international drug industry (x-axis: firms introducing 0,1, ..., 8 NCE's; y-axis: frequencies thereof. Source Bottazzi et al. (2001).

Labor Productivities (Italian data)

i) Again, widespread heterogeneity within sectors, cf. Fig. 29 (see also Dosi and Grazzi, 2006).

ii) Stability of the distribution over time and persistence of productivity differential over time (cf. the survey of Bartelsman and Doms, 2000).

iii) Asymmetries in the distribution of (log) labor productivity (cf. Fig. 30):

- ⇒ Both coefficients (b_l and b_r) of the asymmetric Subbotin < 2 but the left tail is much ticker.
- ⇒ Support to the hypothesis of a weak selection process
- ⇒ The support does not shrink over time ⇒ Table 3 ratio of the top over the bottom decile.

iv) Some (mild) regression to the mean tendencies (Table 4).

v) Exponential distributions of growth rates Fig. 31 and Bottazzi et al. (2005).

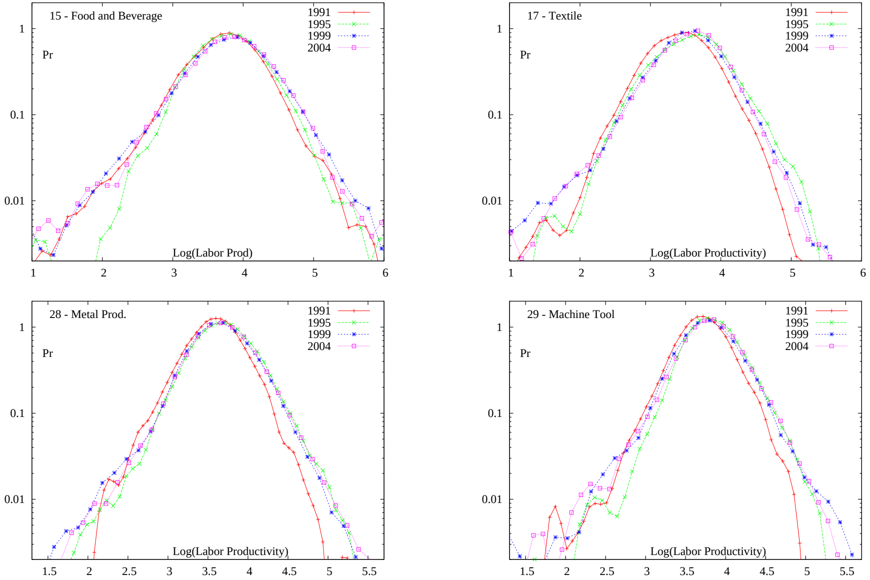

Figure 29: Empirical densities of (log) Labor Productivity. Deflated with production price index. Our elaboration on Micro.3.

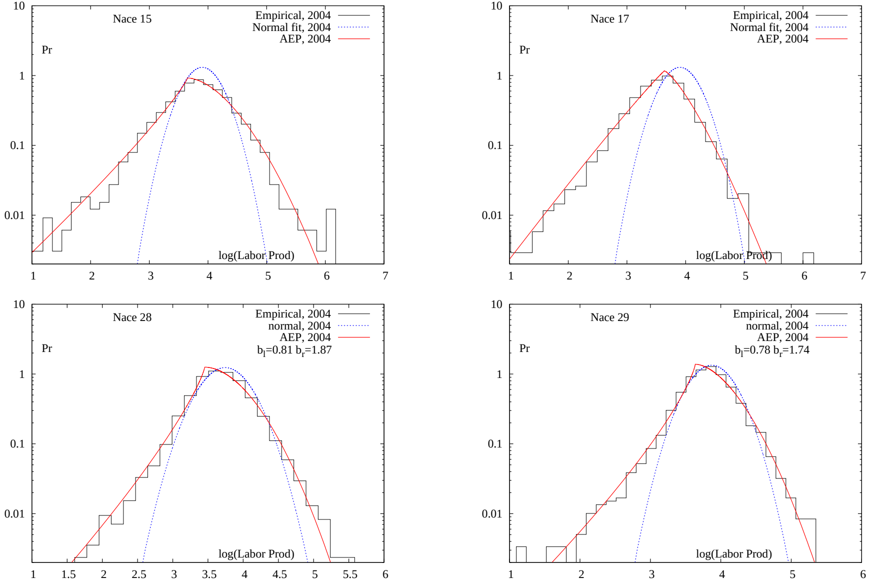

Figure 30: Empirical densities of (log) Labor Productivity, together with Normal and Asymmetric Exponential fit. Our elaboration on Micro.3.

NACE	'89	'91	'93	'95	'98	'00	'02	'04
15	6.9	6.7	7.2	5.9	8.0	8.0	8.3	8.2
	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
17	5.5	5.2	6.4	6.3	6.3	5.7	5.6	6.0
	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.3
18	6.6	7.1	8.2	7.4	9.1	11.6	11.0	11.8
	0.3	0.3	0.4	0.3	0.4	0.5	0.5	0.7
19	5.3	5.9	6.0	6.1	6.0	6.5	6.7	6.3
	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.3
24	4.8	4.7	5.2	6.2	8.3	8.6	7.0	8.3
	0.3	0.2	0.3	0.6	0.7	0.6	0.4	0.6
25	4.0	4.2	5.0	5.1	4.6	4.9	4.5	4.9
	0.1	0.2	0.3	0.2	0.1	0.3	0.2	0.2
26	5.2	5.2	5.6	5.3	5.0	6.0	5.8	6.2
	0.2	0.2	0.2	0.2	0.2	0.6	0.2	0.2
27	4.3	3.9	4.5	5.4	4.7	5.0	4.9	6.1
	0.2	0.1	0.2	0.3	0.2	0.3	0.3	0.4
28	3.6	3.6	3.8	4.1	4.3	4.5	4.2	4.3
	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
29	3.5	3.4	3.9	3.5	4.3	4.3	4.1	4.2
	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
34	3.7	4.0	5.0	4.2	5.2	5.2	5.3	5.5
	0.2	0.2	0.3	0.3	0.4	0.4	0.3	0.4
35	4.5	5.2	7.3	5.2	5.5	6.8	8.6	6.9
	0.3	0.5	0.7	0.4	0.6	0.6	1.5	0.7
36	3.7	3.9	4.4	4.3	4.7	5.2	4.9	5.3
	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2

Table 3: Ratio of the average productivity (and relative std err) of the top decile over the bottom one. Source: Our elaboration on Micro.3

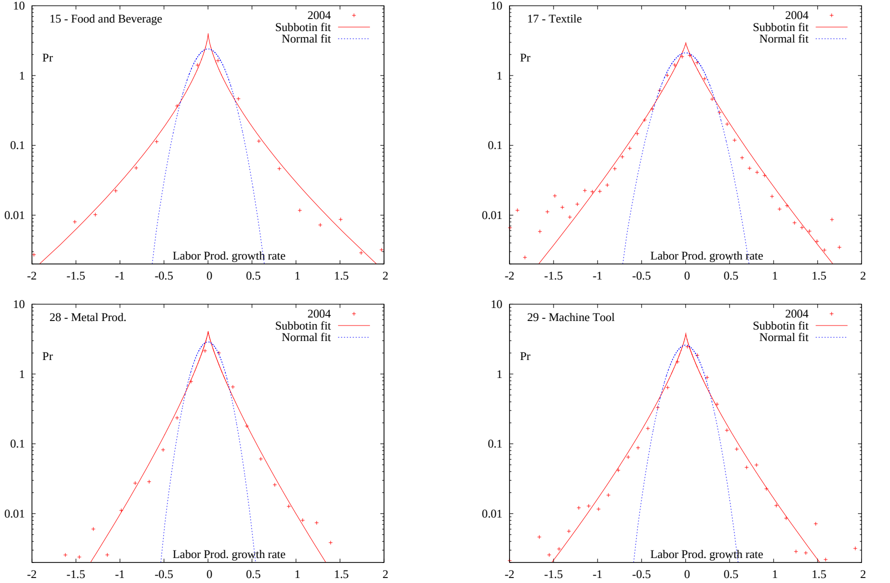

Figure 31: Empirical densities of Labor Productivity growth rates, together with Normal and Asymmetric fit. Our elaboration on Micro.3.

NACE SECTOR	Levels AR(1)	Levels std err	Differences AR(1)	Differences std err
15 Food products and beverages	0.8619	0.0092	-0.2641	0.0208
17 Manufacture of textiles	0.8699	0.0076	-0.2770	0.0171
18 Wearing apparel; dyeing of fur	0.9285	0.0087	-0.3428	0.0250
19 Tanning, dressing of leather manuf. of luggage, footwear	0.8932	0.0158	-0.3123	0.0398
20 Manuf. of wood &cork prod	0.8357	0.0154	-0.3254	0.0312
21 Manuf. of pulp & paper prod	0.8772	0.0140	-0.2348	0.0030
22 Recorded media	0.8391	0.0127	-0.1596	0.0319
24 Manuf. of chemicals products	0.7947	0.0132	-0.1883	0.0234
25 Rubber and plastic products	0.8920	0.0108	-0.2831	0.0244
26 Other non-metallic mineral prod	0.9057	0.0077	-0.3065	0.0195
27 Basic metals	0.8583	0.0135	-0.1645	0.0270
28 Fabricated metal products	0.8572	0.0079	-0.3299	0.1580
29 Machinery and equipment n.e.c.	0.8098	0.0079	-0.3177	0.0143
31 Electrical machinery n.e.c.	0.8534	0.0119	-0.1072	0.0236
35 Other transport equipment no cars	0.7518	0.0299	-0.3490	0.0481

Table 4: Autocorrelation of Labor Productivity Levels and Growth Rates. Our elaborations on Italian data (1989-1997).

Patenting Activity and Productivity

- Registered patents of Italian firms bigger than 20 employees (both USPTO and EPO).

⇒ Only 1883 firms have registered patents over 64000 of the manufacturing sector (Italian census Micro.3)

- Apparent differences in terms of labor productivity

- ... but not in terms of profitability (as ROS = GOM/Sales)

NACE	Total	Patenting	%	NACE	Total	Patenting	%
241	273	26	9.52	291	661	87	13.16
243	179	8	4.47	292	1494	139	9.30
244	267	75	28.09	293	214	26	12.15
245	184	4	2.17	294	457	60	13.13
246	230	14	6.09	295	1185	197	16.62
24	1177	132	11.21	297	199	34	17.09
251	256	16	6.25	29	4236	547	12.91
252	1569	103	6.56	30	112	7	6.25
25	1825	119	6.52	311	252	14	5.56
261	236	15	6.36	312	213	21	9.86
262	143	7	4.90	316	594	45	7.58
263	212	9	4.25	31	1329	92	6.92
264	124	2	1.61	322	211	13	6.16
266	573	8	1.40	32	406	24	5.91
267	244	5	2.05	332	198	23	11.62
26	1692	56	3.31	33	668	73	10.93
273	166	3	1.81	342	141	4	2.84
275	333	7	2.10	343	394	45	11.42
27	848	27	3.18	34	574	54	9.41
281	1145	16	1.40	35	395	25	6.33
284	522	11	2.11	361	1434	48	3.35
285	1772	31	1.75	362	282	8	2.84
286	324	32	9.88	366	211	15	7.11
287	973	52	5.34	36	2027	85	4.19
28	4930	158	3.20				

Table 5: Number of patents for a selection of 2 Digit and some of their nested 3 Digit sectors. Our elaboration on Micro.3

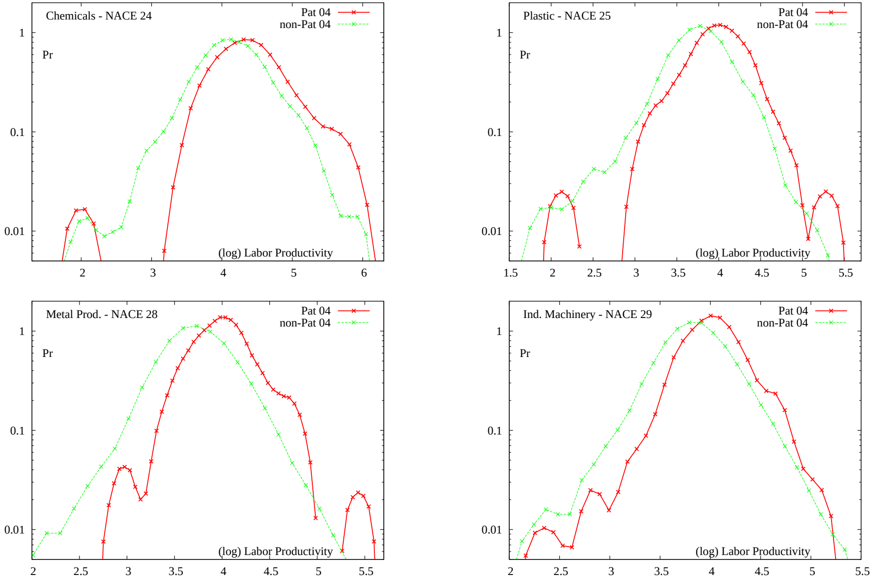

Figure 32: Empirical densities of Labor productivity for patenting and non-patenting firms in 2004. Our elaboration on Micro.3.

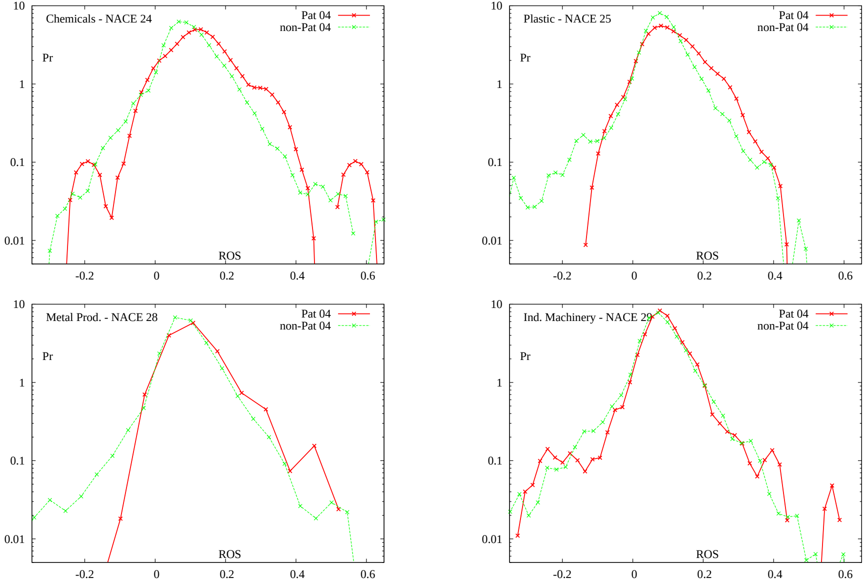

Figure 33: Empirical densities of Profitability (proxied by ROS) for patenting and non-patenting firms in 2004. Our elaboration on Micro.3.

Plants vs. Firms

Heterogeneity across plants, their dynamics and their relation with firms characteristics
(as from Baily et al. (1992) but cf. also Rumelt (1991) Baldwin (1998) Power (1998) and others) [caveat: most analyses are undertaken in terms of Total Factor Productivities, with all the ambiguities associated with the notion...]
Plant-level evidence

i) High degrees of heterogeneity in plant productivities
ii) Increasing output shares in high-productivity plants and the decreasing shares of output in low-productivity plants are very important to the growth of manufacturing productivity
iii) Plants at the top of the productivity distribution are able to stay on the top for long periods
iv) High degrees of persistence (cf. 10-years transition matrix, showing strong plant-specific fixed effects)

Firm-level influences Strong firm effects:

a) Plants that are part of the high-productivity firms will also have higher productivity levels
b) Plants in firms where there is rapid productivity growth will grow more rapidly

Major issues

⇒ comparisons between within- vs. across firms measures of heterogeneity

⇒ what are the specificities in the relationship learning vs. selection across plants / within firms as distinct from that across firms

an irreducible heterogeneity at all levels of observation

As Griliches and Mairesse (1999) put it:
“we ... thought that one could reduce heterogeneity by going down from general mixtures as "total manufacturing" to something more coherent, such as "petroleum refining" or "the manufacture of cement". But something like Mandelbrot’s fractal phenomenon seem to be at work here also: the observed variability-heterogeneity does not really decline as we cut our data finer and finer. There is a sense in which different bakeries are just as much different from each others as the steel industry is form the machinery industry.”

An interpretative framework

[broadly in an evolutionary framework: cf. Nelson and Winter (1982), Winter (1984), Dosi et al. (1995)]

1) At any “initial” time there is a distribution of (short-term fixed) input coefficients across firms.
2) Heterogeneous firms compete with each other, and given prevailing input and output prices obtain different returns (or, putting it in a rather different language, different - positive or negative - “quasi-rents” above/below notional “pure competition” input prices).
3) Leaving aside any entry/mortality phenomenon, surviving incumbents undergo changes in their market shares and therefore in their relative (and, of course absolute) outputs.

An interpretative framework (cont'd)

4) Realized market shares and realized profitabilities affect the future supply (and often future prices) of the various firms.

[N.B. So far, point 2, 3 and 4 describe selection/adaptation processes given initial conditions. Note also that this basic story, so far, may well be enriched by explicit details on demand structures, e.g. "horizontal', "vertical" differentiation (à la Sutton) entailing correspondingly more "rugged" selection landscape]

5) Over time firms learn/innovate/initiate changing their input efficiencies and product characteristics.

$\Rightarrow$ Hence, what are the relationships between innovativeness/production efficiency, on the one hand, and economic performances (growth and profitabilities on the other).

Major Properties

i) Weak or non existent relationship between growth and relative productivities: more efficient firms do not grow more (cf. Fig. 34, on Italian data).
   - ⇒ This remains true even if we focus on the small sub-sample of firms with patents (cf. Fig. 35)

ii) (In the case of the international pharmaceutical industry) more innovative firms do not grow more (cf. Bottazzi et al., 2001)).

iii) A positive relation between relative efficiency and growth is often recovered through the impact of outliers (the very best and the very worst).

iv) Industries appear to constantly involve the coexistence of heterogeneous types of firms (innovators/imitators, etc.)

Conversely,

v) Innovativeness seems to bear a positive impact upon profitabilities (cf. Geroski et al., 1993, Cefis, 2003a, Roberts, 1999)

vi) Moreover there appears to be a positive relation between relative productivities and profitabilities (Secchi's presentation and Bottazzi et al., 2008)

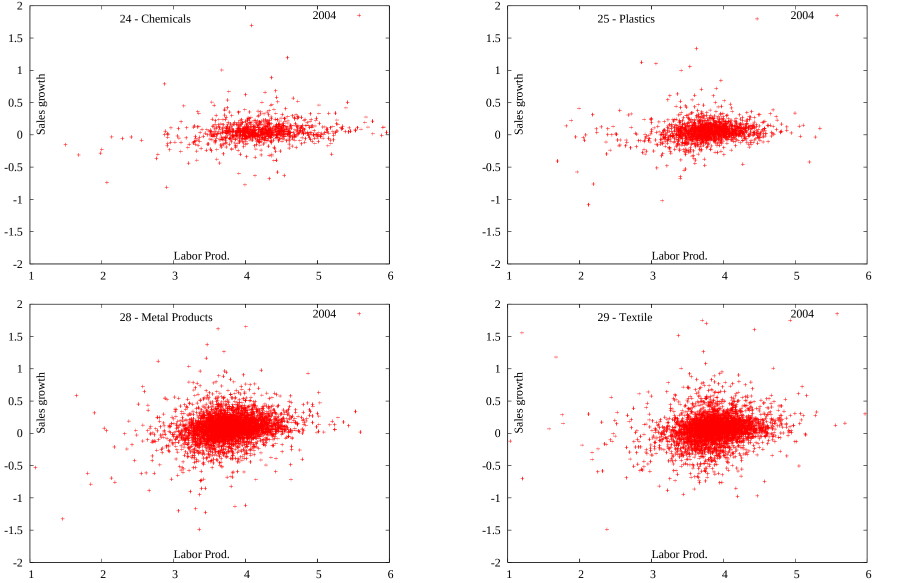

Figure 34: Relation between labor productvity and growth rates of sales, year 2004. Our elaboration on Micro.3.

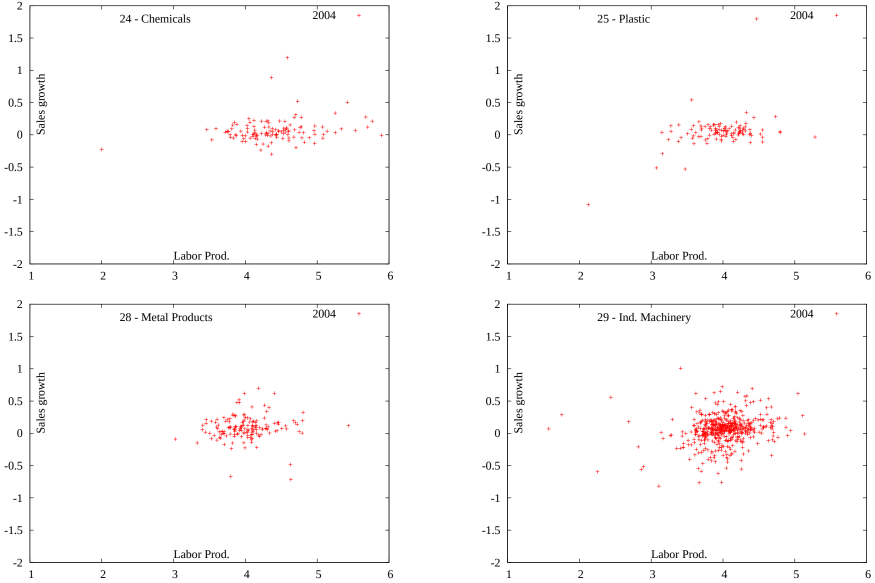

Figure 35: Relation between labor productvity and growth rates of sales for firms with patents, year 2004. Our elaboration on Micro.3.

		1st to 1st quantile	2nd to 2nd quantile	3rd to 3rd quantile	4th to 4th quantile
Pharmaceutical	Productivity	0.1042	0.1408	0.1071	0.7059
	Profitability	0.3559	0.2824	0.3521	0.4521
Primary Metal	Productivity	0.4182	0.0833	0.1778	0.8780
	Profitability	0.5217	0.2500	0.3333	0.6842
Machine Sector	Productivity	0.1746	0.0541	0.2018	0.8542
	Profitability	0.3627	0.2436	0.2763	0.7395
Textile	Productivity	0.1969	0.0784	0.2756	0.9244
	Profitability	0.4514	0.2868	0.4297	0.7379

Table 6: Transition Probabilities in Productivity and Profitability Five-year lag, diagonal values. Source Cefis (2003b)

Concluding Remarks

All these pictures suggest indeed a process of evolution whereby

i) heterogeneity concerns all aspects of firms characteristics and performances, which persist over time;
   - $\Rightarrow$ The importance of the idiosynchratic part is also revealed by the microeconometric evidence $\Rightarrow$ the fixed (firm) effect accounts for a large part of the explained variance of the dependent variable.

ii) various mechanisms of correlation (together with the “sunkness” and indivisibilities of many technological events and investment decisions) yield to a relatively “structured” process of change in most variables (size, productivity, profitability) also revealed by the “fat-tailedness” of the respective growth rates.

iii) Selection do not seem to work particularly well at least on the yearly time scale at which statistics are reported.

iv) Rather different degrees of efficiency and innovativeness at least in the short term, seem to yield relatively persistent profitability differentials.

Concluding Remarks (cont'd)

In turn major issues:

- the interpretation of idiosyncratic characteristics
  - $\Rightarrow$ Capability-based theory of the firm
- Given the organizational characteristics what are the behavioral degrees of freedom?
  - $\Rightarrow$ Behavioral rules and the degrees of discretionarity for strategic management

References

AMARAL, L., B. S.V., H. S., M. P., S. M.A., H. STANLEY, AND S. M.H.R. (1997): "Scaling behavior in economics: The problem of quantifying company growth," *Physica A*, 244, 1–24.

AXTELL, R. L. (2001): "Zipf Distribution of US Firm Sizes," *Science*, 293, 1818–1820.

BAILY, M. N., C. HULTEN, AND D. CAMPBELL (1992): "Productivity Dynamics in Manufacturing Establishments," *Brookings Papers on Economic Activity: Microeconomics*, 4, 187–249.

BALDWIN, J. R. (1998): *The Dynamics of Industrial Competition: A North American Perspective*, Cambridge University Press.

BARTELSMAN, E. J. AND M. DOMS (2000): "Understanding Productivity: Lessons from Longitudinal Microdata," *Journal of Economic Literature*, 38, 569–594.

BOTTAZZI, G., E. CEFIS, AND G. DOSI (2002): "Corporate Growth and Industrial Structure. Some Evidence from the Italian Manufacturing Industry," *Industrial and Corporate Change*, 11, 705–723.

BOTTAZZI, G., E. CEFIS, G. DOSI, AND A. SECCHI (2003): "Invariances and Diversities in the Evolution of Manufacturing Industries," LEM Working Papers 2003/21, S. Anna School of Advanced Studies.

——— (2007): "Invariances and Diversities in the Evolution of Italian Manufacturing Industry," *Small Business Economics*, 29, 137–159.

BOTTAZZI, G., G. DOSI, M. LIPPI, F. PAMMOLLI, AND M. RICCABONI (2001): "Innovation and corporate growth in the evolution of the drug industry," *International Journal of Industrial Organization*, 19, 1161–1187.

BOTTAZZI, G., M. GRAZZI, AND A. SECCHI (2005): "Input Output Scaling Relations in Italian Manufacturing Firms," *Physica A*, 355, 95–102.

BOTTAZZI, G. AND A. SECCHI (2003): "Properties and Sectoral Specificities in the Dynamics of U.S. Manufacturing Companies," *Review of Industrial Organization*, 23, 217–232.

——— (2006): "Explaining the Distribution of Firms Growth Rates," *RAND Journal of Economics*, 37, 235–256.

BOTTAZZI, G., A. SECCHI, AND F. TAMAGNI (2008): "Productivity, Profitability and Financial performance," *Industrial and Corporate Change*, 17, 711–751.

CEFIS, E. (2003a): "Is there any Persistence in Innovative Activities?" *International Journal of Industrial Organization*, 21, 489–515.

——— (2003b): "Persistence in Innovation and Profitability," *Rivista Internazionale di Scienze Sociali*, 110, 19–37.

CEFIS, E. AND M. CICCARELLI (2005): "Profit Differentials and Innovation," *Economics of Innovation and New Technology*, 14, 43–61.

CUBBIN, J. AND P. A. GEROSKI (1987): "The Convergence of Profits in the Long Run: Inter-Firm and Inter-Industry Comparisons," *The Journal of Industrial Economics*, 35, 427–442.

DOSI, G. (1988): "Sources, Procedures, and Microeconomic Effects of Innovation," *Journal of Economic Literature*, 26, 1120–71.

——— (2007): "Statistical Regularities in the Evolution of Industries. A Guide through some Evidence and Challenges for the Theory," in *Perspectives on Innovation*, ed. by S. Brusoni and F. Malerba, Cambridge University Press.

DOSI, G., A. GAMBARDELLA, M. GRAZZI, AND L. ORSENIGO (2008): "Technological Revolutions and the Evolution of Industrial Structures: Assessing the Impact of New Technologies upon the Size and Boundaries of Firms," *Capitalism and Society*, 3.

Dosi, G. and M. Grazzi (2006): "Technologies as problem-solving procedures and technologies as input–output relations: some perspectives on the theory of production," *Industrial and Corporate Change*, 15, 173–202.

Dosi, G., O. Marsili, L. Orsenigo, and R. Salvatore (1995): "Learning, Market Selection and Evolution of Industrial Structures," *Small Business Economics*, 7, 411–36.

Dosi, G., L. Orsenigo, and M. Sylos-Labini (2005): "Technology and the Economy," in *The Handbook of Economic Sociology*, ed. by N. J. Smelser and R. Swedberg, Princeton University Press: Princeton and New York, 2nd ed.

Evans, D. S. (1987a): "The Relationship between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries," *Journal of Industrial Economics*, 35, 567–81.

——— (1987b): "Tests of Alternative Theories of Firm Growth," *The Journal of Political Economy*, 95, 657–674.

Freeman, C. and L. Soete (1997): *The Economics of Industrial Innovation*, London: Pinter, 3rd ed.

Geroski, P., S. Machin, and J. V. Reenen (1993): "The Profitability of Innovating Firms," *RAND Journal of Economics*, 24, 198–211.

Geroski, P. A. and A. Jacquemin (1988): "The Persistence of Profits: A European Comparison," *Economic Journal*, 98, 375–389.

Griliches, Z. and J. Mairesse (1999): "Production Functions: The Search for Identification," in *Econometrics and Economic Theory in the Twentieth Century: the Ragner Frisch Centennial Symposium*, ed. by S. Steiner, Cambridge University Press: Cambridge.

Hymer, S. and P. Pashigian (1962): "Firm Size and Rate of Growth," *Journal of Political Economy*, 70, 556–569.

IJIRI, Y. AND H. A. SIMON (1977): *Skew distributions and the sizes of business firms*, North-Holland, Amsterdam.

LOTTI, F., E. SANTARELLI, AND M. VIVARELLI (2003): "Does Gibrat's Law hold among young, small firms?" *Journal of Evolutionary Economics*, 13, 213–235.

MARSILI, O. (2001): *The Anatomy and Evolution of Industries: Technological Change and Industrial Dynamics*, Edward Elagar.

MUELLER, D. C., ed. (1986): *Profits in the Long-Run*, Cambridge, Cambridge, Cambridge University Press.

MUELLER, D. C. (1990): "Profits and the Process of Competition," in *The Dynamics of Company Profits: an internation comparison*, ed. by D. C. Mueller, Cambridge University Press, Cambridge.

NELSON, R. R. AND S. G. WINTER (1982): *An Evolutionary Theory of Economic Change*, The Belknap Press of Harvard University Press: Cambridge, MA.

POWER, L. (1998): "The Missing Link: Technology, Investment, And Productivity," *The Review of Economics and Statistics*, 80, 300–313.

ROBERTS, P. W. (1999): "Product Innovation, Product-Market Competition and Persistent Profitability in the U.S. Pharmaceutical Industry," *Strategic Management Journal*, 20, 655–670.

RUMELT, R. P. (1991): "How Much Does Industry Matter?" *Strategic Management Journal*, 12, 167–185.

STANLEY, M., L. AMARAL, S. BULDYREV, S. HAVLIN, H. LESCHHORN, P. MAASS, M. SALINGER, AND H. STANLEY (1996): "Scaling behaviour in the growth of companies," *Nature*, 379, 804–806.

STEINDL, J. (1965): *Random Processes and the Growth of Firms*, London: Charles Griffin & Company.

SUTTON, J. (1997): "Gibrat's Legacy," *Journal of Economic Literature*, 35, 40–59.

TEECE, D. J., R. RUMELT, G. DOSI, AND S. WINTER (1994): "Understanding corporate coherence : Theory and evidence," *Journal of Economic Behavior & Organization*, 23, 1–30.

WINTER, S. G. (1984): "Schumpeterian competition under alternative technological regimes," *Journal of Economic Behavior and Organization*, 5, 287–320.