Input Output Scaling Relations in Italian Manufacturing Firms

Giulio Bottazzi [a], Marco Grazzi [a] Angelo Secchi [a]

[a] *Scuola Superiore S.Anna, Pisa, Italy*

Abstract

Recent analyses on different database have proposed some regularities with respect to size and growth rates distribution of firms. In this work we explore some basic properties of the dynamics of productivity in Italian manufacturing firms. We investigate relations between different inputs and output examining the impact of productivity in shaping the pattern of corporates evolution.

Key words: Input Output Relation, Labor Productivity

1 Introduction

The statistical analysis of firm size and its dynamics constitutes one of the traditional problems in the Applied Industrial Organization literature. Early investigations date back to the work of Gibrat [1]. Recent contributions [2,3] have focused the attention on the properties of the distribution of corporate size and growth rates. New suggested "stylized facts" refer to the tent-like shape distribution of growth rates and the scaling relation between size and variance of the growth process. The aim of this paper is to add to the analysis variables which contribute to shape the observed dynamics. We identify these measures in input/output ratios and technical efficiency of the production process. We present relations among inputs in different 2-digit sectors and their dynamics over time. Labor productivity, which accounts for technical efficiency, displays a significant and persistent heterogeneity within sectors.

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Table 1
Scaling parameters of the relation Labor-Sales. Estimated parameter of the regression $log(S_t) = log(a) + b\ log(L_t)$ and standard errors.

SECTOR	SIC	1989		1991		1994		1997	
	Code	Coeff.	Std Err	Coeff.	Std Err	Coeff.	Std Err	Coeff.	Std Err
Food/Beverages	15	1.040	0.024	1.062	0.021	1.072	0.021	1.151	0.027
Textiles	17	1.053	0.025	1.074	0.022	1.146	0.023	1.181	0.025
Leather/Footwear	19	1.153	0.052	1.267	0.041	1.318	0.040	1.309	0.053
Wood Manufact.	20	1.195	0.047	1.180	0.044	1.283	0.044	1.299	0.048
Paper/Allied Prod.	21	1.084	0.030	1.114	0.027	1.143	0.034	1.197	0.034
Chemicals Prod.	24	1.158	0.020	1.119	0.019	1.067	0.019	1.151	0.022
Rubber/Plastics	25	1.024	0.023	1.043	0.022	1.108	0.022	1.134	0.026
Basic Metals	27	1.080	0.032	1.080	0.027	1.100	0.028	1.167	0.030
Metal Products	28	1.123	0.018	1.132	0.016	1.183	0.016	1.207	0.018
Indust. Machinery	29	1.063	0.011	1.078	0.011	1.107	0.011	1.135	0.012
Electr. Machinery	31	1.081	0.018	1.110	0.019	1.118	0.021	1.123	0.023
Forniture Manuf.	36	1.160	0.025	1.219	0.023	1.245	0.024	1.240	0.026

2 Empirical Evidence

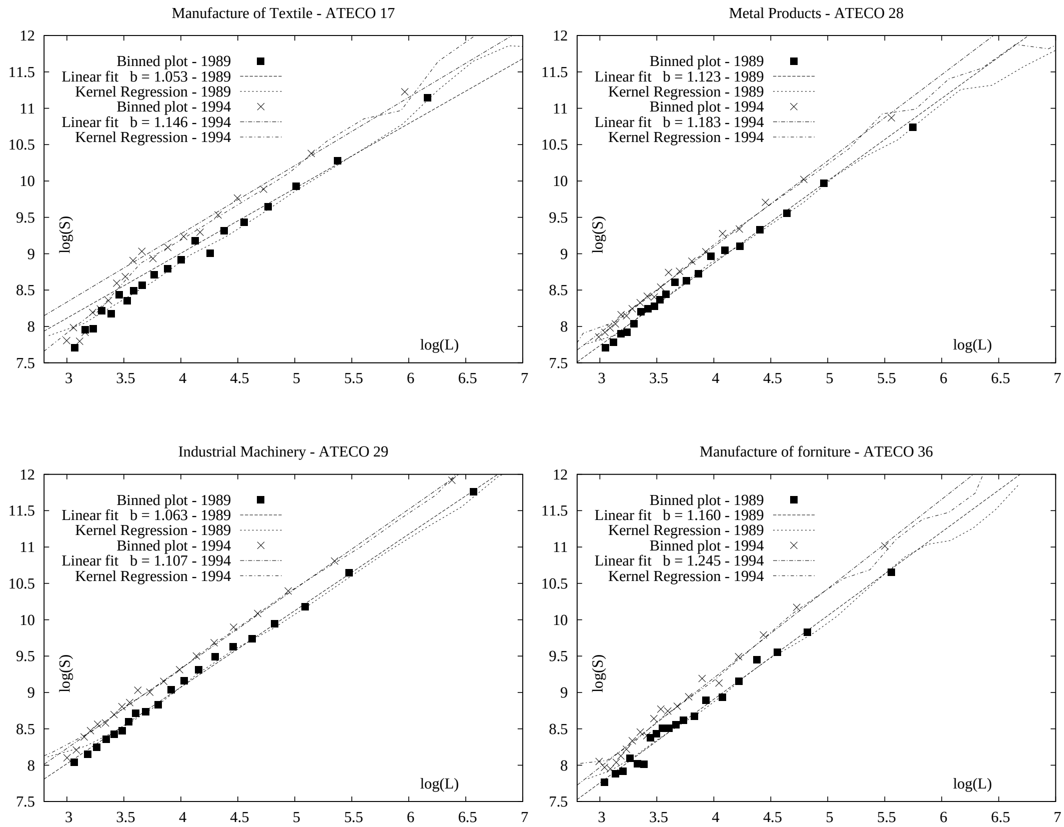
Recent years have seen a relevant increase in studies on productivity. This is partly due to the rising availability of longitudinal micro-level data (LMD). The trend is also motivated [4] by the development of a rich theoretical microeconomic foundation and displeasure with the concept of the aggregate production function. A considerable feature of longitudinal micro-level data is that they enable to observe the empirical distribution of productivity measures at firm's and sector's level.

The research we present here draws upon the MICRO.1 databank developed by the Italian Statistical Office (ISTAT) [1] . MICRO.1 contains longitudinal data on a panel of several thousands of Italian manufacturing firms with employment of 20 units or more and it covers the years 1989-97. Firms are classified according to their sector of principal activity [2] . The database contains information on the many variables appearing in firms' balance sheet. The "panel" nature of the database allows us to keep track of the same firm during the considered interval. The richness of the longitudinal dimension of the sample allows to partially overcome shortcomings due to the limited time span of the dataset.

Table 1 reports the scaling parameters of labor, L, proxied by number of employees and output, S, measured as total sales. Sectors appearing in tables

[1] The database has been made available to our team under the mandatory condition of censorship of any individual condition.
[2] The Italian ATECO closely matches the ISIC one.

Fig. 1. Relation between (log of) Labor and (log of) Output.



are those with highest number of observations. We report here coefficients relative to some of the years in the interval (1989-97) to provide a concise history of the observed trend. Plots of figure 1 and the small standard errors of the estimates in table 1 point out the suitability of the linear relation for labor and output. It is also worth noting that parameters are always greater than one, thus revealing a tendency towards increasing returns for labor as input. Coefficients also display relative heterogeneity across sectors and stability over time.

Table 2 displays the scaling relation between capital and output, where capital, K, is proxied by tangible fixed assets. Differences in coefficients' estimates across sectors together with the small magnitude of their standard errors hint at a significant heterogeneity across different industries. Further investigation of table 1 reveals for year 1994 a slight, but common to all sectors, decrease of the scaling parameter. The contraction becomes sharper in the following years. This trend, which will not be further investigated here, may be due to distortions caused by Italian Tremonti's law, which enabled corporates to benefit from partial tax exemption of profits re-invested in the business. The law fostered investments and plants renewal but the new capital goods were not immediately productive. Tremonti's law was in force for 1994 and 1995 only, but economic consequences outlived the norm itself.

Table 2
Scaling parameters of the relation Capital-Sales. Estimated parameter of the regression $log(S_t) = log(a) + b\ ln(K_t)$ and standard errors.

SECTOR	SIC	1989		1991		1994		1997	
	Code	Coeff.	Std Err	Coeff.	Std Err	Coeff.	Std Err	Coeff.	Std Err
Food/Beverages	15	0.748	0.017	0.744	0.015	0.681	0.015	0.574	0.015
Textiles	17	0.620	0.014	0.610	0.013	0.598	0.011	0.513	0.015
Leather/Footwear	19	0.696	0.019	0.672	0.018	0.693	0.017	0.561	0.024
Wood Manufact.	20	0.662	0.028	0.662	0.023	0.658	0.022	0.496	0.026
Paper/Allied Prod.	21	0.692	0.019	0.692	0.017	0.667	0.019	0.524	0.021
Chemical Prod.	24	0.743	0.017	0.735	0.017	0.706	0.018	0.601	0.018
Rubber/Plastics	25	0.726	0.016	0.708	0.015	0.660	0.015	0.546	0.016
Basic Metals	27	0.866	0.019	0.811	0.017	0.793	0.019	0.641	0.021
Metal Products	28	0.654	0.012	0.640	0.011	0.603	0.009	0.443	0.011
Industr. Machinery	29	0.687	0.011	0.635	0.011	0.628	0.010	0.558	0.011
Electr. Machinery	31	0.701	0.014	0.687	0.014	0.661	0.014	0.577	0.017
Forniture Manuf.	36	0.590	0.017	0.608	0.015	0.591	0.015	0.477	0.017

Graphical inspection of figure 2 adds useful insights to the analysis. The linear relation between (log of) capital and (log of) output appears to be stationary in time. The small standard errors of coefficients in table 2 confirm the good approximation of the linear fit, nevertheless the non-parametric regression reveals presence of non-linearity. Referring to economic reasoning, the (mild) convexity shown by the local regression expresses the tendency of capital to shift from a severe decreasing return to scale regime to a more favorable situation for firms with higher capitalization. According to database we employed this seem to be a (weak) property limited to capital, as figure 1 does not reply such relation for labor.

The analysis of relations between inputs and output show that the use of factors of production is sector-specific and stable over time. We now consider the dynamics of productivity at the firm and sector level [5], focusing on the degree of heterogeneity and the relation between productivity and the growth process.

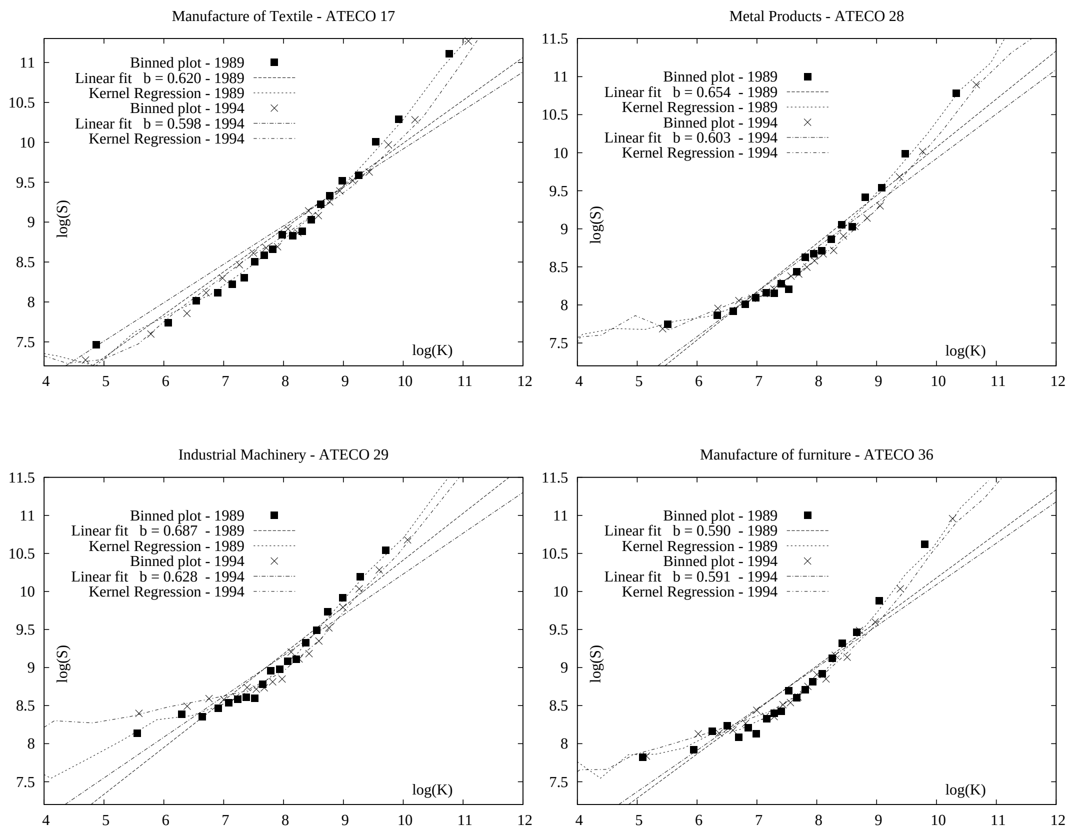
Economic literature is extremely rich in terms of measures of productivity employed [6]. In this work we consider a basic measure as labour productivity. Although elementary, this criterion offers the advantage of being accurately approximated given the available data, and it does not need to specify a production function.

We define labour productivity (π_l) as output (S) over labor (L):

$$\pi_l = S/L \tag{1}$$

It is often convenient to consider the normalized logarithm of this variable

Fig. 2. Relation between (log of) Capital and (log of) Output.



[7]. Henceforth we will employ the following two quantities for the analysis of levels and growth rates of productivity.

$$\pi_{l,i}(t) = \log(\pi_{l,i}(t)) - < \log(\pi_{l,i}(t)) >_i \quad (2)$$

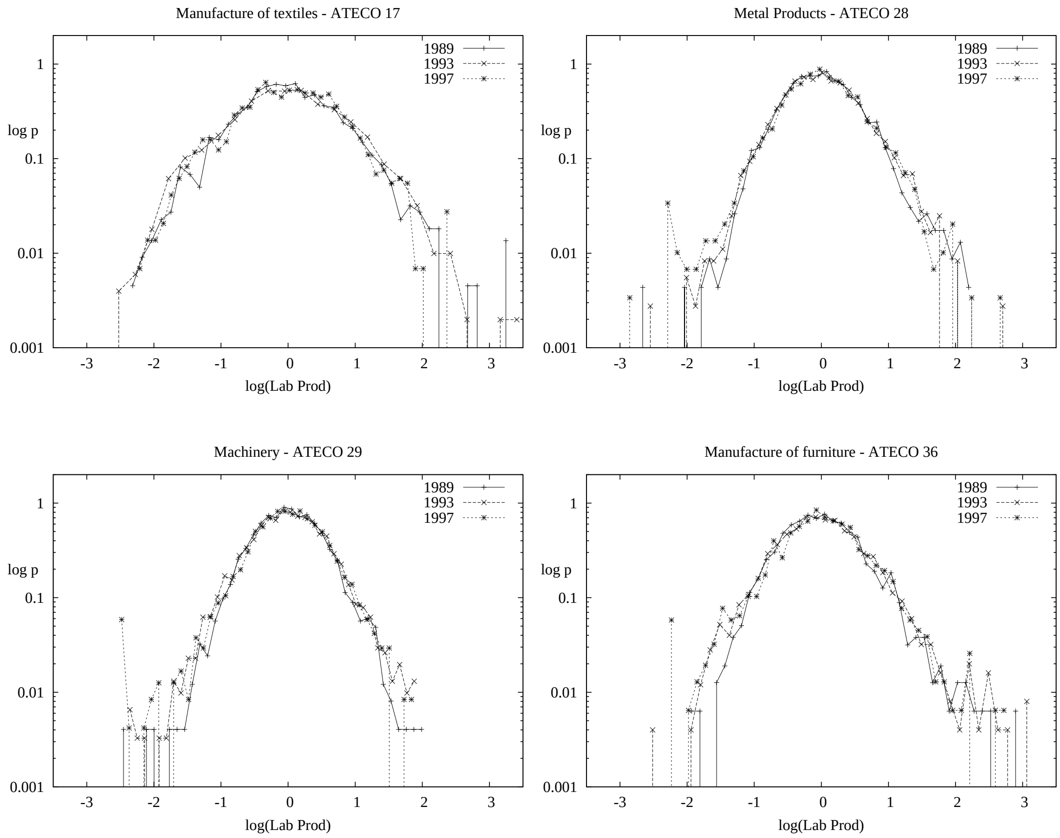
$$g_i(t) = \pi_i(t) - \pi_i(t-1) \quad (3)$$

where $< . >_i$ stands for the sector average over all the firms at a given time. The normalization procedure enables to remove common trends, so that growth rates considered in the analysis are not affected by inflation or sector expansion.

Figure 3 displays on a log scale the distribution of labour productivity for most populated sectors. The distribution reveals a wide support, suggesting coexistence in the same sector of firms whose productivity differs of several order of magnitude. Plots in figure 3 enable us to conclude that the wide support is not shrinking over time (at least in the interval considered) as one could expect.

To provide a parsimonious characterization of the distribution of productivity growth rates we fit the Subbotin family of distribution [8] which presents a

Fig. 3. Distribution of Labor Productivity (in logs).



wide range of tail (from Gaussian to Laplacian) and kurtotic behavior. Empirical distributions in figure 4 display a tent-like shape. Via maximunm likelihood estimation [9] we obtain a value of the parameter b. The results (figure 4) are very close to the value 1 that characterizes the Laplace density; thus, the distribution of growth rates for productivity reproduces similar properties as those found on size growth rates [2,3,10].

Finally, we are interested to explore the presence of a relation between the relative efficiency of a firm (in terms of labor productivity) and its growth process. The findings shown in figure 5 hint at a lack of such a relation. We also consider the possibility of lagged effects of productivity on growth but also this extension does not reveal presence of any dependence.

3 Conclusions

We present results concerning relations between factors of production and output. This provides a framework in which the analysis of the growth process of firms is enriched by considering inputs employment and productive efficiency. Relations among inputs and output vary across sectors but are relatively stable

Fig. 4. Distribution of growth rates of Labor Productivity growth rates (in logs) and Subbotin fits.

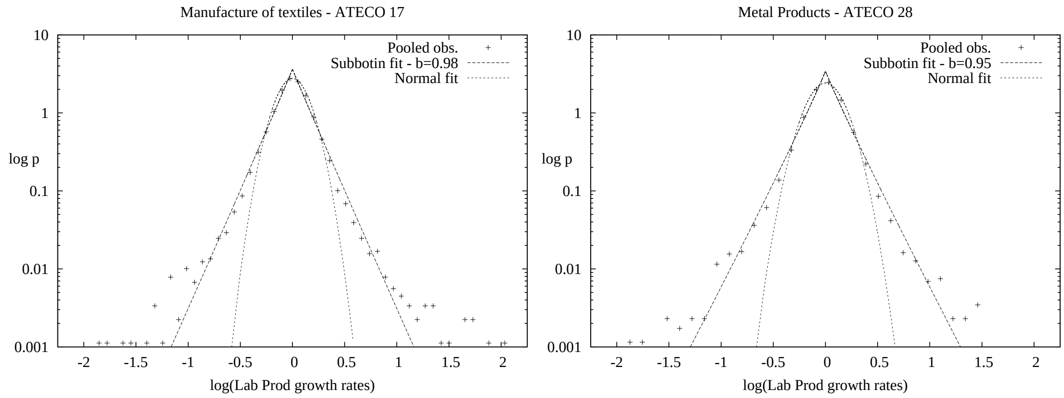
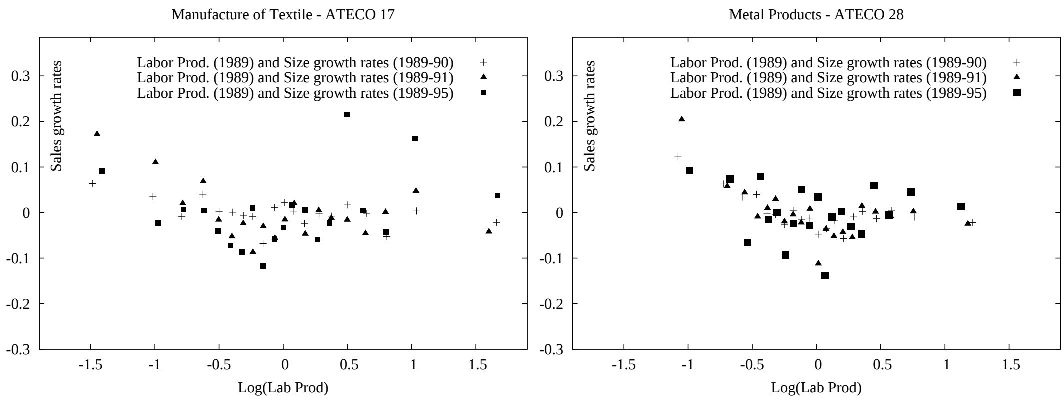


Fig. 5. Relation between (log of) Labor Prod. and Size growth rates.



over time within a single industry. The analysis of labor productivity reveals a significant level of heterogeneity at the sector level. Different performances in productivity are persistent over time and do not appear to affect the growth process of firms.

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