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Four Essays on Productivity and Cost structure in Business Firms

Marco Grazzi

Laboratory of Economics and Management

Scuola Superiore Sant'Anna

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Dissertation Committee

Prof. Giulio Bottazzi

Prof. Giovanni Dosi

Prof. Enrico Santarelli

Prof. Christopher Tucci

Prof. Sidney Winter

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Contents

Chapter 1

Introduction

This dissertation presents an analysis of the organization of production process in business firms by means of econometric and theoretical analysis. It investigates the properties of the distribution of some relevant measures which provide an account of how production is organized in different firms operating within the same sector and across various manufacturing industries. It then appraises the outcome of the production process and considers some proxies for output to embrace measures of "internal" efficiency, i.e. various notions of productivity, as well as other results also depending, at least partially, on some forms of market interactions, i.e. growth rates.

The methodology employed, which is exerting a direct influence on the content of the present work, could probably be easily labeled under the rubric of "bottom up" approach. More precisely, in the empirical analysis we begin by identifying some relations among variables of interest, and then move forward in search of - possibly - parsimonious explanations of the observed phenomena. This way of proceeding finds its consistent counterpart in statistical methods which move incrementally from exploratory and non parametric analysis, to the specification of more structured models. This *modus operandi* also allows to separate - at least to some extent - the level of empirical investigation and search for regularities from the subsequent moment of providing some suggested interpretations for the observed evidence.

This is an opportunity only recently disclosed to the economist, as well witnessed by the following quote from Kuznets where the author refers to his own work as "[...] perhaps 5 per cent empirical information and 95 per cent speculation, some of

it possibly tainted by wishful thinking (Kuznets, 1955, p. 26).[1]" Quite obviously, the quotation is also expressing some discontent for what was not a deliberate choice. Limited data availability was indeed a "curse" for many empirical works in economics. In this respect, one of the purposes of the present work is trying to reverse, at least partially, the 5% proportion of empirical evidence *Vs* speculation. Our effort to achieve, even partially, a turnaround of such proportion found a fertile ground in the improved and more systematic data collection at the micro level. What the author himself considers a main contribution is keeping up with the possibilities disclosed, and thus to "comply" with the data more than selectively speculate on them. This way of proceeding is inspired by Simon's concern on realism and evaluation of hypothesis (Ijiri and Simon, 1977, chap. 6), also as re-addressed in Dosi (2004).

The present thesis takes the form of four essays. The research questions we address in the following are very much related to each other and find a further unifying point in the empirical analyses, all drawing on a database of Italian manufacturing firms (more details in Chapter 2).

The first essay analyzes the role of input/output relations and technical efficiency measures in shaping the patterns of firms dynamics. A preliminary analysis of labor productivity reveals a significant degree of heterogeneity at sectoral level. Further, such different performances in productivity display persistency over time and do not appear to affect the growth process of firms. The second essay provides a description of production processes for Italian firms in manufacturing sectors. The use of non-parametric techniques discloses the presence of a relevant degree of heterogeneity in the way production is carried out by firms within each sector. Then, results of the parametric analysis lend support to the conjecture of high sectoral stability of the technical coefficients over time. The third contribution further investigates these heterogeneities, also focusing on productivity differentials of firms at a greater level of sectoral disaggregation. In this respect we consider the role of organizational knowledge, path dependency, and organizational routines in contributing to the observed and persistent differences in performances and production techniques. As a very natural extension of the scope of our analysis, in the last essay we consider the impact

[1] Clearly the author was referring to a different field of application, but the message is, we believe, further reaching.

of size and organizational structure in determining the substantial heterogeneity in labor costs detected for firms operating in the same sector.

Regarding the scientific background of the present work, what follows is not intended to be a complete review of the relevant literature; on the contrary it is purported at spelling out and make clearer the existing links with previous works.

Describing the production technology has traditionally proved to be a relevant issue in economics. Such a characterization allows indeed to address a number of meaningful questions about the extent of substitutability or complementarity of inputs, the source of productivity differentials across firms (and its measurement) or the magnitude of economies of scale, to mention but a few. Further and equally interesting is the analysis of the role of some measures of firm level productivity in explaining aggregate growth at the sector level, also accounting at the same time for the relative importance of entries and exits.

On the empirical side our reference point is a strand of literature making use of micro data to address these questions. In this respect - bearing all risks of citing only a subset of relevant works - we find to share many of the research questions as addressed in Baily et al. (1992), Baldwin (1998), Caves (1998) Bartelsman and Doms (2000), Foster et al. (2001), Bottazzi et al. (2006) and Dosi (2006). Resorting to earlier works, we reckon the present dissertation to be rooted in the tradition of statistical and applied economic analysis as, for instance, in Barna (1962) and Prattern (1971), although there the authors had to put up with much less detailed database than those available today.

On the interpretative side, the framework of this work is at least partly grounded in the evolutionary literature, as there heterogeneity finds a natural way to be accounted for (Dosi, 2000; Nelson and Winter, 1982). Here we pursue to explicitly account for those firms' idiosyncrasies which, we believe, find their counterpart in the persistently heterogenous performances observed. In this respect, concepts as organizational capabilities (Dosi et al., 2000), routines and routine as truce in intra-organizational conflict (Nelson and Winter, 1982) provide a rich interpretative framework for some of the results of the empirical analysis, such as the persistency of above-average performance of firms, on the one side, and the considerable stability of input coefficients over time, on the other. The present work is also an attempt to reinforce those fruitful interactions between simulation-based studies of industry dynamics (Dosi et al., 1995)

and more data-oriented analysis, where the latter continues to provide the building blocks for the "stylized facts" one wants to reproduce. Note that the evolutionary framework and the degrees of freedom which come along with it enable for the analysis of some compelling issues which are almost discarded within an orthodox setting. A remarkable example is represented by the difficulties in the sheer replicability of, for instance, a corporate division keeping unchanged the original performance (Szulanski and Winter, 2002; Winter, 1982, 2005). In this respect, evolutionary theory provides the convenient framework to address the hardship of replicability by explicitly considering stickiness and tacitness in knowledge.

Let us review some of the "stylized facts" that one might gather from the empirical literature we mentioned above, also trying, at the same time, to unravel how the present work intends to add to this evidence and to the related interpretations.

First, a noteworthy opening remark is the impressive diversity among plants[1] and among industries as reported in Baily et al. (1992). Productivity levels greatly differ among plants and most notably there is no hint of a convergence over time to any notion of "industry average" with random departure from it. On the contrary such diversity in performance gets reinforced due to, for instance, arrivals of high-productivity entrants and low-productivity entrants. These findings are common to a growing stream of literature devoting considerable attention to "microeconomic evidence", see for instance Bartelsman and Dhrymes (1998), Foster et al. (2001), Bartelsman et al. (2005), Bottazzi et al. (2006), Baldwin and Gu (2006). Further, when the database at hand allows to properly account for entry and exits, it is possible to consider the decomposition of some measures of productivity growth at the sector level to account for the contribution, respectively, of increased productivity at the plant level, reallocation of output shares to "better" units and finally the role of *death* and entry of new entities. The result of this "evolutionary accounting", although not always appearing under such a label, confirms and refines the initial picture of significant and persistent heterogeneities in the levels of production efficiency of plants and firms.

Summing up, probably the most striking result of these works is the amount and persistency of heterogeneity of relative productivities. Remarkably, this *fact* holds

[1] As explained in greater detail later on, the typical unit of observation for U.S. database is the plant, whether for Europe it is the firm.

true irrespectively of the methodology employed, which in this strand of literature embraces comparison of distributions over time, analysis of autoregressive structure and transition matrices.

With this regard, the analysis presented here lends further support to the aforementioned evidence providing similar results on Italian manufacturing firms. In addition - and with some degrees of novelty - the non-parametric analysis in Chapters 4 and 5 shows that the intensity with which the different inputs contribute to firm's output varies a lot: this suggests that firms belonging to the same sector possess very diverse production structures. In Chapter 3 we sketch out an evolutionary interpretative framework combining together concepts from the domains of technology studies, technological innovation and organizational knowledge in the attempt to shed some light on such regularities. An evolutionary account appears quite straightforward in that it predicts persistent heterogeneity in production efficiencies - and in the degrees of innovativeness: cf. the discussions in (Dosi, 1988, 2006; Freeman, 1994) -, as the outcome of idiosyncratic capabilities (or lack of them), mistake-ridden learning and forms of path-dependent adaptation. Differences in innovative abilities and efficiencies (together with differences in organizational set-ups and behaviors) make-up, we suggest, the distinct corporate "identities" which in turn influence those different corporate efficiencies revealed by the evidence ranging from the foregoing Italian one to that presented in the works cited above (together with the insightful discussion in Winter (1982) and Winter (1987)).

In all of this, the role of the market as the place of competitive interaction and selection do not appear to be equally harsh and accurate everywhere. For instance, we do observe different degrees of tolerance to persistent below-average performance. Then if one looks closer at the impact exerted on market as ground for selection by particular institutional mechanisms, think at access to credit for firms, the picture gets even more blurred; for a complementary analysis focusing on this specific issue see Bottazzi et al. (2006b) and Fagiolo and Luzzi (2006).

Second, a closely related stream of literature is the one concerned with firm growth rates. Indeed, one cannot aim at a purposefully comprehensive analysis of industry dynamics disregarding the relation between some measures of performance on one side, i.e. productivity or profitability, and their effects on the growth process, on the other. As far as the description of business firm growth is concerned, the Gibrat's

law (Gibrat, 1931) represents a sort of null hypothesis more than an interpretation. Gibrat's assertion - in its stronger form - is that the probability of size change of any specified percentage magnitude is independent of a firm's present absolute size. Since Gibrat's contribution there has been a constant interest in the literature to investigate the relation between size of the firm and growth process. We refer the interested reader to Sutton (1997) and Lotti et al. (2003) for a careful review of the theoretical and empirical issues.

In the intention of the present work one also wants to recover a more comprehensive picture which is informative of how persistently different performances map into the observed patterns of growth of firms. There exists indeed a long tradition of literature that investigates the *persistence of profitability differences across firms* starting with the seminal papers by Brozen (1970) and Mueller (1977) and that is - in many respects - complementary to those empirical works on persistence of productivity, cited above. But, on the contrary, a far smaller number of contributions directly addresses the relation between productivity (or profitability) and growth, among these see Baily et al. (1996) and Foster et al. (2001). In this respect our contribution to this strand of empirical work are the results reported in Section 3.2 which, consistently with the above cited contributions, stand for the lack of correlation between higher than average productivity levels and growth rates, even accounting for different lags.

Third, a last broadly homogenous domain of investigation pertains to the role played by size in shaping the organization of production activities, its implication on relative productivity levels and, possibly, its dynamics over time through different technological paradigms. Even more than before, it would be almost impossible to provide a short self-contained review of the literature and we will focus on those contributions which we find to better represent those research questions we empirically address. At a more general level, a crucial point is the long-standing issue of the existence of (technical) economies of scale and their effect on the organization of industries; contrasting arguments and circumstantial evidence can be found in Prattern (1971) and Barna (1962) on the one hand, and in Piore and Sabel (1984) on the other. Further in Dosi et al. (2006) an attempt is made to explicitly account for the effect of a change in the technological paradigm on the structure of industries and its determinants, i.e. size distributions of firms, vertical integration, etc (see also Bottazzi et al. (2001)). To preserve the internal consistency of the present work, here we

focus, at a lower level of generality, on issues concerning the relation between wage-rate and firm size, on the one hand, and scale of the activity and productivity, on the other. An admittedly preliminary analysis of the distribution of wage rates within single disaggregated industries is presented in Chapter 6. Our results on the existence of a wage-rate gap between big and small firms are largely consistent with previous empirical analyses (Brown and Medoff, 1989; Brunello and Colussi, 1998; Davis and Haltiwanger, 1991; Main and Reilly, 1993). More interesting our findings show that this relation holds true even when explicitly accounting for the various levels of labor productivity that characterize different firms.

Concluding this short review of results and related literature, it is fair to acknowledge that scientific contributions on firm and industrial dynamics have considerably moved forward in making use of increasingly available firm level data. This appears to have generated a "virtuous cycle" where growing accessible database foster scientific production in a more empirically disciplined manner, and in turn, this gets reflected in the demand for a greater detail of information and longer time series. The present work has benefited in many ways of this trend and of the corresponding attention in the literature. At the same time, such spur in the scientific production is to be found, we believe, also in some discontent for the persistency of many findings contradicting the implications of standard economic theory. Clearly, here one only begins to scratch the surface of some empirical and interpretative questions. Nonetheless, the discipline is now endowed with more systematic tools of research and an unprecedented - for amount and quality - sources of data with whom to tackle the challenge. It will also be a matter of lending more credit to the evidence than to some "wishful thinking".

Outline of the Essays

Input Output Scaling Relation

The aim of this chapter is to analyze the role of input/output relations and technical efficiency measures in shaping the patterns of firms dynamics. Our results suggest the emergence of scaling relations, "labor *vs.* output" and "capital *vs.* output", that seem stable over time and display a significant degree of heterogeneity at sectoral level. Concerning technical efficiency, proxied by labor productivity, our analyses highlight the coexistence in each sector of firms whose performances are substantially different.

Finally, we find that this heterogeneity is persistent over time and that productivity levels do not appear to influence the growth dynamics of firms.

For a published essay drawing on the same research project see Physica A, 355, pp. 95-102, 2005, coauthored with Giulio Bottazzi and Angelo Secchi.

Characterizing the Production Process

This chapter provides a description of the production process by comparing different frameworks in which to analyze the relations between inputs and output. The analyses are performed on a representative sample of Italian manufacturing firms. We employ both parametric and non-parametric analysis. The latter allows to detect the presence of heterogeneity in the way the production is carried out within each sector.
Results of the econometric analysis show that coefficient estimates tend to be robust with respect to the different models employed.

A version of this essay, coauthored with Giulio Bottazzi and Angelo Secchi has been published on Rivista di Politica Economica, I-II, pp. 243-270, 2005.355, pp. 95-102, 2005. It is also available as LEM working paper 2004/24.

Theory of Production: a broader interpretative framework

In this chapter we discuss the relation between three different levels of analysis of technologies, namely as (i) bodies of problem-solving knowledge, (ii) organizational procedures, and (iii) input-output relations. We begin by arguing that the "primitive" levels of investigation, "where the action is", are those which concern knowledge and organizational procedures, while in most respects the I/O representation is just an ex post, derived, one. Next, we outline what we consider to be important advances in the understanding of productive knowledge and of the nature and behaviors of business organizations which to a good extent embody such a knowledge. Finally, we explore some implications of such "procedural" view of technologies in terms of input-output relations (of which standard production functions are a particular instantiation). We do that with the help of some pieces of evidence, drawing both upon incumbent literature and our own elaboration on micro longitudinal data on the Italian industry.

A complementary analysis, coauthored with Giovanni Dosi, has been published on Industrial and Corporate Change, vol. 15, pages 173-202, 2006. It is also available as LEM working paper 2005/26.

Wage structure in Italian Business firms

This chapter aims at jointly considering some pieces of evidence regarding peculiarities of industries' structure which are often separately addressed. Italian business firms are known to be characterized by a high proportion of small enterprises that also suffer "constraints to growth". We look at the interplay of variables accounting for size, productivity and labor cost, and also assess the relevance of organization structure in determining the structure of cost for wage. We start by exploring the wage-size effect in Italian manufacturing firms and investigate the extent to which such a trend is offset by a positive and counterbalancing relation linking together productivity and size. We investigate how size contributes to the wage differential within a firm on the earnings of distinct categories of employees. The empirical findings we present reveal that organizational structure matters in determining the wage cost structure of firms.