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Interfirm heterogeneity: nature, sources and consequences for industrial dynamics. An introduction

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1 Introduction

Contemporary economic analysis is largely subject to rather bizarre schizophrenic syndromes. On the one hand, over the last thirty years or so, macro theories have tried to squeeze the interpretation of whatever aggregate dynamics down to some sort of decision-theoretic framework in which the increasingly mythical “representative agent” was doing all the action. Whatever statistical properties of the time-series, being it productivity and GDP growth, fluctuations, employment, investment, had to be explained as the equilibrium outcome of some sophisticated inter-temporal maximization exercise by such an agent. Dynamic Stochastic General Equilibrium models are the dominant genre in this spirit. On the micro side largely the opposite has happened. Empirical analyses drawing upon an increasing ensemble of micro longitudinal datasets have powerfully highlighted the ubiquitous, large and persistent heterogeneity in all dimensions of business firms’ characteristics and dynamics one cared to look at.

This Special Section of *Industrial and Corporate Change* adds both to the statistical evidence on the various dimensions of micro heterogeneity and on the ways diverse interacting entities make up for more aggregate dynamic profiles in variables such as productivity, output, sales, employment and the like.

Granted that (and also on that much more evidence is needed), the investigation is bound to ask what drives persistent asymmetries in performances and heterogeneity in corporate characteristics. This is a second major domain of analysis to which several of the papers which follow significantly contribute.

Third, a set of tricky and difficult questions regards precisely the relationships between corporate characteristics, performances and their dynamics. There are here both empirical challenges and tangled theoretical issues. For example, can one rationalize such relationships in terms of some underlying general equilibrium, albeit of a rather weird kind? What would that add to our interpretation of the evidence? Or, conversely, should one understand it as far from equilibrium evolutionary dynamics? In any case, what drives such processes? What is the balance in it between idiosyncratic and mistake-ridden innovation, learning, adaptation, on the one hand, and environmental selection amongst competing firms, but also products, technologies, patterns of organization, behavioral rules, on the other?

Fourth, a crucial domain of analysis still at its infancy, concerns the investigation of the links “from micro to macro and back”, as Bartelsman (2010) in this issue puts it. A few of the questions in this domain concern broadly speaking aggregation issues, basically involving the mapping between the features and dynamics of whatever distribution (productivities, profitabilities, rates of growth and so on) and their averages. Other questions bear more direct normative implications. How does the “macro”, especially in terms of institutional conditions (e.g. in terms of effectiveness of competitive market selection, entry and exit conditions, labor hiring and firing rules, etc.), influence micro behaviors and performances?¹

The papers in this Special Section improve, we believe, our knowledge in all the foregoing domains. In order to set such advancements in context, let us briefly map out the broad contours of the state of the art in these areas of investigation.

¹Incidentally, note also that any answer to these questions is likely to bring our understanding of the political economy of different institutional set-ups much further than trying to answer questions like: how would an inter-temporally maximizing representative agent behave under institution x as compared to institution y ?

2 Heterogeneity wherever one looks

Thanks to massive infusions of micro-data (at plant and firm level levels) into economic investigation over the last 20 years, economists have begun to identify a few robust statistical properties characterizing industrial structures, their changes, and performance indicators such as corporate growth and profitability.

A first, extremely robust, stylized fact regards the quite wide variability in firm size. Throughout industrial history, across all countries and irrespectively of the size proxy adopted, one observes unimodal highly right-skewed firm size distribution resemble quite closely a Power Law² (within a large literature see Hart and Prais, 1956; Steindl, 1965; Bottazzi and Secchi, 2005; Bottazzi et al., 2006; Dosi, 2007). And skewness and large supports of the distributions themselves hold across all level of disaggregation. Independently of the precise form of the density function, the intuitive message is the coexistence of many relatively small firms with quite a few very large ones. In turn, of course, the robustness of this finding militates against any naive notion of optimal size and against any theory of production centered around some invariant U-shaped cost curve.

Moreover, a recent body of finer sectoral investigations suggests that sectoral firm size distributions (say at three digit level) are highly diverse in terms of shape: some sectors presents distributions rather similar to the aggregate one, others are unimodal but symmetric and yet others are bimodal or even multi-modal (cfr. for few examples Bottazzi et al., 2006).

All this evidence taken together, corroborating a conjecture put forward in Dosi et al. (1995), hints at the fact that near-paretian aggregate distribution may well be a puzzling outcome of sheer aggregation among firms belonging to different sectors characterized by different regimes of market interactions and of organizational and technological learning.

A somewhat similar message is conveyed by the empirical investigations regarding concentration ratios: confirming the older findings in Schmalensee (1989) (and also the inter country comparison in Pryor (1972)) remarkable intersectoral differences are found in concentration ratios which, in turn, do not appear to be correlated with (sectoral) average firm size (cfr. Bottazzi et al., 2006).

Firm size distributions and their properties are by definition the outcome of the growth dynamics undergone by every firms in the industrial population together of course with entry and exit processes.³

It is handy to start the analysis of the statistical properties of firm growth by mean of a simple phenomenological model based on the classical Gibrat (1931). Let s_t be the logarithm of firm size at time t . The simple integrated process $s_t = s_{t-1} + \epsilon$ with *iid* shocks, known as the “law of proportionate effects” has been shown to yield a fairly good first order description of the observed dynamics of firm size (in a vast literature see Mansfield, 1962; Kumar, 1985; Hall, 1987; Sutton, 1997; Lotti et al., 2003; Bottazzi and Secchi, 2003).

There are, however, significant deviations from this simple statistical benchmark. To synthetically account for them Bottazzi et al. (2010c) introduce a generalization of the original specification

$$s_t - s_{t-1} = c + \lambda s_{t-1} + \sigma(s_{t-1})\epsilon_t, \quad (1)$$

where λ captures the autoregressive component in firm’s size, σ is a function describing the heteroskedastic structure of the process while ϵ is a growth shock assumed independent from size. This extended framework allows to discuss the most relevant deviations from the benchmark represented by the “Law of Proportionate Effects”.

²A Power Law distribution is a relationship of the type: $Pr(X > x) = ax^{-b}$ where $Pr(X > x)$ is the probability that a random variable X is greater than x , and a and b are constants.

³The discussion which follows will not address explicitly the stylized facts on entry and exit dynamics. A fairly recent survey on the issue is Bartelsman et al. (2005).

First, in the vast majority of empirical investigations on firm and plant level data λ has been found to be negative, suggesting that smaller (surviving) firms grow faster than larger ones (see Lotti et al., 2003, for an in-depth review of the empirical literature). Moreover, the relationship between size and growth is modulated by the age of firms themselves with age exerting negative effects on growth rates but positive on survival probabilities, at least beyond some post-infancy threshold (Evans, 1987).

Additional precious clues on the basic properties of the process of corporate growth are captured by the function σ which describes the dependence of the standard deviation of growth shocks on size. Since the early insights in Hymer and Pashigian (1962) a quite robust evidence shows that smaller firms experience more volatile growth patterns. This evidence has been recently refined showing that this relation robustly displays an exponential shape, with an exponent approximately equal to -0.2 , in variety of different databases (cfr. Amaral et al. (1997); Bottazzi and Secchi (2003) on US Compustat data, Bottazzi et al. (2001) on the international pharmaceutical industry and Bottazzi et al. (2010c) on a sample of limited Italian firms). A plausible interpretation of this stylized fact, put forward in Bottazzi and Secchi (2006b), is that the variance-scale relation is essentially a diversification-scale relation: business firms grow by both expanding within their incumbent lines of business and by diversifying into new ones. If market dynamics across activities are not perfectly correlated and if size goes together with an increasing number of lines of business in which a firm operate, then one should expect a lower variance of growth for bigger firm sizes. In turn, this diversification dynamics can be interpreted in terms of a branching process which appears intuitively consistent with a capability-driven pattern of diversification where the expansion into new activities build incrementally upon the knowledge and the complementary assets accumulated within the existing ones (see Teece et al., 1994, on the ensuing “coherence” in the diversification profiles).

Finally the extended model of firm dynamics in equation (1) suggests that other important features of the growth patterns of business firms might be found in the statistical properties of the growth shocks ϵ , i.e. of the firm growth rates $s_t - s_{t-1}$ once the autoregressive component and the heteroskedastic structure have been taken into account. Since the pioneer investigations in Stanley et al. (1996) the evidence suggests an extremely robust stylized fact: the distribution of firm growth rates is characterized by tails fatter than in the Gaussian case and it is, in general, well approximated by the Laplace or by others distributions, like the Exponential Power, which posses an even fatter tail behavior. This property is among the most robust in the industrial organization literature: it holds across different levels of disaggregation, across countries and using different size proxies, even if one observes some diversity in shapes emerging across finer sectoral disaggregation (see Stanley et al. (1996); Bottazzi and Secchi (2003) on US Compustat data, Bottazzi et al. (2001) on the international pharmaceutical industry, Bottazzi et al. (2006) on Italian manufacturing industry and Bottazzi et al. (2010a) on the French manufacturing industry).

Such statistical property of growth rates - the generalized presence of fat tails in their distribution - implies the presence of much more structure in the growth dynamics than generally assumed. More specifically, ubiquitous fat tails are a sign of some underlying correlating mechanism which one would not observe if growth events were small and independent. In Bottazzi et al. (2006) and Dosi (2007) one puts forward the conjecture that such mechanisms are likely to be of two types. First, it seems plausible that the very process of competition induces correlation: a firm’s gain in market share is some other firms’ loss. Second, one could naturally expect “lumpy” growth events due to introduction of new products, the construction or closure of plants, entry/exit of firms in/from a particular market. In this vein, Bottazzi and Secchi (2006a) attempt to model an increasing returns dynamics able to reproduce the observed fat-tailed distribution.

A final important piece of evidence on the structure of firm growth processes concerns the possible autocorrelation over time of growth rates. A caveat is required. The investigation of this aspect

of the growth process would require time series long enough to describe the properties of the sample path of each firm on the ground of the possibility that the evolutionary pattern of each firm may be specific to each entity in its interaction with the population of other firms with which it competes in that particular market in those particular times. Very often the available evidence falls well short of that. Interestingly, in an industry for which one has reasonable longitudinal panel data at different level of disaggregation, the international drug industry, one does find robust autocorrelation structures up to the 7th lag (Bottazzi et al., 2001). In other investigations, pooling together firms belonging to the same (two or three digit) industrial sector, the autocorrelation structures in the growth dynamics appears to be weakened due to the aggregation of several different line of business each characterized by its own autoregressive profile (Bottazzi and Secchi, 2003; Bottazzi et al., 2006; Coad, 2007). However, using bootstrap techniques Bottazzi et al. (2002) tend to confirm that there are systematic but idiosyncratic differences in autocorrelation structures, which are not captured by sectoral “average” autoregressive coefficients.

Together with growth in market shares, profitability is another crucial measure of revealed corporate performances. Irrespectively of diverse empirical proxies for profitability⁴ two robust finding have clearly emerged in the last three decades. First, the extent of the observed heterogeneity in profitabilities is wide irrespectively of the level of disaggregation considered: in the same sector co-exist firms with large profit margins with firms incurring substantial losses (cfr. the recent evidence on two different samples of Italian firms in Bottazzi et al., 2008; Grazzi, 2009). Second, given such a piece of evidence, a crucial issue regards the persistence of such differentials. Indeed a low persistence could simply mean that capitalism involves daring and heroic efforts by multitudes of firms which happen to make many mistakes as well as reap huge rewards, with markets there to help and quickly redress individual mistakes and wash away abnormal rents. It turns out that this view does not quite match the evidence. There is, on the contrary, a quite wide literature on the *persistence* of profitability differences across firms, with extremely high autocorrelation over time in profitabilities even at very narrow levels of disaggregation (cfr. Muller, 1986; Cubbin and Geroski, 1987; Geroski and Jacquemin, 1988; Muller, 1990; Goddard and Wilson, 1999; Cefis, 2003; Gschwandtner, 2004; Dosi, 2007).

Summing up, we believe that there are two main messages coming from all the foregoing empirical evidence.

First, there is a rich statistical structure in the dynamics of business firms and industries that goes well beyond the ones identified simply focusing on average relations between corporate performance and corporate characteristics. Moreover, this revealed structure in the stochastic process describing industrial evolution bears clear signs common to all complex system dynamics including the fat-tailed distributions in the rates of changes of all the variable of interest. That, in turn, is likely to witness for the existence of some underlying correlation mechanism, which makes the system self-organized in its growth process. In these respects, all the evidence on industrial change corroborates the exciting conjecture that evolutionary phenomena tend to undergo non-gaussian lives influenced by persistent positive or negative interactions among agents within and across the relevant populations.

Second, the two key indicators of corporate performance , growth and profitability, reveal a widespread and profound heterogeneity across firms that persist over time notwithstanding the competition process. All this brings naturally the attention to the sources of such heterogeneities.

⁴Among the most common we find ROS (Gross Operating Margins over Total Sales), ROI (Return on Investment) and a variety of other proxies capturing also results from extra operational activities such as financial and tax policies.

3 Behind heterogeneous performances: heterogeneous productivities, capabilities to innovate and organizational set-ups

The most plausible candidates for the explanation of the widespread and persistent heterogeneity in firm performances discussed in the previous section are, with little doubt, to be found in the diverse efficiencies with which firms turn input into output (i.e. different productivities) and in the (price-weighted) characteristics of outputs themselves. However, notwithstanding the relative simplicity of the concept, measuring productivity has shown to be not an easy task. As known, in the literature one finds two basic types of productivity measures, namely single factor and multi factor indexes. The former include ratios of some measures of output (total sales or value added) over the number of employees or, better, of worked hours. These single-factor measures do not require any assumption on the existence and form of underlying production functions but have the drawbacks of being affected by the intensity of use of the excluded inputs. Conversely, in order to overcome this limitation, many researchers willing to make many far from innocent assumptions on the form of the production function itself - including the absence of complementarities among production inputs and many others - have resorted to a multifactor productivity measures. This is not the place to discuss in details pros and cons of the choice between single and multi factor productivity measures (cfr. Dosi and Nelson, 2010; Dosi and Grazzi, 2006; Hulten, 2000, for discussion of different approaches underlying the choice). Here let us just warn the reader that, since data on output quantities are usually not available, almost any productivity measure used in the literature we are going to briefly review below will be a revenue-based measure, hence representing an accurate productivity index only in those cases where product quality differences are fully reflected in prices.

In any case, irrespectively of the proxy for productivity and of the highly diverse countries analyzed few, unambiguous results have emerged.

First of all, at any level of disaggregation we observe widespread differences in productivities which tend to persist over time. Moreover, higher productivity tend to be associated with higher survival probabilities. Hence, also at the level of input efficiencies the general picture is characterized by general, profound and persistent heterogeneity across plants and firms.

Before discussing, in the next section, if, how and on what time scales heterogeneous “identities” affect performances, let us try to offer a telegraphic overview of the main determinants of the persistent heterogeneity in productivities identified in the last decades by the empirical literature. A complete review of the full range of candidates to explain productivity dispersion clearly goes far beyond the scope of this introduction (more in Nelson, 1981; Dosi and Nelson, 2010; Syverson, 2010). Here let us briefly recall three groups of factors that repeatedly appear in the interpretations of why firms display so diverse productivities, namely the quality of inputs, the R&D and innovation strategies and idiosyncratic organizational capabilities.

Characteristics of the workforce, management and capital inputs

As one might expect productivity appears to be positively correlated with the quality of labor as captured by personal characteristics of workers such as education, experience, training (Abowd et al., 2005; Fox and Smeets, 2010). Moreover, similar evidence has recently emerged on the impact of managerial practices on productivity. Bloom and Van Reenen (2007) document that higher “quality” management practices are positively correlated with various proxies of productivity, and the same seems to hold for “quality” of management itself (cfr. for example Shearer, 2004).

Together, as a good deal of technological advances is capital-embodied, other things being equal, one should expect firm’s productivities to depend on the vintage distribution of its capital equipment.

That was also the conjecture put forward decades ago by Salter (1966). Unfortunately, the scarcity of data has largely prevented so far much empirical advance in this area. And similar considerations largely apply also to the role of intangible assets. On the contrary, over the last decade scholars have learned a great deal about the impact of that particular type of capital embodying various forms of ICT. Indeed information and communication technologies have shown to play an important role in accounting for the boom of productivity in the US in the last twenty years (Jorgenson et al., 2008) and, furthermore, the delay in their adoption seems also to have contributed to a European productivity gap vis-à-vis the USA (Van Ark et al., 2008).⁵

A recent literature has started to use micro-data in order to illuminate the impact of ICT technologies at the firm or even at the worker level. Brynjolfsson and Hitt (2000) review the two main strands of these micro-studies. First, a case-based literature provides evidence that the impact of ICT at the firm level goes together with changes in organizational practices, such as changes in authority relationships, decentralization of local decisions, shifts in task content and/or changes in reward schemes. Many of these studies (see for instance Brynjolfsson et al., 1997) show, however, that in the face of changes in organizational practice, many workers still remain trapped in old work practices. Inertial forces are at work, which explain the inability of firms to instantaneously exploit the potential of new technologies. Second, an econometric literature has also emerged, using large scale data recently becoming available from official sources. Pilat (2004) provides an overview of these studies, available now for many countries. Let us briefly summarize the main results.

First, most of them find a positive relation between level of ICT and firm productivity. (Note that this is a correlation, more work needs to be done in understanding causality linkages).

Second, the evidence points at different factors moderating the impact of ICT at firm level, including the co-occurrence of matching skills of the workforce, appropriate organizational practice and other forms of organizational and technological innovation. Moreover, the size and age of the firm seem to influence the impact of ICT adoption upon productivity.

Third, while improvements in IT technology tend to be quickly available throughout the economy, the complementary organizational changes at the firm level rely on a process of 'co-invention' by individual firms (Bresnahan and Trajtenberg, 1995) suggesting co-evolutionary processes combining the adoption of information technology with complementary organizational changes and innovation in the form of new products and services (Bresnahan et al., 2002). Conversely there is some evidence that the sheer adoption of ICT without corresponding changes in organizational practices might be simply detrimental for the company. It is the combination of the three changes mentioned above that can drive productivity gains.

Fourth, some econometric works (cfr. Brynjolfsson and Hitt, 2000; Greenan et al., 2001, for US and France respectively) have used fixed effects models to estimate the impact of ICT on productivity in order to capture firm-specific determinants. The estimates controlling for fixed effects are substantially lower and indicate that much of the ability of firms to exploit gains from ICT relates to intrinsic pre-existent organizational somewhat capabilities.

Bartelsman and Doms (2000) also discuss insights coming from micro studies on the relationship between productivity and advanced technology. Use of the latest technology turns out to be highly correlated with other variables (such as human capital). A study by Doms et al. (1997) shows that plants that had above average productivity because of ICT, also had the same before the introduction of ICT because they consistently were the ones choosing the most advanced technologies. In this sense, also under an ICT-centered regime of technological change asymmetries across firms are the rule: some firms show a much higher performance and persistently so. In turn, this can easily

⁵How big has been the gap and how much it is due to difference in ICT diffusion as compared to differences in the sectoral composition of output is, however, an issue beyond the scope of this introduction.

be interpreted as an evolutionary story of path-dependence and persistent performance differentials among firms.

Faggio et al. (2010), in the present issue, add new evidence on the nature of the tie between ICT and productivity dispersion. Using a new panel of UK firms from both manufacturing and service sector they show that the observed increase in the wage dispersion, within groups of workers homogeneous in terms of experience, gender and skills, has been accompanied by an equally strong rise in productivity inequality among firms within the same industries. What matters most for the present discussion is that they reveal that those industries which adopted ICT more intensively are also those experiencing the highest increase in productivity dispersion.

Characteristics of R&D and innovation strategies

A second important set of plausible determinants of productivity dispersion regards R&D and innovation strategies. For the most part, the empirical literature in this domain has focused on the link between R&D expenditures and the residual part of firms productivity not accounted by other inputs, under the implicit assumption that this residual is the outcome of technical change induced by research and development efforts. Also in this case, despite the many measurement and econometric issues involved, a common result has emerged: elasticities of productivity to R&D expenditures are positive and rather large in most of the countries and sectors investigated and they are in general larger than those to ordinary capital (a complete review of the results on this issue is Hall et al., 2010).

Of course, R&D is only one, and in quite a few sectors not the most relevant aspect, of the firm overall innovative efforts. However, whether or not innovative search is undertaken via formal R&D activities, a crucial component, likely to impact on the observed dispersion of productivity levels, is to be found in the wide differences in the ability of firms to innovate and to adopt product and process innovation developed elsewhere. It should come as no surprise, at this point of the discussion, that also regarding firms' innovation strategies and outcomes the literature has identified wide and persistent heterogeneity (cfr. among many others Freeman, 1982; Dosi and Nelson, 2010). Innovative capabilities appear to be highly asymmetric with a rather small number of firm responsible of a good deal of innovation output, irrespectively of the country or of the sector analyzed.

These differential degrees of innovativeness are generally persistent over time, often revealing a small core of systematic innovators (Cefis, 2003). Relatedly, while the arrivals of major innovations are rare events, they are not independently distributed across firms: rather recent evidence suggest they tend to arrive in firm-specific chunks of different sizes (Bottazzi et al., 2001).

Similar considerations apply to the adoption of process innovations as robustly revealed by the major stylized facts on diffusion already reported by the early classic investigations including Griliches (1957); Mansfield (1961); Nasbeth and Rey (1974); Rosenberg (1972, 1976). Telegraphically, diffusion is a time consuming process, whose speed varies widely across technologies and across countries. A good percentage of innovations never diffuses but when they do the diffusive processes follow S-shaped asymmetric profiles. This evidence is well in tune with the presence of ubiquitous heterogeneity among would-be adopters on nearly every dimension which one may think of as influencing adoption ranging from sheer size all the way to different absorptive capacities (Cohen and Levinthal, 1990) and abilities to use new techniques and pieces of equipment.

Diverse organizational capabilities

The quality of the inputs, we suggest, does not exhaust the interpretation, paraphrasing Nelson (1981), of why firms differ and how does it matter, while, at the same time, the differences in innova-

tiveness, broadly defined, demand themselves an explanation. Here it is where the analysis of determinants of heterogeneous corporate performances links with a growing body of research addressing the nature and dynamics of *organizational capabilities* (more in Dosi et al., 2008, 2000; Levinthal, 2000; Montgomery, 1995; Teece et al., 1997; Winter, 2003). Such capabilities are grounded in those particular forms of organizational knowledge that account for organization's ability to perform and extend its characteristic "output" actions - particularly the creation of a tangible product or the provision of a service and the development of new products and services. In turns these capabilities involve to a good extent ensembles of organizational routines which account for the problem-solving abilities of the organization (Dosi et al., 2000).

The crucial research question here is the identification of robust and *non-tautological* proxies for capabilities.⁶ While the search is far from over researchers are painstakingly pointing at an increasing number of (often sector-specific) indicators of capabilities (see for example Baldwin and Johnson, 2001; Argote and Darr, 2000; Henderson and Cockburn, 2000; Pisano, 2000)

Firm characteristics and export performances

An important consequence, and probably also cause, of heterogeneous productivities are diverse export performances. The issue has received a great deal of empirical attention after the theoretical contributions by Eaton and Kortum (2002) and Melitz (2003) which attempt to formalize the link between firms with heterogeneous productivities and their international trade involvement. Several investigations have documented a strong positive correlation between productivity levels and trade exposure suggesting that exporters are almost always more productive than their non-exporter competitors (cfr. the reviews in Wagner, 2007; Greenaway and Kneller, 2007). That is, the vast majority of these studies support the idea that already more productive firms self-select themselves to access international markets (this is usually called the "self-selection into export" hypothesis: cfr. among many others Roberts and Tybout, 1997; Bernard and Jensen, 1999). On the other hand, some studies have found (less robust) support to the idea that firms increase their productivity after and because they start to export, through a sort of learning-by-exporting process which lead to subsequent improvements of their efficiencies (two examples are in Van Biesebroeck, 2005; De Loecker, 2007).

The relation between international exposure and productivity has been studied also in the older stream of literature analyzing the process of economic growth and development and, in particular, the process of productivity catching-up of "lagging behind" countries (Gerschenkron, 1962; Dosi et al., 1990; Fagerberg, 1994). Traditionally the studies in this field have been focusing on aggregate units (such as countries, regions or at best sectors) neglecting the widespread firm heterogeneity and its impact on economic development largely due to lack of appropriate data. The explosion in the availability of micro evidence has substantially refocused the attention to sectors and firms(plants). Within the latter literature relying on multi-country micro data Bartelsman et al. (2008) build measures of global and national technological frontiers and firms' distance from them highlighting the frequent possibility that firms characterized by big technology gaps vis-à-vis the international frontiers might well not be able to have a grasp of it and incrementally learn. However, even when this is the case Iacovone and Crespi (2010) find below on the ground of a large panel of Mexican manufacturing plants that learning just the domestic "best practice" might be somewhat easier. They explore the relative effect of internal R&D and export exposure upon catching-up with both the domestic and "global" frontiers. Not so surprisingly Mexican plants are much faster in catching-up vis-à-vis national technological best practice rather than with global one. Much more interestingly they provide evidence supporting the idea that plants making larger technological efforts, in terms of R&D

⁶Obvious tautological measures are of course those performances that one tries to explain by means of organizational capabilities themselves

and technology transfers, tend to catch up much faster to the global frontier but the same does not apply to catching-up to the domestic one. Conversely, increasing exposure to trade allows Mexican firms appears to speed up the adoption of best domestic technological practices but it does not affect to the same extent the convergence with the global technological frontier.

A final important point. Most often the determinants of differential efficiencies discussed above do not operate in insulation. Rather various complementarities are the norm. We have already mentioned the findings on the complementarities between ICT adoption and organizational change. Another example of such interactions is presented in Ito and Lechevalier (2010), below. Using a large Japanese administrative survey the authors show that innovation and exporting strategies are characterized by strong complementarities which define coherent productive models and patterns of learning. In turn, diverse combinations of innovation and export strategies affect persistently firms' productivities and survival probabilities.

4 Selection vs Adaptation and Idiosyncratic Learning

Different productivities, organizational setups, propensities to innovate and behaviors make up the distinct corporate identities which in turn should somehow influence firms' performances. A crucial empirical issue concerns the ways and the extent to which such influences actually operate.

Let us consider first the impact of different productivities upon profitability, growth, and survival probabilities.

Mainly North American evidence, mostly at plant level, does suggest increasing output shares in high-productivity plants and decreasing shares of output in low-productivity ones as drivers in the growth of average sectoral productivities, even if the process of displacement of lower efficiency plants is rather slow (Baily et al., 1992; Baldwin, 1998; Ahn, 2001; Baldwin and Gu, 2006).

In complementary efforts, a growing number of scholars has indeed began doing precisely what we could call evolutionary accounting (even if most do not call it that way; however for an early example of the genre, cfr. Nelson and Winter, 1982). The fundamental evolutionary idea is that productivity distributions change as a result of learning by incumbent entities, differential growth (i.e., a form of selection) of incumbent entities themselves, death (indeed, a different and more radical form of selection), and entry of new entities. Favored by the growing availability of micro longitudinal panel data, an emerging line of research (cfr. Olley and Pakes, 1996; Foster et al., 2001; Bottazzi et al., 2010c, and the discussion in Bartelsman and Doms (2000)) investigates the properties of such decompositions, identifying the contribution to productivity growth of (i) firm-specific changes holding shares constant (sometimes called the *within* component), (ii) the changes in the shares themselves, holding initial firm productivity levels constant (also known as the *between* component), (iii) entry and (iv) exit. Of course, there is a considerable variation in the evidence depending on countries, industries and methods of analysis. However, some patterns emerge.

First, the within component generally is significantly larger than the between one: putting it another way improvement of productivity by existing firms dominates upon selection across firms as a mode of industry advancement at least concerning productivity (both labor and TPF). This emerges both from the foregoing evolutionary accounting exercises and from estimates of the relationship between efficiency and subsequent growth, allowing for firm fixed effects. Using data for France and Italy Bottazzi et al. (2010b), below, show that, in both countries, firms identified as more productive tend also to be more profitable than other firms. The impact on growth is, instead, much less clear-cut. Both Italian and French data (cfr. again Bottazzi et al., 2010b, in the present issue) show a weak or nonexistent relationship between relative (labor) productivities and growth: more efficient firms do not grow more. Moreover even when some positive relation between efficiency and growth

appears, this is almost exclusively due to the impact of few outliers (the very best and the very worst). And, this holds in both the short and the medium term. So, for example, in the analyses of Bottazzi et al. (2010c) on Italy and France, firm-specific factors generally account for almost an order of magnitude more than selection in the explained part of the variance in firm growth rates.

Second, relative efficiencies do influence survival probabilities, and it may well turn out that selective mechanisms across the population of firms operate much more effectively in the medium/long term at this level rather than in terms of varying shares over the total industry output.

In any case, the foregoing patterns hint at a sort of a puzzle, awaiting further research, in that such statistical evidence appears to be somewhat at odds with more qualitative reconstructions of industrial evolution whereby improvements in productivity (and in product characteristics), as induced by technological and organizational advances appear to be at the center of competitive advantages and ultimately a crucial driver toward corporate leadership: cfr. among others Dosi (1984) on semi-conductors and Murmann (2003) on chemicals.

We have focused so far upon the linkages between admittedly rough proxies for productivity, on the one hand, and growth and survival, on the other. What about the relationships between profitability and the latter two variables? The evidence we are familiar with strikingly shows little or no link between profitability and firm growth of incumbents (cfr. again Bottazzi et al., 2010c, on Italian and French longitudinal data). However, other pieces of evidence suggest also systematic effects of profitability upon survival probabilities (cfr. the discussion in Bartelsman and Doms, 2000; Foster et al., 2008).

Certainly, there are other determinants of differential growth which have been neglected so far, largely due to lack of appropriate data. One ensemble of variables regards product characteristics which in market generally characterized by product differentiation (of both the “horizontal” and “vertical” kinds) ought to bear important consequences in terms of the growth potential of each firm. Another set of variables concerns the organizational characteristics and strategic orientations of firms themselves. In this respect, the evidence presented in Seo et al. (2010) in this volume highlights the importance of organizational forms (e.g. being a conglomerate or not) and ownership (e.g. state-owned or not) in terms of differential value of the firms. However, interestingly, there appear to be no unequivocally superior set-up. A lot seems to be contingent on the historical periods and on the stage of development.

The implications of all the empirical regularities identified so far are far-reaching. Certainly, the recurrent evidence at all levels of observation of interfirm heterogeneity and its persistence over time is well in tune with an evolutionary notion of idiosyncratic learning, innovation (or lack of it) and adaptation. Heterogeneous firms compete with each other and, given (possibly firm-specific or location-specific) input and output prices, obtain different returns. Putting it in a different language, they obtain different quasi-rents or, conversely, losses above/below the notional pure competition profit rates. Many firms enter, a roughly equivalent number of firms exits. In all that, the evidence increasingly reveals a rich structure in the processes of learning, competition and growth.

As mentioned, various mechanisms of correlation, together with the sunkness and indivisibilities of many technological events and investment decisions, yield a rather structured process of change in most variable of interest, for example size, productivity, profitability, also revealed by the fat-tailedness of the respective growth rates.

At the same time, market selection among firms - the other central mechanism at work together with firm-specific learning in evolutionary interpretations of economic change - does not seem to be particularly powerful, at least on the yearly or multi-yearly time scale at which statistics are reported. Conversely, diverse degrees of efficiencies seem to yield primarily relatively persistent profitability differentials. That is, contemporary markets do not appear to be too effective selectors delivering rewards and punishments in terms of relative sizes or shares, no matter how measured, according

to differential efficiencies. Moreover, the absence of any strong relationship between profitability and growth militates against the naively Schumpeterian notion that profits feed growth (by plausibly feeding investments).

Selection among different variants of a technology, different vintages of equipment, different lines of production does occur and is a major driver of industrial dynamics. However, it seems to occur to a good extent within firms, driven by the implementation of better processes of production and the abandonment of older less productive ones.

Finally, the same evidence appears to run against the conjecture, put forward in the 1960s and 1970s by the managerial theories of the firm on a tradeoff between profitability and growth with managerialized firms trying to maximize growth subject to a minimum profit constraint.

In turn, the (still tentative) observation that market selection that winnows directly on firms may play less of a role than that assumed in many models of evolutionary inspiration (Nelson and Winter, 1982; Winter, 1984; Silverberg and Lehnert, 1993; Dosi et al., 1994a, 1995, 2006; Iwai, 1984a,b; Silverberg and Verspagen, 1996; Malerba et al., 1999; Bottazzi et al., 2001) demands further advances in the understanding of how markets work (or do not), and of the structure of demand (see the discussion in Nelson, 1991, 2008).

First, one measures productivity, supposedly a driver of differential selection, very imperfectly: we have mentioned above that one ought to disentangle the price component of value added (and thus the price effects upon competitiveness) from physical efficiency to which productivity strictly speaking refers. This applies to homogeneous products and even more so when products differ in their characteristics and performances: as this is often the case in modern industries, one ought to explicitly account for the impact of the latter upon competitiveness and revealed selection processes.

Second, but relatedly, the notion of sharp boundaries between industries and generalized competition within them is too heroic to hold. It is more fruitful in many industries to think of different submarket of different sizes as the locus of competition Sutton (1998). The characteristics and size of such submarkets offer also different constraints and opportunities for corporate growth. Ferrari and Fiat operate in different submarkets, face different growth opportunities and do not compete with each other. However, the example is interesting also in another respect: Fiat can grow, as it actually happened, by acquiring Ferrari.

Third, a growing microevidence highlights the intertwining between technological and organizational factors as determinants of Schumpeterian competition: Bresnahan et al. (2008) illustrate the point in the case of IBM and Microsoft facing the introduction of the PC and the browser, respectively. Both firms, the work shows, faced organizational diseconomies of scope precisely in the corporate activities where they were stronger.

Fourth, in any case, the links between efficiency and innovation, on the one hand, and corporate growth, on the other, are mediated by large degrees of behavioral freedom, in terms, for example, of propensities to invest, export, expand abroad; pricing strategies; patterns of diversification.

The other side of the process of “creative destruction” generated by industrial dynamics involving entry, exit and ever-changing market shares is a continuous process of job creation, destruction and relocation. Since the seminal works of John C. Haltiwanger and Steven Davis, at the beginning of 90s, an increasing attention has been devoted to the processes of job creation and job destruction which are pervasive in all capitalist economies. All the investigations in this tradition document the impressive amplitude of labour flows in and out and also the role of the idiosyncratic firm characteristics in explaining the emergence and the persistence of such job and worker flows (cfr. among many others Davis and Haltiwanger, 1992; Davis et al., 1996; Davis and Haltiwanger, 1999).

However, the analyses in this stream of literature are often ridden with problems regarding the definitions of the variables which might severely limit the comparisons across countries (for two exceptions see Haltiwanger et al., 2008; Wolfers, 2009). Bassanini (2010) in this volume offers

an attempt to overcome these difficulties exploiting a unique database built with homogeneously defined variables and under the same collection protocols. On the ground of this higher quality data, the paper confirms that firm characteristics such as industry, age and size are key factors in shaping gross job flows in all countries. Further, even after controlling for these idiosyncratic factors, cross countries differences appear large especially comparing US and UK with many continental European countries. Broad, country-specific, institutional arrangements do significantly modulate the processes of labour creation, relocation and destruction. The paper offers also further insight into the link between gross job flows and productivity. These investigations are the complement of the “evolutionary decomposition” mentioned above, seen in terms of labour relocation and churning - generally associated with relatively high flows of job creation and destruction. Inside this micro turbulence Bassanini (2010) also shows a basic asymmetry: in most of the countries, inefficient firms tend to destroy more jobs during contractions while, on the contrary, during expansions firms with higher productivity display relatively smaller rates of employment growth.

“Restless capitalism”, as Metcalfe puts it, entails persistent (mistake-ridden) learning and innovation by a (changing) population of heterogeneous firms, whose interactions also shape their opportunities, constraints and ultimately their fate in terms of survival. Together, the whole process leaves varying amount of “disruption” along the way, including, of course, labour disruption. Only recently researchers have begun to analyze in detail such processes, even if important advances in our understanding have already been achieved. And the works which follow importantly contribute to it.

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