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Productivity Growth Persistence: Firm Strategies, Size and System Properties

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ABSTRACT.

This paper investigates the dynamics of productivity in a large sample of Italian manufacturing firms, focusing on the determinants of firm-level persistence in time of high Total Factor Productivity (TFP) growth rates relative to the corresponding sectoral distributions. In particular, we assess the impact of both the internal characteristics of companies, including size and management strategies, and external systemic conditions, including business cycles and regional innovation performance. In order to disentangle the effects of the mix of internal and systemic factors in shaping firm-level persistence, we implement both Transition Probability Matrices and dynamic probit models. Results reveal the presence of significant persistence in TFP growth rates. Such persistence turns out to be path dependent since it is shaped by a number of complementary and contingent factors that locally affect the dynamics of the process.

KEYWORDS: PRODUCTIVITY; PERSISTENCE; DYNAMIC CAPABILITIES, PATH DEPENDENCE; TFP, EMERGENT SYSTEM PROPERTIES.
JEL CODES: O31, C23, C25, L20, M20

1. Introduction

Over the past few decades a broad range of research activities has been dedicated to the study of productivity growth and its sources. Traditionally, empirical analyses were based on macro or industry-level aggregate data. More recently, a large number of studies, based on micro data, has been produced also due to the increasing availability of firm level data (for extensive reviews, see Bartelsman and Doms, 2000; Ahn, 2000; Foster et al., 2001; Syverson, 2011; Mohnen and Hall, 2013). The discovery of ubiquitous, extensive, and persistent productivity differences has shaped research agendas in a number of fields. Macroeconomists decompose aggregate productivity growth into various micro-components with the aim of providing a better understanding of the sources of this growth. Models of economic fluctuations driven by productivity shocks are increasingly being enriched to account for micro-level patterns and are estimated and tested using plant or firm level productivity data (Bartelsman et al., 2009). In this context it has been possible to analyse the differentiated role played by firms of different size groups in explaining aggregate patterns of productivity growth. This has led to recognize the contribution that SMEs may have in fostering productivity growth due to the process of creative destruction that they are able to engender (Hölzl, 2009; Henrekson and Johansson, 2010; Colombelli et al., 2014) and to their ability to creatively adapt existing technological knowledge to the conditions of local product and factor markets (Antonelli and Scellato, 2015).

Moreover, two important lessons have been learned from this extensive field of research. First, the level of productivity dispersion is extremely large, i.e. some firms are remarkably more efficient than others. Second, firms that are highly productive today are more than likely to be highly productive tomorrow. In other words, the literature has clearly pointed out the existence of a high degree of persistence in productivity differences across producers (Bartelsman and Doms, 2000; Syverson, 2011; Raymond et al., 2013).

The identification of such high and yet persistent productivity dispersion across producers has led to the emergence of a huge amount of empirical literature that attempts to explain the sources of these productivity patterns. This evidence casts major doubts on and raises substantial criticism to the new growth theory according to which the rates of productivity growth and of the introduction of technological innovations should be homogeneous across firms that belong to the same system (Aghion and Howitt, 1997). The relevance of this empirical evidence and its theoretical implications has led to the identification of a number of factors that could determine systematic differences in the productivity performances of producers, including the role of innovative activities and the diffusion of ICTs (Griliches, 1979; Brynjolfsson and Hitt, 2000; Crépon, Duguet and Mairesse, 1998; Faggio et al., 2009 Raymond et al. 2013). Among firm specific characteristics that are capable of affecting the productivity growth of producers, particular attention has been devoted to assessing the impact of human capital and the quality of management practices on different measures of productivity and firm performance (for recent contributions, see McEvily and Chakravarthy, 2002; Ilmakunnas et al., 2004; Galindo-Rueda and Haskel, 2005; Bou and Satorra, 2007; Bloom and Van Reenen, 2007 and 2010). In this context of analysis, the presence of persistent patterns of above average productivity growth at the firm level can be interpreted as the result of the capability of firms to exploit dynamic capabilities to sustain competitive advantages as highlighted by management studies (Teece and Pisano, 1994; Verona and Ravasi, 2003; Teece, 2007; Vergne and Durand, 2011). In particular, building on recent developments in the economics of innovation that have paid attention to the analysis of innovation persistence (Malerba et al., 1997; Cefis, 2003; Peters, 2008; Roper and Dundas, 2008; Antonelli et al., 2012, 2013), it can be claimed that the repeated interactions between the accumulation of knowledge and the creation of routines to valorize and exploit it within the same organization may lead to the creation of dynamic capabilities that favour the systematic realization of above average productivity performances (Nelson and Winter 1982; Rothaermel and Hess 2007; Verona and Ravasi, 2003). This framework emphasizes that the past has a significant impact on current and future performances. However, the dynamic capabilities approach recognizes that a business enterprise is shaped but not necessarily trapped by its past. Management strategies can make big differences through investment choices and other decisions. Hence, the role of knowledge cumulativeness and the relevance of strategic decisions to leverage internal and external knowledge is considered to be crucial in shaping path-dependent dynamics of productivity growth (Antonelli et al., 2013; Crespi and Scellato, 2014).

Moreover, in the present study, we investigate the potential role of size as another important firm level characteristic capable of shaping persistent patterns of productivity growth. On the one hand, large corporations may have an advantage in sustaining higher performances in terms of productivity growth for longer time spans due to their superior ability to invest in R&D activities and benefit from high levels of cumulated knowledge (Chandler, 1977, 1990). On the other, persistency patterns can be independent of size as shown by the literature on 'gazelles' i.e. high-growth firms, where persistent abnormal sales or employment growth rates have been identified in subsets of companies belonging to all sizes classes (Henrekson and Johansson, 2010; Lopez-Garcia and Puente, 2012; Colombelli et al., 2014).

Finally, the proposed analysis aims to take into account the role played by system properties that shape the context in which the persistence of TFP growth occurs. In particular, the effects on persistency patterns played by the amount of knowledge externalities, the dynamics of market forces and the different types of sectoral systems are explored.

The empirical analysis is based on a large sample of Italian firms and follows a two-step empirical strategy consisting of a preliminary identification of persistence in total factor productivity growth through Transition Probability Matrices (TPMs) and an econometric analysis that aims to qualify the persistence of productivity growth as an emergent system property that depends on the combination of firms' characteristics and specific properties of the system in which the strategy of firms take place. The paper is structured as follows. The literature on persistence in productivity is reviewed in Section 2, the hypotheses and research design of this study are outlined in Section 3, empirical evidence is presented in Section 4 and the main results are summarized in the conclusions.

2. The persistence of productivity performances

Under the assumption of random productivity differences across producers, relative productivity would be uncorrelated from one period to another. There would be no persistence in productivity distribution and the TFP of a producer in one period would have no predictive power on the TFP in another period. However, empirical investigations have shown that there are large and persistent differences in productivity across plants and firms in the same industry (Bartelsman and Doms 2000). When analysing persistence in productivity, many studies have followed an approach based on transition probability matrices relative to plant/firm productivity distribution (see, for example, Baily et al., 1992 and Bartelsman and Dhrymes, 1998). The calculated transition matrices exhibit large diagonal and near-diagonal elements, indicating that producers that are high in the distribution in one period tend to continue to have a high rank in the distribution in subsequent periods.

Baily et al. (1992) ranked the plants in their sample regarding the 1972-1988 period according to their relative productivity for each year and divided them into quintiles. They then calculated a transition matrix that highlighted "an enormous amount of persistence in the productivity distribution". Of all the plants that were in the first quintile in 1972, a weighted 60.75 percent was again in the first quintile in 1977 and of all the plants that were in the first quintile in 1977, a weighted 52.89 percent of them had come from the first quintile in 1972. The persistence in the 10-year transitions was even stronger than that found for 5 years. More than 58 percent of the plants in the top quintile in 1972 were still in the top two quintiles in 1982. Bartelsman and Dhrymes (1998) found a similar high degree of persistence in productivity ranking through an examination of the behaviour of TFPs in selected industries over the 1972–1986 period in the USA. They showed, in particular, that about 60 percent of the plant-year observations did not move away by more than one decile from their previous rank. Moreover, they found that larger plants exhibited more stability and that the probability of staying close (one decile) to the previous position increased with age and size. They concluded that this evidence could have been the result of some form of "learning by doing" that may characterize the evolution of the productivity performance of plants.

More recently, Giannangeli and Gomez-Salvador (2008) have used annual account data over the 1993-2003 period for a balanced panel of manufacturing firms in a selected panel of five European countries. They have found a high degree of persistence of the relative efficiency of firms. Around 25% of firms in all countries considered in the analysis remained in the middle of the distribution, while more than half of the sample persistently remained at the top and bottom of the distribution. The authors concluded that the high persistence of relative productivity levels suggests that firm efficiency levels are structurally different from firm to firm.

As far as Italy is concerned, Bottazzi et al. (2008) have carried out an analysis based on a large panel of Italian firms active in both Manufacturing and Services, during the 1998-2003 period, which has confirmed the presence of a strong and positive correlation in productivity over time. Bottazzi and colleagues explored the links between the persistence in productivity and profitability and found that more efficient firms also tend to be more profitable.

Although these empirical investigations have shown that there are large and persistent differences in productivity levels across plants and firms, productivity growth rates have usually been found to exhibit an important transitory component. Baily et al. (1992) show clear evidence of regression to the mean effects in productivity growth regressions. Similarly, Bartelsman and Dhrymes (1998) detected a strong negative correlation between a plant's growth rate over a five-year period and its productivity growth over the previous five years. Giannangeli and Gomez-Salvador (2008), on the other hand, showed that when lagged productivity growth is included in the econometric model, it is positive and significant, thus indicating some persistence in labour productivity growth at the firm level.

Gerosky et al. (2003 and 2009) specifically investigated persistence in productivity growth. In the first paper, using a sample of 147 UK firms observed continuously for more than 30 years, they showed that growth rates are highly variable over time and that the differences in growth rates between firms do not persist for very long. This outcome was considered to be due to the random nature of the innovative activities of firms which translates into random shocks on productivity. Again, in the second paper, they found that, in general, individual firms do not outperform their peers for very long when stable firm characteristics, via firm fixed effects, are accounted for. However, the analysis showed that the few instances of sustained productivity growth performance that had been observed appeared to have been triggered mainly by prior innovative activity and the disciplining effect of corporate debt.

The significance of the role of innovation in determining the persistence of productivity performances can be better understood by recognizing that innovation itself is characterized by a certain degree of persistence. The theme of innovation persistence in recent years has attracted the interest of scholars in different research perspectives, ranging from the economics of knowledge to the economics of organization and the economics of innovation (Malerba et al. 1997; Cefis and Orsenigo, 2001; Peters, 2009; Antonelli et al., 2012, 2013; Clausen and Pohjola, 2012)[1]. Most of the empirical analysis provides evidence in favour of the presence of persistency patterns in innovative efforts at the firm level related to technological learning processes that eventually generate new

[1] Our previous analyses studied persistence in innovation (Antonelli Crespi Scellato, 2012) whereas this paper focuses specifically on the determinants of persistence in productivity growth taking into account in the analysis the role of firm characteristics such as size, their evolving internal capabilities and management strategies, on the one hand, and systems properties such as the macroeconomic, sectoral and regional contexts into which persistence displays its effects, on the other.

knowledge for the innovating company. As suggested by Gerosky et al. (2003 and 2009), these effects probably translate into the dynamics of TFP growth at the firm level.

3. The sources of persistence in productivity growth

The reviewed evidence indicates that productivity growth persistence may be substantial, suggesting that past productivity performances influence subsequent patterns. However, it seems clear that previous behaviour is not sufficient to warrant the ability to keep outperforming levels of total factor productivity. TFP growth persistence occurs when a number of complementary and contingent factors sustain and strengthen the hysteresis generated by previous dynamics. The identification of the dynamic features of the sources of persistence is at the core of our analysis. In this respect, a firms' TFP reflects the levels of a broad range of technological, organizational and managerial capabilities along with the ability to exploit it through appropriation of the results of the introduction of technological innovations. TFP performance is in fact related to the systematic capability to generate new knowledge, apply it to the broad array of activities that firms carry out, and exploit it. The exploitation of knowledge includes both the introduction of innovations and the adoption of technological and organizational innovations introduced by suppliers and competitors.

Knowledge cumulability, related to knowledge indivisibility and knowledge non-exhaustibility, plays a central role in this context. The achievement of higher performance in terms of productivity dynamics can be easier for firms that can command a larger internal knowledge base and have access to and the ability to use larger knowledge bases than other agents operating in the same system (Antonelli, 2011; Colombelli and von Tunzelmann, 2011). For this reason, the effects of knowledge cumulability are typically path dependent (David 1985, 2007). Knowledge accumulated in the past exerts a strong influence on the future generation of new knowledge. Such effects, however, can change over time because the rates of accumulation and the conditions of access are not fixed (Dobusch and Schüler, 2013). Past knowledge, in fact, is not the single, deterministic factor: management strategies appear to be crucial in shaping the amount of knowledge that each firm is able to generate at each point in time and in sustaining persistent higher performances in terms of TFP growth through R&D investment choices and other decisions related to the acquisition of specific pieces of external knowledge. In this respect, the economics of organization has shown that repeated interactions between the accumulation of knowledge and the creation of routines to valorize and exploit it within the same organization eventually lead to the creation of dynamic capabilities that favour the systematic reliance on innovation as a competitive tool (Nelson and Winter 1982; Rothaermel and Hess 2007; Verona and Ravasi, 2003). In particular, only firms able to leverage their dynamic capabilities can be persistently among the top TFP performers over a long period of time (Teece, 2007).

This framework emphasizes that the past has an important impact on current and future performances. However, as acknowledged by the dynamic capabilities approach, firm strategies are indeed influenced but not necessarily trapped by their past. Management can make big differences through investment choices and other decisions. Hence, managers can act creatively and strategically to shape firms' growth paths (Parker et al., 2010). Firm heterogeneity in the form of strategic differences across firms constitutes a key driving force behind a firm's probability to sustain TFP growth over time (Clausen et al. 2012). In this perspective, firms focusing their strategy on acquisition, assimilation and exploitation of externally available knowledge are able to continuously renew their knowledge stock and strengthen their dynamic capabilities. Hence, managers can deal with and even reap benefit from path dependence if they are able to select appropriate self-reinforcing mechanisms along the capability paths that emerge from the firm–environment interaction (Vergne and Durand, 2011). Therefore, management strategies appear to be crucial to sustaining superior productivity performance over time through investment choices and other decisions related to the leveraging of dynamic capabilities and the exploitation of strategic assets. Managerial contingencies in fact affect the non-ergodic dynamics of innovation persistence (Clausen et al. 2012).

In this analysis it is argued that productivity persistence is an emergent system property that takes place when there is appropriate matching between the system properties and the characteristics and conduct of individual agents. This amounts to specifying the hypothesis that productivity persistence is determined by a mix of: a) strategic decisions; b) firm level characteristics with special reference to size; c) system properties. Since the dynamics of emergent system properties are influenced by a mix of interacting factors where each one exhibits high levels of dynamic variance and non-ergodicity, path dependence is claimed to be an intrinsic feature of TFP growth persistence. The interaction between different processes is in fact most likely to generate path rather than past dependence. Hence we put forward the complementary hypothesis that the persistence of productivity exhibits the typical traits of a non-ergodic process influenced by the past and yet sensitive to events that occur along the growth path.

In order to capture the effects related to firms' managerial strategies on persistency patterns over time we have focused our attention on three main dimensions: the decisions related to business process outsourcing, the strategies on the accumulation of intangible assets, and the propensity to assume a long-term perspective in investment choices. The analysis of these aspects should allow us to qualify the observed firms in terms of their strategic commitment to rely on the valorization of intangible assets and dynamic capabilities to persistently sustain superior productivity performances.

With respect to the first dimension, the literature suggests that in the last decades there has been an increasing tendency by firms to outsource a significant part of their non-core activities in order to achieve advantages in terms of productivity increases (Gilley and Rasheed, 2000; Grossman and Helpman, 2005; Merino and Rodríguez Rodríguez, 2007; Amiti and Wei, 2009). When outsourcing processes are successfully implemented, firms are able to focus on their core competencies and hence improve efficiency and productivity, explore new potential sources of revenues, implement new investment projects (Heshmati, 2003; Broedner, 2009). Moreover, through business outsourcing, external long-run sources of total factor productivity growth may be activated as those services are typically carried out by highly specialised experts and heavily rely on information and communication technologies, a major driver of productivity gains (Abramovsky and Griffith, 2006; Crespi, 2007). Finally, significant complementarity effects between internal and external R&D may emerge when business processes are successfully outsourced (Lokshin et al., 2008).

In parallel, the strong heterogeneity in firms' investments in intangible assets and the identification of strong cumulative processes of intangible asset accumulation suggests that the different propensity to invest in intangible assets can be explained by specific characteristics, internal capabilities and managerial strategies at the firm level (Arrighetti et al., 2014). In this context, we expect persistence in higher productivity performances to be sustained when managers adopt a strategy based on the systematic reliance and valorization of intangible assets as a way to leverage dynamic capabilities (Bontempi and Mairesse, 2008; Corrado et al., 2009; Marrocu et al., 2012).

Finally, intangible investment, in particular that related to R&D activities, tends to be approached as long-term investment whose influence, in terms of business performances, is shaped by experience and learning processes provided by previous accumulation of technological, organizational and other capabilities (Winter, 1987). Hence, we expect the financial structure of firms to reflect the strategic commitment of managers towards long-term investment. Hence, a higher propensity to rely on long-term debt can be interpreted as an indication of a strategic perspective to continuously fuel competitive advantages.

In addition to strategic factors, other internal characteristics of firms are expected to play a role. Firm size is a specific internal characteristic that is worth analysing in the context of productivity persistence. In particular, we claim that it is important to distinguish between two effects of firms' dimensions on the dynamics of productivity. The first is a direct influence of size on productivity performance, due to the relation of size to various efficiency-enhancing activities such as the use of information and communications technology (ICT), labour skills and training activities, the intensity of R&D investments and the introduction of innovations (Cohen and Klepper, 1996; Bartelsman and Doms, 2000; Syverson, 2011). The second may be related to the idea that cumulability effects are mainly relevant in large corporations: the hysteretic influence of past productivity growth on current and future performances increases with size along with the accumulation of competence as a strategic assets. However, while we expect the first effect of size to be relevant, we suppose that persistency patterns can be identified independently of size. Small firms can counterbalance the effects of knowledge cumulability that favour corporations with positive effects of entrepreneurship (Colombelli et al., 2014). Moreover, recent empirical evidence showed that persistence in innovation activities can be found also for in the case of SMEs, where persistency appear to be shaped by success-breeds-success, sunk costs and demand-pull effects (Máñez et al., 2014; Le Bas and Scellato, 2014), with a stronger associations between sales growth and subsequent R&D growth in small firms than larger firms (Deschryvere, 2014). Such persistency patterns in SMEs can be particularly relevant in high-tech industries (Máñez et al., 2014), where the role technological start-ups is potentially significant (Santarelli and Vivarelli, 2007) and, in general, have been found to represent an important source of employment and productivity growth (Triguero et al., 2014)

Finally in this analysis we highlight the role of system properties such as the amount of knowledge externalities and the dynamics of market forces. As the economics of knowledge suggests, different forms of external knowledge, i.e. scientific, commercial, technological and organizational, as well as different kinds of activities close to R&D activities and learning, such as searching, networking, absorption and scientific outsourcing, are required to generate and exploit new knowledge (Adams, 2009; Johansson and Lööf, 2008). Following this approach, the system properties add to internal ones and shape the context in which the persistence of TFP growth occurs. This approach is confirmed by a wave of recent empirical studies that stress the role of the system properties in shaping the strategies of firms that are able to be persistent innovators, namely Ito and Lechevalier (2010) who stress the positive role exerted by qualified interactions in international markets with qualified users for Japanese firms that are able to export systematically. These positive feedbacks support the persistent introduction of innovations as a key component in their exporting strategies. Triguero and Corcoles (2013) and Triguero et al. (2014), emphasize the role of technological opportunities, appropriability conditions and market demand arguing that Spanish firms that take advantage of these factors are better able to implement the persistent introduction of innovations. Suarez (2014) confirms the important role of the macroeconomic context showing that persistence is stronger in economic systems that grow faster and have lower levels of instability. Along similar lines, Bergek and colleagues (2013) provide rich empirical evidence in the automotive and gas turbine industries confirming that incumbents are able to implement the persistent introduction of innovations based on the 'creative accumulation' stirred by the entry of new competitors and technological discontinuities brought about by new technological opportunities. The evidence on Korean firms analysed by Kim and Chang-Yang (2011) confirms that early entrants in industries characterized by high levels of knowledge appropriability and low levels of technological opportunities are able to implement their innovative leadership and become persistent innovators retaining and replicating first-mover advantages.

In sum, a wave of recent studies confirms that the persistence of technological leadership is the result of dynamic capabilities implemented by typical Schumpeterian strategies of firms that are able to expand their knowledge base and use it as a tool to retain the competitive advantage based on the introduction and adoption of innovations in the past, provided that the system properties are favourable. As Brian Loasby (2010) puts it:

capabilities deliver effective performances only in a specific context that includes aspects that are both internal and external to each firm.

Hence, following the distinction elaborated by Harper and Lewis (2012) between resultant properties that qualify both individual agents and aggregate and emergent system properties where individual properties are qualified by the characteristics of the system into which they are embedded, we can put forward the hypothesis that the persistence of innovation is an emergent system property, rather than a resultant property. This hypothesis stems directly from the legacy of Schumpeter (1947) which explains the introduction of innovations as the result of the creative reaction of firms made possible by entrepreneurial strategies contingent upon the system properties. Specifically, this paper stresses the role of system properties, together with the characteristics and strategies of firms, in particular the level of dynamic capabilities, as critical factors that make the persistent achievement of superior TFP growth performances possible. In this context, the persistence of productivity growth acquires all the characteristics of an emergent property of the system into which firms are embedded that shares the typical traits of a path-dependent process, influenced by the past and yet sensitive to events that occur along the growth path (Antonelli, 2011).

4. EMPIRICAL ANALYSIS

In order to test the relevance of these arguments, a two-step empirical strategy was set up. In a first step the analysis focused on the identification of persistence in total factor productivity growth through a sequence of Transition Probability Matrices (TPM) considering different sub-samples. Such an approach accounts for changes that take place throughout the process which are expected to have significant effects on the path-dependent dynamics of TFP persistence (Antonelli, 1997). In the second step, the analysis concentrated on the drivers of persistence in order to qualify the role of the contingent events that affect the dynamics at work.

4.1 Dataset

The dataset is based on financial accounting data from a large sample of Italian manufacturing companies observed over the years 1996-2005. The original data were extracted from the AIDA database provided by Bureaux Van Dick which reports complete financial accounting data for public and private Italian firms with a turnover greater than 0.5 million euros. The companies included in the analysis were founded before 1995, were registered in a manufacturing sector according to the Italian ATECO classification, and were still active by the end of 2005. All companies with at least 15 employees at the end of the 1995 fiscal year have been included. After collecting balance sheet data, all the companies with missing values were dropped. In order to drop outliers, due to possible errors in the data source, we computed a number of financial ratios and yearly growth rates of employees, sales and fixed capital stock. After manual checking we eventually dropped 45 companies. We ended up with a balanced panel of 7020 companies. All financial data were deflated according to a sectoral three-digit deflator using year 2000 basic prices. In the following table we show the sectoral distribution of the companies.

The firm level TFP was calculated using Cobb-Douglas production functions with constant return to scale for each industry included in the sample .

$$TFP_{i,t} = \frac{Q_{i,t}}{L_{i,t}^{\beta} K_{i,t}^{1-\beta}} \qquad (1)$$

where:

$Q_{i,t}$:deflated value added

$L_{i,t}$:average number of employees

$K_{i,t}$:fixed capital stock.

In order to compute the capital stock through time a perpetual inventory technique was applied according to which the first year accounting data i.e. year 1996, in the present case, were used as the actual replacement values. The subsequent yearly values of fixed capital was computed using a depreciation parameter δ , assumed equal to 6.5%, and adding deflated yearly investments.[2] The investment parameter ($I_{i,t,}$) was computed as the yearly variation in the net fixed capital in the companies' balance sheets plus yearly amortizations. Hence, the time series of fixed capital is defined as:

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[2] The level of yearly depreciation of physical capital was chosen following the approach applied in previous studies that applied perpetual inventory techniques to estimate yearly fixed capital levels, adopting depreciation parameters in the 5%-10% range for physical capital. Since the adopted depreciation parameter is constant across industries, changes should not be expected in the significance of estimate coefficients for slight changes in δ.

$$K_{i,t} = (1 - \delta)K_{i,t-1} + I_{i,t}/p_t \qquad (2)$$

In order to identify the parameter β at industry level to compute equation 2, the following equation was estimated for each industry, where α_i is a firm specific effect and α_t is a time specific effect :

$$Log\left(\frac{Q_{i,t}}{K_{i,t}}\right) = \beta \times Log\frac{L_{i,t}}{K_{i,t}} + \alpha_i + \alpha_t + \varepsilon_{i,t} \qquad (3)$$

In order to analyse the dynamics of firm level TFP growth rates, we calculated the variable ΔTFP, defined as the logarithmic growth rate of the TFP level between year t-3 and year t:

$$\Delta TFP_{i,t} = \log(TFP_{i,t}) - \log(TFP_{i,t-3}) \qquad (4)$$

We then proceeded with a classification of the values taken from the variable $\Delta TFP_{i,t}$ on the basis of the distribution of the TFP growth rates of all the companies in the same sector of company i between year t-3 and year t. This procedure allows us to evaluate the persistence of firm level TFP growth rates, taking into account industry specific trends. In particular, we analyse the probability of a company's TFP growth rate being persistently located within a specific quantile of the distribution of TFP growth rates of all companies in the same industry[3]. Sensitivity analyses were conducted to assess whether, and to what extent, the thresholds adopted for the discretization of the TFP growth rate distribution (e. g. using tertiles or quartiles) affect the estimated intensity of persistence.

Two complementary approaches were followed in the empirical analysis. Initially, we investigated the presence of firm-level persistence by means of transition probability matrices (TPM). Then, we explored firm-level persistence by means of discrete choice panel data models, based on the estimator proposed by Wooldridge (2005). While the initial TPM approach is expected to provide only summary evidence on the persistence

[3] This measure of persistence is substantially different from the one adopted in Antonelli et al. (2013). As in the previous study, the state variable simply reflected the existence of positive changes in TFP over time.

of the TFP growth rates of firms over time, the panel data analysis is aimed at identifying true state persistence after controlling for relevant contingent factors. Independent variables used in the econometric analysis include size, return on equity, leverage, an indicator of vertical integration, an indicator of debt maturity composition and intangible intensity, computed as the yearly incidence of intangible to tangible assets. Table 1 reports summary statistics of the variables used in the econometric analysis.

Table 1 – Description and summary statistics of the variables used in the econometric analysis.

Variable	Description	Mean	Median	St. dev	1%	99%
SIZE i,t	Log of the total assets of company i in year t (based on the perpetual inventory method)	14.30	14.33	1.38	10.97	17.70
INTANG i,t	Ratio of the book values of intangible assets to tangible assets for company i in year t	0.15	0.08	0.19	0	0.85
LEV i,t	Book value of debt / (book value of debt + book value of equity)	0.68	0.72	0.20	0.17	0.98
ROE i,t	Net income / book value of equity	0.32	0.04	0.6	-1.59	0.73
VERT_INT i,t	Value added/ turnover	0.28	0.28	3.30	0.05	0.68
DEBT_MAT i,t	Long-term debt / total debt	0.13	0.08	0.15	0	0.61
EMPLOYEES i,t	Number of employees	111	56	330	16	921

4.2 *Transition Probability Matrixes on TFP growth rates*

The following three tables report the results obtained for the persistence of TFP growth rates over time, using different discretization criteria. In Table 2 we calculated the TPM by splitting the distribution of firm level TFP growth rates in tertiles. We also report the standard errors of the related transition probabilities in the table[4].

The data show that, during the observed years, the firms that were in the top tertile of TFP growth rates in their sector in year t-1 were again in the top tertile in year t with a probability of 54.04%. Overall, the data in Table 2 highlight the presence of strong persistence: the main diagonal terms are larger than 33%. The incidence of inter-temporal transition between the lowest and the highest tertiles is quite low in both directions and is below 20%. The analysis was replicated by splitting the distributions into quartiles (see Table A1 in Annex A). Again, the data confirmed the presence of non-negligible persistency patterns. As could be expected, inter-quantile mobility was higher for the intermediate intervals. This evidence seems to highlight the presence within the

[4] Let P_{ij} and $\hat{P}_{ij}$ denote the population and sample probabilities of a transition of a company from status i to status j. This transition process can also be seen as the outcome of a binomial distribution. Hence, standard errors of the estimated transition probabilities can be calculated as a binomial standard deviation: $\sqrt{P_{ij} \times (1 - P_{ij})/N}$ where N equals the number of companies in status i. As N increases, $\hat{P}_{ij}$ tends to P_{ij}.

sample of sub populations of firms than are capable of repeatedly outperforming their peers in terms of TFP growth.

Table 2. Transition Probability Matrix on the tertiles of the sectoral distribution TFP growth rates for all years and all companies.

	High Growth t	Mid Growth t	Low Growth t
High Growth t-1	0.5404 (0.0041)	0.2776 (0.0035)	0.172 (0.0031)
Mid Growth t-1	0.2911 (0.0038)	0.4232 (0.0041)	0.2857 (0.0038)
Low Growth t-1	0.1807 (0.0032)	0.2826 (0.0038)	0.5367 (0.0042)

Standard errors in parenthesis

Interestingly, persistence in TFP growth rates is a phenomenon which appears not to be confined to large companies as shown in Table 3, though the transition probabilities in the main diagonal of the matrices are greater in the group of large companies. However, this last result may be spurious as it may simply reflect the relevance of what we called the direct effect of size on productivity dynamics. A better assessment of this issue will be provided through the econometric analysis.

Table 3. Transition Probability Matrix on the tertiles of sectoral distribution TFP growth rates for all years. Firms split according to size.

Firms with more than 250 employees at t-1	High Growth t	Mid Growth t	Low Growth t
High Growth t-1	0.5746 (0.017)	0.2625 (0.015	0.1569 (0.012)
Mid Growth t-1	0.2730 (0.014)	0.4378 (0.016	0.2892 (0.014)
Low Growth t-1	0.196 (0.011)	0.2607 (0.013	0.5457 (0.014)

Firms with less than 250 employees at t-1	High Growth t	Mid Growth t	Low Growth t
High Growth t-1	0.5341 (0.004)	0.2836 (0.004)	0.1823 (0.003)
Mid Growth t-1	0.2867 (0.004)	0.4241 (0.004)	0.2913 (0.004)
Low Growth t-1	0.1700 (0.003)	0.2901 (0.004)	0.5399 (0.004)

Standard errors in parenthesis

In Tables 4 and 5 below we split the transition probability matrixes considering different sub-periods, sectors and regions. This splitting approach has the aim of capturing the presence of divergences in persistency patterns of TFP growth rates due to the influence of the system properties. In particular, we claim that the knowledge intensity of the local context may be relevant in shaping differentiated patterns of persistence in productivity growth. For this purpose, we split Italian regions into High R&D and Low R&D regions, on the basis of the average aggregate R&D expenditures during the observed years. High R&D regions fall into the top 33% of the distribution of regions in terms of Gross R&D Expenditures/GDP. Moreover, the macroeconomic context is expected to play an important role in influencing the productivity performance of firms and their reactions to changing economic conditions in terms of contingent behaviour and strategic decisions. Considering that the time span adopted for the analysis can be conveniently divided into two sub-periods which identify an upward economic cycle (until 2001) and a downward cycle (after 2001) in Italy, we split the TPMs in order to eventually detect any differences in persistency dynamics across the two sub-periods. Finally, we divided the sample into groups according to the technological intensity of different economic sectors in order to account for the effects that sectoral system properties may have on the persistence of

TFP growth[5]. Table 4 reports figures on the share of companies belonging to the top 15% of the sectoral distribution of TFP growth rates for two subsequent periods, for subsamples selected according to periods, the R&D intensity of regions and the technology intensity of sectors[6].

This approach allows us to see whether the observed aggregate persistency patterns are the averaged outcome of processes with peculiar trends over different regions, sectors and time. The differences between the results can be in fact interpreted as a first indication that system properties are capable of shaping persistence by affecting its dynamics.

Table 4 Share of companies in the top 15% of the sectoral distribution of TFP growth rates in two subsequent times for selected regions, sectors and periods.

Region	Sector	Period	Probability of high-high growth	Standard error
LOW R&D	HITECH	1998-2000	0.4040	0.0236
LOW R&D	HITECH	2001-2005	0.3829	0.0183
LOW R&D	LOWTECH	1998-2000	0.3671	0.0199
LOW R&D	LOWTECH	2001-2005	0.3758	0.0135
HIGH R&D	HITECH	1998-2000	0.3718	0.0232
HIGH R&D	HITECH	2001-2005	0.4514	0.0169
HIGH R&D	LOWTECH	1998-2000	0.3224	0.0173
HIGH R&D	LOWTECH	2001-2005	0.3906	0.0133

The results reported in Table 4 show that there are significant differences between the different sub-groups, ranging from 0.32 to 0.45. The highest transition probability for top performing companies in two subsequent times is associated with the group of firms in High R&D regions, and High-Tech sectors observed in the period 2001-2005.

[5] Sectors were divided into High-Tech and Low-Tech according to the Italian 3 digit ATECO industry classification.

[6] In order to simplify the description of results, we report only the probability associated with persistent top performers. Moreover, to be consistent with subsequent econometric models, controlling for the same system level factors in productivity persistence, we consider the same selection criteria to identify top performers i.e. the first 15% in the sectoral distribution of TFP growth rates. Persistency patterns do not significantly change with respect to different thresholds. All results are available upon request from the authors.

The role of sectoral systems appears to be of particular relevance since, everything else being equal, the probability of continuously performing in the top 15% of the distribution is always higher for firms operating in High-Tech sectors. In parallel, the macroeconomic cycle appears to have a differentiated impact according to the type of regions where business takes place. In particular, for High R&D regions there is a significant tendency towards an increase in TFP persistence after 2001, while the dynamics is more stable for Low R&D regions.

When interpreting these results, it is fundamental to consider that companies that start with lower TFP levels are more likely to exhibit higher TFP growth rates. This aspect could be relevant in explaining the high level of persistence for outperforming companies in Low R&D regions before 2001 which may be related to firms starting with lower TFP levels and taking advantage of the macroeconomic expansion that occurred until 2001. The inversion of the economic cycle has powerful effects: firms belonging to the High R&D regions seem to be more capable of sustaining persistently higher levels of productivity growth. One possible interpretation of this result is that in this economic phase the dominating effect could be related to the best companies that react to the changed economic context and which strategically invest in innovative activities to sustain persistently higher TFP gains.

4.3 Econometric Analysis

4.3.1 Modelling structure

The previous descriptive evidence clearly calls for a more detailed analysis of the actual underlying dynamics and its driving factors. In order to analyse the persistence of TFP growth rates throughout the analysed periods, we constructed a time varying dummy variable that equals one in period t if a company shows a TFP growth rate that falls within the top 15% of the distribution of ΔTFP for all the companies in the same sector. We applied a dynamic discrete choice model in which such a variable is regressed against its past realization and a set of appropriate controls[7].

The observed persistence may be due to true state dependence or permanent unobserved heterogeneity across the analysed companies. From a theoretical perspective, if the source of persistence is due to permanent unobserved heterogeneity, individuals show higher propensity to make a decision, but there is no effect of previous choices on

[7] We carried out a sensitivity analysis to investigate whether, and to what extent, the results are related to the selected threshold. Results are largely confirmed for different thresholds and are available upon request from the authors.

current utility and past experience has no behavioural effect (Heckman, 1981). Hence, in order to estimate true state persistence, it is important to capture the variance of the state indicator which is explained by both the structural characteristics of the firms and by contingent, time-varying observable factors and then to analyse whether its past values still have a significant effect (Peters, 2009; Antonelli et al., 2012; Lopez-Garcia and Puente, 2012).

The baseline specification for a dynamic discrete response model is the following:

$$y_{it}^* = \gamma y_{it-1} + \beta x_{it} + u_i + \varepsilon_{it} \tag{5}$$

where y_{it} (with possible values 0,1) is the state indicator (i.e. indicating whether a firm is in the top 15% of the TFP growth rate distribution in its sector in year t.

The estimation of the above model is based on a strong assumption on the initial observations y_{i0} and their relationship with u_i, the unobserved individual effects. If the origin of the analysed process does not coincide with that of the available observations, y_{i0} cannot be treated as exogenous and its correlation to the error term would give rise to biased estimates of the autoregressive parameter that represents the measure of persistence. In order to deal with this issue in this paper we apply the method developed by Wooldridge (2005) which proposes specifying the distribution of u_i conditional on y_{i0} and x_i. In particular, we follow the approach used by Peters (2009) by using the first realisation of the dependent variable (y_{i0}) and the time-averaged covariates as predictors of the individual effect.

As previously mentioned, in order to identify true state persistence, it is necessary to account for the time varying firm-level characteristics which are expected to be correlated to the observed outcome of the dichotomous dependent variable, and to control for the properties of the system in which firms operate. With respect to aspects related to firms' strategies, we tested the relevance of three variables that are linked to management decisions to sustain persistent higher productivity growth rates i.e. the indicator of vertical integration along the value chain (VERT_INT), the indicator of debt maturity composition (DEBT_MAT) and the indicator of intangible intensity (INTANG). As highlighted in Section 3, we claim that lower values of vertical integration can be attributed to the strategic decision of focussing on those segments of the value chain that are characterised by higher value added. Hence, a negative relationship with TFP growth rates is expected[8]. Moreover, while in principle the capital structure should have a neutral or non-significant effect, it is here claimed that a higher incidence of long-term debt can be associated with the willingness of managers to adopt a more long-term investment strategy. Since structural innovation investments require a stable commitment, we expect sustained higher performances in TFP growth rates to be observed for those firms that have longer debt maturity. This, in turn, is a signal that such firms have made significant investments in long-term infrastructures. Finally, intangible assets intensity is expected to capture the effort of a firm to build innovative competences by means of both in-house R&D and external expenditures.

Additional firm level variables that are likely to affect TFP growth used in the econometric analysis include firm size (SIZE), leverage (LEV), and an indicator of firm profitability (ROE)[9]. With respect to the role of firm dimension, besides taking into account the direct effect of size on productivity performances by including this variable in the tested models, we will also test if differences in the impact of previous TFP growth rates on current performances emerge for groups of firms with different dimensions. All time varying firm-specific factors have been used in the model specifications with a 3 year lag.

Finally, in the analysis we take into account the effects of the properties of the system by testing our model after splitting the sample of companies according to the categories used in the descriptive analysis, namely two sub-periods (before and after 2001), two macro-regions (High R&D and Low R&D regions) and macro-sectors (High-Tech and Low-Tech industries). The time spitting should help grasp the effects on persistence of the macroeconomic cycle. The regional splitting should capture the effects of the local intensity of R&D expenditures, while the sectoral splitting should account for the role of sectoral systems in productivity persistence. Consistently with the review of the literature and the set of hypotheses that we have developed, we expect to find systematic and significant differences between the sub-samples that indicate that the properties of the system affect the strategy of firms with consequent effects on persistence.

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[8] This intuition is particularly relevant given that the sample is composed of manufacturing companies that operate to a large extent in traditional sectors and that during the observed years have carried out significant restructuring outsourcing of the production activities.

[9] The empirical evidence on the relationship between profitability measures and productivity is mixed, even when taking into account operative profitability (ROI or ROA). In general, the identification of linear effects appears to be difficult (See Antonelli and Scellato (2011) for a discussion).

4.3.2 Results

In the following tables we show the results of the model tested on different samples for the evaluation of persistence along time of TFP growth rates. Results reported in Table 5 (Column I) confirm the summary evidence reported in the previous TPMs and indicate the presence of substantial persistence. Being in the top 15% of the distribution of TFP growth rates in year t-1 has a positive and largely significant impact on the likelihood of the firm still being in the top 15% in year t, with a marginal effect at means of about 27%[10]. What is relevant in the proposed analytical framework is that even after accounting for firm level time varying factors, there is still a significant impact of the lagged dependent variable. This implies that the persistence detected in the descriptive analysis is not spurious.

Moreover, the results for the covariates provide interesting insights that can be used to qualify such persistence. First, the estimated relevance of contingent factors allows us to exclude the ergodic nature of the process under scrutiny. The evidence shows that the dynamics is influenced by the past but it is not past-dependent as it is sensitive to changes along the path. This confirms its path dependent nature. Second, with respect to the analysis of firm level control variables, the strategies pursued by companies appear to have a significant effect on persistence dynamics. In this respect, the negative and significant effect of the vertical integration can easily be interpreted. Those companies that have reduced their vertical integration on average had a significantly higher likelihood of being among the best performers in terms of TFP growth rates. This evidence confirms that specialization strategies in high value added enhances the possibility of obtaining long lasting outperformance in productivity growth.

The variable related to debt management highlights how those companies that have been able to finance long-term investments through credit channels show higher TFP growth rates. This may mean that this subsample of companies is less financially constrained and does not have to rely solely on internal cash flows to finance growth and productivity enhancing assets. The summary statistics from the sample in fact reveal that a significant share of companies has a very limited incidence of long-term debt, meaning that these companies implicitly use (or are forced to use) external financial sources with a maturity of less than a year to support assets that are defined in the long run. While in this analytical setting it is not possible to assess whether such apparently irrational behaviour

[10] We also tested different specifications for the growth rate of TFP, using both a two year and a four year interval. Results were not affected.

is determined totally by external constraints (i.e. inefficiency of the credit markets), the data still provide a clear indication of the non-trivial effects of the sources of finance. Finally, we do not find a significant effect associated with the variable capturing intangible intensity whose effects are probably absorbed by past TFP growth or limited by the broad definition of this variable in companies' financial account data.

With respect to other variables reflecting firm level characteristics, as expected, size has a positive and significant effect, while we have identified a non-statistically significant effect of past levels of Return on Equity on subsequent TFP growth rates. This latter result might be due to the fact that, in the present sample, companies within an industry tend to differ more in terms of operational efficiency than ROE along time.

In order to take into account the effects of system properties, regressions were run for different sub-samples of companies. Columns II-V of Table 5 show the results for sub-samples referring to High-Tech and Low-Tech sectors during the expansion and contraction phases of the business cycle. The results confirm the descriptive evidence presented in the previous section on the relevance of system properties and show differentiated dynamics of persistence across sectors and in time. In particular, after the year 2001, the magnitude of the coefficient associated with the lagged dependent variable significantly increases in both sector groups, suggesting that the macroeconomic cycle affects persistence dynamics in productivity growth. Moreover, sectoral systems appear to play an important role since in more technology-intensive industries persistence effects are always greater than in lower intensive ones. Table 6 synthesizes all results obtained on the lagged dependent variable for all tests on different sub-samples including the regional split[11]. System properties are seen to be relevant in shaping persistence patterns also when the regional component is taken into account. There is in fact huge variance in the magnitude of marginal effects of the lagged dependent variable, ranging from 0.327 for companies in High R&D regions, High-Tech sectors observed in the years 2001-2005 to 0.106 for companies in Low R&D regions, Low-Tech sectors observed in the years 1998-2000.

This result, interpreted in the context of the previous literature, sheds some light on how and why it may differ from those of other countries, in particular the US and UK. The important role of external factors in supporting the persistence of productivity growth

[11] Given that the effects of relevant control variables do not largely differ across estimates produced on different samples, we do not report results for all estimated coefficient in order to save space. All results are available upon request from authors.

might be associated to the low levels of industrial concentration of the Italian economic system characterized by the pervasive role of small firms. Here system properties and specifically knowledge externalities play much a stronger role than in economic systems characterized by large corporations for which the persistence of productivity growth relies more on internal factors[12].

[12] See Antonelli et al. (2014) and Antonelli, Scellato (2015) for complementary evidence. This interpretation for which we acknowledge the suggestion of one of the anonymous referees might be the object of further empirical investigations on a comparative basis.

Table 5. Dynamic probit model on the persistence of TFP growth rates.

	All years	1998-2000	1998-2000	2001-2005	2001-2005
	All sectors	High Tech	Low Tech	High Tech	Low Tech
	I	II	III	IV	V
HighGrowth $_{t-1}$	0.269***	0.232***	0.112***	0.309***	0.271***
	(0.007)	(0.047)	(0.030)	(0.013)	(0.010)
SIZE $_{t-3}$	0.072***	0.069***	0.081***	0.057***	0.083***
	(0.004)	(0.011)	(0.008)	(0.009)	(0.008)
ROE $_{t-3}$	0.000	-0.018***	-0.009***	0.001	0.000
	(0.000)	(0.005)	(0.002)	(0.001)	(0.000)
INTANG $_{t-3}$	0.014	-0.015	0.060*	-0.023	0.026
	(0.017)	(0.045)	(0.033)	(0.032)	(0.027)
VERT_INT $_{t-3}$	-0.270***	-0.187***	-1.006***	-0.316***	-0.298***
	(0.013)	(0.032)	(0.064)	(0.026)	(0.024)
LEVERAGE $_{t-3}$	0.001	-0.007	-0.032***	0.010	0.014
	(0.001)	(0.006)	(0.012)	(0.006)	(0.010)
DEBT_MAT $_{t-3}$	0.096***	0.114**	0.065**	0.060*	0.105***
	(0.017)	(0.046)	(0.032)	(0.033)	(0.029)
AVGSIZE	-0.068***	-0.058***	-0.081***	-0.053***	-0.079***
	(0.005)	(0.011)	(0.008)	(0.009)	(0.008)
AVGROE	0.001*	0.009**	-0.000	0.002	0.001
	(0.000)	(0.004)	(0.001)	(0.002)	(0.001)
AVGINTANG	0.071***	0.041	-0.038	0.132***	0.088**
	(0.020)	(0.051)	(0.038)	(0.038)	(0.034)
AVGVERT_INT	0.004*	0.031*	0.903***	0.040***	0.001
	(0.003)	(0.016)	(0.067)	(0.011)	(0.003)
AVGLEVERAGE	0.000	0.001**	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AVGDEBT_MAT	-0.112***	-0.198***	-0.071	-0.023	-0.153***
	(0.025)	(0.068)	(0.045)	(0.047)	(0.041)
HighGrowth $_{t0}$	-0.009**	0.015	0.033**	-0.007	-0.008
	(0.005)	(0.025)	(0.016)	(0.009)	(0.008)
Observations	42,117	5,268	8,772	10,536	17,541
Chi2	3319.1***	423.3***	563.1***	1036.7***	1395.7***
LogLik	-16027.2	-1983.5	-3319.3	-3883.0	-6678.5

*The dependent variable (HighGrowth$_t$) is equal to 1 in year t for firm i if the corresponding growth rate of TFP falls within the top 15% of the related sectoral distribution of the TFP growth rates. Marginal effects are reported. Significance levels: * 90% **95% ***99%*

Table 6 Marginal effects of lagged dependent variable (HighGrowth t-1) for different samples based on the model specification reported in Table 5.

Region	Sector	period	HighGrowth $_{t-1}$ Marginal effect	Stand. error
ALL	ALL	1998-2005	0.269***	(0.007)
ALL	HITECH	2001-2005	0.309***	(0.013)
ALL	HITECH	1998-2000	0.232***	(0.047)
ALL	LOWTECH	2001-2005	0.271***	(0.010)
ALL	LOWTECH	1998-2000	0.112***	(0.030)
LOW R&D	HITECH	2001-2005	0.282***	(0.019)
LOW R&D	HITECH	1998-2000	0.247***	(0.037)
LOW R&D	LOWTECH	2001-2005	0.255***	(0.014)
LOW R&D	LOWTECH	1998-2000	0.106**	(0.042)
HIGH R&D	HITECH	2001-2005	0.327***	(0.018)
HIGH R&D	HITECH	1998-2000	0.188***	(0.066)
HIGH R&D	LOWTECH	2001-2005	0.286***	(0.014)
HIGH R&D	LOWTECH	1998-2000	0.126***	(0.046)

*Significance levels: **95% ***99%*

Finally, we test the significance of size effects on the magnitude of the hysteretic influence on current TFP growth of past productivity performances by adding an interaction term between the lagged dependent variable and a dummy variable which takes value 1 if the company has more than 250 employees (LARGE FIRM DUMMY) to the previous model specification. As indicated by results reported in Table 7, the interaction term is not significant in all the specifications. This seems to suggest that after controlling for all firm level characteristics, including the direct effect on productivity dynamics exerted by companies' dimension, there is no productivity growth "persistency premium" for large companies since the magnitude of the effect of the lagged dependent variable does not significantly change across firms of different dimension. This result points out that persistency patterns can be independent of size and that not only large corporations are capable of sustaining higher productivity performances in time.

Table 7 Dynamic probit model on the persistence of TFP growth rates. Model specification with interaction between lagged dependent variables and the Large Firm dummy.

	1998-2000	1998-2000	2001-2005	2001-2005
Sector	High Tech	Low Tech	High Tech	Low Tech
HighGrowth $_{t-1}$	0.224***	0.112***	0.304***	0.266***
	(0.047)	(0.030)	(0.014)	(0.010)
HighGrowth t-1 * LARGE FIRM DUMMY	0.070	0.027	0.022	0.042
	(0.045)	(0.041)	(0.023)	(0.026)
SIZE $_{t-3}$	0.068***	0.081***	0.057***	0.083***
	(0.011)	(0.008)	(0.009)	(0.008)
ROE $_{t-3}$	-0.018***	-0.009***	0.001	0.000
	(0.005)	(0.002)	(0.001)	(0.000)
INTANG $_{t-3}$	-0.015	0.060*	-0.022	0.027
	(0.045)	(0.033)	(0.032)	(0.027)
VERT_INT $_{t-3}$	-0.190***	-1.008***	-0.317***	-0.299***
	(0.032)	(0.064)	(0.026)	(0.024)
LEVERAGE $_{t-3}$	-0.007	-0.032***	0.010	0.015
	(0.006)	(0.012)	(0.006)	(0.010)
DEBT_MAT $_{t-3}$	0.113**	0.066**	0.061*	0.104***
	(0.046)	(0.032)	(0.033)	(0.029)
AVGSIZE	-0.059***	-0.081***	-0.054***	-0.080***
	(0.011)	(0.008)	(0.009)	(0.008)
AVGROE	0.009**	-0.000	0.002	0.001
	(0.004)	(0.001)	(0.002)	(0.001)
AVGINTANG	0.038	-0.039	0.130***	0.084**
	(0.051)	(0.038)	(0.038)	(0.034)
AVGVERT_INT	0.031*	0.905***	0.040***	0.001
	(0.016)	(0.068)	(0.011)	(0.003)
AVGLEVERAGE	0.001**	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
AVGDEBT_MAT	-0.188***	-0.070	-0.020	-0.149***
	(0.069)	(0.045)	(0.047)	(0.041)
HighGrowth $_{t0}$	0.015	0.033**	-0.007	-0.008
	(0.025)	(0.017)	(0.009)	(0.008)
Observations	5,268	8,772	10,536	17,541
Chi2	426.37***	565.90***	1037.47***	1398.71***
LogLik	-1981.9	-3319.01	-3882.71	-6677.0

5. CONCLUSIONS

This paper provides empirical evidence on the crucial role of the interplay between the internal characteristics of companies including their size, management strategies and system properties, such as the access conditions to local pools of knowledge and the dynamics of economic activity, in assessing the path-dependent persistence of productivity growth. These results confirm the hypothesis that productivity persistence is an emergent system property that takes place when there is appropriate matching between the system properties and the characteristics of individual agents. The analysis of the persistence of total factor productivity growth has been conducted through the use of Transition Probability Matrixes (TPMs), which have been split considering different system property dimensions, providing interesting results. The subsequent econometric analysis of firm level TFP has shown that firms which have been able to improve the general efficiency of their production process at time t are more likely to sustain above average performance in the subsequent periods of time than firms with lower past rates of TFP growth. Moreover, our analysis identified persistency patterns that are independent of size, suggesting that not only large corporations are capable of sustaining higher productivity performances in time, hence confirming the significant role SMEs may have in enhancing productivity dynamics of economic systems.

The identified persistence turned out to be path dependent rather than past dependent since it is shaped by a number of complementary and contingent factors that affect locally the dynamics of the process. The identification of the path-dependent character of persistence in productivity growth helps to understand and appreciate the variety of results in the previous literature. The differences in the results of an increasing array of empirical investigations can be interpreted as follows: innovative activities have indeed potential hysteretic effects that only become actual persistence in productivity growth when a number of complementary and contingent factors concur to making the process actually non-ergodic. At each point in time, the creative reaction of firms and the probability of introducing, adopting and imitating further innovations and of outperforming competitors in TFP growth is in fact affected by the sequence of results in the past but is also conditioned by the actual levels of their internal dynamic capabilities to accumulate and exploit technological knowledge and human capital. These in turn are influenced by the changing characteristics of the system into which firms are embedded, confirming that the persistence of productivity growth shares the intrinsic characteristics of an emergent system property. Considering that not only the dynamics but also the structural characteristics of economic systems are relevant in shaping persistency patterns, differences across countries in the way system properties may influence firms' productivity persistence might be relevant. This comparative aspect of the analysis can certainly represent an interesting issue to be scrutinized in further research.

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ANNEX A – Robustness checks

Table A1 Transition Probability Matrix on quartiles of the sectoral distribution TFP growth rates. All years and companies.

	High Growth t	Mid-High Growth t	Mid-Low Growth t	Low Growth t
High Growth t-1	0.4748 (0.0048)	0.2496 (0.0042)	0.1617 (0.0035)	0.1134 (0.0030)
Mid-High Growth t-1	0.2472 (0.0041)	0.3343 (0.0045)	0.2585 (0.0042)	0.1595 (0.0035)
Mid-Low Growth t-1	0.1576 (0.0035)	0.2624 (0.0042)	0.3356 (0.0045)	0.2442 (0.0041)
Low Growth t-1	0.1169 (0.0031)	0.1563 (0.0035)	0.2471 (0.0042)	0.4795 (0.0048)

Standard errors in parenthesis