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INTANGIBLE ASSET DYNAMICS AND FIRM BEHAVIOUR

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Abstract

We study the adoption of different intangible investment strategies in manufacturing firms. Contrary to most of the previous literature, we find such strategies to be highly differentiated. In particular we identify three types of investment behaviour: high and persistent, low and persistent, discontinuous. Using as a reference the capability-based view of the firm, we define and provide support for a set of hypotheses on the determinants of such behaviours. We obtain the following results: first, absorptive capacity led by R&D expenditures is a key competence in sustaining the adoption of an intangible investment strategy, which may be either persistent or discontinuous; second, the implementation of a persistent intangible investment strategy necessarily requires specific investments in the quality of human resources to be made; third, firms with a greater propensity to operate in international markets are more likely to adopt a persistent intangible investment strategy than they are to adopt a discontinuous one; fourth, firms that undertake a growth path that is based on highly uncertain demand segments and high organisational flexibility are likely to adopt a discontinuous intangible investment strategy; and five, the historical intangible asset base represents an important constraint on firms' investment behaviour.

Keywords: *intangibles, firm behaviour, asset accumulation, organisational capabilities, R&D, investment strategy*

JEL codes: **D22** (Firm Behaviour: Empirical Analysis); **L21** (Business Objectives of the Firm); **L25** (Firm Performance: Size, Diversification, and Scope); **O32** (Management of Technological Innovation and R&D)

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1. Introduction

Intangible assets consist of the stock of immaterial resources that enters the production process and are necessary for the creation and sale of new or improved products and processes. These assets include designs, blueprints, patents, licences, trademarks as well as technology-related consulting services, and other immaterial resources. In recent years, a large body of management and economics literature has shown intangible assets to play a major role in modern economies. Several works have found that intangible assets attract a growing amount of resources at both the country (Nakamura, 2003; Corrado et al., 2005, 2006) and firm level (Hulten and Hao, 2008; Miyagawa and Kim, 2008; Marrano and Haskel, 2006; Jalava et al., 2007; van Rooijen-Horsten et al., 2008; Bontempi and Mairesse, 2008). Other studies have also stressed a positive link between the accumulation of intangible assets and firm performance, especially in terms of productivity (Marrocu et al.; 2012; Oliner et al., 2007; O'Mahony and Vecchi, 2009), market value (Hall et al.; 2005; Greenhalgh and Rogers, 2006; Sandner and Block, 2011), and internationalisation (Denekamp, 1995; Braunerhjelm, 1996; Delgado-Gómez and Ramírez-Alesón, 2004). Overall, it appears likely that intangible assets will continue to be a major source of competitive advantage in the years to come and that the process of their accumulation within firms will increasingly be a relevant topic in academic and policy debate.

Although the literature on intangible assets is extensive, to date, there has been little empirical work on the determinants of intangible asset accumulation at the firm level. One of the few exceptions in this sense is a recent paper by Arrighetti et al. (2011), which uses balance sheet and survey data on Italy to study firms' propensity to invest in intangible resources. Interestingly, this work finds a quasi-Pareto distribution in firms' propensity to invest, with few firms making substantial investments and many others investing almost nothing (i.e., displaying high heterogeneity). In addition, the results show firm-specific features such as size, human capital, organisational complexity and the historical intangible asset base to play a major role in explaining the level of investments.

Along these lines, one aspect of the overall process of intangible asset accumulation that continues to merit in-depth empirical investigation is the dynamics of investment at the firm level. In theory, intangible assets are often described as resources whose process of

accumulation is highly persistent. This persistence is usually explained by relying on some specific technological feature, such as the existence of both fixed costs and complementarities within the asset stock (Teece, 1987; Dierickx and Cool, 1989; Knott et al., 2003). To some extent, a certain degree of persistence in intangible investments is also confirmed by the analysis reported in Arrighetti et al. (2011).

However, a careful examination of the data (see Section 2) reveals that, if adequately investigated, the dynamics of intangible investments may be much more differentiated than typically thought. When a sufficiently long time span is considered, in fact, distinct typologies of firm behaviour begin to emerge. In our dataset, in particular, there are firms (approximately 55% of the sample) that exhibit highly persistent behaviour characterised either by very high investments or by no investments at all. However, there exist others (45% of the sample) that exhibit substantial discontinuities. The latter, in particular, show alternate periods of positive investments with periods of relative stasis for an overall pattern of investment that is highly volatile.

Based on this evidence, the present paper investigates the factors that may explain the existence of these different types of investment dynamics among firms. Given that intangible assets and, more generally, knowledge assets are usually described as resources that exhibit fairly persistent accumulation dynamics, how can we explain the degree of volatility that distinguishes a large proportion of firms? Are these firms simply converging towards some equilibrium level of accumulation, or they are rather adopting specific strategies in planning their investments? What are the factors that may explain the evolution of these distinct paths of intangible investments over time? These are the main questions addressed in the remaining sections of the paper.

In line with the capability-based view (see Penrose, 1959; Teece, 1980; Nelson and Winter, 1982; Chandler, 1990; Barney, 1991; Dosi et al., 2000), we argue that the main determinants of these differences in firm behaviour lay in firms' internal capabilities. From this perspective, intangible assets represent both resources that require a particular set of capabilities to be accumulated and assets that themselves add to the set of competences available in a firm. For this reason, the existence of a variety of intangible investment profiles may be explained both by the heterogeneity of firms' organisational capabilities and the diversity of firms' strategic objectives.

A hypothesis of particular interest in interpreting the different types of conduct undertaken by firms stems from the so-called real option theory, discussed in Cuervo-Cazurra and Un (2009) with specific reference to R&D expenditures. R&D investments and intangible assets have in common ill-defined property rights and obsolescence risks. Starting from these characteristics, together with the importance of intangible resources in the competition process, we should expect firms to implement positive and constant investment over time. However, firms do not behave as expected. On the contrary, some firms do not invest at all, some invest sometimes, and some invest constantly over time.

In Cuervo-Cazurra and Un (2009), the explanation of such conduct is related to the presence (or absence) of internal (human capital, workforce education, previous investments in absorptive capacity) and external knowledge sources (suppliers, research laboratories, customers and consumers). The lack of technological resources and human capital makes it impossible to make internal investments in intangible assets, as they are preconditions for the incorporation of the benefits associated with the presence of intangible resources. The existence of firms characterised by no or extremely limited intangible asset bases may thus be explained by the absence of the key prerequisites for their actual production and exploitation. The availability of both internal resources and external information sources (suppliers, customers and consumers) then gives rise to another type of conduct characterised by the minimisation of investment in intangible assets and a marked variation in their level over time. When the knowledge necessary to run the project is (a) contractible, (b) based on the recombination of not strictly proprietary and publicly available knowledge, (c) highly specific with respect to the client, the investment in intangible resources may be intermittent and is a function of the often discontinuous demand coming from the operational units. Such conduct may also be associated with difficulties in planning investments with applications in extremely turbulent and unpredictable contexts or in environments not yet sufficiently well known by the firm.

The last type of conduct includes firms with a significant endowment of internal intangible resources and human capital but with limited access to external information and knowledge sources, which are absent, inconsistent with the project to be developed or subject to opportunism. This is the case of investments in intangible assets that are necessary for developing radical innovations, requiring a very high entry threshold but also suffering the risk of being imitated or subject to obsolescence. Therefore, there exists a

need for high and stable investments to enhance complementarity and cumulative effects and to constantly protect the intangible investment from imitation and obsolescence.

Given this broad theoretical framework, we define and provide support for a set of hypotheses concerning the factors explaining the adoption of distinct intangible investment strategies. In particular, we focus on four factors: (i) the internal competences necessary for a persistent vs. discontinuous accumulation of intangible assets to be undertaken; (ii) the types of competitive advantage that intangible assets are likely to generate with specific reference to the market in which firms operate; (iii) the degree of demand uncertainty that firms face as a result of their overall growth strategy; and (iv) the technological factors that may constrain the firm's intangible investment decisions. Firms are classified according to their investment profile using a rank-based algorithmic procedure. The theoretical hypotheses are tested on a rich dataset on Italian manufacturing firms.

Overall, we obtain five main results: first, absorptive capacity is a key competence in sustaining the adoption of an intangible investment strategy, which may be either persistent or discontinuous; second, the implementation of a persistent intangible investment strategy necessarily requires specific investments in the quality of the human resource base to be made; third, firms with a greater propensity to operate in international markets are more likely to adopt a persistent intangible investment strategy than they are to adopt a discontinuous one; fourth, firms that undertake a growth path that is based on highly uncertain demand segments and high organisational flexibility are likely to adopt a discontinuous intangible investment strategy; and five, the historical intangible asset base represents an important constraint on firms' investment behaviour. The combination of these results adds to the previous literature, which is completely silent on the determinants of a firm's intangible investments.

The paper is organised as follows. Section 2 discusses the evidence concerning the existence of both persistent and discontinuous intangible investment strategies. Section 3 presents a brief overview of the literature on organisational capabilities and intangible assets and introduces our research hypotheses. Section 4 describes the dataset and the procedure of classifying firms. Section 5 discusses the empirical strategy employed in the estimation and presents the main variables included in the analysis. Section 6 presents and discusses the results. Section 7 lists several robustness checks. Finally, Section 8 concludes.

2. Intangible assets dynamics: persistence or volatility?

Intangible assets are typically described as resources that exhibit highly persistent accumulation dynamics. The reason is usually related to the existence of increasing returns in intangible investments due to both fixed costs and complementarities within the asset stock (Teece, 1987; Dierickx and Cool, 1989; Knott et al., 2003). Along these lines, the main strategic problem faced by managers has often been associated with the process through which firms are able to effectively converge towards persistent paths of intangible accumulation, being confident that such convergence can steadily sustain competitive advantages over time.

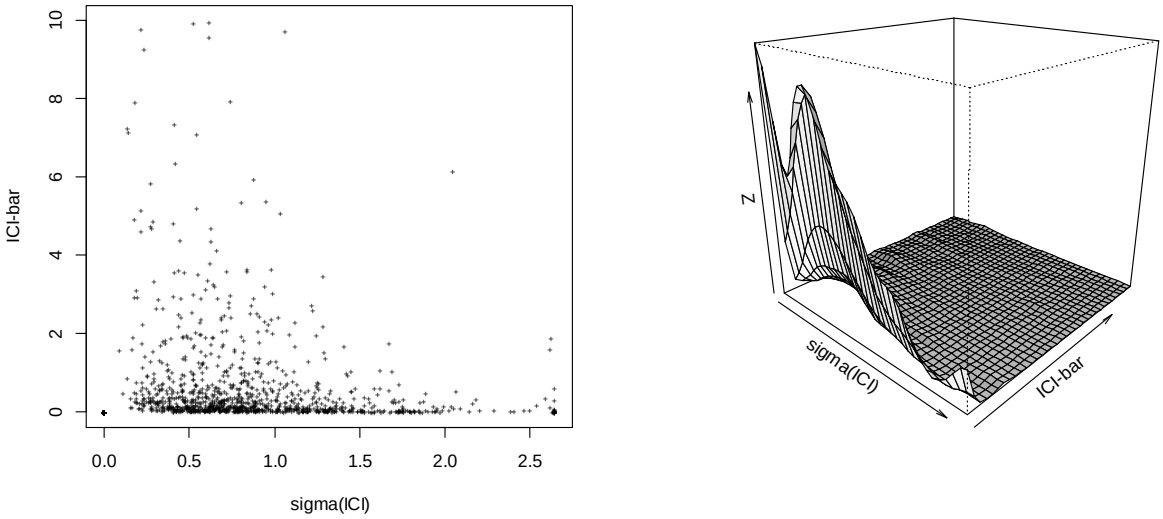
Although some evidence on the persistence of intangible investments exists (e.g., Arrighetti et al., 2011), actual data reveal that when one considers sufficiently long time spans, the taxonomy of firms' behaviour is far more differentiated than is usually thought. In particular, firms tend to adopt strategies that vary considerably in terms of the level and volatility of intangible investments, with the latter dimension being particularly relevant for a surprisingly large fraction of firms.

On this respect, Figure 1 presents the relationship between the average level and the volatility of the ratio of intangible assets over total assets for the sample of Italian manufacturing firms included in our dataset. We call this ratio intangible capital intensity (*ICI*) and compute the volatility ($\sigma(ICI)_i$) as the standard deviation of *n*-years windows of $ICI_{i,t}$ normalised by the *n*-years average level of $ICI_{i,t}$ ($\overline{ICI}_i$) – for more details on how volatility is computed, see the Appendix. The value of both intangible and total assets is derived from the firms' disaggregated balance sheets (see Section 4). Panel A reports the observed values for $\overline{ICI}_i$ and $\sigma(ICI)_i$ on the vertical and horizontal axes, respectively. Panel B reports the associated kernel density function.[4] In computing these values, we consider a time span of eight years, with *t* ranging from 2001 to 2008 (i.e., $n = 8$)

[4] To facilitate the interpretation of this graphic, we report observations where $\overline{ICI}_i \leq 10$.

Figure 1 – Intangible assets investments and volatility

Panel A Panel B



Legend: Panel A reports the two-way plot of the average level and volatility of ICI_i, for the time-span 2001-2008. Panel B reports the bivariate density estimation associated with Panel A. As it is easy see there exist three main groups of firms: those who invest very little in intangible assets, and do so persistently (peak on the left side of Panel B); those whose investments are on average low but highly volatile (central peak in Panel B); and finally, those who invest a large amount of resources in intangible assets, and do so persistently (long tail towards the north-east corner of Panel B).

At an intuitive level, firms tend to concentrate in three main groups. First, we have the firms belonging to the peak on the left side of Panel B, in coincidence with the combination $\overline{ICI}_i = 0$ and $\sigma(ICI)_i = 0$ (plus some neighbouring points). These are firms that persistently invest very little in intangible assets.[5] Second, moving rightward, we have a large group of firms belonging to the main peak in Panel B, characterised by positive values of both $\overline{ICI}_i$ and $\sigma(ICI)_i$. These are firms whose investments in intangible assets tend to be low on average but highly volatile. Finally, we have the long tail, which corresponds to firms characterised by a high level of $\overline{ICI}_i$ (> 1%) and a relatively low $\sigma(ICI)_i$ – consider that the mean and median values of $\sigma(ICI)_i$ for the entire sample are 0.77 and 0.68,

[5] Although the combination $\overline{ICI}_i = 0$ and $\sigma(ICI)_i = 0$ appears as a single dot in Panel A, we know that it counts 157 observations, i.e., nearly 13% of the sample. These are firms that for the entire period of 2001-2008 report no investment in intangible assets on their balance sheet.

respectively. These are firms that persistently invest a large amount of resources in intangible assets. Overall, especially in light of the large number of firms that exhibit high volatility, this figure reveals the process of intangible asset accumulation to be fairly different from a plainly flat and stable phenomenon and that different investments profiles exist in the population of firms.

However, this result is only apparently unexpected. Previous works have indeed shown that some intangible-related investments such as R&D can be markedly discontinuous over time. Moreover, these works have also shown that a large share of firms tends not to invest at all in this type of asset. Blazenko *et al.* (2012), for instance, show that in firms with positive investments in R&D for at least 10 years, the volatility of expenditures is very high. At the same time, Cohen et al. (1987) reveal that in large U.S. firms, approximately 25% do not report any formal investment in R&D. Similar results are obtained by Galende and Suarez (1999) and Goodwin and Ahmed (2006) as well. The latter, in particular, use Australian data to show that only a minority of firms (30%) capitalise intangibles and that those that do capitalise the values for the various measures of intellectual capital at the firm level exhibit high variance (on this point, see also Clarke et al. 2011).

Similar results have also been achieved in works inspired by the so-called behavioural theory of the firm. Greve (2003), for example, shows that investment in R&D may be highly volatile and offers a possible interpretation for such a result. This volatility is associated with the finding that R&D expenditures tend to increase when low performance leads to "problemistic search" and when excess resources cause "slack search". In this sense, higher performance is associated with less innovation, and higher slack is correlated with higher R&D intensity. In addition, a punctuated equilibrium framework implies that firms adopt different patterns of immaterial investments over time. Firms are moving from exploitation and low R&D activity during periods of stability to exploration and high R&D activity during phases of change (Mudambi and Swift 2011).

Furthermore, significant differences emerge even among firms belonging to the same industry. On this issue, Ballester *et al.* (2003) show that even within very narrowly defined sectors, the differences between firms in capitalised R&D investments are considerable.

All the same, this literature, together with the intuitive characterisation of the different types of firm behaviour portrayed in Figure 1, suggests that intangible investment strategies may indeed vary considerably across firms. Alongside differences in the level of

investments, intangible investment strategies may also diverge in terms of dynamics. Firms that undertake strategies characterised by highly persistent investments tend in fact to co-exist with firms exhibiting huge discontinuities. The main aim of the remaining parts of the paper is thus to investigate the origin of such a high degree of heterogeneity in the dynamics of investments. On this issue, a set of hypotheses within the frame of the so-called organisational capabilities view will be presented in the following section.

3. Organizational capabilities and intangible investments

An important stream of the management and business economics literature locates the main determinants of firm strategic behaviour in what are usually called *organisational capabilities* (Penrose, 1959; Teece, 1980; Nelson and Winter, 1982; Chandler, 1990; Barney, 1991; Dosi et al., 2000). Generally defined as a firm's specific "ways of doing" (Dosi et al., 2006), organisational capabilities are often indicated as a major source of a firm's competitive advantage and are deemed to explain different paths of performance across firms. Chandler (1992), for instance, cites organisational capabilities as the main base upon which managers create firm-specific and difficult-to-imitate assets, which in turn sustain firms' competitiveness in the market. Teece et al. (1997), in a similar fashion, describe organisational capabilities as the key determinant of firms' strategic behaviour in that they both delimit the set of decisions that firms can actually make (i.e., they define the resource/competence base for such decisions) and represent the main strategic target upon which sustained competitive advantage can be accrued. More recently, Augier and Teece (2009) suggest organisational capabilities to be a crucial theoretical construct for understanding the role of both managers and management in the processes of organisational and strategic renewal.

With specific reference to intangible assets, the role of organisational capabilities has been widely discussed (Amit and Shoemaker, 1993; Teece, 2000; Gold et al., 2001; Koruna, 2004; Galbreath, 2005; Pike et al., 2005). As suggested by Teece (2011), intangible assets consist for the most part of non-codified knowledge and thus contribute to extend the set of difficult-to-imitate resources accumulated within firms. Even when they are bought on the market (as in the case of, e.g., patent, license, technology-related consulting services),

intangible assets are usually combined with complementary firm-specific assets, thus enriching the competence base through which competitive advantages are sustained. Meanwhile, intangible assets are complex resources that require specific dynamic capabilities to be both accumulated and managed. Especially in contexts characterised by rapid technological change, in fact, the process of intangible asset accumulation cannot abstract from the existence of appropriate organisational routines and processes, which help firms to constantly refine and deploy their knowledge base (Grant, 1996).

Within this theoretical framework, the behavioural diversity observed in Section 2 may be partly explained by the specific competence position that a firm must acquire before a persistent process of intangible asset accumulation may be maintained. If on the one hand such a position increases the probability that a sustained competitive advantage is acquired, on the other, it may be very costly to achieve in that it requires firm-specific investments in competence and capability building. This phenomenon may in turn lead firms to diverge in their investment decisions, with some firms choosing to adopt a linear path of persistent accumulation and others undertaking a mixed strategy of discontinuous investment. The latter, unlike the others, tend to alternate periods of repeated investments with periods during which the accumulation process is halted.

To test the validity of this interpretation, we will consider a set of variables that may help in explaining why a firm chooses to adopt a specific path of intangible investment as opposed to another. Our attention, in particular, will be placed on four broad typologies of factors: (i) the internal competences that are necessary for a persistent vs. discontinuous accumulation of intangible assets to be undertaken; (ii) the types of competitive advantage that intangible assets are likely to generate with specific reference to the market in which firms operate; (iii) the degree of demand uncertainty that a firm faces as a result of its overall growth strategy; and (iv) the technological factors that may constrain the firm's intangible investment decisions. For each of these categories, we will define a specific set of hypotheses.

3.1 Internal competences

Among the several types of internal competences that have been deemed to facilitate the strategic accumulation of intangible assets, one that has received particular attention in the

literature is the so-called *absorptive capacity*. Originally introduced by Cohen and Levinthal (1990), absorptive capacity refers to the firm's ability to value, assimilate, and apply new knowledge. Mowery and Oxely (1995) expand on this notion by defining absorptive capacity as the broad set of skills needed to address the tacit component of transferred knowledge and the need to modify this imported knowledge. A direct link with the framework of dynamic capabilities is then offered by Zahra and George (2002, p. 186), according to whom absorptive capacity is as a set of 'organisational routines and processes by which firms acquire, assimilates, transform, and exploit knowledge to produce a dynamic organisational capability.' In all these cases, absorptive capacity is conceived as a key component of a firm's capability to identify external sources of knowledge and to recombine them internally in a coherent intangible investment strategy. Therefore, our first hypothesis is as follows:

Hypothesis 1A – *A firm with more absorptive capacity has a greater probability of adopting an intangible investment strategy (either persistent or discontinuous).*

In addition to the routinised ability to search and exploit the knowledge landscape, however, another critical resource in the process of intangible asset accumulation is the quality of a firm's human resource base, i.e., the set of firm-specific skills and abilities that are embedded within the organisation. Several authors have indeed suggested that the quality of the human resources employed by firms is a basic condition both for generating intangible assets and for their economic exploitation (Abramovitz and David, 2000; Galor and Moav 2004). In this framework, the human resource base goes beyond the simple investment in R&D so far as to include the formal education received by the workforce before hiring as well as formal and informal on-the-job training (Barney, 1991; Nerdrum Erikson 2001). Moreover, the human resource base includes the internal structuring and organisation of the firm (e.g., the share of white-collar workers), which in turn affects the nature of the acquired organisational knowledge. All these resources represent specific investments at the firm level (Teece et al., 1997), whose cost is often relevant. However, firms that are able to sustain such costs gain a resource position that allows them to both accumulate and manage a large and complex stock of intangible assets, whose value must

be continuously replenished. On these grounds, we expect firms with a large human resource base to persistently invest in intangible assets:

Hypothesis 1B – *A firm with a large human resource base is more likely to adopt a persistent intangible investment strategy than a discontinuous intangible investment strategy.*

3.2 Competitive advantages and markets

In addition to the competence position, another factor that certainly impacts the type of intangible investment strategy adopted by firms concerns the typology of market (national vs. international) in which firms operate. As argued above, in fact, intangible assets are themselves the source of important competitive advantages for organisations, especially when they are associated with tacit and difficult-to-imitate knowledge components (Itami, 1987). For this reason, firms that operate in highly competitive international markets may be more keen to persistently invest in this type of asset than firms operating only locally (or at best at the national level) because they actually require these assets to beat competitors. On this issue, López Rodríguez and García Rodríguez (2005) provide some empirical evidence supporting the role of intangible assets as key drivers of the success of firms' exports. On this basis, the second hypothesis that we advance is as follows:

Hypothesis 2 – *A firm that is export-oriented is more likely to adopt a persistent intangible investment strategy than a discontinuous intangible investment strategy.*

3.3 Uncertainty

It is reasonable to expect that the type of intangible investment strategy depends also on the growth strategy that is pursued by firms as well as the link between the latter and the required degree of organisational flexibility. According to the punctuated equilibrium approach, the volatility of intangible expenditures is indicative of aggressive management

and is correlated with the firm's having a growth orientation. Firms choose to concentrate their intangible investments in periods of change and growth and tend to reduce investment activity in periods of relative stability (Mubandi and Swift, 2011). Furthermore, firms that adopt growth-oriented strategies focused on markets characterised by high uncertainty must be sufficiently flexible in their internal organisation. This approach, as suggested by the cumulative capability or 'sand cone' model literature (Ferdows and De Meywr, 1990; Schroeder et al. 2010), necessarily requires the adoption of direct actions to support the quality of the production process, with particular attention paid to the implementation of innovative practices (e.g., total quality management). Meanwhile, however, the need for flexibility imposes a limit on the possibility of basing such procedural improvements on a persistent strategy of intangible accumulation, which may in turn increase the risk of being locked into disadvantageous technological trajectories. On the contrary, firms with these characteristics will tend to adopt more volatile investment strategies that allow them to rapidly switch across the different intangibles that they must acquire. On this ground, the third hypothesis we advance is as follows:

Hypothesis 3 – *A firm that is pursuing a growth-oriented strategy in contexts characterised by high uncertainty is more likely to adopt a discontinuous intangible investment strategy than a persistent intangible investment strategy.*

3.4 Cumulative effects

Finally, moving from the type of markets and demand that the firm serves to the technological factors that may constrain behaviour, a crucial role may also be played by the previously accumulated stock of intangible assets. In this respect, several features of the process of intangible asset accumulation may be important. First, intangible assets consist of knowledge, which is cumulative by nature. Within the context of the organisational capabilities literature, for instance, Dierickx and Cool (1989) suggest the existence of economies of scale in the generation of the intangible asset base from the existing asset stock. According to Knott et al. (2003), this finding implies that a greater level of intangible assets is associated with a lower marginal cost of investing in the further extension of the

asset stock. The reason may be the existence of what Teece (1987) calls the *interconnectedness of asset stocks*, i.e., complementarities among the different components of the knowledge stock. When these complementarities exist, it is obvious to expect firms that invest significantly in the past to persistently invest in the future as well.

Moving from the structural characteristics of intangible assets to the specific features of the firm's behaviour, a similar argument for the existence of a positive relationship between the size of the intangible asset base and the persistence of investments can be formulated by relying on the idea of organisational learning (see Dosi et al., 2006). In a nutshell, the idea of organisational learning suggests that when a firm adjusts its internal organisation to (a) search the knowledge landscape and (b) invest in a particular type of asset, the firm learns a set of capabilities. These capabilities are likely to generate a relative advantage in pursuing investments in similar and related assets compared to competitors that do not invest in the first place. Consequently, a larger set of intangible resources accumulated in the firm at any given point in time indicates a lower cost of each additional investment and thus a stronger propensity to persistently invest.

Based on these arguments and independently of the factors that have the strongest power in explaining the cumulative path, our fourth and last hypothesis is thus as follows:

Hypothesis 4 – *A firm with a large intangible asset base is more likely to adopt a persistent intangible investment strategy than a discontinuous intangible investment strategy.*

4. Data and firm type taxonomy

To test the hypotheses defined in the previous section, we use a joint dataset retrieved from two main sources. The first source is the IX wave of Capitalia's Survey on Manufacturing Firms, which covers the period 2001-2003 and contains qualitative and quantitative information for a large stratified sample of Italian firms. In particular, it contains information on workforce composition and education, R&D expenditures, sales, exports, competitors, quality management certification (e.g., ISO 9000), subcontracting, and process and product innovations. The second source is the AIDA-Bureau van Dick database, which

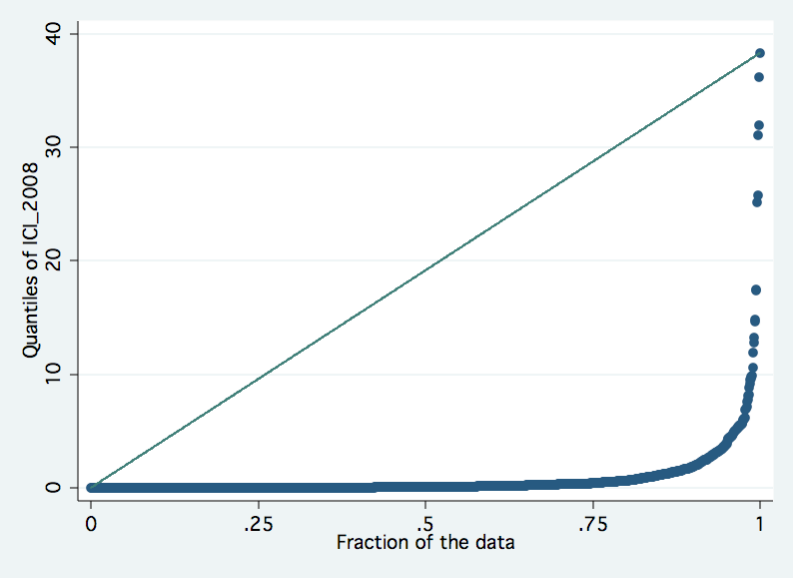
contains all Italian firms' disaggregated balance sheet information for the period 2001-2008. With these two sources combined, the final dataset contains 1,116 observations. The representativeness of the original sample is maintained in terms of firm size and industry.[6]

The measure of intangible assets that we consider in our analysis is the sum of three types of costs reported on the firm's balance sheet, i.e., the "costs for research and advertisement", the "costs of patents" and the "costs of licensing". This measure is then normalised by each firm's total asset size to compute the firm's intangible capital intensity (*ICI*). It is important to note that the variable that we obtain in this way is to be considered a proxy of the immaterial resources employed in the production process and in itself is not a measure of interest. For each firm, our main focus is on the relative size of such measure with respect to all the other firms included in the sample and on the way in which such measure evolves over time.

Given this set of data, the first step that we take in our empirical investigation is to classify firms according to their intangible investment strategy. In doing so, the main difficulty that we encounter is related to a relatively non-well behaved distribution of ICI_t. In each year, in fact, this variable takes a value of zero for a large portion of firms in the sample (24% on average). Moreover, as shown in Figure 2 for the year 2008, the distribution of ICI_t tends to be very concentrated, with over 75% of the firms investing less than 1% of total assets and the top 10% investing from 2% to 38% of their total assets. An analysis of firms' behaviour based on this type of distribution would inevitably reduce the degree of heterogeneity in the sub-sample of low- and medium-investing firms ($\overline{ICI_i} \leq 1\%$) and exacerbate the differences between the latter and the high-investing ones ($\overline{ICI_i} > 1\%$). On this basis, given that the main focus of our investigation is to identify any difference in investment strategies within the sub-sample of low and medium investing firms, we must transform ICI_t accordingly.

[6] Tables reporting on the sample's representativeness are available from the authors upon request.

Figure 2 – Quantile distribution of *ICI* for the year 2008.



Legend: quantile distribution of the ratio intangible assets over total assets in 2008 for the sample of firms included in our dataset. The distribution shows that investments in intangible vary considerably across firms.

In the literature, two transformation rules are usually employed to smooth the shape of distributions, namely taking logs or computing growth rates. In our case, however, none of these options is viable due to the large share of zeros in the distribution. In alternative, we choose to transform *ICI* by taking into consideration ranks. In particular, we follow a three-steps classification procedure. First, for each period *t* in our 8-year window (2001-2008), we rank firms according to their level of *ICI*. We call r^t the variable containing the complete *ICI*-rank of firms at time *t*. We then attribute to each firm *i* the vector $\mathbf{r}_i = (r_i^{2001}, r_i^{2002}, \ldots, r_i^{2008})$, where r_i^t is the *ICI*-rank of firm *i* at time *t*. This vector is composed of integer numbers and describes the investment profile of each firm relative to all the other firms included in the sample. Finally, we run the Ward's linkage algorithm (Ward, 1963) on the set of r^t for $t = 2001,\ldots,2008$ to identify clusters of firm profiles.[7]

Overall, the adoption of a rank-based classification procedure in studying the evolution of firms' investments presents both costs and benefits. On the side of costs, it makes the investment profile of each firm relatively difficult to interpret because it becomes a

[7] An alternative solution would be to consider transitions across percentiles. In this respect, however, the analysis based on ranks allows for a thinner classification procedure.

function of the investment decisions taken by all the other firms in the sample. On the side of benefits, it achieves two main objectives: first, it smooths the distance between highly investing firms on the one hand and medium and low investing firms on the other; and second, it increases the variability in the sub-sample of low- and medium-investing firms, thus making it possible to distinguish possible different types of strategic behaviour. Overall, especially in light of the data we have, we believe that this type of classification procedure represents a useful solution to investigate the evolution of firm behaviours.

Given this classification procedure, we then proceed to validate the clusters, i.e., to establish the number of clusters that most meaningfully captures the distinct profiles of firm behaviour present in our data. We are aware that imposing a number of clusters equal to two would reproduce a result similar to that examined in Arrighetti et al. (2011), namely that we have a dichotomy in our data with a large majority of firms whose intangible assets account for less than 1% of total assets and a few other firms investing massively (with figures ranging from 2% to 38% of total assets). For this reason, we compute cluster validation indexes for three or more groups, being conscious that ultimately we are interested in a clustering procedure that meets our research objectives.

Table 1 reports the results of five distinct cluster validation tests for the number of imposed clusters (k) varying from 3 to 6. The average silhouette width (ASW) index (column 1) is high for both k=3 and k=4 and much smaller for k>4, implying a moderate amount of similarity between the former two groupings. The values of Pearson Gamma (column 2) suggest on the contrary to consider k=4 the most suitable solution, whereas, according to Calinski and Harabasz's index (column 3), the best clustering of the data is with k=3. The results of version 1 of Dunn's index (column 4) are in line with the ASW index, showing k=3 and k=4 to be the two optimal choices. The main goal of this measure is to maximise inter-cluster distances (distance between different clusters) while minimising intra-cluster distances (distance between members of a cluster). Version 2 of Dunn's index is similar but focuses on the concept of average dissimilarity and thus yields a somewhat different result, suggesting that k=3 is the optimal number of clusters (although the value of the index is very similar for k=4). All in all, given that three indexes out of five indicate k=3 to be the most meaningful solution, we adopt the latter as the main reference in

the remaining sections of the paper.[8]

Table 1 – Rank-based Clusters Validation, *k* = number of clusters.

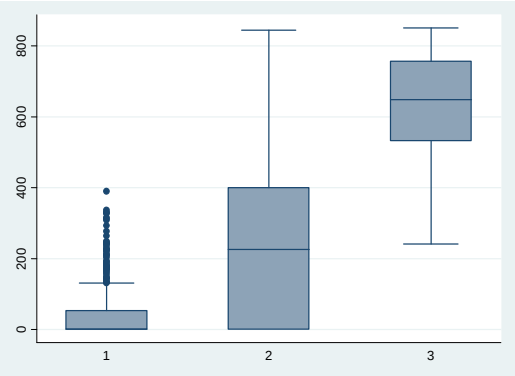
	ASW	P-GAMMA	CH	DUNN1	DUNN2
	(1)	(2)	(3)	(4)	(5)
k = 3	0.2988	0.5028	548.9742	0.0877	1.0918
k = 4	0.3012	0.5736	456.8676	0.0877	0.9741
k = 5	0.2509	0.5479	389.5179	0.0669	0.7704
k = 6	0.1991	0.4568	328.9468	0.0552	0.4850

Note: abbreviations ASW=average silhoutte width; P-GAMMA= Pearson Gamma; DUNN1= dunn minimum separation / maximum diameter. DUNN2= minimum average dissimilarity between two cluster / maximum average within cluster dissimilarity. For additional details see Halkidi et al. (2002).

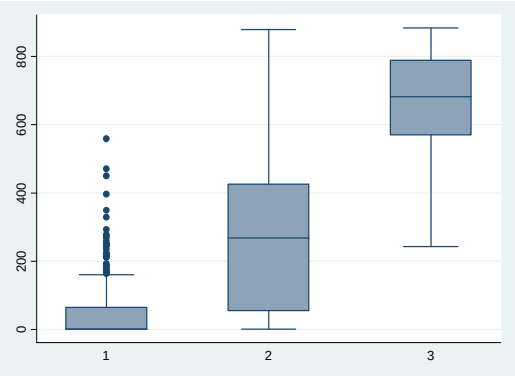
Our initial intuition on the relationship between average level and the volatility of *ICI* reported in Figure 1 may be summarised as follows. Three main typologies of firm exist: those that persistently invest very little in intangible assets; those whose investments are highly volatile and relatively low on average; and those that persistently invest a large amount of resources in intangible assets. This intuition appears to be confirmed by the results of the cluster analysis. On this issue, the box plots in Figure 3 report the distribution of the firms' *ICI*-rank per year and firm cluster while imposing *k*=3. These plots clearly show that every year, the three clusters tend to be distinguished in terms of both the mean and variability of the ranks. In particular, we observe that there exist two groups of firms, those labelled 1 and 3 in the figure, exhibiting a relatively low and high average rank, respectively, together with limited variance and range of variation. Meanwhile, there is one group of firms, labelled 2, characterised by an intermediate average rank combined with large variance and a wide range of variation.

[8] From a qualitative point of view, the computed indexes suggest that the solution with *k*=4 is not very different from the one with *k*=3. The main distinction comes from the fact that when we impose *k*=4, the algorithm tends to split the cluster of firms with a volatile investment behaviour into two, thus adding little in interpretative terms. This finding reinforces our choice of opting for *k*=3 rather than *k*=4.

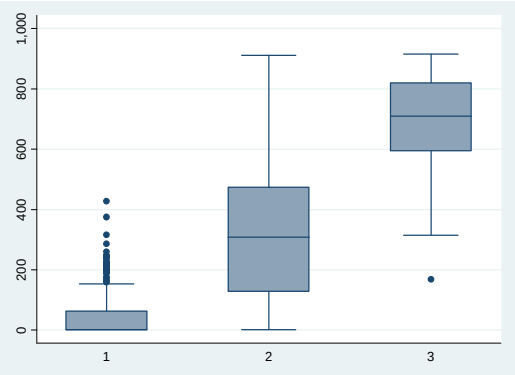
Figure 3 – Distribution of *ICI*-rank by firm clusters and year.



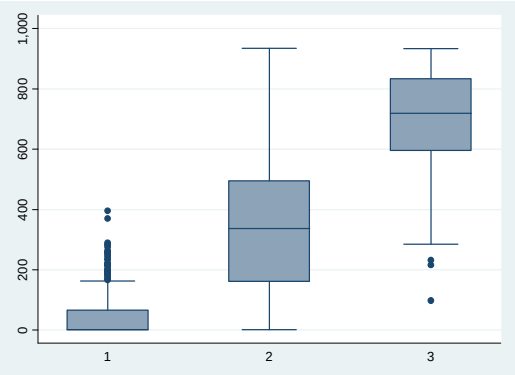
Year 2001; 1=LIFs, 2=VIFs, 3=HIFs.



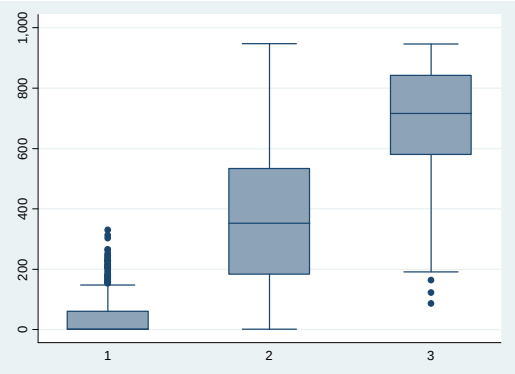
Year 2002; 1=LIFs, 2=VIFs, 3=HIFs.



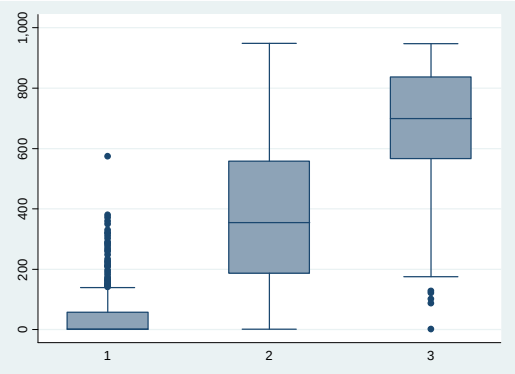
Year 2003; 1=LIFs, 2=VIFs, 3=HIFs.



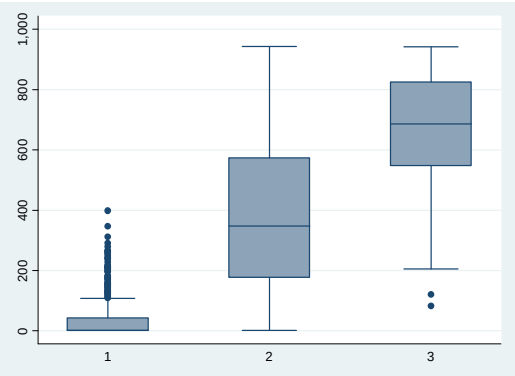
Year 2004; 1=LIFs, 2=VIFs, 3=HIFs.



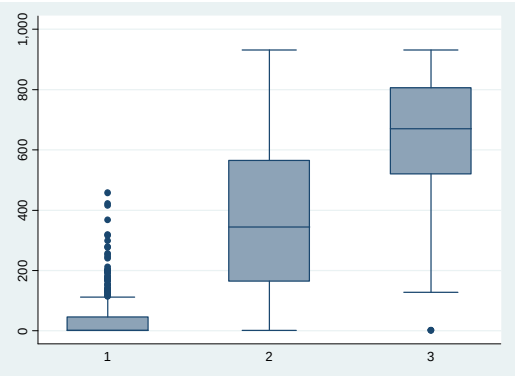
Year 2005; 1=LIFs, 2=VIFs, 3=HIFs.



Year 2006; 1=LIFs, 2=VIFs, 3=HIFs.



Year 2007; 1=LIFs, 2=VIFs, 3=HIFs.



Year 2008; 1=LIFs, 2=VIFs, 3=HIFs.

When considered together, these results suggest that although ranks are by themselves loose measures that depend heavily on what other firms do, the clusters that we identified do capture part of the behavioural differences existing in the underlying data. As a matter of fact, we observe that whereas for one group of firms (i.e., group 2 in the figure) the actual ranks span the entire possible range, for the two other groups, the variation is fairly limited. This difference may in part also be reflected in the distinct evolution of behaviours over time, with the firms belonging to the first group exhibiting high variability and those belonging to the second showing high persistence.

Some additional features of the three clusters confirm the existence of important differences in terms of firms' behavioural pattern over time. Table 2 reports some descriptive statistics for the computed clusters, with the last column reporting the results of an F-test on the difference between the means. Similarly to the case reported in Figure 3, clusters tend to distinguish in terms of both the average level and the volatility of *ICI*. On one extreme (left-hand side of the table) exists a cluster of firms (25% of the sample) that on average exhibit a high level of *ICI* (1.99%) and relatively low volatility (0.54). We call this group High Investment Firms (HIFs). On the other extreme (right-hand side of the table), there exists another cluster of similar size (26% of the sample) that on average exhibits a low level of *ICI* (0.01%) and low volatility (0.68). We call this group Low Investment Firms (LIFs). In the middle exist a large cluster of firms (49% of the sample) that on average exhibit relatively low level of *ICI* (0.41) but high volatility (0.97). We call this group Volatile Investment Firms (VIFs). Each of these clusters is deemed to represent a specific typology of firm behaviour.

The remaining statistics reported in Table 2 offer the possibility to derive a better understanding of the specific features of the firms belonging to each cluster (for a detailed description of the variables' meaning see the Appendix). By comparing HIFs and VIFs against LIFs, we can first observe that the former two tend to be on average larger (*SIZE*) than the latter and exhibit a greater per-employee expenditure on R&D (*R&D*). This finding goes together with a greater investment in sustaining the quality of the production process, as shown by the large fraction of HIFs and VIFs having ISO 9000 certification (*D_ISO*). Meanwhile, HIFs have a greater proportion of graduated employees (*UNIDEG*) than both VIFs and LIFs and a higher staff ratio (*STAFFRATIO*). This finding lends support to the idea according to which although both HIFs and VIFs are characterised by a larger

competence base than LIFs, HIFs have made more systematic investments in sustaining the quality of their human resources compared to VIFs.

Table 2 – Clusters' descriptive statistics

	HIFs			VIFs			LIFs		
	N.	**mean**	**sd**	**N.**	**mean**	**sd**	**N.**	**mean**	**sd**	**F-test**
ICI (%)	303	1.99	2.93	504	0.41	1.38	313	0.01	0.01	***
σ (ICI) (volatility)	303	0.54	0.27	504	0.97	0.49	313	0.68	0.80	***
SIZE (empl.)	303	121.38	168.76	504	87.45	104.88	313	65.84	91.83	***
UNIDEG	303	0.08	0.09	504	0.05	0.06	313	0.04	0.06	***
STAFFRATIO	303	1.05	3.56	504	0.56	0.99	313	0.60	2.43	**
AVEDU	303	10.69	1.43	504	10.29	1.33	313	10.06	1.35	***
R&D (exp./empl.)	303	0.26	0.49	504	0.14	0.53	313	0.06	0.15	***
D_EXPORT	303	0.89	0.32	504	0.77	0.42	313	0.71	0.45	***
SUBCT (% sales)	303	50.51	44.46	504	52.66	45.47	313	58.13	45.59	*
COSTLAB (norm.)	303	1.05	0.34	504	1.00	0.32	313	0.95	0.28	***
D_ISO	303	0.64	0.48	504	0.62	0.49	313	0.49	0.50	***
D_INNO	303	0.84	0.36	501	0.74	0.44	312	0.67	0.47	***
σ (SALES) (volatility)	303	39.88	106.08	504	43.73	179.94	313	30.57	74.31	
G_SALES (growth rate)	303	0.12	0.27	504	0.13	0.34	313	0.11	0.31	

Legend: *=sig. 10%; **=sig. 5%; ***=sig. 1%

Moving from the analysis of the internal characteristics to the context in which firms operate, it is possible to identify some clear distinctions as well. First, HIFs tend to be more internationalised than both VIFs and LIFs in the sense of being oriented towards export (*D_EXPORT*) and facing international competitors (*D_COMPETITORS*). Meanwhile, LIFs exhibit a larger fraction of sales due to subcontracting compared to both VIFs and HIFs (*SUBCT*). This finding may suggest the existence of the different positioning of the distinct types of firms along what is usually defined as the global value chain.

Finally, by examining the statistics concerning the dynamics of sales and innovation, it is possible to identify some differences also in terms of the particular growth strategy that firms are undertaking. In particular, VIFs on average experience a higher growth rate in sales compared to both HIFs and LIFs (*G_SALES*) in combination with a greater volatility of sales (σ(*SALES*)) (even though such differences are not statistically). Meanwhile, both

HIFs and VIFs exhibit a greater propensity towards innovation than LIFs (*D_INNO*). Combining these findings, VIFs appear to be pursuing a growth strategy that is focused on relatively uncertain demand segments compared to HIFs and VIFs. This strategy is partially sustained by a high rate of product and process innovations, which help the companies to constantly outcompete their competitors.

Overall, the descriptive statistics associated with HIFs, VIFs and LIFs tend to be aligned with the hypotheses formulated in Section 3. To have a clear test of the latter, we now proceed with a systematic empirical investigation.

5. Empirical strategy

Following the generic approach defined in Arrighetti et al. (2011), we model the propensity to adopt a particular type of investment strategy as a function of two main types of variables. On the one hand, we consider systemic variables, such as the industry in which the firm operates. These variables are treated as controls in our analysis. On the other, we consider firm-specific characteristics, with particular attention being paid to absorptive capacity, the human resource base, the degree of internationalisation, the historical intangible asset base and firm size. On this basis, we want to estimate the effect of each of such variables on the probability that a firm belongs to a different behavioural type, i.e., HIF, LIF, and VIF, during the period 2001-2008.

Formally, the model to be estimated takes the following form. Let $TYPE_i$ be a discrete variable defining the cluster firm *i* belonging to, i.e., *i*'s behavioural type. $TYPE_i$ can take three different values: 1 if a firm is HIF, 2 if a firm is VIF and 3 if a firm is LIF. Then, the probability that anyone of the behavioural type is observed is

$$\Pr(TYPE = k) = \frac{\exp(XF_i'\beta_F^k + XC_i'\beta_C^k)}{1 + \sum_{j=1}^{3}\exp(XF_i'\beta_F^j + XC_i'\beta_C^j)} \quad \text{for} \quad k = 1, 2, 3 \qquad (1)$$

where XF_i is a vector of firm-specific characteristics, XC_i is the vector of control variables, β_F^j and β_C^j are vectors of parameters, which are usually different for each j = 1, 2, 3.

Equation (1) represents a standard multinomial logit model, which is estimated via maximum likelihood estimation.

All independent variables in equation (1) are evaluated at the beginning of the time span under analysis, i.e., taking into consideration the three-year period 2001-2003 – except for certain variables, for which we considered the period 2001-2004 (see below). In this way, we can control for all sorts of endogenous effects that may be derived from the simultaneous definition of both a firm's intangible strategy profile and some of our independent variables. To control for omitted variable bias, not having the ability to add firm fixed effects (data are cross-sectional), we saturate the vector of controls with several variables that could be correlated with the decision to adopt a specific type of intangible investment strategy, such as age (*AGE*), investments in ICT (*ICT_INV*), labour productivity, measured in terms of added value per employee (*LAB_PRDTY*), whether the firm faces international competitors (*D_COMPETITORS*) and the cost of labour normalised by the average cost in the industry in which the firm operates (*COSTLAB*). To control for the business cycle, we also add the volatility of total assets (σ (*TOT_ASSETS*)) as an independent variable. In addition, we include a series of firm-specific accounting indexes such as financial autonomy (*FIN_AUTON*) (net worth over total assets, where the net worth includes equity, non-distributed shares and annual profit/loss) and the profitability or gross earnings over total turnover (*PROFIT*). Finally, we also control for geography-related effects with the introduction of regional dummies and for industries with the addition of dummies for Pavitt's categories (see Pavitt, 1984).

To represent the firm-specific characteristics that are the main object of our analysis, we consider the following variables. With respect to absorptive capacity, we follow the previous literature and consider as a proxy the per-employee expenditure in R&D (*R&D*). As a proxy for the human resource base, we consider a synthetic index elaborated with a factorial analysis (*FCT_EDU*) using as inputs the ratio between "white collar" and "blue collar" workers (*STAFFRATIO*), the workforce's average number of years of education (*AVEDU*) and the percentage of employees holding a university degree (*UNIDEG*). As discussed in Section 3, we believe that these two variables capture two distinct aspects of a firm's competence base. *R&D* captures the firm's ability to value and assimilate new knowledge and to eventually engage in intangible stock-expanding activities. *FCT_EDU* reflects instead a long-term commitment by the firm to sustain the quality of its human

resources and acquire the internal competences necessary for a complex intangible stock to be steadily managed. The empirical evidence also confirms our view. In fact, the factorial analysis that we conducted to compute *FCT_EDU* revealed *R&D* to contain a different set of information with respect to *STAFFRATIO*, *AVEDU* and *UNIDEG*.

Moving from the firm's internal competences to the context in which the firm operates, we consider the following variables. As a proxy for the propensity to operate in international markets, we consider a dummy variable (*EXPORT*) that takes the value 1 if the firm has exported during the period 2001-2003 and 0 otherwise. The features of the firm's growth strategy are instead captured by a synthetic index elaborated with a factorial analysis (*GROWTH_FCT*) combining the growth (*G_SALES*) and volatility of sales (σ(*SALES*)), a dummy variable taking the value 1 if the firm is certified ISO 9000 and 0 otherwise (*D_ISO*) and a dummy taking the value 1 if the firm innovated (i.e., engaged in either product or process innovation) during the period 2001-2003 and 0 otherwise (*D_INNO*). From our perspective, such an index captures the characteristics of the firm's growth strategy along three dimensions: uncertainty (σ(*SALES*)), innovativeness (*D_INNO*), and the quality of the production process (*D_ISO*). A greater index value indicates that the firm is to a greater extent pursuing a growth-oriented strategy that involves both uncertainty and organisational flexibility[9].

Finally, for a proxy for the degree of accumulated intangible capital, we consider a dummy taking the value 1 if the firm belongs to the fourth quartile of the lagged value of *ICI* (average 2001-2003) and 0 otherwise (*D_ICI_PAST*). Such a variable is aimed at capturing the extent to which the intangible asset base accumulated in the past constrains the type of intangible investment strategy a firm can pursue.

6. Results

Table 3 reports the multinomial logit estimates of our model, translated into marginal and impact effects for the continuous and dummy variables, respectively. The coefficients are obtained by computing estimates of the marginal effects for each firm in the sample and

[9] For the link between flexibility and investments to support the quality and innovativeness of the production process, see Ferdows and De Meyer (1990) and Schroeder et al. (2010).

taking means of those effects.[10] To avoid problems of multicollinearity, we report estimates of two distinct models: in the first one (Model A), we proxy the firm's internal competences using variable *R&D* and test the hypothesis concerned with absorptive capacity; in the second one (Model B), we replace *R&D* with *FCT_EDU* and test the hypothesis related to the human resource base. The two models may also be used as robustness checks with respect to the other hypotheses defined in Section 3.

Table 3 – Results of the multinomial logit estimates, marginal effects for each category

	HIFs		**VIFs**		**LIFs**	
	Model A b/se	**Model B b/se**	**Model A b/se**	**Model B b/se**	**Model A b/se**	**Model B b/se**
R&D (exp./empl.)	0.043**		0.136**		-0.179***	
	(0.02)		(0.06)		(0.07)	
FCT_EDU (index)		0.033**		-0.006		-0.027
		(0.01)		(0.02)		(0.02)
D_EXPORT (d)	0.068***	0.068***	-0.018	-0.028	-0.050	-0.040
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
D_ICI_PAST (d)	0.668***	0.671***	-0.317***	-0.323***	-0.351***	-0.348***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
GROWTH_FCT (index)	0.000	0.001	0.039**	0.038**	-0.040**	-0.039**
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
SIZE (log_empl.)	0.032**	0.032**	0.046**	0.044**	-0.078***	-0.076***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
FIN_AUTON (index)	-0.104	-0.109	-0.170*	-0.160*	0.275***	0.269***
	(0.07)	(0.07)	(0.09)	(0.09)	(0.08)	(0.08)
σ (TOT_ASSETS)	0.000	0.000	0.000	0.000	0.000**	0.000**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LAB_PRDTY (index)	0.000	0.000	0.000	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry Dummies (Pavitt)	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Regional Dummies	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Other Controls	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Obs	1116	1116	1116	1116	1116	1116
LogL	-844.678	-842.298	-844.678	-842.298	-844.678	-842.298
Chi2	698.522***	703.283***	698.522***	703.283***	698.522***	703.283***

[10] Greene (1990) details methods for calculating the marginal effects and the associated standard errors.

The first interesting result that we obtain concerns the per-employee average expenditure in R&D (*R&D*). A one-unit increase in this expenditure significantly increases the probability of being a HIF and VIF and decreases the probability of being a LIF. Quite interestingly, we find that the size of the coefficient for VIFs is three times as large as that for HIFs, suggesting that investments in R&D are a relatively important and distinctive feature of firms adopting a discontinuous intangible investment strategy. On the contrary, firms that choose never to accumulate intangible assets (i.e., LIFs) exhibit a fairly low propensity to invest in R&D.

When in Model B we substitute *R&D* with a proxy of the firm's human resource base (*FCT_EDU*), we find some interesting changes in the significance level of coefficients. Whereas a one-unit increase in *FCT_EDU* positively and significantly impacts the probability of being a HIF, it does not significantly impact the probability of being either a VIF or a LIF. This result tends to confirm our interpretation: *R&D* and *FCT_EDU* capture two distinct features of the firm's internal competences. Moreover, it lends support to the idea that pursing a strategy characterised by persistent intangible investments necessarily requires some forms of specific investments in the quality of human resources to be made. This is not the case for firms adopting discontinuous and persistently low intangible investment strategies.

Moving from the internal competences of the firms to the market in which the latter operate, we find a positive and highly significant effect associated with the dummy for export (*D_EXPORT*) in the case of HIFs and no significant effect for VIFs and LIFs. In our interpretation, this dummy captures the propensity for firms to operate in international markets, where intangible assets are a critical source of competitive advantage. In this sense, this result lends further support to the evidence concerning the positive relationship between intangible investments and export practices (López Rodríguez and García Rodríguez, 2005). Our main contribution in this case is to suggest that firms with a high propensity towards exports are not only inclined to invest in intangible resources but also tend to do so persistently.

In addition to internal competences and the propensity to export, the type of intangible investment strategy adopted by firms tends to be strongly influenced also by the size of the intangible base accumulated in the past (*D_ICI_PAST*). This variable takes a positive and

significant effect for HIFs and a negative and significant effect for both VIFs and LIFs. In terms of coefficients, *D_ICI_PAST* has by far the strongest impact on the probability of being HIFs, thus suggesting that for this type of firm, the existence of cumulative dynamics in intangible investments plays a crucial role. Meanwhile, the negative sign associated with the probability of being VIFs suggests that for a discontinuous intangible investment strategy to be pursued, the size of the intangible base needs to be somewhat constrained, most likely to ensure a certain degree of flexibility in planning investments.

The importance of flexibility as a structural component affecting the implementation of distinct intangible investment strategies is also confirmed by the evidence concerning our last variable of interest, *GROWTH_FCT*. As discussed in Section 5, this variable captures the extent to which firms choose to adopt a growth-oriented strategy that involves both uncertainty and high organisational flexibility. The results suggest that the adoption of such a strategy significantly increases the probability of being a VIF and significantly reduces the probability of being a LIF. Meanwhile, this variable does not have any significant impact on the probability of being a HIF. If considered together, these results reveal two interesting findings on the relationship between intangible dynamics and firm behaviour: first, intangible investments – although discontinuous – appear to be important components of a growth-oriented strategy; second, when this strategy is pursued in contexts characterised by uncertainty, the intangible investment profile tends to be relatively discontinuous.

A careful inspection of the vector of control variables offers some interesting insights with respect to two additional factors. The first one is firm size (*SIZE*). As shown in Table 3, in fact, a larger firm has a greater probability of being either a HIF or VIF and a lower probability of being a LIF. This finding suggests that a firm's size matters for its propensity to adopt an intangible investment strategy regardless of whether this strategy is based on persistent or discontinuous investment. Similar results have been found in previous studies (Arrighetti et al., 2011).

The second dimension along which control variables offer interesting results concerns the index associated with financial autonomy (*FIN_AUTON*). This variable takes a negative and significant value in predicting the probability of being a VIF and a positive and significant coefficient in predicting the probability of being a LIF. No significant effect is found for the probability of being a HIF. The combination of these results suggests that

pursuing an intangible investment strategy may be relatively expensive for firms. On the contrary, the choice of not investing in intangible assets makes the the firm less financially constraint. This phenomenon may represent part of the rationale behind the implementation of strategy characterised by persistently low investments.

Overall, the results of our estimates provide a fairly encouraging picture concerning the test of our theoretical hypotheses. First, in accordance with Hypothesis 1A, we find absorptive capacity (measured in terms of R&D investment) to be a significant predictor of the probability of adopting an intangible investment strategy, whether it features persistent or discontinuous investment. In line with the competence-based view of the firm, therefore, the capability to identify and assimilate external sources of knowledge appears to be a crucial skill that firms must develop if they want to invest in immaterial resources.

Meanwhile, the evidence concerning our proxy of the human resource base (i.e., *FCT_EDU*) allows us to make a contribution regarding the role played by the firm's internal capabilities. If investments in R&D and, more generally, the firm's absorptive capacity represent an important driver of intangible investments, the quality of human resources becomes a key factor affecting the way in which these investments are implemented. A larger and higher-quality human resource base, in particular, renders it more likely that the firm will persistently invest in intangible assets, as it will possess the skills and the routinised knowledge necessary for a complex set of intangible resources to be constantly maintained. This finding lends direct support to Hypothesis 1B.

With reference to Hypothesis 2, which concerns the role of the propensity to operate in international markets, our main finding is that firms with a greater propensity towards export are more likely to adopt a persistent intangible investment strategy. This finding is in line with the argument that intangible assets are critical sources of competitive advantage and allow firms to acquire and defend market share. In this sense, the persistence of investment is motivated by the fact that firms must continuously replenish their intangible stock to beat out their competitors.

Clear supporting evidence is also found with respect to Hypothesis 3, which concerns the impact of demand uncertainty and organisational flexibility on intangible investments. Firms that at the beginning of the period are undertaking a growth-oriented strategy that is based on highly uncertain demand segments and high organisational flexibility are more likely to adopt a discontinuous intangible investment strategy than a persistent intangible

investment strategy. The reason for this finding is essentially related to the risks of being locked into disadvantageous paths of technological development. In this sense, the implementation of discontinuous investments requires the firm to have the capability to quickly adapt to external unpredictable changes.

Finally, for Hypothesis 4, we find some evidence concerning the role of the historical intangible asset base. In both estimated models, we find that the coefficient associated with the past level of intangible assets is positive and significant in explaining HIFs and negative and significant in explaining VIFs and LIFs. This finding implies that firms with high intangible capital intensity at a given point in time tend to remain on the same technological trajectory, characterised by persistent investments. On the contrary, firms with a small accumulated intangible asset base tend to diverge either towards a strategy characterised by persistently low investment or towards the implementation of discontinuous investments. As argued in Section 3, the causal mechanisms underlying this trend may be related to (a) the existence of complementarities among knowledge assets and (b) a process of organisational learning. Although both factors may theoretically play a role, we are unable to distinguish between them based on our data.

7. Robustness checks

To increase the reliability of our results, we conduct a series of robustness checks. First, we test alternative taxonomies for the industries, considering in particular the Eurostat NACE Rev. 1 classification (NACE) instead of Pavitt's classification (1984). The results, reported in Table 4, clearly show no significant changes with respect to Table 3. For all our variables of interest, all coefficients maintain the same sign and degree of significance. In addition, the size of the marginal effects is of the same order of magnitude. On this basis, we can conclude that our hypotheses tend to be confirmed irrespectively of the taxonomy that we use for the industry.

Second, because several contributions have found a relatively strong effect of intangible assets on productivity (e.g., Marrocu et al., 2012; Olier at al., 2007), we also try different measures of productivity in our vector of control variables. In particular, apart from the value added per employee, which we use in the estimates reported in Tables 3 and 4, we

estimate total factor productivity using the method developed by Levinsohn and Petrin (2003). The new estimates are reported in Table 5. In this case too the results do not change.

Finally, given the relevance that scale effects play in the literature on industrial dynamics, we also test how our results react to a different specification of size. In particular, we estimate the model reported in Equation (1) by substituting the continuous measure for size with dummy variables for medium-sized ($50 < SIZE \leq 100$) and large firms ($SIZE > 100$). The results are reported in Table 6 and are in line with those reported in Tables 3, 4 and 5. Size appears to be an important predictor of the probability to adopt an intangible investment strategy, regardless of whether it involves persistent or discontinuous investment. Quite interestingly, we find that for firms adopting a strategy of discontinuous investment, only the dummy for large size (*D_SIZE_L*) is significant. This finding does not necessarily mean that these firms are on average larger than the persistently investing ones; as we observed in Table 2, this is not actually the case. However, this result points toward a representation of VIFs as well-structured firms whose relatively large size is an important characterising feature. This finding tends in turn to support the view that such firms are not simply in transition but instead represent a distinct behavioural type.

Table 4 – Results of the multinomial logit estimates with NACE classification for industries, marginal effects for each category

	HIFs		VIFs		LIFs	
	Model A	**Model B**	**Model A**	**Model B**	**Model A**	**Model B**
	b/se	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**
R&D (exp./empl.)	0.038**		0.123*		-0.161**	
	(0.02)		(0.06)		(0.07)	
FCT_EDU (index)		0.028*		-0.003		-0.025
		(0.01)		(0.02)		(0.02)
D_EXPORT (d)	0.059**	0.060**	-0.010	-0.002	-0.049	-0.058*
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
D_ICI_PAST (d)	0.666***	0.662***	-0.317***	-0.311***	-0.349***	-0.352***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
GROWTH_FCT (index)	0.008	0.008	0.029	0.032*	-0.037**	-0.039**
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
SIZE (ln_empl.)	0.029**	0.028**	0.042**	0.042**	-0.071***	-0.071***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
FIN_AUTON (index)	-0.104	-0.100	-0.165*	-0.175*	0.269***	0.274***
	(0.07)	(0.07)	(0.09)	(0.09)	(0.08)	(0.08)
D_COMPETITORS (d)	0.002	0.006	-0.022	-0.023	0.020	0.018
	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.05)
σ(TOT_ASSETS)	0.000	0.000	0.000	0.000	0.000**	0.000**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LAB_PRDTY (index)	0.000	0.000	0.000	0.000	0.001	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry Dummies (NACE)	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Regional Dummies	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Other Controls	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Obs	1107	1107	1107	1107	1107	1107
LogL	-830.181	-832.008	-830.181	-832.008	-830.181	-832.008
Chi2	711.168***	707.513***	711.168***	707.513***	711.168***	707.513***

Table 5 – Results of the multinomial logit estimates with total factor productivity, marginal effects for each category

	HIFs		VIFs		LIFs	
	Model A	**Model B**	**Model A**	**Model B**	**Model A**	**Model B**
	b/se	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**
R&D (exp./empl.)	0.044**		0.133**		-0.177**	
	(0.02)		(0.06)		(0.07)	
FCT_EDU (index)		0.034**		-0.010		-0.024
		(0.01)		(0.02)		(0.02)
D_EXPORT (d)	0.066**	0.067***	-0.031	-0.022	-0.035	-0.045
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
D_ICI_PAST (d)	0.672***	0.669***	-0.324***	-0.317***	-0.348***	-0.352***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
GROWTH_FCT (index)	0.001	0.000	0.038**	0.040**	-0.039**	-0.040**
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
SIZE (ln_empl.)	0.034***	0.035***	0.042**	0.043**	-0.076***	-0.078***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
FIN_AUTON (index)	-0.109	-0.105	-0.159*	-0.169*	0.268***	0.274***
	(0.07)	(0.07)	(0.09)	(0.09)	(0.08)	(0.08)
D_COMPETITORS (d)	-0.002	0.003	-0.015	-0.016	0.017	0.013
	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.05)
σ(TOT_ASSETS)	-0.000*	-0.000*	0.000	0.000	0.000**	0.000**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TFP (index)	0.002	-0.027	0.115	0.136	-0.117	-0.108
	(0.11)	(0.11)	(0.15)	(0.16)	(0.13)	(0.13)
Industry Dummies (Pavitt)	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Regional Dummies	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Other Controls	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Obs	1115	1115	1115	1115	1115	1115
LogL	-841.389	-843.830	-841.389	-843.830	-841.389	-843.830
Chi2	702.549***	697.667***	702.549***	697.667***	702.549***	697.667***

Table 6 – Results of the multinomial logit estimates with dummy variables for firm's size, marginal effects for each category

	HIFs		VIFs		LIFs	
	Model A	**Model B**	**Model A**	**Model B**	**Model A**	**Model B**
	b/se	**b/se**	**b/se**	**b/se**	**b/se**	**b/se**
R&D (exp./empl.)	0.044**		0.148**		-0.192***	
	(0.02)		(0.06)		(0.07)	
FCT_EDU (index)		0.034**		-0.007		-0.028
		(0.01)		(0.02)		(0.02)
D_EXPORT (d)	0.070***	0.070***	-0.022	-0.011	-0.048	-0.059*
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
D_ICI_PAST (d)	0.671***	0.667***	-0.323***	-0.316***	-0.348***	-0.352***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
GROWTH_FCT (index)	0.001	0.001	0.039**	0.040**	-0.040**	-0.041**
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
D_SIZE_M (d)	0.042*	0.047*	0.016	0.015	-0.058**	-0.062**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
D_SIZE_L (d)	0.072**	0.072**	0.075*	0.074*	-0.147***	-0.146***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
FIN_AUTON (index)	-0.106	-0.103	-0.152	-0.162*	0.258***	0.265***
	(0.07)	(0.07)	(0.09)	(0.09)	(0.08)	(0.08)
D_COMPETITORS (d)	0.005	0.009	-0.019	-0.020	0.014	0.010
	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.05)
σ(TOT_ASSETS)	0.000	0.000	0.000	0.000	0.000**	0.000*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LAB_PRDTY (index)	0.000	0.000	0.000	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry Dummies (Pavitt)	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Regional Dummies	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Other Controls	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Obs	1116	1116	1116	1116	1116	1116
LogL	-842.542	-845.292	-842.542	-845.292	-842.542	-845.292
Chi2	702.794***	697.294***	702.794***	697.294***	702.794***	697.294***

8. Conclusion

Considering the impact of intangible investments on performance, a positive and relatively constant stream of intangible investment is expected at the firm level. However, in reality, this is not the case: some firms do not invest at all; many others invest occasionally, and few invest constantly over time.

We provide an interpretive framework of this behaviour seeking to consider the adoption of different intangible investment strategies in manufacturing firms. In particular, we identify three types of investment behaviour: high and persistent, discontinuous, and low and persistent. Using as a reference the capability-based view of the firm, we define and provide support for a set of hypotheses on the determinants of such behaviours.

We focus on firm-specific characteristics, with particular attention being paid to absorptive capacity, human resource quality, the degree of internationalisation, historical intangible asset accumulation and firm size. The verification of the hypothesis is based on a dataset containing economic and financial information concerning 1,116 Italian manufacturing firms and covering a period spanning from 2001 to 2008.

Multinomial logit estimates of our model show the following: first, absorptive capacity, led by R&D expenditures, is a key competence in sustaining the adoption of an intangible investment strategy, regardless of whether it involves persistent or discontinuous investment; second, the pursuit of a persistent intangible investment strategy is associated with high-quality human resources; third, firms with a greater propensity to operate in international markets are more likely to adopt a persistent intangible investment strategy than a discontinuous one; fourth, firms that undertake a growth path characterised by demand uncertainty and requiring organisational flexibility are likely to adopt a discontinuous intangible investment strategy; and five, a firm's historical intangible asset base represents an important constraint on its investment behaviour.

In sum, the paper provides an articulated representation of the heterogeneous patterns followed by firms in their investment and management of intangible resources and enriches our knowledge on the main variables impacting their accumulation over time.

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Appendix.

A1. Volatility of Intangible Capital Intensity

Taking into consideration a *n*-period time series for $ICI_{i,t}$, we define the weighted volatility of ICI_i as the standard deviation of *n*-years windows of $ICI_{i,t}$ normalized by the *n*-years average level of $ICI_{i,t}$. Formally, we compute the weighted volatility of ICI_i as follows:

$$\sigma(ICI_i) = \frac{\sqrt{\sum_{\tau=\tau_0}^{\tau_0+n}(ICI_{i,\tau} - \overline{ICI}_i)^2}}{\overline{ICI}_i}$$

where $\overline{ICI}_i$ is the average of $ICI_{i,t}$ between $t = \tau_0$ and $t = \tau_0 + n$. For the firms who reported $ICI_i = 0$ in every years of the considered windows, we directly imputed $\sigma(ICI_i) = 0$.

A2. List of the Variables

- *ICI:* % Intangible Assets / Tot. Assets, average for the eight-years period 2001-2008.
- *σ (ICI)*: volatility of *ICI.*
- *SIZE* (empl.): average number of employees for the three-years period 2001-2003.
- *UNIDEG*: Graduated Employees / Tot. Employees in 2003.
- *STAFFRATIO*: "White Collars" / "Blue Collars" in the three-years period 2001-2003.
- *AVEDU*: Workforce Average Education in the three-years period 2001-2003.
- *R&D* (exp./empl.): R&D Expenditure / Tot. Employees three-years period 2001-2003.
- *D_EXPORT*: = 1 if the firm has exported in 2003.
- *SUBCT* (% sales): % of sales due to subcontracting.
- *COSTLAB* (norm.): cost f labor normalized over the average of the industry to which the firm belongs.
- *D_ISO*: = 1 if the firm is certified ISO in 2003.
- *D_INNO* = 1 if the firm innovate (either product, process or organizational) in 2001-

2004.

- *σ (SALES)* (volatility) = volatility of total sales in the four-years period 2001-2004.
- *G_SALES* (growth rate) = sales growth in the four-years period 2001-2004.
- *ICT_INV*: € Invested in ICT / Tot. Turnover in the three-years period 2001-2003.
- *AGE*: 2010 less the year of foundation.
- *LAB_PRDTY*: Added Value per Employee in the three-years period 2001-2003.
- *PROFIT*: Gross Earnings / Tot. Turnover in the three-years period 2001-2003.
- *FIN_AUTON* (Index): Net Worth / Tot. Attest in the three-years period 2001-2003, where Net Worth = Equity + Non-distributed Shares + Annual Profit (or Loss)
- *D_COMPETITORS*: = 1 if the firm faces International competitors.

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