INTANGIBLE ASSETS AND HUMAN CAPITAL IN MANUFACTURING FIRMS

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Abstract

The positive impact of intangible assets on several measures of economic performance is well documented in the literature. Less clear is what leads firms to invest in intangible assets in the first place. The latter is particularly important since, at least for the Italian manufacturing sector, firms exhibit a very strong heterogeneity in their level of intangible asset investments. In line with the capability-based theory of the firm we argue that the firm's propensity to invest in intangible assets can be explained by factors that are internal and specific to the firm. Making use of a rich dataset we test and provide support for our hypotheses. In particular we find that the propensity to invest in intangible assets increases with the firm's size, human capital and organizational complexity and with the past level of intangible assets. This points toward the existence of a cumulative dynamics in the process of intangible assets accumulation that may account for most of the heterogeneity observed in the data. The paper adds to the previous literature in two ways: first it highlights the existence of a strong intra-industry heterogeneity in intangible assets investments; and second, it offers an explanation for such heterogeneity.

Key words: *intangible assets, human capital, firms heterogeneity, organizational complexity, complementarity, knowledge economy, organizational capabilities*

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1. Introduction

Intangible assets consist of the stock of immaterial resources that enters the production process and are necessary to the creation and sale of new or improved products and processes. They include both internally produced assets – e.g. designs, blueprints, brand equity, in-house software, and construction projects – and assets acquired through external market – e.g. technology licenses, patents and copyrights, and the economic competences acquired through purchases of management and consulting services (Corrado et al., 2006). A large and growing body of empirical literature has shown intangible assets to play a major role in the modern knowledge economy. Corrado et al. (2005), for instance, estimates that in the early 2000s the value of US intangible assets was already close to $3.4 trillion and suggest that in the same period intangible assets accounted for more than the 75% of US output growth. Similarly, Nakamura (2003) shows that in the last 40 years intangible assets as a proportion of US GDP have more than doubled raising from 4.4% to 10%, and in the year 2000 almost one third of the value of US corporate assets were intangibles. At the firm level, Hulten and Hao (2008) show that for US firms the value of total assets increases by 57% when R&D expenditure and intangible capital is considered in addition to conventional financial accounts. Similar trends, among the other countries, have been shown to exit in Japan (Miyagawa and Kim, 2008), UK (Marrano and Haskel, 2006), Finland (Jalava et al., 2007), Netherland (van Rooijen-Horsten et al., 2008) and Italy (Bontempi and Mairesse, 2008).

In addition to the quantitative dimension of intangible assets, various works have also stressed the qualitative link between intangible assets and firm performance. Marrocu et al. (2009), Oliner et al. (2007) and O'Mahony and Vecchi (2009), for example, find a positive contribution of intangible assets to both firm and industry productivity. Hall et al. (2005), Greenhalgh and Rogers (2006) and Sandner and Block (2011) show intangible assets to significantly contribute to company values in financial market. Denekamp (1995), Braunerhjelm (1996), and Delgado-Gómez and Ramírez-Alesón (2004) provide evidence for a positive relationship between firms' intangible assets and internationalization.

In spite of this large and growing literature, however, little research has been so far conducted on the determinants of intangible assets investments within firms. Although it is widely accepted that intangible assets are becoming a critical source of competitive advantage (Barney, 1991), very few empirical works have actually investigated the factors that may lead firms to undertake this type of technological investment in the first place. In the majority of the cases, on the contrary, the level of intangible assets has been taken as given and treated more as an explanatory variable rather than as a variable to be explained. From the point of view of both managers and policy makers, however, the achievement of a clear understanding on what determines the firms' propensity to invest in intangible assets can be of crucial importance, especially if it helps identifying the variables that discriminate between high and low-performance businesses. Moreover, such a perspective is interesting for the academic debate too, in that it may offer a test for alternative theories of the firm. For these reasons, this paper will make some first steps in filling such gap.

When the firm level of intangible assets is taken as the main variable to be explained, the first striking evidence that comes out of the data is that, at least for the Italian manufacturing sector, intangible assets investments seem to vary considerably across firms. On this respect Panel A of Figure 1 reports the quantile distribution of intangible assets as a proportion of total assets in 2008 for the sample of Italian manufacturing firms included in our dataset. The value of both intangible and total assets is derived from the firms' disaggregated balance sheet (see Section 3). On average, intangible assets account only for the 0.8% of total assets. A more detailed analysis, however, reveals that there exist high heterogeneity in the population. The median of this ratio, in fact, is barely above 0% and for more than the 75% of the firms intangible assets count for less than 1% of total assets. At the same time there is a top 10% of firms that massively invest in intangible assets, with figures that range from 2% to 38% of total assets.

[Figure 1 about here]

The evidence resulting from Panel A of Figure 1 is even more interesting if one considers that the observed heterogeneity in intangible assets investments remains high even at the industry level. In this respect Panel B reports the quantile distribution of the same variable reported in Panel A, after normalizing the ratio by the sample (right) and the industry mean (left). In particular, the Eurostat NACE Rev. 1 classification (NACE) has been used for the industry. As it is easy to see the shape of the distribution remains practically unchanged in the two cases, with a 10% of firms that seems to invest in intangible assets from 3 to 60 times more than the average firm of the industry they belong to. Such a distribution reveals quite clearly that there exist a degree of heterogeneity that extent well beyond what could be reasonably explained by inter-industry structural differences alone. The main aim of the present paper is thus to investigate the factors that, in addition to the industry, can effectively explain this degree of heterogeneity.

In line with the capability-based view of the firm we argue that the heterogeneity in intangible assets investments ought to be studied by focusing on firm-specific traits, such as size, organizational structure, human capital and the historical evolution of the organization. In this sense we see the firm's propensity to invest in intangible assets more as a product of the unique bundle of resources and capabilities that the firm has evolved over time, rather than as the consequence of exogenous technological contingencies. Intangible assets, in fact, represent a form of technological investment that (a) needs a certain set of internal resources to be carefully identified, planned, and managed and (b) is addressed at the satisfaction of needs that can be purely organizational in nature (e.g. to facilitate the management of a complex organization). Where such internal resources lack and/or the internal structure of the firms does not require this type of specific investments, intangible assets are less likely to be included in the firm's business strategy, and hence they are less likely to be accumulated. Moreover, for a given distribution of intangible assets in the population of firms, the existence of complementarities among different components of the intangible stock may generate a process of accumulation whose dynamics is largely persistent, with the consequent permanence of heterogeneity over time. Making use of a rich dataset in terms of firm-specific characteristics we test and provide support for our hypotheses.

Overall, the paper contributes to the previous literature on intangible assets and industrial dynamics in two ways. First, it highlights the existence of a large heterogeneity in intangible assets investments. This dimension of the problem has so far received little attention in the literature, and it has certainly not been documented with respect to the Italian manufacturing sector. Second, the paper suggests a capability-based view explanation for the firm's propensity to invest in intangible assets and provide an empirical test of this hypothesis. In this way the paper can make much sense of the observed heterogeneity and it offers some insights for managerial policy design too. Overall, the results of the paper can open new interesting lines of research

The structure of the paper is the following. Section 2 presents a brief overview of the literature on firms heterogeneity and intangible assets, and motivates our hypotheses. Section 3 describes the dataset and the variables included in our models. Section 4 discusses the empirical strategy employed in the estimation. Section 5 presents and discusses the results. Section 6 lists some robustness checks. Section 7, finally, concludes.

2. Literature review and theoretical hypotheses

Most of the authors in the business and management literature have focused on the relative effect of intangible assets on economic performance (Marrocu et al., 2009; Olier at al., 2007; Bontempi and Mairesse, 2008; Corrado et al. 2006). On the contrary, contributions concerning the factors influencing the level of intangible assets accumulated in the firm are rarer.

Among organizational and business scholars the factor that has received the widest attention for its effect on the firm's propensity to invest in intangible resources is surely the industry. Since innovation intensity and appropriability differ significantly across industries (Cockburn and Griliches, 1988), firms face different incentives for the development and formalization of intangible assets. Changing the market structure, the nature of technology and the regulatory environment, firms may consider appropriate to invest different amounts of resources in innovation and in its protection. On this ground, industry-related variables are expected to be able to explain most part of the variability of intangible assets accumulation (Villalonga 2004; Daley 2001). Gu and Lev (2001), for instance, shows that the level and growth rate of intangible assets are different across industries: the highest levels are measured in insurance, drugs, and telecommunications; the lowest in trucking and wholesale trade. Similarly, Klock and Megna (2000) show that in more innovative industries the market value of the firm, capturing the importance of intangible assets, is markedly higher than book value, while in the traditional ones the difference between the two variables turns out to be modest. Similar findings are discussed in Gleason and Klock (2003), Ballardini et al. (2005) and Abowd et al. (2005). In addition, Vergauwen et al. (2007) maintain that non-traditional industries have more incentive in disclosing more information about intangibles since investors expect continuous investments in R&D and immaterial projects. Firms in traditional industries, on the contrary, tend to invest less and randomly in immaterial assets and are less prone to reveal since such expenditures may signal to competitors innovative strategies.

As previously underlined and shown in Figure 1, however, the available evidence for Italy suggests that industries can explain only a small proportion of the distribution of intangible assets investments. Even at the industry level, in fact, manufacturing firms tend to be largely heterogeneous so far as the level of accumulated intangible assets is concerned. In this sense some factors other than the industry must necessarily play an important role. Our main aim is thus to identify what these "other" factors actually are.

A stream of literature that has placed particular attention on the sources of inter-firms heterogeneity is the one associated with the so-called capability-based theory of the firm (Dosi et al., 2000). Such an approach, which bears large overlapping with another well-known theory among management scholars such as the resource-based view (Barney, 1991, 2001), defines capabilities as firm's specific "ways of doing" and stresses heterogeneity as the distinctive feature of business organizations (Dosi et al., 2006). Although a thoughtful discussion of this theory goes beyond the scope of our paper (for this we refer to Dosi et al., 2000), it suffices to notice that according to such view firm's decisions are determined mainly by the capabilities that the firm has evolved over time, and only marginally by exogenous technological contingencies. On this basis, the explanation of a given firm's behavioral path must necessarily rely on the interaction between firm's specific and system-specific (e.g. industry-related) factors, and admit an explicit dynamics of capabilities acquisition (Dosi et al., 2006).

The adoption of a capability-based approach in the study of intangible assets investments prompts us to focus on a set of firm-specific traits that, in interaction with external factors, can actually explain the firm's propensity to undertake this type of technological investment. On this basis, we choose to focus on four variables in particular: size, human capital, organizational complexity, and the past level of the accumulated intangible stock. The role that each of these variables play in affecting the firm's decision to invest in intangible assets will be analyzed separately.

2.1 Firm's size

Size is a firm's trait that, independently of the industry in which the firm operates, is likely to have a positive impact on the propensity to invest in intangible assets. In the first place large firms are better able than small ones to exploit economies of scale in intangible assets accumulation (Dierickx and Cool, 1989). Secondly, big firms can be more effective in protecting their intangible stock than small ones, and thus have a greater incentive to invest. Thirdly, it may be argued that large firms are also capable of supporting a greater share of the uncertainty that is associated with intangible assets investments as compared to small firms (Ghosal and Loungani, 2000). On this basis, the first hypothesis that we put forward is that:

Hypothesis 1 – *The probability that a firm invests in intangible assets is greater the larger the firm's size.*

2.2 Firm's human capital

In addition to size, another trait that is likely to affect the propensity to invest in intangible assets is the firm's human capital. 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 human capital is made up not only by the formal education received by the workforce before the enrolment, but also by formal and informal on-the-job training (Barney, 1991; Nerdrum Erikson 2001). It represents the collection of skills and abilities that are embedded in the members of the organization (Bontis and Fitz-enz, 2002) and can be leveraged to expand intangible resources at the firm level. In this sense, therefore, the more a firm is endowed with a highly educated workforce, the more we should expect the firm to have the managerial and innovative capabilities necessary to extend her intangible stock.

As noticed by Abowd et al. (2005), however, human capital in the form of workforce education is not by itself the only driver of the accumulation of intangible resources. It is how human capital is organized that explains the variance of productivity and the endowment of intangible assets. The way workers are organized, together with the quality of human resources, yield in fact complementarities that may facilitate the generation of innovation and create in turn incentives for the accumulation of the intangible stock. An organizational variable that could reflect such complementarities is for instance the amount of human resources effectively employed in direct R&D activities (Liu et al. 2000). In the language of the capability-based view the latter is synonymous with the adoption of routines and procedures that facilitate the exploitation of external sources of knowledge (Dosi, 1988; Cohen and Levinthal, 1990) and that support, as a consequence, the process of intangible assets accumulation. In this respect some supporting evidence comes from Lu et al. (2010) who find R&D expenses to impact positively on the firm's intangible assets with predictably positive effects on future cash flow and firm value.

On the basis of the above arguments, and considering workforce education and R&D activities as different proxies of a firm's human capital, we formulate our second hypothesis as follows:

Hypothesis 2 – *The probability that a firm invests in intangible assets is greater the larger the firm's human capital.*

2.3 Firm's organizational complexity

Another firm-specific trait that, similarly to human capital and size, can affect the process of intangible assets accumulation is the degree of organizational complexity[4]. According to some authors, in fact, the firm's intangible stock includes assets that directly increase what has come to be known as the firm's organization capital – see Kaplan and Norton (2004), Lev and Radhakrishnan (2003) and Bontis (2001) among the others. The latter, in the seminal contribution by Prescott and Visscher (1980), was defined as the set of information assets that the firm uses in order to coordinate the material factors of production, namely physical capital and labour. Lately, more managerial definitions have been formulated, e.g. Lev and Radhakrishnan (2003), Hsu

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[4] Organizational complexity has been defined and measured in different ways. In this paper we will follow Damanpour (1996) and define it as the degree of variety in the organization's spatial, occupational, hierarchical and functional dimensions (Hall 1977, Miller and Contay 1980).

(2007), Atkeson and Kehoe (2005). Under all the alternative specifications, a direct link between the complexity of the firm's internal organization and the accumulation of organization capital – and thus of intangible assets, seems to emerge.

Piekkola (2009), for instance, argues that globalized firms use more organization capital. The higher the number of employees in the firm that are working abroad, the greater the amount of organization capital that is needed in order to monitor the relationships between different production units and markets. A similar relationship has been identified by Denekamp (1995) and Braunerhjelm (1997) with reference to the need of managing a variety of foreign direct investment (FDI), and by Bartel et al. (2007) and Brynjolfsson et al. (2002) with respect to the need of complementing the enhancement of ICT with parallel extensions of organizational resources. Concerning the dynamics of vertical integration, moreover, the results obtained by Gonzalez et al. (2000) suggests the existence of a positive relationship between the degree of vertical disintegration and the amount of organizational capital accumulated in subcontractors as a way to cope with increasingly complex market transactions.

From a different but similar perspective, other authors have stressed the role that competition and the pace of technological progress play in shaping the firm's internal complexity, and thus in affecting the accumulation of intangible resources. The sharpening of competition in the markets, in fact, leads firms to integrate resources focused on protecting from imitation and updating the most specific internal assets. This means in turn an extension of the managerial resources but also an increase in their complexity. Petrick et al. (1999), for instance, show that as the speed of comparable tangible asset acquisition accelerates and the pace of imitation quickens, firms resort to the less imitable intangible assets to enhance their distinctive know how and product differentiation. Hence, the greater the complexity of the relationship with the market the greater will be the investment in intangibles.

From the association between intangible assets and organization capital, and by relying on the above arguments on the relationship between complexity and organizational resources, we deduce that:

Hypothesis 3 – *The probability that a firm invests in intangible assets is higher the greater the firm's organizational complexity.*

2.4 Cumulative dynamics

Finally, considering the issue of intangible asset investments from a dynamic perspective a crucial role may be played also by the stock of intangible assets accumulated in the past. In this respect, several dimensions of the process of intangible assets accumulation can be important.

First of all intangible assets consists of knowledge and the latter is by its own nature cumulative. Within the context of the resource-based view, for instance, Dierickx and Cool (1989) defines two main features that seem to distinguish intangible assets accumulation from physical capital accumulation: *asset mass efficiency*, i.e. economies of scale in the production of intangible asset stock from existing asset stock; and *time compression diseconomies*, i.e. diminishing returns to current period investments in intangible assets. As argued by Knott et al. (2003) *asset mass efficiency* implies that the more intangible assets a firm has, the lower the marginal cost of investing in further extension of the asset stock. The reason could be the existence of what Teece (1987) calls interconnectedness of asset stocks, that is complementarities among the different components of the knowledge stock. *Time compression diseconomies* imply instead that intangible assets accumulation can't be rushed. ‘Even if an entrant invests in one year the total sum of the incumbent investments made over several years, it won't achieve the same resource position’ (Knott et al., 2003:192). The combination of these two factors lead to the inevitable emergence of divergent intangible assets accumulation paths, where the firms who invested more (less) in the past tend to invest more (less) also in the future.

Moving from the structural characteristics of intangible assets to the specific features of firm’s behaviour, a similar argument for the existence of a cumulative dynamics can be formulated by relying on the idea of organizational learning (see Dosi et al., 2006). In a nutshell, the idea of organizational learning suggests that when a firm adjusts her internal organization in order to (a) search the knowledge landscape and (b) invest in a particular type of asset, the firm learns a set of capabilities. Such capabilities are likely to generate a relative advantage in pursuing investments in similar and related assets compared to competitors who did not invest in the first place. As a result the set of intangible resources accumulated in the firm at any given point in time largely becomes a function of prior accumulated set of resources. Highly persistent intangible assets accumulation are then the most likely consequence.

On the basis of these arguments, and independently of the factors that have the strongest power in explaining the cumulative path, our fourth and final hypothesis is thus that:

Hypothesis 4 – *The probability that a firm invests in intangible assets is greater the larger the stock of intangible assets accumulated in the past*.

3. Data, variables and descriptive analysis

In order to test the hypotheses defined in the previous section we use a joint dataset retrieved from two main sources. The first one is the 9th wave of the Survey on Manufacturing Firms collected by Capitalia. The time span of data is 2001-2003. The dataset contains qualitative and quantitative information for a large stratified sample of Italian firms. In particular, it gathers a wealth of information on the structure of the workforce and governance aspects; information on innovation, distinguishing whether product, process or organizational innovations; information on investments and R&D expenditures. The second source is the database AIDA-Bureau van Dick that contains information on all Italian firms' disaggregated balance sheets for the period 2001-2008. After combining these two sources the final dataset counts nearly 1,500 observations. The representativeness of the original sample is maintained in terms of both firm's size and industry of activity.[5]

In the literature there are several possible ways of measuring intangible assets. In particular, two main approaches have been pursued: the first is based on estimates derived from firm expenditures on "intangibles" such as R&D, training and innovation; the second uses direct measures based on stocks originally reported as assets in companies' balance sheets. For a discussion on the relative adequateness of these two approaches within the framework of Italian legislation we refer to Bontempi and Mairesse (2008). In our paper we choose to adopt a balance sheet-type of measure and

[5] Data on sample representativity are available from the authors upon request.

to consider, in particular, a subset of the costs usually reported under the item “intangible fixed assets”, i.e. the “costs for research and advertisement”, the “costs of patents” and the “costs of licensing”. In doing so we differ from some previous contributions based on similar data (e.g. Marrocu et al., 2009) that considered the total item instead. The reason why we make this choice is that the item “intangible fixed assets” includes also expenditures such as the start-up/goodwill costs whose capitalization is highly subject to managers’ discretion and is therefore difficult to interpret. On the contrary, the items that we consider in our measure are all objective expenses incurred by the firms.

On the basis of this measure of intangible assets, we define a firm’s intangible capital intensity (*ICI*) as the percentage of intangible assets over total assets. At any given point in time ICI_i represents the amount of intangible assets accumulated by firm *i*, and can be considered a proxy of *i*’s propensity to invest in intangible assets. *ICI* is the crucial variable of our analysis. In particular, for the firms in our sample, we want to understand which factors can explain the probability to be an intangible capital intensive firm (*ICIF*), where the latter is defined as a firm that belongs to the 10^{th} decile of *ICI*.

Following the discussion presented in Section 2, we focus our attention on two main types of explanatory variables. First we consider systemic-like variables such as the industry in which the firm operates. The main classification that we adopt is the NACE (see Appendix). In the empirical strategy, in order to fully capture the observed heterogeneity, we choose to control for industry-related effects through a normalization of the dependent variable by the industry mean (see Section 4).

The second type of explanatory variables that we consider consists of a vector of firm-specific characteristics, with particular attention being paid to size, human capital, organizational complexity and the degree of intangible capital accumulated in the past. To each of these dimensions corresponds a set of proxies.

As a proxy of size we considered the total number of employees (*SIZE*). In particular, in order to control for non-linearities, we classified firms as *small* ($SIZE \leq 50$), *medium* ($50 < SIZE \leq 100$) and *medium-large / large* ($SIZE > 100$) according to their size. For each of these groups of firm we then considered an apposite set of dummy variables (*D_SIZE_S*, *D_SIZE_M*, *D_SIZE_L*)

As a proxy of human capital we considered a combination of two distinct variables: the first is a synthetic index elaborated with a factorial analysis (*FCT_EDU*) using as inputs the ratio between “white collars” and “blue collars” (*STAFFRATIO*), the workforce’s average years of education (*AVEDU*) and the percentage of employees holding a university degree (*UNIDEG*); the second variable is instead the percentage of employees engaged in R&D (*R&D*). The rationale behind such specification is that in our view *FCT_EDU* and *R&D* capture two distinct effects of human capital[6]: *FCT_EDU* is a proxy of a firm’s capability to manage knowledge-intensive assets, *R&D* captures instead the firm’s propensity to engage her human resources in intangible stock expanding activities, including the evaluation, assimilation and application of new knowledge. As argued in Section 2, each of these dimensions of human capital has been treated as a relevant component of the process of intangible asset accumulation in the literature.

For what concerns instead the degree of organizational complexity we considered a synthetic index based on a scale going from 0 to 4 for min and max complexity respectively (*COMPLEX*). The index captures two distinct features of the firm: first, the extent to which the firm does business as a subcontractor; and second the degree of internationalization. The idea in this case is that the more the firm is internationalized and operates as subcontractor, the more diversified and flexible her structure, and thus the more complex her organization. In particular the index is constructed on the basis of four distinct variables: the percentage of turnover due to subcontracting (*SUBCT*); the portion of turnover due to subcontracting that is earned abroad (*SUBCT_ABD*); a dummy taking value 1 if the firm faces international competitors (*D_INTCOMP*), and a dummy taking value 1 if the firm realized investments abroad (*D_FDI*). A complete description of how the index is constructed is reported in the legend of Table 1.

Finally, as a proxy of the degree of accumulated intangible capital we considered a dummy taking value 1 if the firm belonged to the fourth quartile of the 5-years lagged value of *ICI* (*ICI_PAST*) and zero otherwise (*D_ICI_PAST*). In this case, since we were interested in the impact of the past level of intangible assets in absolute terms, the non-normalized value of *ICI* has been considered.

[Table 1 about here]

[6] Our view is confirmed also by the empirical evidence. In fact, the factorial analysis that we conducted in order to compute *FCT_EDU* revealed *R&D* to contain a different set of information with respect to *STAFFRATIO*, *AVEDU* and *UNIDEG*.

Table 1 reports some descriptive statistics relative to our dataset. Indices are differentiated for *ICIF*s and the whole sample. Apart from *ICI* which is evaluated at 2008, all the other variables are evaluated over the three-years period 2001-2003. When looking at the whole sample it is interesting to notice the high standard deviation associated with variables such as *SIZE*, the various proxies of human capital (*UNIDEG*, *STAFFRATIO*, *AVEDU*) and intangible capital intensity (*ICI*, *ICI_PAST*). This is symptom of a high degree of heterogeneity in the population along several firm-specific demographic dimensions. Regarding the sub-sample of *ICIF*s we can observe that on average, compared to non-*ICIF*s, they are bigger, more complex, and have a greater endowment of human capital. In addition, *ICIF*s have a level of past accumulated intangible assets that is nearly eight times the level of non-*ICIF*s. This points towards persistence in intangible assets investments.

[Table 2 about here]

The propensity of firms to maintain a level of intangible assets investments that is closely related to the level realized in the past is confirmed also by Table 2. In this case we reported in Panel A the distribution of firms across four classes of *ICI* – *null* (= 0), *low* (> 0 and < 1%), *medium* (≥1% and <5%) and *high* (> 5%) – for the year 2008 (columns) and the average 2001-2003 (rows). On this basis we computed in Panel B the transition probabilities by simply averaging the content of each cell over the total of the row. The result, for instance, reads that a firm that belonged to the class *null* in 2001-2003 had a 69% of probability to belong to the same class also in 2008. We notice that the highest probabilities are the ones on the main diagonal. Moreover, the average probability below the main diagonal is greater than the average probability above, which in turn implies that if a process of movement across classes had existed it tended to take place from high to low classes and not the reverse. Coupled with the fact that on average the level of intangible capital intensity has increased moving from 2001-2003 to 2008 (as shown in Table 1), the latter result means that not only the population of firms was characterized from the very beginning by heterogeneity, but also such heterogeneity has polarized over the last decade. The identification of the factors that could explain such an increased polarization is the main objective of our empirical investigation.

4. Empirical strategy

The model that we want to estimate takes the following form:

$$ICI_i = f(IND_i, XF_i, XC_i, \varepsilon_i) \ , \ \varepsilon_i \sim N(0, \sigma^2) \qquad (1)$$

where IND_i stands for the industry in which firm *i* operates; XF_i is a vector of firm-specific characteristics including $SIZE_i$, FCT_EDU_i , $R\&D_i$, $COMPLEX_i$ and $D\_ICI\_PAST_i$; XC_i is the vector of control variables; and ε_i is the vector of normally distributed residuals.

The key issue affecting the estimation of model (1) is the censored nature of *ICI*. As argued above this occurs because a large proportion of the firms included in our sample do not invest in intangible assets at all. In such a context the application of standard OLS would generate biased estimates, with the magnitude of the bias being linked to the proportion of non-censored observations in the sample. In order to avoid this problem we decided to use an alternative estimation techniques based on a Probit specification. Moreover, in order to investigate the role that different variables may play at different point of the distribution of *ICI*, we also estimate the same model by the mean of quantile regressions (Koenker and Bassett, 1978). The combination of these two techniques should give us sufficient confidence in interpreting the results.

In the Probit specification we follow three steps. First, for each firm, we normalize the value of *ICI* by the mean value of the industry in which the firm operate. In this way we can eliminate from the distribution of *ICI* all sorts of industry-related effects. We call this new industry-normalized variable $\underline{ICI}$. Secondly, we classified as $\underline{ICIF}$ all the firms belonging to the 10th decile of $\underline{ICI}$. Finally, we transformed our dependent variable in a dichotomic variable taking value 1 if the firm is $\underline{ICIF}$ and zero otherwise ($\underline{ICIF_i}$). All the other variables remain the same as in model (1), except that now IND_i will obviously disappear from the right-hand side of the equation. The idea in this case is to estimate the probability for a firm to be intangible-capital intensive *relative* to the mean of her own industry, given a set of firm-specific characteristics. The baseline equation to be estimated thus becomes:

$$\Pr[\underline{ICIF}_i = 1] = \Phi(XF_i{}'\beta_F + XC_i{}'\beta_C) \tag{2}$$

where $\Phi(\cdot)$ is the cumulative distribution function for the standard normal, and β_F and β_C are the vectors of parameters to be estimated. The parameters of model (2) are estimated via maximum likelihood (ML) estimation.

We also conjecture that the different variables included in our baseline model may play a different role as determinant of *ICI* depending on the point of the distribution that we consider. For instance, it could be the case that firms at the very top of the distribution (*i.e.* the highly intangible-capital intensive firms) are following a strategic pattern according to which the stock of intangible assets requires to be constantly renewed and updated (e.g. because its accumulation required high specific investments by the firm). On the contrary, firms at the bottom may be simply adopting a blinking-like strategy according to which intangible assets are accumulated for limited period of time and bought directly on the market. If that were the case, we should then expect the different components of human capital – *i.e.* R&D and workforce education, to change their relative impact along the distribution, with R&D being more relevant at the top (as a source of intangible assets extension) and workforce education at the bottom (as a source of intangible assets administration).

In order to test for these different types of effect we estimate a set of quantile regressions. An important advantage of this method, in fact, is that it reveals differences in the relationship between the dependent and the independent variables at different points of the conditional distribution of the dependent variable (see Koenker and Hallock, 2001). In this case too we control for the industry through the normalization of *ICI* by the industry mean. The quantile regression model that we estimate can be thus written as follows (see Coad and Rao, 2008):

$$\underline{ICI}_i = X_i{}'\beta\theta + u\theta_i \quad \text{with} \quad \text{Quant}\theta(\underline{ICI}_i \mid X_i) = X_i{}'\beta\theta \tag{5}$$

where $X_i = (XF_i, XC_i)$ is the vector of regressors, $\beta = (\beta_F, \beta_C)$ is the vector of parameters to be estimated, and u is a vector of residuals. $\text{Quant}_\theta(\cdot)$ denotes the θ^{th} conditional quantile of $\underline{ICI}_{\text{i}}$ given X_{i}. The θ^{th} regression quantile, $0 < \theta < 1$, solves the following problem:

$$\min_\beta \frac{1}{n}\left\{ \sum_{i:\underline{ICI}_i \geq X_i'\beta} \theta\left|\underline{ICI}_i - X_i'\beta\right| + \sum_{i:\underline{ICI}_i < X_i'\beta} (1-\theta)\left|\underline{ICI}_i - X_i'\beta\right| \right\} \qquad (6)$$

$$= \min_\beta \frac{1}{n}\sum_{i=1}^{n} \rho_\theta(u_{\theta i})$$

where $\rho_\theta(\cdot)$, which is known as the 'check function', is defined as:

$$\rho_\vartheta(u_{\theta i}) = \begin{cases} \theta u_{\theta i} & \text{if} \quad u_{\theta i} \geq 0 \\ (\theta - 1)\theta u_{\theta i} & \text{if} \quad u_{\theta i} < 0 \end{cases} \qquad (7)$$

The solution of this minimization problem gives OLS estimates that approximates the θ^{th} conditional quantile of the dependent variable, rather than the conditional mean. The model coefficients are therefore allowed to vary across quantiles of the conditional distribution of *ICI*, giving us the possibility to test the performance of our explanatory variables at different points of *ICI*.

In each of these estimation methods, there are two additional issues we need to tackle. The first is multicollinearity, while the second is endogeneity. For what concerns the former it is interesting to notice that in spite of what one could reasonably expect, the degree of correlations among most of our regressors is relatively low. Table 3 reports the correlation matrix for all the variables included in *XF* and for some of the controls. With the exclusion of the three variables that we used in order to compute the synthetic index for human capital (*UNIDEG*, *STAFFRATIO*, *AVEDU)*, all other significant correlations have a coefficient smaller than 0.30. Interestingly *SIZE* seems to be correlated only with *AGE* and with a very low coefficient (0.06). On this basis we can conclude that although some degree of multicollinearity exist, the latter does not represent a severe issue in our estimates.

[Table 3 about here]

With respect to endogeneity things are trickier. Given our specification of XF_i, in fact, a certain degree of correlation between some of the regressors and the error term could emerge for two main reasons: simultaneity, e.g. the amount of human capital available in the firm is jointly determined with the investments in intangible assets; and omitted variables, e.g. human capital affects investments in intangible assets through some unobservable effect that we have not included in the model. Both reasons are quite stringent and need to be dealt with directly.

The first option that we could exploit is to rely on an instrumental variables approach. In our case, however, this approach is difficult to implement because of the correlations that exist among many of the regressors that are most likely to be effectively endogenous with respect to *ICI*, e.g. *FCT_EDU* and *R&D*. Given the lack of a clear understanding of how decisions are taken inside each individual firm, in fact, the likelihood of finding a viable instrument is low.

As an alternative solution, and this is the key methodological feature of our empirical strategy, we choose to exploit what is likely to be the main strength of our dataset, that is the availability of a detailed set of information for a relatively large number of firms and years. In particular, we adopt two strategies. First, in order to deal with simultaneity, we evaluate the dependent variable of each model at 2008 and the independent variable at 2003 (for some of the latter we also consider the average for the three-years period 2001-2003) so that there exist a lag of at least five years between them and the regressors. Such a period of time makes it difficult (at least in principle) for the dependent variables and the regressors to be simultaneously determined, and thus reduces the risk of inconsistent estimates.

For what concerns instead the issue of omitted variable, the second strategy that we adopt is to saturate the third group of regressors (XC_i) with as many variables as we can in order to control for any kind of firm-specific fixed effects. Since our concern is especially related to *FCT_EDU* and *R&D*, we focused our attention on variables that could be correlated with human capital and the propensity to invest in R&D, including: age (*AGE*), investments in ICT (*ICT_INV*), and labor productivity measured in terms of added value per employee (*LAB_PRDTY*). In addition we included a series of firm-specific accounting indexes such as the ACID-test (short-term liquidities / total assets) and the profitability or gross earning over total turnover (PROFIT). Finally we controlled also for geography-related effects with the introduction of regional dummies. This solution, together with the rather detailed specification of vector XF_i , should reduce the likelihood of omitted variable bias even though, especially for the proxies of human capital, some care must be taken in interpreting the coefficients.

5. Results

Table 4 reports the Probit estimates for our model, translated into marginal and impact effects for the continuous and dummy variables respectively. We added the regressors included in XF_i one at the time, so that we estimated a total of 4 models (Probit_1 – Probit_4).

[Table 4 about here]

The first interesting result in the Probit estimates concerns the two dummies for firm's size (*D_SIZE_M* and *D_SIZE_L*). To be a medium or large firm positively and significantly contributes to the probability of being *ICIF* in the first model, when the two dummies are considered alone (i.e. Probit_1). As soon as the dummy associated with the past level of intangible capital intensity is included (*D_ICI_PAST*), however, only the dummy for medium sized firms continues being positive and significant. This result seems to suggest that, although on average size matters, beyond a certain threshold of firm dimension the positive effect of being large is overwhelmed by the effect associated with a cumulative dynamics in intangible assets investment. From the theoretical point of view this is an interesting finding, in that it suggests that for large firms the existence of complementarities and/or learning dynamics in the process of intangible assets accumulation plays a more powerful role than size alone in explaining the propensity to invest.

For what concerns human capital the dimension that seems to be the best predictor of the probability to by ICIF is the amount of human resources employed in direct R&D activities (*R&D*). The effect of R&D investments, in fact, is positive and significant in all the models in which the variable has been included (Probit_3 – Probit_4). On the contrary, no significant effect seems to be associated with the level of workforce education (*FCT_EDU*). As previously argued, however, this effect may depend on the particular segment of the overall distribution of ICI that the Probit approximates (*i.e.* top

10% of firms).

In addition to size and R&D activities, the probability of being <u>*ICIF*</u> in 2008 is also positively associated with the presence of high intangible capital intensity in 2001-2003 (*D_ICI_PAST*). The coefficient in this case is positive and significant in all the models. Quite interestingly, the size of the coefficient in the most complete model (Probit_4) is even greater than the one associated with R&D investments. Overall, this effect seems to confirm the evidence reported in Table 2 on the persistence of intangible assets investments.

Finally, in the last model (Probit_4), we also find a positive and significant effect associated with organizational complexity (*COMPLEX*). Although in terms of both significance level (10% confidence) and marginal impact such an effect does not seem to be particularly strong, it is important to notice that the effect holds after controlling for all the other independent variables included in our baseline model, such as human capital, size and past level of ICI. In this sense, such a results lend credibility to our hypothesis according to which organizational complexity plays an independent role as a determinant of a firm's intangible capital intensity.

[Table 5 about here]

Similar results are obtained from the estimates of the quantile regressions. For the sake of simplicity we report in Table 5 only the results for the 25th, 75th and 95th percentile, together with the median (50th percentile). In this case the impact of each variable can be investigated in more detail.

First of all we find that, even after controlling for the past level of intangible assets (*D_ICI_PAST*), the two dummies for medium and large sized firms (*D_SIZE_S* and *D_SIZE_M*) are positive and significant for most part of the distribution of <u>*ICI*</u>, except for the 95th percentile. This result provides further evidence in support of the idea that size actually matters. However, it also confirm the evidence from the Probit that for firms with very high investments in intangible assets the scale effects associated with size are of fairly low importance.

Secondly we obtain that, in line with size, also the effect of human capital changes according to the quantile considered. In particular, while the coefficient of the R&D

component (*R&D*) is positive and significant in the central part and right tail of the distribution (median, 75th and 95th percentile), the educational component (*FCT_EDU*) is positive and significant in the central part and left tail (median, 25th and 75th percentile). If compared to the Probit, this result is interesting in that it confirms our hypothesis according to which the two components of human capital can play a different role for firms with a different level of intangible capital intensity.

The third result that we obtain from quantile regressions is a fairly strong effect of the dummy for the past level of intangible capital intensity (*D_ICI_PAST*). The coefficient associated with the latter, in fact, is always positive and significant, independently of the quantile that we approximate. This suggests, once again, that there exist a path dependency in the process of intangible assets accumulation. If we consider also the outcomes of the Probit estimates, this is definitely the most robust effect that we observe.

Finally, we interestingly find that for all proxies of size, human capital and past level of intangible capital intensity the marginal effects tend to increase the more we move up in the conditional distribution of *ICI*. This seems to suggest the existence of increasing return to scale in intangible assets investments. Moreover, it supports the idea that, overall, there is a tendency toward an increased polarization in so far as the level of intangible capital intensity is concerned.

For the sake of completeness it is also important to notice that in the quantile regression we do not find any significant effect associated with organizational complexity (*COMPLEX*).

Bringing together the results obtained from the Probit and quantile regressions we derive a fairly encouraging picture concerning the test of our theoretical hypotheses. First of all, in accordance with HP1, we find size to be a significant predictor of the firm's level of intangible capital intensity. The dummy for medium sized firms is positive and significant in all the estimated models with the only exception of the quantile regression approximating the 95th percentile. The dummy for large sized firms, on the contrary, is significant in the quantile regressions but only limitedly in the Probit. Overall this result is the symptom of the fact that, while for the large majority of firms in our sample in the process of intangible assets accumulation scale effects are important, there exist a set of highly intangible capital intensive firms for which size matters little. The latter represents a group of firms that, independently of the size and the industry in which they operate, have deliberately adopted a business strategy that entails a substantial investment in intangible assets.

With reference to HP2, i.e. the role of human capital, the main finding that we obtain is that the different dimensions of human capital – i.e. workforce education and R&D– affect the propensity to invest in intangible assets in different ways depending on the point that we consider in the conditional distribution of *ICI*. This result could reflect the fact that firms with different levels of intangible capital intensity tend to accumulate different types of intangible assets, and thus rely on different components of human capital to procure them. In relative terms, both the Probit and the quantile regression estimates suggest that the strongest effect is the one associated with the amount of human resources involved in active R&D. Such a finding supports the idea that it is not only the quality of human resources that matter in the process of intangible assets accumulation, but also the ways in which the latter are organized.

It is important to notice that in all the estimated models the different proxies of human capital are positive and significant controlling for both industry and firm's size. Such finding confirms our view according to which human capital explains by itself part of the propensity to invest in intangible assets. In particular, the role of human capital seems to be particularly robust exactly for the group of firms for which size has no explanatory power, i.e. the sub-sample of firms that belongs to the 95th percentile of *ICI*. For the latter, in fact, the amount of human resources involved in R&D is the regressor with the strongest marginal impact on the level of intangible capital intensity.

A relatively weaker empirical evidence is instead found in support of the third explanatory variable that we considered in our hypotheses, that is organizational complexity (HP3). Our proxy of organizational complexity, in fact, turns out to be only weakly significant in the Probit, and not at all significant in the quantile regressions estimates. One of the reasons for this result could be that with our index of complexity we are capturing only two dimensions of the firm's organizational structure, that is the role as subcontractor and the degree of internationalization. The latter dimensions are likely to require relatively specific investments in organizational capital, and are therefore unable to offer a complete proxy of the firm's managerial needs. Overall, however, especially in consideration of the fact that in spite of such specificity our index turns out to be significant in some of the estimates, we do not reject HP3. Further analysis is anyway required on this issue.

Finally, for what concerns HP4, we find a clear supporting evidence in favor of the existence of path dependency in the dynamics of intangible assets accumulation. The most robust finding that we obtain across all estimates, in fact, is that the coefficient associated with the past level of intangible assets is positive and significant. This implies that firms having high intangible capital intensity at a given point in time tend to remain on the same technological trajectory, while the others tend to diverge towards less knowledge-intensive types of productions. The size of the coefficient, moreover, suggests that such divergent dynamics in technological trajectories is fairly strong, and becomes even stronger the more we move up in the conditional distribution of *ICI*. The latter result confirms the existence of an increased polarization in level of intangible capital intensity. As argued in Section 2 the causal mechanisms underlying this dynamics could be related to: (a) the existence of complementarities among knowledge bits; and (b) a process of organizational learning. Although both factors could theoretically play a role, we are unable to distinguish between them on the basis of our data.

6. Robustness checks

In order to increase the reliability of our results we conducted a series of robustness checks[7]. First of all, in normalizing the dependent variable, we tried out alternative taxonomies for the industries, including the OECD (2009) and Pavitt (1984) classifications. In both cases the results do not change. Independently of the taxonomy that we adopt, in fact, firms remain very heterogeneous so far as their level of intangible assets investments is concerned. Moreover, for all industry classifications, the proxies of size, human capital, organizational complexity and past levels of intangible capital intensity turn out to be the most significant regressors.

Secondly, as a further test on the role of the industry, we also tried a different empirical strategy in which, instead of normalizing, we control for industry-related effects by adding an apposite set of dummy variables. In this case too the results are in line with our hypotheses. In all the estimated models, in fact, the type of industry –

[7]The results are available from the authors upon request.

being it a macro category as in OECD (2009) and Pavitt (1984) or a micro sector as in NACE – does not significantly predict the firms' intangible capital intensity. On the contrary, size, human capital, organizational complexity and past levels of intangible capital intensity remain highly significant.

Since several contributions found a relatively strong effect of intangible assets on productivity (e.g. Marrocu et al., 2009; Olier at al., 2007), we also tried different measures of productivity in our vector of control variables. In particular, apart from the value added per employee which we used in the estimates reported in Tables 4 and 5, we estimated total factor productivity using the method developed by Levinshon and Petrin (2003). Also in this case, however, results do not change.

Given the relevance that scale effects play in the literature on industrial dynamics, we also tested how our results react to a different specification of size. In particular we estimated both the Probit and the quantile regressions by substituting the dummy variables for medium and large sized firms with the continuous measure instead. The results are in line with the ones reported in Table 4 and 5 with the effect of size that, in the Probit, tends to disappear as soon as the proxy for the past level of intangible assets is introduced. This test lend further credibility to our interpretation.

A final robustness check is related to a possible sample selection bias. As discussed in Section 3, our sample of manufacturing firms is based on the original dataset coming from the 9th Capitalia's survey (about 4,500 observations). However, it was possible to obtain data on intangible assets only for about 1,500 firms having a detailed balance sheet report. In fact, in this case the item "intangible fixed assets" is actually detailed in sub-items such as "costs for research and advertisement", the "costs of patents", "costs of licensing", etc. ect. We tried to control for this possible selection bias by applying a two-step Heckman procedure. First, a Probit estimate of selection from the whole sample (all firms in the original Capitalia's dataset) is made; second, a Probit estimate (in the case of Probit_4 specification) for the selected sample of firms using the Inverse Mill's ratio obtained from the first step is used as a correction factor (Heckman 1976). We did not find evidence of selection bias in our results[8].

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[8] The tables are not reported, but are available from the authors upon request.

7. Conclusions

The results of our estimates tend to confirm our initial hypotheses. In particular we find that size, human capital and the past level of intangible capital intensity significantly increase the probability of being ICIF. A similar outcome is obtained for the proxy of organizational complexity, although the evidence concerning the latter is weaker. All these results are obtained after controlling for industry-related effects.

Overall these results suggest three main conclusions. First of all, it seems clear that firm-specific traits are important determinants of intangible assets investments. In our sample, in fact, what makes the difference between *ICIF*s and the other firms is the presence of a composite mix of internal resources (e.g. high human capital and accumulated intangible stock) that enable a firm to effectively absorb, manage and reproduce intangible resources. Secondly, there seems to exist a rather specific although weak relationship between the dynamics of intangible assets investment and the need to manage complex market transactions. In this sense, and as a way to complement the most standard interpretation which is focused on the link with innovations, the choice of investing in intangible assets seems to have also an organizational connotation. Finally, there is evidence of a strong cumulative effect among the determinants of intangible capital accumulation. Such an effect can be held responsible to generate a divergent dynamics in intangible assets investments, and may thus explain a relevant part of the observed heterogeneity.

These conclusions, according to us, open new interesting research questions First of all it would be interesting to investigate how the propensity to invest in intangible assets evolves over time. In this respect, we believe that some of the variable included in our baseline model may still play an important role. Secondly, it would be of value an analysis aimed at testing how firms with different degree of intangible capital intensity react to exogenous shocks. In this sense, the recent economic depression may represent an interesting application.

Appendix

***Correspondence between aggregate and 2-digits Eurostat NACE Rev.1* classification codes:**

S01 – NACE code 15 (food products and beverages);

S02 – NACE code 17 (textiles), 18 (wearing apparel; dressing and dyeing of fur) and 19 (Tanning and dressing of leather; luggage, handbags, saddlery, harness and footwear);

S03 – NACE code 20 (wood and of products of wood and cork, except furniture; articles of straw and plaiting materials), 21 (pulp, paper and paper products) and 22 (Publishing, printing and reproduction of recorded media);

S04 – NACE code 23 (coke, refined petroleum products and nuclear fuel), 24 (chemicals and chemical products) and 25 (rubber and plastic products);

S05 – NACE code 26 (other non-metallic mineral products);

S06 – NACE code 27 (basic metals) and 28 (fabricated metal products, except machinery and equipment);

S07 – NACE code 29 (machinery and equipment n.e.c.);

S08 – NACE code 30 (office machinery and computers) and 31 (electrical machinery and apparatus n.e.c.);

S09 – NACE code 32 (radio, television and communication equipment and apparatus) and 33 (medical, precision and optical instruments, watches and clocks);

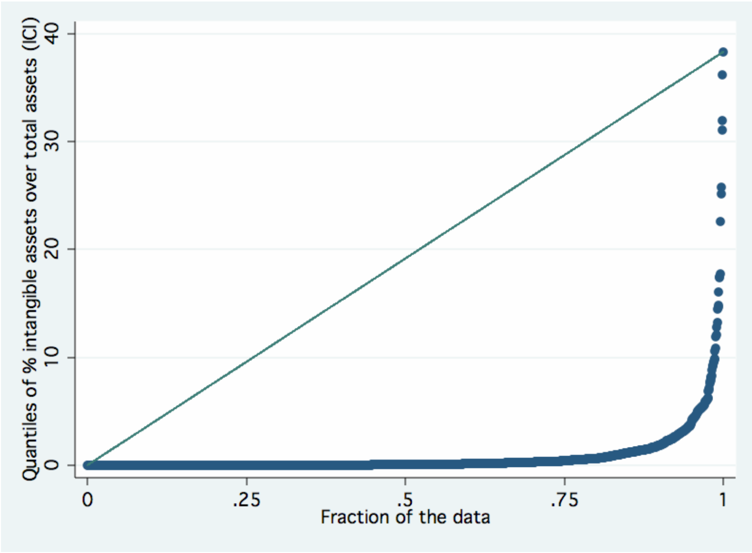
S10 – NACE code 34 (motor vehicles, trailers and semi-trailers) and 35 (other transport equipment);

S11 – NACE code 36 (furniture; manufacturing n.e.c.).

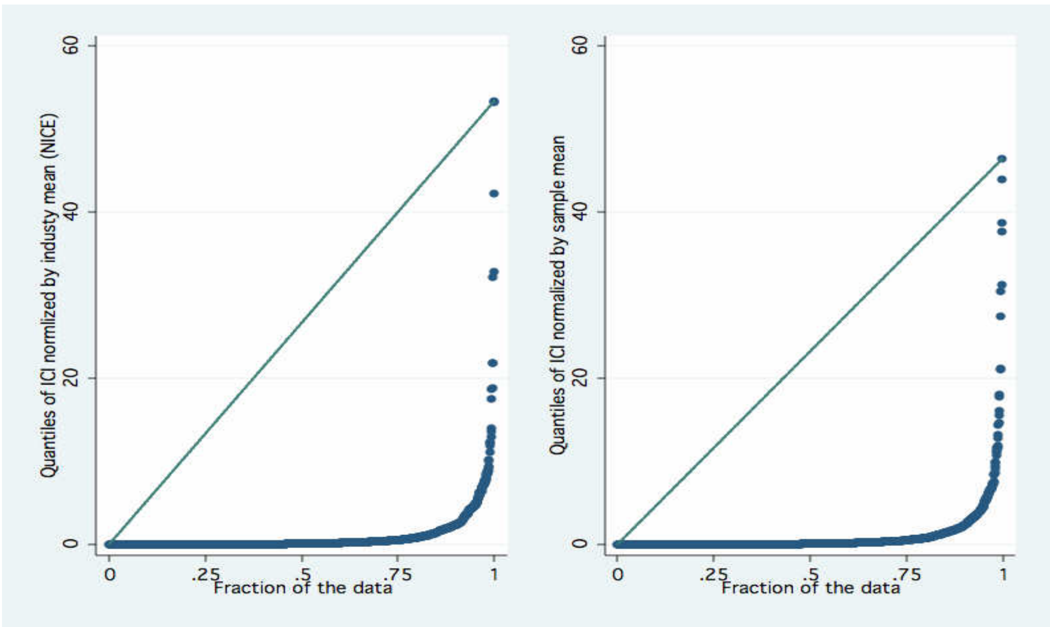
Figures and Tables

Figure 1 – Quantile distribution of the ratio intangible assets over total assets before (Panel A) and after the normalization by the sample and industry mean (Panel B).

Panel A



Panel B



Legend: Panel A reports the quantile distribution of the ratio intangible assets over total assets for the sample of firms included in our dataset. Panel B reports the quantile distribution of the same variable after normalizing the ratio by the sample (right) and the industry (left) mean. As it is easy to see the shape of the distribution does not change significantly after the normalization. This suggests the existence of high heterogeneity at the industry level.

Table 1 - Descriptive statistics.

	All firms			ICIFs			non-ICIF		
	N	**Mean**	**StDv**	**N**	**Mean**	**StDv.**	**N**	**Mean**	**StDv**
ICI:	1343	0.8	2.8	135	6.2	6.6	1208	0.2	0.4
ICI_PAST	1343	0.7	2.0	135	3.1	4.7	1208	0.4	1.1
UNIDEG	1343	0.06	0.07	135	0.08	0.08	1208	0.05	0.07
STAFFRATIO	1331	0.7	2.2	133	0.9	2.0	1198	0.7	2.3
AVEDU	1343	10.4	1.4	135	10.8	1.4	1208	10.3	1.4
R&D (employm.)	1343	0.0	0.1	135	0.1	0.1	1208	0.0	0.1
AGE	1343	36.4	19.3	135	37.6	19.6	1208	36.3	19.3
SIZE (employm.)	1343	108.9	392.0	135	222.7	1037.3	1208	96.2	223.1
COMPLEX (index)	1343	0.5	0.8	135	0.7	0.9	1208	0.5	0.7
ICT_INV	1343	3.0	9.8	135	4.1	6.8	1208	2.9	10.0
LAB_PRDTY	1343	55.9	28.4	135	54.8	28.2	1208	56.0	28.4
PROFIT	1343	0.1	0.1	135	0.1	0.1	1208	0.1	0.1
ACID	1343	0.1	0.1	135	0.1	0.1	1208	0.1	0.1

Legend:

ICI: % Intangible Assets over Total Assets in 2008.
ICI_PAST: % Intangible Assets over Total Assets in 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 (employm.): R&D Employees / Tot. Employees in 2003.
AGE: 2010 less the year of foundation.
SIZE (employm.): number of employees in 2003.
COMPLEX (index): composite index based on the three-years period 2001-2003 taking the following values: 4 if the firm generates 100% of her turnover through subcontracting out of which more than 50% abroad, invests abroad and faces international competitors; 3 if the firm generates 100% of her turnover through subcontracting out of which more than 50% abroad and either invests abroad or faces international competitors; 2 if the firm generates 100% of her turnover through subcontracting out of which more than 50% abroad and neither invests abroad nor face international competitors; 1 if the firm generates 100% of her turnover through subcontracting out of which less than 50% abroad; 0 if the firm generates less than 100% of her turnover through subcontracting.
ICT_INVESTM: € Invested in ICT / Tot. Turnover in the three-years period 2001-2003.
LAB_PRDTY: Added Value per Employee in 2003.
PROFIT: Gross Earnings / Tot. Turnover in 2003.
ACID: Short-term Liquidity / Tot. Assets 2001.

Table 2 - Intangible assets persistence.

Panel A: distribution of firms across classes

		Classes 2008				
		Null	**Low**	**Medium**	**High**	**Total**
Classes 2001-2003	**Null**	197	75	11	2	285
	Low	128	638	81	19	866
	Medium	9	68	63	11	151
	High	6	2	13	20	41
	Total	340	783	168	52	1343

Panel B: transition probabilities across classes

		Classes 2008				
		Null	**Low**	**Medium**	**High**	**Total**
Classes 2001-2003	**Null**	0.69	0.26	0.04	0.01	1.00
	Low	0.15	0.74	0.09	0.02	1.00
	Medium	0.06	0.45	0.42	0.07	1.00
	High	0.15	0.05	0.32	0.49	1.00

Legend**:** We consider four distinct classes of the ratio intangible assets over total assets: null (=0), low (>0 and <1%), medium (>=1% and <5%) and high (>5%). Panel A reports the number of firms who were in the jth class in period 2001-2003 (rows), and in the ith class in 2008 (columns). Panel B reports the transition probabilities across classes.

Table 3 – Correlation matrix.

	UNIDEG	STAFF RATIO	AVEDU	R&D	AGE	SIZE	COMPLEX	ICI_ PAST
UNIDEG	1.00							
STAFFRATIO	0.32*	1.00						
AVEDU	0.60*	0.32*	1.00					
R&D	0.18*	0.06*	0.18*	1.00				
AGE	0.00	-0.04	-0.07*	0.00	1.00			
SIZE	0.05	0.00	0.01	0.01	0.06*	1.00		
COMPLEX	-0.05	-0.04	-0.04	0.04	-0.04	-0.02	1.00	
ICI_PAST	0.13*	0.03	0.10*	0.08*	-0.01	0.03	-0.01	1.00

Legend: * = sig. 5%.

Table 4 – Determinants of Intangible Assets: Probit regressions, dependent variable <u>*ICIF*</u>

	Probit_1	**Probit_2**	**Probit_3**	**Probit_4**
	b/se	b/se	b/se	b/se
Controls	*Yes*	*Yes*	*Yes*	*Yes*
Regional Dummies	*Yes*	*Yes*	*Yes*	*Yes*
D_SIZE_M (d)	0.058**	0.039**	0.040**	0.037*
	(0.02)	(0.02)	(0.02)	(0.02)
D_SIZE_L (d)	0.061**	0.021	0.022	0.021
	(0.02)	(0.02)	(0.02)	(0.02)
D_ICI_PAST (d)		0.214***	0.198***	0.198***
		(0.03)	(0.03)	(0.03)
FCT_EDU (index)			0.013	0.013
			(0.01)	(0.01)
R&D (employm.)			0.207***	0.195**
			(0.08)	(0.08)
COMPLEX (index)				0.015*
				(0.01)
Obs	1331	1331	1331	1331
LogL	-412.891	-357.812	-352.585	-350.891
Chi2	39.149**	149.307***	159.761***	163.150***

Legend**:** *** = sig. 1%; ** = sig. 5%; and * = sig. 10%; standard errors in parentheses; marginal effects are reported. Notice: the marginal effects are evaluated at the means of the independent variables for the unconditional expected values of the dependent variable; for the binary variables, we report the discrete change from 0 to 1.

Table 5 – Determinants of Intangible Assets: Quantile regressions, dependent variable *ICI*

	Qreg_25 b/se	Qreg_50 b/se	Qreg_75 b/se	Qreg_95 b/se
Controls	*Yes*	*Yes*	*Yes*	*Yes*
Regional Dummies	*Yes*	*Yes*	*Yes*	*Yes*
D_SIZE_MEDIUM (d)	0.0011**	0.0390***	0.1610***	0.1436
	(0.0005)	(0.0089)	(0.0497)	(0.9635)
D_SIZE_LARGE (d)	0.0058***	0.0597***	0.1645***	0.0452
	(0.0006)	(0.0096)	(0.0538)	(1.0300)
D_ICI_PAST	0.1615***	0.6779***	2.1551***	6.3827***
	(0.0005)	(0.0088)	(0.0487)	(0.9432)
FCT_EDU (index)	0.0013***	0.0292***	0.0843***	0.6277
	(0.0004)	(0.0059)	(0.0303)	(0.6368)
R&D (employm.)	0.004	0.1285**	1.0090***	12.5485**
	(0.0038)	(0.0552)	(0.3139)	(5.3499)
COMPLEX (index)	0.0002	0.0059	0.0389	0.4446
	(0.0003)	(0.0049)	(0.0285)	(0.5334)
Costant	-0.0005	0.0217	0.2076**	1.3326
	(0.0009)	(0.0158)	(0.0919)	(1.7356)
Obs	1331	1331	1331	1331

Legend**:** *** = sig. 1%; ** = sig. 5%; and * = sig. 10%.; standard errors in parentheses.

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