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INTANGIBLE RESOURCES AND ORGANIZATION CAPITAL: MEASUREMENT AND ECONOMIC EVALUATION

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Introduction

In the last few decades economic systems have pervasively gone trough a structural change. On the one hand, the latest "wave" of globalization processes, characterized by new emerging powers (Harris, 2005) and international fragmentation (e.g Jones and Kierzkowski, 2003), along with phenomena such as deregulation and privatization, has augmented the degree of market competition dramatically, both intensively and extensively. On the other hand, the increasing complexity of the innovative processes (Gottfredson and Aspinall, 2005) and volatility of consumer preferences have made both technological and market uncertainty more intense.

In this new scenario, firms have been forced to reconsider the sources of their competitive advantage and the barriers to its erosive imitation. Focusing on internal resources and competences is no longer sufficient; understanding which of them are more strategic has become necessary (Barney, 1991).

Both theoretical and empirical studies have thus started to bring to the front of the debate the role of the so called firms' *intangibles*, claiming these resources – such as R&D, innovative business process and designs, management structures and organizational systems, human capital, patents and copyrights - rather than tangible resources – such as physical machinery, plant and equipment - to be the key factors in providing firms with sustained competitive advantage in the new scenario. Indeed, the literature supporting this argument is becoming massive and one is almost naturally led to conclude this to be the new strategic "business credo" (e.g. Hall, 1992, Lev, 2001, Edvinsson, 2000).

This is also the starting point of the present thesis, whose aim is to investigate whether, and eventually how far, the "supposed" key role of intangible resources in driving firm competitiveness actually has robust scientific foundations, both from a theoretical and an empirical perspective. In particular, this thesis intends to critically re-examine the notion of intangibles as such, the economic nature of its causal link to firm performance and the empirical impact that a "special" kind of intangibles – as we will see, the organizational capital (OC) – has on a large number of firms in the European area.

Although the massive literature on the topic apparently seems to make such a research effort redundant, its relevance and originality become evident on the basis of the following considerations.

At the outset, one should recognize that the peculiar features that differentiate intangibles from physical resources, and make them key factors to gain competitive advantage, are also responsible for several problems related to their definition, such as lack of consensus on terminology (capital, asset, resource, investments), clear inclusion and exclusion criteria to meet in order to belong to the category, classification problems such as definition of sub-classes of intangibles and their content. This is also why intangibles have recently attracted the growing interests of scholars from different disciplines (e.g. Griliches and Mairesse, 1981, Lev, 2003, Andriessen, 2004, Garcia-Ayuso, 2003, Bianchi and Labory, 2002). Yet, even though many have written about them, there is still no consensus concerning the real nature of these resources. This first issue (definition problems) deserves special attention and is thus addressed in the first part of this thesis (Chapter 1). Here, in order to tackle the definition problems, intangibles are, at first, considered as a unified category, and the problems that such a perspective brings about are analysed. Looking for a possible general and theoretical approach to analyse intangibles, the first part of the research is based on general contributions that address all intangibles, and not intangible resources taken individually. The most recent literature reviews related to the topic have been selected and their references compared to identify the leading authors in the field; their most recent publications have then been included to study the latest developments. The selected criteria have privileged contributions coming from strategic management, finance and social science fields; intangibles have been analysed from the firm's perspective and this has left little room for the analysis of macroeconomic aspects.

From this frist part of the thesis, a certain degree of confusion emerges in the terminology used to identify intangibles ("intangible assets", "intangible resources", "intellectual capital" or simply "intangibles"), in their definition and classification. What is more, attempts to create a more rigorous framework through the identification of their sub-components have generated further terminological and conceptual problems, without improving the understanding of the phenomenon.

To the problem of definition one should also add that of their measurement. The peculiar features of intangibles in fact generate problems concerning the capacity of the firms to control intangibles and measure the benefits deriving from them. Due to their immateriality and imperfect appropriability, intangibles are not recorded in financial reports, and markets do not have enough information to value them. Firms and markets are increasingly asking alternative mechanisms for their measurement and valuation. Many alternative measurement methods have been proposed but none have been proven successful. The measurement problems are also reflected in the difficulties that firms have in identifying their intangible portfolio, exploit, develop and generate intangibles.

A second important starting point of this research relates to the economic theory for intangibles or, better to say, the lack of an economic theory for them, an issue which is addressed in the subsequent part of this thesis (Chapter 2). It is argued that the analysis of intangibles is usually not related to a conceptual theory; only a few authors point to the evolutionary theory of the firm and the resource based view (RBV) as possible theoretical frameworks (Hall, 1992, Clement et al, 1998, Fernandez et al, 2000). The contributions of leading authors in the field of the theory of the firm and RBV have therefore been selected in search for a possible intangible – related view and intangible resources and the reasons behind their importance for the firm are analysed in the context of a "theory".

Through an extensive review of the literature, it is possible to show that traditional economics has for long ignored intangibles, due to the peculiar features that make them non- or imperfectly tradable commodities. However, the analysis of the theories of the firm shows that those "heterodox" approaches that reject the assumptions of the neoclassical theory, in particular the evolutionary theory of Nelson and Winter (1982) and its strategic analysis development, the RBV, can possibly provide a theoretical framework for the analysis of intangible resources, and hopefully improve their understanding.

While the evolutionary theory provides a dynamic framework that fits well the representation of the "flows" (investments) in intangibles, the RBV, static approach, offers a possible model for the analysis of the stock of intangible resources by outlining the role of firm resources and the main features that resources must have to generate competitive advantage. The RBV applied to intangible resources has led to the recognition of the role of knowledge, particularly analyzed by the knowledge-base view (KBV) (Grant, 1996) that has underlined the important role of the organisational culture in its transmission and in the generation process of new knowledge.

Building on RBV classifications of intangibles and on the contributions of the literature, mainly managerial, on intangibles, I propose an eclectic classification of intangibles that groups them in human capital, organizational capital (OC), intellectual property and innovation related capital. The application of a RBV model (Barney, 1991), that requires resources to be not only valuable (i.e. controlled and strategically significant) but also heterogeneous and imperfectly immobile in order to be classified as sustainable-advantage resources, seems to indicate that the tacit organisational knowledge of the firm, component of OC, is the resource that better satisfies this conditions. It is however extremely hard to separate tacit organisational knowledge from codified organisational knowledge, other component of OC, as the degree of intertwining between the two is very high, and organisational knowledge also needs its codified dimension. We therefore conclude that OC, identified with codified knowledge (norms, guides and databases), tacit knowledge (corporate culture and organizational routines, co-operation agreement) and reputation, is, for its specific characteristics, a sustainable-advantage resource, therefore crucial for firm performance. This is a first important result of the thesis, although still from a purely theoretical perspective.

Such a theoretical result however needs empirical confirmation. As the theory indicates intangibles, OC in particular, as the most competitive resources of the firm, in search for an empirical confirmation of this theoretical assumption, studies that investigate the effect of intangibles on firm performance are critically analysed (Chapter 3). Once more, the review is critical and, rather than aiming to update the state of the art, wants to outline how the correspondence between theoretical and empirical arguments is actually scanty given that, very often, the former is not truly supported by the latter.

As noticed with respect to works on definition, management and measurement problems of intangibles, empirical works on intangibles belong to different fields, use different methodologies, focus on different types of intangibles and are hardly comparable. For these reasons, a selection criterion has been identified: the most recent and “founding” contributions have been included. The analysis critically presents the most used methodologies and the up to date results related to the link between intangibles and performance.

Studies on the impact of intangibles on performance have focused mainly on R&D and innovation related intangibles. More recently, other dimensions of firm’s intangibles have been analysed: human capital, IT and advertising. The attention on these types of intangibles is due to the fact that there is relatively no consensus in academia about their definition, even though different proxies are used to measure them. Despite concerns about statistical tools, quality of data and measurement errors, the evidence of a positive relationship between these intangibles and firm performance has been somehow confirmed, even though results are not comparable and strongly vary in magnitude. Efforts of researchers who have attempted to measure the effect of OC on firm performance have instead been “uncoordinated and sporadic” (Black and Lynch, 2005) and have not reached conclusive results. An extensive analysis of empirical studies on the relationship between intangibles and firm performance is therefore important to analyze how the causal relationship mechanisms, measurement and econometric problems have been treated with respect to other types of intangible resources.

As OC is a resource formed by the interaction of different components and there is a lack of consensus about what these components are, researchers have chosen to proxy OC using data related to its elements: mainly information and communication technologies (ICT), training, Human Resource Systems (HRS) and workplace practice. Even though there is evidence that these single components have an effect on performance, the same conclusion cannot be reached for OC.

The analysis of the literature on intangibles points out at a specific intangible as the most important for firm performance: OC. The analysis of the empirical evidence of this link instead shows that, while other types of intangibles have been widely empirically analysed, the empirical evidence that links OC to firm performance is not as wide and solid. On this ground, in the attempt to fill this gap, an eclectic model that draws on recent developments in the field (Lev and Radhakrishnan, 2005, De and Dutta, 2007) is presented and tested on a sample of European firms whose data are taken from the Compustat Global database.

This application is original and innovative from both a methodological and an empirical perspective.

As far as the model is concerned, OC, retained an input of the production function, is measured by capitalizing, through the perpetual inventory method, an income statement item (Selling, General and Administrative expenses) that includes expenses linked to information technology, business process design, reputation enhancement and employee training. This measure of OC is employed in a cross-sectional estimation of a firm level production function - modeled with different functional specifications (Cobb-Douglas and Translog) - that measures OC contribution to firm output and profitability. The model is estimated in levels and first difference, through the OLS, controlling for heteroskedasticity of errors, endogeneity of inputs and influence of outliers.

The research work of this thesis is also valuable in terms of its application. Indeed, the quantitative data, on which the empirical analysis has been based, is drawn from the Compustat Global database that provides normalised financial data on over 28,500 worldwide publicly traded firms that represent more than 90% of the world's market capitalization. The dataset selected for this analysis includes 1,309 (Euro area, Denmark and UK) reporting Selling, General and Administrative Expenses. Data for each firm in the sample include: industry, country, yearly revenues (2005-2006), yearly SGA (2000-2006), yearly property, plant and equipment (2005-2006), yearly intangible assets (2005-2006), yearly R&D expenses (2000-2006), yearly n. of employees (2005-2006), net income (2005-2006).

As I will argue more extensively in the conclusions, results that are quite robust across the different specifications validate the theoretical assumption that OC, idiosyncratic, firm-specific, interrelated and hard to imitate, identified as a sustainable advantage resource is, in fact, determinant and positively affects firm performance. Furthermore, the effect of OC on performance is significantly higher compared to the effect of physical capital; this backs up the literature that supports the new strategic "business credo" that identifies intangibles as the main competitive advantage resource.

Nonetheless, the significant effect of physical capital also supports the RBV, according to which firm resources are interconnected, bundles, and need one another in order to produce competitive advantage.

This thesis is structured into 4 chapters. In brief, Chapter 1 attempts to clarify the "terminological soup" related to intangibles and systematically organise, present, and compare different definitions and classifications proposed by the literature. The peculiar features of intangibles and the problems they entail; in particular measurement, management and market valuation, are analysed. Proposed measurement and management methods and solutions are also presented. Chapter 2 analyses the treatment of intangibles in the economic theories of the firm, starting from the neoclassical to the heterodox approach, in particular the evolutionary theory of Nelson and Winter (1982). Intangibles are then analysed in the context of the RBV; a classification model is proposed and OC is identified as the intangible responsible for sustained competitive advantage and therefore crucial for firm performance. Chapter 3 analyses the methodologies used in the empirical literature to investigate the effect of intangibles on firm performance. Studies are grouped according the specific type of intangibles they focus on. Empirical studies on the relationship intangibles-firm performance have been sporadic and have failed to reach firm conclusions with respect to OC; in the attempt to fill this gap Chapter 4 test the effect of OC on a large sample of European firms. A measurement method based on an income statement item (SGA) is presented together with its rational; the model and the estimation method are explained and the dataset analysis in carried out. The two final sections present results, comments and conclusions.

The value of the work is given by several factors. The analysis of chapter 1 re-organise definition issues related to intangibles in an original way, in the attempt to provide methodological order and clarifications. The proposed classification of intangibles is based on theoretical considerations – RBV – and provides conceptual rigorous criteria to identify intangibles responsible for sustained competitive advantage and, therefore, firm performance. The empirical analysis on the effect of OC on firm performance provides a valuable contribution to the existing empirical literature that hitherto has not managed to provide strong evidence. Furthermore, the analysis is original with respect to methodology used to measure OC and model used to analyze its effect on firm performance. Last but not least, the novelty and composition of the dataset, that includes a wide variety of industries, differently form existing studies that mainly focus on R&D intensive sectors, provides further insight. The robustness of the results across the different specifications can be taken as a confirmation of the validity of the methodology and empirical analysis conducted, that has produced interesting findings and confirmed the main hypothesis tested: the importance of OC for firm performance.

Chapter 1. The identification of intangible resources, distinctive characteristics and related problems

1.1 The importance of intangible resources

As argued by many authors in the field, intangible resources are not a new phenomenon. What is new is the increasing importance they have for the enterprise and the economic system. In the past, the economic environment was relatively stable and physical capital and labour were the main factors of production (Bianchi and Labory, 2002). Nowadays the situation has changed: globalisation, deregulation, new information and communication technologies have created a turbulent and uncertain economic environment where competition is fierce and firms survive only by innovating and reaching a competitive advantage. Therefore, the attention needs to be put on those factors that create successful conditions in this economic environment.

The increased competition brought about by deregulation, globalisation and new technologies is not enough to describe how the economic environment has changed. Not only has competition increased, it has also changed in a qualitative way. Society (at least in the developed countries) has reached a certain level of welfare and the basic needs of individuals are satisfied. As a consequence, consumers have become more and more sophisticated and so has the demand for products. Strategies based on price competition do not work anymore in this context, and firms focus on non-price strategies such as differentiation and product innovation to gain and expand market shares.

Another factor that has changed the way in which firms compete is the "commoditization of physical assets" (Lev, 2005, p. 301). The term "commoditization of physical assets" alludes to the development of the mass production system that has made machinery, equipment and technology widely available at a reasonable cost. Everybody can own physical factors of production therefore they are only a necessary condition to operate, not a source of advantage.

Many authors argue that the immaterial, intangible, knowledge part of the firm has now become the key factor of firms' success. Firms can reach sustainable competitive advantage only through the development of capability differentials and "the feedstock of these capability differentials is intangible resources" (Hall, 1992, p. 135).

The growing importance and the increasing role played by this type of resource in assuring performance results have raised the attention of many disciplines, ranging from strategic management, accountancy, finance, organisational theories, economics, and the interest of the business community. The approaches are heterogeneous and privilege different aspects. What is common to all of them is the recognition of the importance of intangibles and the difficult problems they raise due to their peculiar features. Unfortunately, none of the approaches provides a uniform, sound theory of intangibles and all struggle to explain the phenomena related to them.

A clear analysis should start with the identification of its object. However, this is not an easy task in the case of intangibles as they are poorly defined with respect to term, definition and classification (Johanson, 2002; Kaufmann and Schneider, 2004; Meritum, 2002). This research therefore starts with a critical analysis of the terminology, definitions and classifications proposed in the literature on intangibles.

1.2 Intangibles: assets, capital, resources, and investments

Table 1.1 presents a summary of the most frequent terminology used when referring to intangibles. Scholars belonging to accounting, finance and economics use the term "intangible assets"; practitioners and strategic management scholars use the term "intellectual capital" and "intangible resources". Clement et al (1998) focuses on the dynamic aspects of the creation of resources and uses the term "intangible investments". The distinction among the terms used, thus, does not appear too precise and founded on sound conceptual reasons. The majority of the authors, in fact, seldom take a stand regarding the terminology and end up switching back and forth with the term asset, capital or resources, using them indistinctively.

The first conclusion that can be reached is that assets, resources and capital are the most commonly used terms to classify intangibles. These terms need to be clarified and their use justified; however only a few of the authors analysed explain the reasons behind their choice. Hall (1992) defines "assets" as those resources that are protected by legal property rights; only part of intangibles (e.g. patents, copyrights) can therefore be called assets. Some authors (Johanson, 2002; Haanes and Lowendahl, 1997) focus on the distinction between assets and resources; according to them, assets are a subset of resources, as the term “asset” is associated with control or ownership. Based on these considerations and on the peculiar features of intangibles, where “ownership” is not always easy to establish, the preferred term for intangibles should be “resources”.

Table 1.1: Intangible resources: Terminology

Author	Term
Vance, C. (2001)	Intangible assets
Lev, B. (2001, 2003, 2004, 2005)	Intangible assets
Gu, F., Lev, B. (2001)	Intangible assets
Stolowy, H., Jeny-Cazavan, A. (2001)	Intangible assets
Garcia-Ayuso, M. (2002)	Intangible assets
Bianchi, P. and Labory, S. (2002)	Intangible assets
Royal Institute of Chartered surveyors (2003)	Intangible assets
Amir, E., Lev, B., Sougiannis, T. (2003)	Intangible assets
Eustace, C. (2003)	Intangible assets
Kaufmann, L., Schneider, Y. (2004)	Intangible assets
Kaplan, R. S., Norton D. P. (2004)	Intangible assets
Matolcsy, Z., Wyatt, A. (2006)	Intangible assets
Webster, E., Jensen P. H. (2006)	Intangible assets
Sullivan, P. H. (1999)	Intellectual capital
Edvinsson, L. (2000)	Intellectual capital
Brennan, N., Connel, B. (2000)	Intellectual capital
Bontis, N. (2001)	Intellectual capital, knowledge assets
MERITUM (2002)	Intangibles, Intellectual capital
Andriessen, D. (2004)	Intellectual capital
Swart, J. (2006)	Intelletual capital
Barney, J. (1991)	Intangible resources
Hall, R. (1992)	Intangible resources
Bontis, N., Dragonetti, N. C., Jacobsen, K., Roos, G. (1999)	Intellectual capital, intangible resources
Johanson, U. (2000)	Intangible resources
Canibano, L., Sanchez, M. P. (2003)	Intellectual capital and intangible
Bukh, P. N., Johanson, U. (2003)	Intangible capital, knowledge resources
Rastogi, P. N. (2003)	Intellectual capital, knowledge resources
Clement, W., Hammerer, G., Schwarz, K. (1998)	Intangible investments

The MERITUM guidelines (MERITUM, 2002) provide further clarifications about the terminology. While establishing that intangibles and intellectual capital designate the same concept, the report argues that the term “intangible asset” should only be used when referring to intangible investments that can be capitalized, based on the satisfaction of accounting criteria. Academic scholars have started using the term "intellectual capital" after the concept was first created by practitioners[1]. Some authors use the term intellectual capital as formed by intangible "or knowledge" resources.

In this analysis the term intangible resources is mainly used as it refers to a wider category than assets; the abbreviation "intangibles" is used just for simplistic purposes[2], while respecting the terminology used by the original authors. Based on the above considerations, the term "resources" is considered more appropriate to grasp the variety of intangibles and include also those resources that are not taken into consideration by traditional financial reports.

1.3 An analysis of the definitions found in the literature

There are three ways to identify intangibles: by definition, by classifications or by the combination of both. Table 1.2 presents several definitions of intangibles proposed by the literature. As seen for the terminology used to designate intangibles, there is also a lack of consensus around their definition. A group of definitions are quite similar (Lev, 2001, 2005; Royal Institute of Chartered Surveyors, 2003; Kaufmann and Schneider, 2004) and define intangible assets essentially by means of two features: lack of physical substance and capacity to generate future profits. It is interesting to note how they are all associated with the term "asset", even though these definitions also include intangible resources such as skills, capabilities and competences that will probably never be classified as assets on firms' balance sheets. This outlines how, when referred to intangibles, the term "asset" is used with a heterodox meaning in comparison with its accounting definition. According to this first set of definitions, intangibles could be apparently very similar to financial assets which also lack physical substance; the feature that renders financial assets different resides in the fact that they represent claims over both tangible and intangible corporate assets; therefore they do not belong to the category of intangibles (Lev, 2005).

[1] Mainly as a result of the work at firms such Skandia, Dow Chemical, Canadian Imperial Bank of commerce (Bontis et al, 1999)

[2] Several times authors just talk about "intangibles" without specifying the implicit term next to it. This is a consequence of the lack of consensus about what "intangibles" really are (Johanson, 2002).

Table 1.2: Intangible resources: Definitions

Author	Term	Definition
Lev, B. (2001)	Intangible assets	"claim to future benefit that does not have a physical or financial (a stock or a bond) embodiment" p. 5
Gu, F., Lev, B. (2001)	Intangible assets (or capital)	"Determined by their drivers: R&D, advertising, brands, Information Technology, Human Resources" p. 1
Royal Institute of Chartered Surveyors (2003)	Intangible assets	"something with a value based on its ability to generate future benefits for a company (usually cash flows) that does not have physical or financial presence." p. 2
Kaufmann, L., Schneider, Y. (2004)	Intangible assets	"Entitlement to future benefits withouth physical form", p 375 (Explicitely states to adopt Lev's definition)
Kaplan, R. S., Norton, D. P. (2004)	Intangible assets	"knowledge that exists in an organization to create differential advantage" and "capabilities of the company's employees to satisfy custumer needs", p. 14
Lev, B. (2005)	Intangible assets	"Sources of future benefits that lack a physical embodiment", p. 299
Webster, E., Jensen P. H. (2006)	Intangible assets	Investment in intangibile capital is a "search for monopoly profits", p. 84
Sullivan, P. H. (1999)	Intellectual capital	"knowledge that can be converted into profits", p.133
MERITUM (2002)	Intangibles, Intellectual capital	"non-physical sources of future economic benefits that may or may not appear in corporate financial reports", p. 9
Swart, J. (2006)	Intelletual capital	"tangible output in the form of products and services within the firm's market place", p 138
Hall, R. (1992)	Intangible resources	Feedstock of capabilities differentials that generate suatainable competitive advantage
Fernandez, E., Montez, J. M., Vazquez, C. J.	Intangible resources	"soft resources which basically consist of knowledge or information", p.81
Bontis, N., Dragonetti, N. C., Jacobsen, K., Roos, G. (1999)	Intellectual capital, intangible resources	"Collection of intangible resources and their flows", (p. 11). Control is a necessary condition to qualify as a
Rastogi, P. N. (2003)	Intellectual capital, knowledge resources	"holistic capacity and prowess to create value through the exploitation of knowledge as the quintessential resource", p. 228

Gu and Lev (2001) define intangible capital through the sources that create it: investments in “R&D, advertising, brands, information technology, and human resources practices” (op. cit., p.1). However these are often classified as intangible assets themselves, therefore Gu and Lev’s “definition” does not add much in terms of clarifying the category.

Common to some definitions is the focus on intangible capital/resources as the knowledge (Fernandez et al., 2000) that generates differential advantages (Kaplan and Norton, 2005) or profits (Sullivan, 1999) or as the capacity to use knowledge to create value (Rastogi, 2003). For Hall (1992) intangible resources are the tools that create capabilities differentials, source of competitive advantage.

Intangibles seem therefore to be frequently associated with knowledge and capabilities to use knowledge; the level of abstractness of the definition is obviously very high. Another element that emerges from the definitions is the interdependence of intangibles: intangibles exist in the organization (Kaplan and Norton, 2005) and are holistic (Rastogi, 2003).

All the definitions have a static approach, aiming to give a picture of intangibles at a certain time; only Bontis et al. (1999) include in their definition of intangible capital the flows related to intangible resources. Resources are defined as "controlled" factors contributing to the value creating processes of the firm. Since control is the condition to qualify as resources, and the degree and scope of control on the resources varies from firm to firm, intangible resources (and therefore intellectual capital) are context-specific. This is outlined as another factor that creates problems in the formulation of an objective definition that can identify intangibles in all situations and for all the firms.

The most peculiar definition is the one offered by Swart (2006). He argues that intellectual capital is a concept that varies according to the perspective used to analyse it. Intellectual capital can be seen as a factor of the production process, as a "value-creation process in itself" (op. cit, p.138) or as knowledge and skills embedded in the tangible outcome of the production process. Swart sees intellectual capital under this last perspective. In this analysis intangible resources are considered as input in the production process.

From this picture it emerges that the second class of problems (the first being related to the terminology) relates to the lack of a clear definition, which does not give clear inclusion and exclusion criteria. Intangibles do not have physical substance, are strictly related to knowledge and capabilities, are interdependent, exist in the context of organizations and are firm-specific, generate future and monopoly profits; this is all that can be said about them from the definitions analysed.

1.4 A reorganisation and comparison of the proposed classifications

Definitions of intangibles based on classifications provide further insights about what intangible resources are. Table 1.3 groups the most used ones on the basis of the number of sub-classes of intangibles identified.

The classifications of the first group are almost overlapping and define intangibles as mainly formed by five types of resources. The most relevant weakness of these two classifications is the fact that they do not specify the content of the classes and provide a list of resources that is not exhaustive.

The second group classifies intangibles in four categories. Lev (2005) labels them product/services, customer related, human resources, and organizational capital. The first category identifies those situations where "the physical component is overshadowed by the intangible ingredient – knowledge – embedded in them" (op. cit., p. 300) and refers, for example, to computers and software. However, it is not specified when the intangible part embedded into the physical component becomes so important that the tangible component is classified as intangible, even if the requirement of lack of physical substance is not respected. This is a strong weakness, especially nowadays, where products become more and more sophisticated and are the outcome of a production process that embodies a great amount of knowledge in them. Customer related intangibles are essentially advertising and brand names; human resources related intangibles are the skills of the workforce; organizational capital is the structure of the firm, when it provides an efficient way to operate. Webster and Jensen (2006) adopt a similar classification, even though they label the categories in a slightly different way. The main difference relates to the extent of relational capital. The authors seem to consider in this category also the relationships with suppliers and distributors, while Lev (2005) focuses only on customers (customer capital). Another similar classification to the two just mentioned, is the one of Brooking (1996) that has measurement purposes and divides intellectual capital in four sub-groups. Market assets comprehend those resources related to the external functioning of the firm (such as customer related capital, alliances and agreement with competitors just to name two); intellectual property is the second sub-group; human centred assets include the collective capabilities of the employees; infrastructure assets include corporate culture and technology, information and communication systems. Bianchi and Labory (2002) refer to the aspects of intangibles studied by economics and more than classifying them, they outline some relevant aspects.

Table 1.3: Intangible resources: Classifications

	Author	Term	Classification
Group 1	Gu, F., Lev, B. (2001)	Intangible assets	5 types: R&D, Advertising, Brands, Human Resources, Organisational Capital
	Royal institute of Chartered Surveyors (2003)	Intangible assets	"Organisational design, brand names, corporate identity, software, R&D", p. 1
Group 2	Brooking, A. (1996)	Intellectual Capital	Market assets, intellectual property, human centred assets, infrastructure assets
	Bianchi, P. and Labory, S. (2002)	Intangible assets	Innovation, human capital, organisation, knowledge
	Lev, B. (2005)	Intangible assets	Products/services, custumer related, human resources, organisational capital
	Webster, E. Jensen P. H. (2006)	Intangible assets	Human, Organisational, Marketing, Relational Capital
Group 3	Sveiby, K. E. (1997)	Intangible assets	External structure, internal structure, individual competence
	Stolowy, H., Jeny-Cazavan, A. (2001)	Intangible assets	R&D, goodwill, other Intangible assets
	Vance, C. (2001)	Intangible assets	Human, internal structural external capital
	MERITUM (2002)	Intangibles, intellectual capital	Human, organizational and relational resources
	Canibano, L., Sanchez, M. P. (2003)	Intellectual capital and intangible resources	Human, structural and relational capital
	Kaufmann, L., Schneider, Y. (2004)	Intangible assets	Proposes different classifications of others. Findings: Mostly 3 groups
	Lev, B. (2001)	Intangible assets	Discovery, organisational practices, human resources
	Kaplan, R. S., Norton D. P. (2005)	Intangible assets	Human, organisational and informational capital
Group 4	Hall, R. (1992)	Intangible resources	Assets and skills
	Evinsson, L., Malone, M. S. (1996)	Intangible resources	Human and structural capital
	Bontis, N., Dragonetti, N. C., Jacobsen, K., Roos, G. (1999)	Intellectual capital, intangible resources	According to the managerial actions required. Human Capital (competence, attitude, intellectual agility) and Structural Capital (relationship, organisation, renewal and development) p. 12
	Sullivan, P. H. (1999)	Intellectual capital	Human capital and intellectual assets
	Eustace, C. (2003)	Intangible assets	Soft intangibles and hard intangibles
Group 5	Johanson, U. (2000)	Intangible resources	Not feasible
	Rastogi, P. N. (2003)	Intellectual capital, knowledge resources	A classification is not feasible: intellectual capital is the result of the interaction of human capital, social captal and knowledge management

The third group uses a threefold classification. With the exception of Stolowy and Jeny-Cazavan (2001) who consider intangible from a strict accounting perspective, the classifications share common sub-groups, even though they use different labels and the content slightly varies.

The first category for all the classifications belonging to this group is human capital, identified with the skills of the workforce. However the MERITUM guidelines (MERITUM, 2002) include the relational skills of the workforce and the organisation in the third category, relational capital.

The second category refers to the "intangible capital of the organization", as separated from the human capital. It includes multiple resources such as governance, management, information and communication systems, routines, procedures, everything (intangible) that belongs to the organisation.

The third category is relational or external capital and identifies the resources that deal with the external environment. The MERITUM guidelines also include in this group the perceptions that external actors have of the firm. However, this seems more a result of the firm's relational capital, than a part of it.

The third group of classification identifies mainly three types of intangibles. A conflicting point, often noticed by comparing the different classifications, relates to the internal or external dimension of intangibles, and it is probably a consequence of the different theories on firms boundaries. Kaplan and Norton (2005), for example, have a strict internal perspective and do not involve the external world – (i.e. what some authors call "relational or external intangible capital") - in their classification criteria. Besides human capital, they add two other categories: organisational culture (values, leadership, capacity to work in teams and "align" competencies, effort and resources to the strategy) and informational capital (informatics and communication systems). These last categories seem to be incorporated into the "intangible capital of the organization" in the other classifications of the group.

Sveiby (1997) instead builds up a classification with measurement purposes through the Intangible Asset Monitor, also includes "external intangibles". The intangibles are, in fact, grouped under external structure, internal structure (culture and operational systems of the firm) and individual competence of the employees. This last category is different from the one of human capital adopted by other scholars. It includes only the professional workers, conceived as that group dealing with everything related to keep and extend the customer base, as opposed to support staff that has ordinary duties, which is classified under the internal structure.

The fourth group uses two categories to identify intangibles. Bontis et al (1999, p. 12) propose a classification based on the type of managerial action required: "if two intangible resources require different managerial actions than they should belong to two different categories". The company does not own intangible resources of the human capital since they are embedded in individuals. These are competencies ("skills and know-how"), "attitude" ("motivation" and "leadership") and "intellectual agility" ("innovation, entrepreneurship" and adaptability). The company instead owns structural capital[3] which is formed by "relations" (with the external environment), "organization" ("structure, culture, routines and processes") and "renewal and development" ("projects for the future").

According to Hall (1992, p. 139) intangible resources can be divided in 'assets' and 'skills' (or 'competences'). While the former enjoys some kind of legal protection, the latter does not. Intangible assets can therefore be identified as 'intellectual property rights' (which include: "patents, trademarks, copyright, registered designs"), "contracts, trade secrets and data bases". On the other side, skills can be identified with the "know how of employees" and the "organizational culture". Reputation, the knowledge and consideration that a product or service has in the public, could be considered as an asset since it can be embodied in a registered brand name, which enjoys a certain degree of legal protection. Intangible resources can also be classified as people dependent or independent.

Sullivan (1999) bases his classification on the experience of the ICM Gathering Group[4] and divides Intellectual Capital into human capital (skills and tacit knowledge of the employees) and intellectual asset (codified knowledge). Intellectual property is defined as the part of structural capital covered by legal rights. The knowledge codification process

[3] Edvinsson defines it as "everything that remains in the company after 5 o'clock" (Bontis et al, 1999, p.12).

[4] An informal knowledge-sharing arena of the most successful and experienced firms in the field of Intellectual Capital Management.

transforms the tacit, not-owned knowledge of individuals into the codified, owned and transferable knowledge of the firm and it is therefore crucial for the success of the enterprise. A similar classification, based on the distinction between tacit and codified intangibles, is adopted by PRISM report (Eustace, 2003) and by Hall (1992) who refers to protected and non-protected intangibles. The PRISM report however does not use a distinct classification where each category is well defined, due to the fact that intangibles are so connected that it is hard to determine where one ends and the other begins. The classification is drawn on a continuous line, where one class slowly fades into another. Soft intangibles include mainly latent capabilities i.e. the capacity of the firm to adapt and innovate, and competences i.e. "codified and proprietary capabilities" (op. cit, p.15) strictly connected with technology, information and communication systems. Hard intangibles (or intangible goods) comprehend the resources that enjoy a certain degree of protection. Hard intangibles are further subdivided into intangible commodities (originated by contractual relationships) and intellectual property (originated by the legal system).

The Skandia Navigator measurement model of Edvinsson and Malone (1996) adopts a classification that can be included in this group. Intellectual capital is measured as the sum of human capital (skills, knowledge and value of the workforce) and structural capital (intellectual property, customer capital, capabilities, software and hardware). As for Sullivan (1999), structural capital assumes a peculiar meaning, including the physical infrastructure of the firm.

Finally, some authors (Johanson, 2000; Rastogi, 2003), representing the fifth group, share a common position: a classification for intangibles is not feasible. Johanson (2000) affirms that a classification of intangibles should be based on the description of the process through which intangible resources convert into outcomes. Even though a classification could be approximated and eventually improved, this process will never be totally explained and, therefore, a fully comprehensive classification will never be reached. Rastogi (2003) argues that classifying intellectual capital into human, structural and customer capital is wrong since intellectual capital is not the sum of them. Intellectual capital, in fact, is the result of the interactions of human capital (skills and knowledge of the employees), social capital (value and vision of the firm) and knowledge management (activities related to the creation and development of knowledge resources). These interactions form the "knowledge nexus", the interface with the external environment that generates the intellectual capital, i.e. the capacity to use skills and knowledge to generate value.

Even though part of the literature (e.g Johanson, 2000; Kaufmann and Schneider, 2004) affirms that the traditional classification in R&D, software, marketing and organization has been overcome by most recent classifications based on human, market (or relational) and structural (or internal) capital, the results of this analysis can only in part agree with this conclusion. Even though there is a group of recent contributions that embrace the threefold classification (see table 1.3, group 3), at the same time there are also influential and recent contributions that propose a classification based on two categories (Eustace, 2003) or on four categories (Lev, 2005), while other authors argue that the classification on four classes is well-accepted (Jensen and Webster, 2006).

Even accepting the existence of a real consensus upon the threefold classification, that could not emerge in this analysis, due to possible biases in the selection of the literature, there is still a problem due to the terminological and conceptual confusion related to the content of the sub-categories (Canibano and Sanchez, 2002; Brennan and Connel, 2000). A recent study (Swart, 2006) tries to "disentangle" the sub-categories by analysing and clarifying their meaning. Accordingly, human capital is represented by the knowledge and skills of the employees; this does not raise too much conflict with the above mentioned classifications which basically agree with this definition. The definition of structural or organizational capital, often used in an interchangeable way, raises more problems. It is suggested that structural (or infrastructural) capital represents the work environment as a whole, including culture and physical; while organizational capital instead, represents the routines, rules and processes through which the firm operates. In this definition structural capital seems to include also tangible resources. If the focus is on the analysis of intangible resources, then the relevant aspects of structural capital is probably identified by its tacit elements such as the capacity to incorporate organizational knowledge, the culture of the firm embedded in routines and the rules through which human capital interacts and generates new knowledge, which can all be identified with organizational capital. Social capital, another element of intangible resources, is defined as "knowledge that is embedded in relationships" (Swart, 2006, p. 142); it is internal to the boundaries of the firm and different from external or relational capital, which is outside the boundaries and involves different learning processes. Social capital is considered distinct from organisation capital; however it is strictly related to it, as the knowledge embedded in the relationships is generated and directly linked to the competence of the firm as a whole. Some doubts therefore can be raised in relation to the treatment of social capital as a distinctive type of intangibles with respect to organisation capital.

1.5 The accounting definition of intangible assets

So far some of the contributions and issues related to the terminology, definition and classifications of intangible resources, often analysed collectively as intellectual capital, have been presented. The last definition I would like to present is the accounting definition that properly refers to intangible "assets".

A study conducted by Stolowy and Jeny-Cazavan (2001) on the accounting definitions provided by 23 national and international accounting standards shows that even in the accounting field there is heterogeneity of approach to the identification of intangible assets. The methodology for identification is the same as seen above: definition, classification or both. However, in this case, the identification process aims at selecting intangibles that are "assets", and can be reported in the balance sheet. The recognition criteria therefore have to be added to the definition or classification. For this reason Stolowy and Jeny-Cazavan (2001) suggest the existence of two classes of intangible assets: capitalized and non-capitalized intangible assets.

Another classification is the one that distinguishes between internally generated intangibles - generally not recognized as assets[5] - and externally purchased intangibles that can instead be recognized. This underlines the fact that the existence of a market helps to solve valuation problems.

Overall, the treatment of intangibles is far from being homogeneous across different countries and this challenges the possibility of reaching harmonization through the adoption of International Accounting standards. One of the main reason behind the

[5] An exception is Development that can sometimes be recognized when certain criteria are met.

differences in accounting principles is due to the on going debate on whether or not to capitalize intangibles that have seen the involvement of the International Accounting standard committee (IASC), who has recently developed the International Financial Reporting standard (IFRS, previously known as International Accounting Standards, IAS) and National Accounting Boards.

According to IAS 38 an intangible resource is qualified as intangible asset and therefore capitalized, when it lacks physical substance, it is different from financial assets, identifiable and controllable (Pozza, 2004). Besides this, the future economic benefits coming from the assets have to be probable and flow directly to the enterprise, while the costs of the assets have to be measurable (Brennan and Connel, 2000). These conditions are very hard to meet in the case of intangibles, which are often not identifiable because of being embedded in the organization or in its human capital and not separable from them. They are also not controllable due the weak property rights associated to them, and hard to measure, due to the lack of physical substance. For all these reasons accountants are reluctant to include them in the balance sheet, with extremely negative consequence for the market and the firms. Intangible assets as defined by IAS 38 are only a small part of the perceived important intangibles, which backs up the perplexity raised by many scholars about the appropriateness of the accounting definition (Johanson, 2000).

1.6 The distinctive features of intangible resources

Intangibles form a heterogeneous class of resources that is hard to identify and classify. This is not only because they lack physical substance and are “not directly visible” (Bianchi and Labory, 2002, p. 4), but also because each type of intangible is characterised by different peculiar features. As a result, it is hard to propose a model that describes intangibles as a particular type of good, with defined economic properties.

Intangible resources are characterised by weak property rights. The level of weakness though, varies across the different types of intangibles. Some resources, called “asset” in the classification of Hall (1992) or “intangible goods” in the classification of the PRISM report (Eustace, 2003), enjoy legal protection, though only in a partial way. Usually, in fact, the protection has a temporal limit and the level of legal uncertainty is very high (Lev, 2005). This is due to the fact that the rights related to intangibles are hard to specify, therefore contracts are incomplete and do not foresee all the possible future uses assigned by the right, with uncertain consequences in case of infringement (Royal Institute of Chartered Surveyors, 2003). Furthermore the presence of international legal disharmony causes further uncertainty, since it does not guarantee an equal protection in all legal systems (Webster and Jensen, 2006). If legal rights are weak for certain intangibles, they are totally absent for others, such as capabilities, competences and organisational design. In these situations the firm has to resort to alternative mechanisms to defend its intangible resources from competitors. The weakness, or absence, of property rights creates a situation of "partial excludability" since the owner of intangibles does not have full control over them and cannot totally exclude others from their use (Lev, 2001, 2005, Webster and Jensen, 2006). As a consequence, the benefits coming from intangible resources are only partially appropriable, and the level of risk in owning them is higher than that related to tangible resources (Gu and Lev, 2001).

Another relevant feature of intangibles is their interdependence (Bianchi and Labory, 2002; Kaplan and Norton, 2004). Intangibles are "complementary, synergistic and integrative" (Rastogi, 2003) and generate value through a complex process that involves the interaction of other tangible and intangible resources. For this reason they are often firm specific or context-dependent, they can be of value only for the firm that has generated them (Royal Institute of Chartered Surveyors, 2003), or cannot produce the same result if implanted in a different context. As an example, the skills and knowledge of the workforce as a whole can be extremely valuable in a certain firm that provides a certain organisational structure, while cannot be as valuable in a firm that uses a different organisational structure. The firm-specificity of intangible resources can be considered as a mechanism of protection alternative to property rights to defend the firm against the consequences of the non-excludability. However, it is not always possible to enhance the level of firm-specificity of intangibles; therefore the firm often faces imitation or sees its intangible resources appropriated by competitors (as in the case of human capital turnover). A negative side of the characteristic of firm-specificity consists in the fact that intangibles are often embedded in tangible resources; this makes the boundaries between the two often not clear, as in the case of software and computer systems (Clement et al, 1998), and causes issues in intangibles identification.

Scholars indicate legal uncertainty and firm-specificity as responsible for the absence of a market for intangibles. Intangible resources are therefore defined non contractible or non marketable (Gu and Lev, 2001, Bianchi and Labory, 2002, Royal Institute of Chartered Surveyors, 2003, Lev 2005). A partial market exists for intangibles covered by legal rights; however argues, it is not a transparent, institutionalised market, since little information is released about transactions that are not even regular (Lev, 2005). The absence of a market, and the consequent absence of a price that can provide a benchmark for valuation purposes, further increases the risk in holding intangibles since they cannot be sold in case of financial distress. The value of intangibles is then dependent on the “firm’s continuity” (Royal Institute of Chartered Surveyors, 2003, p. 4).

Besides legal uncertainty and firm-specificity, there is another factor responsible for the lack of a market for intangibles. When intangible resources, such as inventions, get codified, they become similar to information. Information is hard to sell because the seller cannot communicate relevant information to the buyer, due to the risk of transferring the object of the transaction itself, and so voiding the purpose of the exchange (Lev, 2005). The same problem holds for ideas; as Arrow (1962) argued, once the idea is known, there is no need to buy it.

Uncertainty characterises intangible resources not only from the point of view of their protection but also from the point of view of the process that generates them. The production (or technological) uncertainty is particularly strong in the process that generates innovations which is characterised by high failure rates (Webster and Jensen, 2006; Royal Institute of Chartered Surveyors, 2003). When the firm invests in R&D in fact, it does not know whether the investment will generate the discovery. The same considerations hold for investments in formal training: not always, in fact, they are able to generate an increase in the level of skills and competence of the firm as a whole.

Some investments in intangible resources are also characterised by elevated sunk costs that are not recoverable in case of failure (Bianchi and Labory, 2006). However this is only partially true, if one considers that even if the object is not directly reached, the firm has gained knowledge and capabilities that can generate spillovers and be reinvested in further applications. Furthermore, not all intangible resources require high costs to be created; for example, employees can develop valuable skills just by working in the organisational context through the process of learning by doing. There are no sunk costs involved in these processes and the specific skills that the human capital develops are not only extremely valuable in the production process, but also render it firm-specific, therefore hard to transfer and easier to appropriate (Swart, 2006).

Successful investments in R&D that generate innovations do not guarantee economic benefits to the firm per se. Uncertainty persists for what concerns the possibility to find a market for the invention (commercial uncertainty) and the possibility of imitation by competitors that, acting as free riders, can appropriate the benefits without sharing the costs (Bianchi and Labory, 2006; Lev, 2005).

The peculiar features of intangibles, responsible for the extreme value of these resources, but also for the problems related to them, can be analysed in a cost-benefits perspective (Lev, 2001). Scalability and network effects are considered the main benefits. Scalability refers to the absence of opportunity costs related to the use of intangible resources that can be contemporaneously used in more than one activity. This property is a direct consequence of the fact that intangibles are information and knowledge based resources, and that information and knowledge can be used by many users at the same time and can be combined to generate new knowledge and information (Fernandez et al, 2000). The network effects, generated through partnerships and joint ventures aimed at knowledge and information sharing, foster innovation and the creation of intangible resources, expanding the benefits coming from the intangibles shared through the network. The costs related to intangibles are identified with partial excludability, high risk and uncertainty. These features can counterbalance the benefits deriving from intangibles, if not properly taken into consideration and managed.

On the basis of the analysis just conducted, it can be concluded that the peculiar features that distinguish intangibles from traditional tangible resources and render them capable of generating superior profits are also responsible for the problems related to their definition, measurement and valuation, and management. Intangibles are not visible, only partially controllable, idiosyncratic, interdependent and non contractible. Their value is also relative more than absolute, since it depends on the strategy that the firm adopts and, in some cases, it is only in the future (Kaplan and Norton, 2004). For all these reasons a static concept such measurement is hard to apply to intangible resources that are dynamic, always object of voluntary (for example investment in R&D) and involuntary (learning by doing) activities that modify their extent (Bianchi and Labory, 2002).

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1.7 Valuation and measurement methods

Almost all of the authors selected for this analysis underline the relevance of the "measurement problem" for intangible resources. The focus on measurement and valuation issues is due to the necessity to manage and control intangibles (internal purposes) but also to provide the market with the tools to reach realistic valuations of companies (external purposes). In both cases the aim is to reduce the problem of under investment and resource misallocation (Andriessen, 2004). Many methods have been proposed, yet none have been successful. I analysed the most diffused methods as the follows.

Traditional methods are the cost based approach, the income based approach and the market based approach. The cost-approach, based on the cost of the asset, does not include the future benefits that will be generated and does not consider that the cost of the investment is not a guarantee for results, given the high level of uncertainty that characterises this type of investments (Royal Institute for Chartered Surveyors, 2003). The market-based approach can be feasible for those intangibles that are somehow associated to a market (such as patents, brands and, in general, legally protected intangibles), even though, as already underlined, these transactions are usually characterised by a low degree of publicity. In the absence of a market, which is the case for the majority of intangible resources, it is hard to use this type of measurement. The income-based approach, based on the net present value of future cash flows, has to rely on assumptions that are too subjective and not reliable when related to intangibles (op. cit, 2003).

Over the years many alternative measurement methods have been proposed in search of a solution to the scarce adaptability of traditional methods. Still none have become universally accepted and each one presents some weak points.

Many authors indicate the difference between market and book values of companies as a measure for the value of intangible assets. However others argue that this is incorrect, since this measure takes for granted the ability of the market to determine the real value of the company and ignores that the difference that could be influenced by other factors (Gu and Lev, 2003) such as the under valuation of tangible and financial assets in financial reports (Garcia-Ayuso, 2003).

The Economic Value Added (EVA) is a financial measure of performance given by the difference between the return on net assets and the weighted average cost of capital. It is not an ad-hoc measure for intangibles; however it assumes its maximization as a sign of a sound management of intangibles. Intangibles are still evaluated via traditional tools for long term project valuation, which have been proven to be unfeasible, given the particular features of these resources. In response to this objection, EVA proposes a system of adjustments to the value and cost of capital (Bontis et al, 1999).

Even though it is widespread and well accepted and allows comparison among different firms, the system presents some weak points. It is too complex, relies on subjective assumptions and is based on historic costs, which do not reflect the market value (op. cit., 1999).

According to the classification of Andriessen (2004), traditional methods, the difference between market to book value and EVA are financial valuation methods since they utilise a financial criterion "that reflects the usefulness or desirability of the object" (op. cit., p 238).

Human Resource Accounting is another financial valuation method especially used in service-firms, where human capital is the main resource of the firm. The simplest version, among the one developed, estimates the value of human capital by capitalising wages through the discounted cash flows method. The measure obtained and expressed in financial terms becomes an asset (human capital) in the balance sheet, instead of getting expensed in the income statement. The main perplexity here is that wages do not offer a good measure of the knowledge, abilities, competencies and value that the human capital has in the firm (Bontis et al, 1999).

Gu and Lev (2003) propose a system based on the economic tool "production function", assumed to be generated by physical, financial and intangible assets. Firstly they calculate the expected normalised earnings[6] of the firm. They then calculate the contribution of physical and financial assets using information from balance sheets and industry wide data. The contribution of intangibles, i.e. “intangible assets-driven earnings” is assumed to be the difference between the expected normalised earnings of the firm and the contribution of physical and financial assets. This is a comprehensive valuation that does not allow evaluation of the contribution of single types of intangibles (Webster and Jensen, 2006). However Lev (2005) argues that, in most cases, the aggregate measurement is more important due to the interdependence of these resources.

When the criterion adopted for valuation is not in monetary terms, but can be converted into observable phenomena, the method is classified as a value measurement method. The most common value measurement methods for intangibles are the Balance Scorecard (BSC) and the Intellectual Capital Audit (IC Audit) (Andriessen, 2004).

The Balance Scorecard (BSC) is a system for measurement and management purposes created by Kaplan and Norton in 1992 to measure the performance as given by the combination and interaction of tangible and intangible assets. Financial and non-financial indicators analyse the firm under four perspectives: financial, customer, internal (technology, human capital and communication systems), learning and growth perspective (Bontis et al, 1999).

This last perspective is the one closely related to intangibles and comprehends indicators that describe the interaction of human capital, technology and organisation in the strategy context (Kaplan and Norton, 2004). The concept of “strategic readiness” is used to measure intangibles. Strategic readiness can be compared to the accounting concept of liquidity and represents the “ease with which the asset can be converted into cash” (op. cit., p 14). A higher strategic readiness means that the intangible asset will shortly be converted into a tangible outcome and therefore that value will be generated.

Bontis (2001) describes the IC-audit proposed by Annie Broking. Each of the sub-groups of her model of intellectual capital (paragraph 1.4) are analysed through questionnaires related to the factors that generate it. Once the questionnaires are completed, the qualitative answers are converted into quantitative measures and the

[6] They argue that measures based on past earnings do not capture future value; therefore they use an average of past and future earnings.

intellectual capital is evaluated according to the traditional methods: cost, market or income approach, with the shortcomings already described.

Other common measurement methods are the Skandia Navigator, the Intellectual Capital Index and the Intangible Asset Monitor. These are measurement, not valuation methods because they do not have a criterion or rule to measure the level of usefulness, but simply use a measurement variable related to the object (Andriessen, 2004).

The Skandia Navigator was created by the work of Leif Edvinsson at Skandia. It is a reporting model for intellectual capital that focuses on five areas: financial, customer, process, renewal and development, and human capital. The model associates financial indicators and non financial indicators (percentages and qualitative indicators based on survey results) to each area. The different indicators are then combined through a process described by Edvinsson and Malone, which leads to a percentage and a dollar amount. The financial factor provides the entity of the intellectual potential of the company, while the percentage is an indicator of the capacity to exploit it. The product of these two factors gives the total value of the intellectual capital (Bontis, 2001).

Ross G., Ross J, Dragonetti and Edvinsson are the creators of the intellectual capital index. The novelty of this method, which is based on the same classification of intellectual capital adopted by the Skandia Navigator, is its focus on only the resources that are controlled by the firm. In this model the strategy guides the managers in the choice of the indicators through the identification of the key factors (Bontis, 2001). Once the appropriate indicators have been chosen, with the crucial help of the low levels of the workforce that have a better practical knowledge of the firm, the next step is to group all the indicators (appropriately weighted and adjusted) in a consolidated index. The main weakness is due to the fact that the choice of indicators is subjective; therefore comparison among firms is very hard. However Bontis (1999) argues that a comparison is still possible through the analysis of the relative changes in the index, which also indicate the dynamics affecting the stock of human capital.

Sveiby's Intangible Asset Monitor assigns three types of measurement indicators to each type of intangible assets (according to his classification, paragraph 1.4): growth and renewal indicator (which captures the dynamics), efficiency indicator and stability indicator. Each indicator is identified by two non-financial variables. The indicators are then presented in a format that varies according to the audience. The report aims at capturing the dynamics phenomena, if created for internal management purposes; it aims at reaching a certain level of simplicity and accuracy if it is addressed to investors and analysts (Bontis, 2001).

The valuation/measurement methods outlined here are just the most common and frequently quoted in the analysed literature; however many others exist. Measurement is a recurrent theme in the literature concerning the intangibles, if not the main one. As showed in the first paragraph, even classifications are made with measurement purposes. The fundamental question is whether intangibles can be measured or not. Rastogi (2003) argues that intellectual capital, formed by intangible resources, is a flow, not a stock, therefore a static measure does not capture its dynamic nature. Some authors suggest using more than one method to compare results (Bontis et al. 1999, Royal Institute of Chartered Surveyors, 2003). Given the weakness of each system, companies should aim at reaching a range of values (Royal Institute of Chartered Surveyors, 2003) or a probabilistic value (Bianchi and Labory, 2002) instead of a single measure. Canibano and Sanchez (2002) note that many empirical studies measure intangibles using R&D investments and patents since they are the easiest intangibles to measure. However, they argue that researchers should focus on what they need to measure and not on what they can measure.

The results given by the analysis of the valuation and measurement models are similar to the ones reached by Kaufmann and Schneider (2004). There is no well-accepted measurement/ valuation framework or set of indicators. Many are subjective, abstract, do not really clarify which are the intangibles included and do not allow for comparison among firms (Brennan and Connel, 2000). Scholars, managers and markets are still in search of a solution.

1.8 The problems related to intangible resources

Several problems derive from the peculiar features of intangibles and the lack of a well-accepted measurement system.

From an internal perspective, firms have the difficulties faced to deal with the complex process that allows generating and exploiting intangibles. Canibano and

Sanchez (2002, p 6) argue that only when intangibles are "identified, measured and controlled" can they also be correctly managed. The extent of the management problem is therefore obvious, given that firms often are not able to identify their intangibles, not to mention measure and control them. Johanson (2000) studies how 11 Swedish firms classify intangibles. His findings reveal that the classification is done for measurement purposes and comprehends only intangibles that the firm is able to influence. These are perceived to be "individual competence (knowledge and capabilities), organizational competence (databases, technology, routines and culture) and relational (relations, reputation, and loyalty) resources" (op. cit, p.15).

Several solutions have been proposed in order to face these problems and help the business community in dealing with these resources in a profitable way. A first set of solutions insists on the necessity to coordinate intangibles related decisions with firm overall strategy and improve the quality of non financial information.

According to Sullivan (1999), a good management system for intangible involves several steps. First, the firm has to identify its goals and the context where it operates. This entails an analysis of the external environment, the internal situation (tangible and intangible resources available and their role with respect to alternative strategies) and a description of what the firm does. The firm is then ready to formulate the strategy and assign a role to its intellectual capital in function of the strategy adopted. The most important phase is the development of the capacity to manage the intellectual capital. Intangible resources can generate value in two ways; tactical and strategic. The tactical way, that produces value in the short run, is mainly related to management actions concerning the protection and commercialisation of intellectual property. The strategic way is related to the generation of new intangible resources to produce value in the long run. Others (Canibano and Sanchez, 2002) focus their attention on the ability that a firm should develop to understand the cause-effect relationships among resources (connectivity), report and measure frequently (regularity) and link the history of the firm with future actions (regularity) in a dynamic perspective. Kaplan and Norton (2004) suggest the use of the BSC in order to manage intangible assets and outline the critical steps needed to create a sound strategy. First of all, managers have to balance the need to have a good financial performance in the short term, obtained by cutting costs, with the need to invest in intangibles for the long term growth and development of the firm. The strategy of the firm should then be formulated through the analysis of the four perspectives of the model that help identifying the crucial factors for success. The "internal" and "learning and growth" perspectives give the tools (mainly intangible assets) to achieve the wished results in the "financial" and "customer perspective". The critical stage is to align and integrate the intangibles to the strategy: only in this way intangibles have a value for the firm. The BSC is also proposed as an ex-post strategy mechanism to verify the results of the implemented strategy.

Even though the solutions proposed are different and there is no consensus about what is the optimal way to identify and manage intangibles, the different proposals share a common point of view: investment in intangible assets drivers such as R&D, Advertising, Human Resources and Practice, Organisational capital, create value for the corporation and intangibles based systems of measurement provide better information than traditional financial reports (Gu and Lev, 2001).

Besides the problems related to management, firms face a second type of problems due to the difficulties of communicating the value of intangibles to the market. Some solutions are proposed by that part of the literature that analyses problems related to intangibles from an external point of views.

Amir et al. (2003) measure the relevance of non-financial information through the analysis of the analysts' contribute to investors' decision, assuming that financial analysts use also non-financial information in the valuation process. The results of their study show that the analysts' understanding of intangibles has improved, especially in intangible intensive firms; however they still do not fully value intangibles especially in low-intensive intangible firms. Based on their findings they suggest the need to improve the quality and quantity of non-financial information. Through his IC growth model, Edvinsson (2000) shows that companies can follow certain steps leading to increased appreciation by financial markets. The steps involve information increase, focus on human capital, transformation of human capital into structural capital and exploitation of structural capital through its expansion outside the border of the firm. The role of the knowledge codification process is then crucial as the main factor fostering the transformation from human (not owned) to structural capital, owned by the firm. Others argue that two types of indicators should be used in reporting intangibles (Canibano and Sanchez, 2002). The first type, 'Core indicators', are general indicators adoptable by all types of firms, allowing for comparison. "Context-specific" indicators are instead related to the unique structure of the firm. Furthermore, the indicators addressed to the external audience should provide information about the future, not a static picture of the firm. In the end, firms should be aware of the fact that not all intangibles are value-generators and be able to distinguish which ones are relevant.

The difficulties in communicating intangible resources to the market are due to the deficiencies of financial reports and the lack of a well-accepted measurement system. The value of intangibles is in fact often not understood by the market, which is left without crucial information for valuation purposes. The consequence is a high cost of capital for those firms that heavily rely on intangibles, especially when they are start-ups and not well established. Managers end up under investing or allocating resources to incremental innovations instead of radical innovations, proven to generate higher profits (Lev, 2004). Several authors (Garcia-Ayuso, 2003, Canibano and Sachez, 2002) indicate the qualitative and quantitative improvement of information disclosure as a possible solution to the misallocation of resources. Lev (2004) outlines that the majority of information released concerns intangibles such as research and development, software, marketing, while little or no information is released about other types of investments, especially the ones related to human capital and development of new organisational practices.

The scarcity of information released is not only due to the that fact that managers worry about the possibility to reveal relevant information to competitors, but also to the fact that managers themselves are often not aware of the portfolio of their intangibles or of their potential in creating value, which is again connected to the measurement-management problem (Sullivan, 1999). Lev (2004) suggests the necessity to improve two information streams related to intangibles. The first stream focuses on the productivity in terms of returns on the investments, while the second stream focuses on the identification of the resources that form the intangible capital. However the proposed solution brings back the tricky problems related to the valuation of intangibles, whose costs can possibly be identified with a certain level of precision but whose benefits are highly uncertain and difficult to disentangle due to their interconnected nature. It also brings back the still unresolved problems related to the lack of a common framework for identification.

Besides increasing the qualitative and quantitative level of non-financial information, a second set of solutions focuses on the necessity to improve the reliability of the information release through a very regular and sound reporting activity. An empirical study (Vance, 2001) compares the view of the corporate world with the view of the "city" regarding the valuation of intangibles. The study is conducted through interviews with finance directors of FTSE100 companies, analysts and fund managers. The results show that the importance of intangibles varies across different sectors; however human capital (in particular R&D teams and capabilities to work in teams), brands and customer base are perceived as the main intangibles. The measurements systems used are mainly EVA and the BSC and the reason behind the decision to avoid disclosure is mainly dictated by the risk related to intangibles (litigation and disclosure of relevant information to competitors). The study shows that analysts value companies focusing on their capacity to produce future revenues; however intangibles, the main drivers of this capacity, are not really recognized. Analysts particularly value the strategy of the management and a regular reporting activity, taken as a sign that the management knows and control these resources. Both parties underline the need of guidelines, more than binding rules.

The results of the empirical studies found in the literature seem to validate the solutions presented. However, there are no standardised methods to conduct empirical tests and no theoretical defined framework to test for intangibles. Case studies, interviews with managers, analysis of financial reports, informal arena discussion with practitioners, are the main tools used to analyse possible management and reporting methods, together with proxies and indicators. As Webster and Jensen argue (2006, p.93), studies that aim at showing the importance of intangibles are "suggestive rather than definitive" due to the quality of data and the absence of a measurement system. Furthermore studies based on qualitative data to interpret risk to present results that are influenced by the researcher's point of view (Canibano and Sanchez, 2002). Finally, probably the most needed result has not yet been found: the real impact of intangibles on the performance

A final class of problems related to intangibles can be analysed from a public policy perspective. The resource misallocation has impact not only on the performance of the firm but also on the society, and raises questions about the role of public institutions (Jensen and Webster, 2006). Public policies have to find the delicate balance between the necessities to foster innovation and the necessity to guarantee an adequate level of diffusion to let the society benefit as a whole. The result of this situation is therefore a mixed system that reduces the non-excludability problems through the concession of legal property rights (with all the limits already showed) and increases the diffusion of knowledge by conceding public grants for research. The system is, however, still imperfect since the property rights are uncertain, the process to obtain patents is complex, costly and firms often patent innovation that do not have practical application, using them as a tool to scare away potential competitors. The importance of structuring a balanced public policy is determinant to generate the right amount of investment in intangibles at the advantage of firms and society as a whole. Institutions have obviously an important role in the creation of an environment that can foster the creation and diffusion of innovation and knowledge at a national and local level (Bianchi and Labory, 2002).

Public institutions are also retained responsible for developing standardised guidelines to manage and report intangibles (Brennan and Connel, 2000, Vance, 2001, Garcia-Ayuso, 2003). Guidelines have been issued by the OECD, the MERITUM project (2002), and by the Danish Ministry of Science and Technology; however, there are still many issues that still call for improvement (Buhk and Johanson, 2003, Eustace, 2003). The general argument that seems to be shared by all scholars that treat this issue suggests that, given the state of the art, it is still too early to impose mandatory rules for reporting and that the only actual feasible solution is to encourage voluntary disclosure of information. A study conducted on Australian firms during the first year of the application of IAS 38 (Matolcsy and Wyatt, 2006) supports the idea that mandatory rules for reporting intangible assets cannot improve the problems related to them. Results of this study indicate that when managers have the option to capitalise internally generated and externally purchased intangible assets (as it was the case in Australia before the adoption of IAS 38), they chose to capitalise only when the uncertainty about the possible future value of the intangible investment is low. Market and analysts have therefore a recognisable signal that can guide them in the valuation process, and earnings forecast errors are lower. Without giving the option to capitalize, managers cannot signal their situation to the market and consequently errors related to the evaluation of companies increase.

1.9 Intangibles: a first set of conclusions

A first set of conclusions can be drawn from this first part of the analysis. Intangible resources have raised the interests of scholars from different research fields due to their importance as factors for competitive advantage and to the problems they raise as a consequence of their peculiar features. However a clear perception of what they are is still lacking and many problems are still unresolved.

There is no consensus about their definition and classification, and the different contributes have generated a real "terminological soup" that needs to be clarified. In this research I have analysed the identification problems, trying to clarify the content of the intangible 'black box'. Among the different terms (capital, asset, resource, investments) adopted to refer to intangibles, I have chosen "resources" as a wider category than assets, able to grasp the variety of these resources and include also the ones that are not taken into consideration by traditional financial reports.

Intangibles have not yet been clearly defined. The definitions found in the literature describe them, alternatively, as knowledge-based resources, lacking physical substance, interdependent, firm specific and capable of generating future profits. However, they do not offer clear inclusion or exclusion criteria. The accounting definition of IAS 38 instead, offers precise, but too strict recognition criteria that do not recognize the most valuable intangibles of the firm.

Scholars have tried to improve the framework for the analysis of intangibles by further classifying them in sub-groups. Classifications have been made with the aim of creating a framework for their analysis, but also with measurement or management purposes. I have reorganized the different classifications found in the literature and grouped them according to the number of sub-groups used. The classification based on three sub-groups seems to be the most common, but also classifications in two and four sub-groups seem diffused. The real problem, however, concerns the content of the sub-groups that not only are named differently, but also have different meaning, according to the different authors.

Intangibles form a heterogeneous class of resources with peculiar features that vary across the different type of intangibles. The heterogeneity of intangibles is surely one of the causes of the lack of a clear definition.

Weak property rights or no property rights cover intangibles. This generates a situation of partial excludability that renders the benefits deriving from intangibles only partially appropriable. Intangibles are non contractible, and do not have a market; furthermore, they are characterised by high risk and uncertainty levels regarding their production and the capacity to the appropriate benefits that they generate.

Many measurement and valuation methods have been proposed, but none has been successful; however the more diffused seems to be the Balance Scorecard of Kaplan and Norton. In general, measurement and valuation methods are quite abstract, do not allow for comparison among firms and utilise imperfect indicators and proxies, often chosen with subjective criteria.

The need to measure and valuate intangibles is shared by both the market and the firms. Firms need to measure intangibles in order to manage and exploit them in the strategy context. Some authors provide management models for intangibles (Sullivan 1999, Kaplan and Norton, 2004), however they are quite abstract and do not seem to provide concrete answers. Firms face also the necessity to communicate the value of their intangibles to the market, that otherwise, left without information and "measures", does not value intangibles. The consequence is a high cost of capital and resource misallocation. Several authors (Garcia-Ayuso, 2002, Canibano and Sachez, 2003, Lev, 2004) indicate the qualitative and quantitative improvement of information disclosure as a possible solution to these problems, together with the diffusion by public institutions of non-mandatory guidelines in order to improve and facilitate voluntary disclosure (Brennan and Connel, 2000, Vance, 2001, Garcia-Ayuso, 2002).

Even though several authors lament the lack of a "theory of intangibles", the majority of them do not refer to a "theory" in their analysis. Only Hall (1992), Clement et al. (1998) and Fernandez et al. (2000) analyse intangibles in the context of frameworks related to the "heterodox" approaches to the economic theory of the firm. If the lack of a theoretical framework is often blamed as one of the causes of the still lacking understanding of intangible resources, it is worth to analyse whether economics can be useful in clarifying some of the aspects related to intangibles, and possibly provide the base for a theoretical framework.

Chapter 2: On the theoretical analysis of intangible resources

2.1. Intangible resources and economic theory

The economic theory does not appear the exist a coherent framework for intangible resources, and more than “the Economics of Intangibles” one should talk about the partial view of intangibles offered by this discipline that “considers intangibles in four main aspects: human capital, innovation, organization and knowledge” (Bianchi and Labory, 2002, p. 9).

The models (e.g. Fernandez et al., 2000; Hall, 1992; Clement et al, 1998) for the analysis of intangibles that refer to a theoretical framework are based on the evolutionary theory of the firm of Nelson and Winter (1982) and on the resourced-based view (RBV) of the firm. These are both approaches that develop the traditional economic theory of the firm. For this reason I draw a kind of indirect analysis of intangibles that passes through the theories of the firm, their critique and development. I argue that the review of some of the most representative contributions concerning the explanation of the existence, boundaries and organization of the firm, can help to understand how economic theory has started focusing on these types of resources, what are the assumptions that have caused their neglect up to the last few decades and how the relaxation of these assumptions has uncovered the importance of intangibles, their features and the way in which they interact with other tangible resources to improve firm performance.

Before starting the analysis a very last point should be clarified. The authors that do not belong to the heterodox[7] approach never explicitly use the term intangible resources. As the analysis of the theories of the firm is conducted through the lens of the authors belonging to the heterodox approach, the more orthodox contributions are read under the evolutionary and resource based perspective point of view. The aim of the analysis is not an exhaustive and detailed reconstruction of all the different theories of the firm that have been presented; the aim is to outline the contributions that are relevant to the analysis of intangible resources.

[7] With “heterodox” approach I refer to the theories of the firm that criticize and refuse the assumptions on which the neoclassical theory of the firm (orthodox approach) relies.

2.2 Intangible resources in the classical economic theory

The first economist who observes the existence of intangibles is Smith, in his "Wealth of Nations". In his analysis of the division of labour, Smith outlines how workers could specialise and increase their skills and labour productivity through the learning-by-doing process and how the accumulation of capital includes also 'acquired and useful talents' besides the increase of fixed or circulating capital (Hodgson, 1998; Bianchi and Labory, 2002; Webster and Jensen, 2006). However, even though their importance is recognised, the understanding that Smith has of those intangible resources classified as skills, to use the definition of Hall (1992), is quite reductive. As a matter of fact, Smith identifies the advantages of learning by doing as increases in manual dexterity and does not recognise the role of knowledge, information and the unity of knowing and doing (Hodgson, 1998). Furthermore, the contribution of the organisation and corporate culture in shaping the learning process is neglected and the productive power of a nation (or enterprise) is identified with the sum of the productive powers of its single components. The role and characteristics of knowledge and organisation are therefore absent in Smith's analysis.

Babbage (1830, 1832) makes a more explicit reference to knowledge. While studying the technological features of the capitalist system, Babbage underlines the necessity to stabilise strong connections among production, science and technology and argues that knowledge can improve the productive process. He even states the equivalence between knowledge and power. Marshall (1949, p. 115 as quoted in Hodgson, 1998, p. 37) makes a step further and identifies immaterial goods as main components of capital. He explicitly identifies knowledge as "the most important engine of production" and recognises what Smith had neglected: the important role of organisation in fostering knowledge.

These more or less implicit insights concerning the importance of some of intangible resources (such as human skills, knowledge and organisation) in the production process have not been deepened and better analysed neither by classical economists nor by the successive generations of scholars, who have disregarded these early hints and instead focused more on tangible resources such as labour, land and machinery.

2.3 The neoclassical theory of the firm and the assumptions hiding intangible resources

Intangible resources have not been very much discussed in mainstream economics. As several authors (Nelson and Winter, 1982, Hodgson, 1998, among others) have recognized, the only intangible resource that is somehow considered in the neoclassical theory of the firm is knowledge, even though in a way that misrepresents its real nature and characteristics.

The concept of knowledge is strictly related to the one of 'production set'[8], which describes the capabilities of the firm, i.e. what the firm is able to do. As Nelson and Winter (1982, p. 60) outline, the production set is delimited by a technical type of knowledge, "articulable and articulated: you can look it up" and publicly available. Knowledge is therefore considered equal to the information at disposal and, as well as information, can always be translated in codes and formulas. The cognitive and interpretative problems raised by the transformation of information into knowledge are totally ignored, and learning is considered merely as the "acquisition and accumulation of additional information" (Montresor 2004, p. 413). Knowledge is also considered equal for all the firms of the economic environment, since it is publicly available and transferable at zero costs.

As the production set, knowledge is fixed as it can be inferred by the analytical condition of the theory 'given the state of knowledge', which exemplifies how dynamic phenomena related to the knowledge possessed by the firm are a secondary issue in economic analysis (Webster and Jensen 2006). This makes impossible to understand the role of intangible resources such as skills, organisational design and patents in the expansion of the capabilities of the firm, since they are considered given, as the production set, and cannot modify it. Knowledge is perceived only in its individual dimension, i.e. as the knowledge of the individuals that belong to the enterprise, while the knowledge of the organisation is either that of its 'chief engineer' in Nelson and Winter's term, or the sum of that of its constituencies. There is no sign of the concept of organisational knowledge as the superior knowledge that is something more than just the

[8] The production set is the set of technically feasible input-output combinations representing the capabilities of the firm (Montresor, 2004)

sum of the knowledge of its single components (Montresor, 2004). The theory postulates a capacity to organise that is totally disconnected from the single elements that form the organisation, and therefore “resides in nothing” (Nelson and Winter, 1998, p. 63).

This view of knowledge and the lack of consideration of other intangible resources is a consequence of the aims of the neoclassical theory and the strong assumptions made to keep coherence in the internal static framework.

The neoclassical theory of the firm is interested in how firms maximize profit through the price mechanism. The firm is therefore seen as a “black box” (Nelson and Winter, 1982, p.51), a mechanism connecting production, price, cost and revenue functions, to obtain a certain profit, while the way in which production is organised is left outside the analysis. As Nelson and Winter (op. cit.) underline, neoclassical economists see the internal coordination mechanisms of the firm as a field that goes beyond their scope and analyse the organization of production only through the pricing mechanism. Being a theory of economic exchange, the production process is considered as an extension of exchange, not as “the intentional creation by human beings of a good or service, using appropriate knowledge, tools, machines and materials” (Hodgson, 1998, p. 33).

Obviously, the analysis of intangible resources cannot take place in a theory that ignores the aspects of the organisation of production. The focus on exchange is also one of the reasons why knowledge is identified with information: knowledge has to be embedded into a physical support in order to be treated as an economic good and exchanged (Bianchi and Labory, 2002).

The theory assumes and focuses on rational individuals, considered able to make the best decision (i.e. optimise) in a complex environment where information is perfect. This leads to the neglect of the importance of mechanisms such as learning and personal development, since learning implies that not all the knowledge needed to optimise is possessed, and individuals cannot optimise while being in the process of learning (Hodgson, 1998). Having neglected the existence of learning phenomena that allow the firm to expand its knowledge stock, the consideration of knowledge as a given factor is a logical direct consequence. A further consequence is the view of human capital as a passive factor of production.

The individualistic and atomistic approach does not allow considering the role of the organisational capital, and the knowledge production that emerges from working in teams. The firm is considered as an isolated atom and relationships among firms are ignored. As a consequence, the relational capital is not considered as an intangible resource.

Another crucial assumption does not allow for the treatment of organisational capital: the only aim of the firm is assumed to be profit maximization. With this assumption, together with the view of production as an "extension of exchange", the role of the organisation in coordinating individuals' different objectives and the production process cannot be recognized.

Last but not least, the static approach of the theory creates further obstacles in the analysis of intangible resources. In fact, technological innovation and dynamic change are neglected, being "a serious problem for the equilibrium-oriented approach" (Hodgson, p. 34). Learning is mainly ignored since it allows for creativity, which destroys the equilibrium framework. Growth is only accidentally considered as adjustments to reach the perfect size, and not in the sense of increase in production capacities (Penrose, 1959).

Even though the neoclassical theory of the firm does not offer an analysis of intangible resources, its validity and importance is not questioned here. The firm is a complex reality that can be observed under different points of view, therefore there are many theories of the firm that give different explanations of the same phenomena and complete each other, helping to better understand this complex reality (Penrose, 1959; Grant, 1996b). The neoclassical theory simply privileges aspects different from intangible resources; its critical analysis has been useful to understand the assumptions that hide the 'discovery' and the focus of intangible resources.

2.4 The path towards the "discovery" of intangible resources: the critique to the assumptions of the neoclassical theory of the firm

As seen from the previous analysis, the neoclassical theory of the firm is particularly concerned with the analysis of the behaviour of the firm in external markets.

As a consequence, the internal mechanisms of the firm in coordinating and creating its resources are not investigated (Grant, 1996b).

Important contributions in this sense have come from those theories that “amend” the neoclassical theory, including aspects regarding the organisation. The shift of attention towards internal mechanisms has started from the observation that some of the assumptions made by the neoclassical theory are unrealistic. From the analysis and critique of these assumptions, new theories have emerged that have widened the scope of the analysis by introducing aspects regarding the boundaries, the existence and the internal organisation of the firm (Montresor, 2004). These contributions have been fundamental in the development of an approach that includes the analysis of intangible resources. The most relevant ones are analysed in the following sections.

2.4.1 Imperfect information, bounded rationality and market failures: the contributions of the contractarian approach to the theory of the firm

Even though intangible resources are still disregarded, the contractarian approach introduces important novelties and shifts the attention towards an important intangible resource: the organisational structure.

Hodgson (1998) describes this approach as grouping together several research lines originated by Coase’s intuition that markets are not perfect mechanisms for the allocation of resources, due to transaction costs (cost of writing contracts - ex ante costs - and costs to assure the respect of contracts – ex post costs). Even though the several theories grouped under this ‘umbrella’ differ in assumptions and focus, they see the firm as an alternative coordinating mechanism that minimises transaction costs through the internalisation of certain activities. Transaction costs are the only explanation for the existence of the firm; therefore their determinants are investigated. It is through this analysis that the approach brings up important observations that are (indirectly) related to the study of intangible resources.

Information is no longer complete and costless; there is a cost in acquiring it (Foss, 1999). Economic agents are characterised by bounded rationality and limited computational capabilities.

Williamson (1975) analyses the crucial features of transactions that cause market failures, and identifies the specificity of the assets as one of the causes. Some activities related to human capital are idiosyncratic (in the sense of context-dependent) and usable only in certain types of transactions. As already stated (see 1.6), these are aspects that characterise transactions related to intangible resources.

The property rights approach outlines that contracts related to certain activities are incomplete due to unforeseeable events, bounded rationality of agents, and high costs of specifying the different possible uses of the activity object of the contract (Brynjolfsson, 1994). Again this is a crucial aspect related to intangibles.

The contractarian approach does not link these aspects with the category "intangible resources", which remains largely uncovered. The theory in fact inserts new elements coming from the discovery of transaction costs in the architectural framework of the neoclassical theory, but the methodological premises are still the same.

Even though bounded rationality and incomplete information are recognised by scholars of certain research lines belonging to this approach, economic agents are still assumed to have given interpretative, perceptive and cognitive capabilities, therefore, as in the neoclassical theory, phenomena such as learning and personal development are neglected (Hodgson, 1998). The technology and the production capabilities of the firm are still given and the role of human skills and organisational structure in shaping them is still disregarded. The theme of organisational structure as a resource of the firm is introduced, however only with respect to transaction costs. The determinants of economic organisation not related to incentive conflicts, such as information processing, organisation of production and coordination and development of resources are not included in the analysis.

This approach, however, is included here because it recognises that the firm operates in a complex environment, that agents have limited rationality and that information is incomplete and asymmetric: when these elements are discovered, it becomes necessary to focus on how economic agents organise themselves to face these problems.

2.4.2 The bounded rationality of the firm: the behavioralist approach

'Managerial theories' contest the uniqueness of the firm's objective and identify the existence of different groups with conflicting interests within the firm. The behavioralist approach (Cyert and March, 1963) draws on this point and identifies the firm as a coalition of different groups of interests (not only managers and owners), interested in the maximisation of an objective different from the firm's profit. Behavioralist scholars, borrowing the concept of bounded rationality of Simon, argue that, due to the limited processing capabilities of individuals and to the complexity of the problems, the firm can only adopt simple decision rules, which cannot be optimal. Agents cannot express coherent objectives, while accounting for their opportunity costs (Nelson and Winter 1982). As a result, the firm stays in a situation of "quasi-resolution of conflict" (op. cit. p.55) and tries to satisfy expectations, aspiration levels.

The important step taken concerning the analysis of intangible resources is the recognition that the limits constraining the economic agents, also constrain the firm, which is formed by single economic agents. The capabilities of the firm are not infinite, as assumed by the neoclassical approach (Hodgson, 1999). If this is the case, it is then fundamental to identify the resources that help the firm to minimise these constraints: the intangibles, as it would be recognised by the heterodox approach. The behaviouralist approach recognises the importance of one of them: the organisational structure. However, the focus is, as in the contractarian approach, on the incentive mechanisms that the organisational structure can put in place to solve the conflicts of interests within the firm. Its role in the production process is still disregarded. The behavioralist approach is anyway fundamental for its critics to the concept of rational optimising behaviour that shuts off the themes of the devices actually employed to cope with severe information process constraints (Nelson and Winter, 1982).

2.4.3 The need to cope with uncertainty: a role for the resources of the firm

Another fundamental step towards the recognition of the value of intangible resources in the theory of the firm is the introduction of uncertainty, and the need to find a way to cope with it; this is the main theme in Knight's (1921) analysis. Knight identifies the concept of uncertainty as distinct from the one of probabilistic risk. In the presence of uncertainty, not even the attachment of a numerical probability to an event is possible. Given this concept of uncertainty, uncertain events cannot be specified by contracts, and insurance cannot cope with them. Yet, the firm can group together and coordinate reserves of skills to face unforeseeable and uncertain events. As a result, Knight sees the existence of the firm as originated by the presence of uncertainty (Hodgson,1998).

In Knight's theory the resources of the firm take a greater role with respect to previous theories. In particular, intangible resources such as knowledge, human skills and organisation, are considered extremely valuable. The firm can, in fact, reach profitability only through the development of the capacity to cope with uncertainty, given by the ability to coordinate and develop its resources, which is the task of the organisational structure. A crucial role in his analysis is given to the management, which has to coordinate the activities, give incentives and develop skills (in particular the capacity to judge) in the firm's workforce. Another important point in Knight's analysis is the observation that the crucial competences required to cope with uncertainty cannot be given a market value. While Coase looks at the managerial and entrepreneurial competences as contractible, Knight recognizes that this is not the case. In this way, one of the main features of several types of intangible resources is underlined: they cannot always be bought and there is not a complete market for them.

Viewing the firm as a mean to cope with uncertainty related to future events and opportunities helps to shift the attention towards those resources that can help to do so. Following the steps of Knight's analysis, Penrose (1959) further investigates these issues, creating the basis for the RBV that assigns a great role to intangible resources. In her "Theory of the Growth of the Firm", she outlines that a "firm is more than an administrative unit; it is also a collection of productive resources" (op. cit., p. 94). The focus is therefore not only on organisational structure as a mechanism to solve conflicts of interest or incentive problems. Organisational structure is fundamental in the production process and in the coordination of resources. Penrose also focuses on the role of other productive resources and investigates the characteristics of certain types of intangibles, such as knowledge and skills. Knowledge is tacit, hard to transmit because a great part of it cannot be taught or communicated. Knowledge is not identified simply as information, as it was in the orthodox approach. Furthermore, knowledge is the result of learning in the form of personal experience and learning-by doing. Through these processes, the skills of individuals develop through the acquisition of new knowledge and capacity to use it (Hodgson, 1998). Individuals are not given anymore. They learn and increase their stock of knowledge and skills, helping the firm to cope with the uncertainty and complexity of the continuously changing environment.

The main assumptions of the neoclassical theory, indicated as a cause of the neglect of intangible resources, are therefore dropped. The approach is not static anymore, and the concept of growth is directly linked to the development of the firm competences in which knowledge and skills are fundamental factors. Knowledge is the main resource in Penrose's theory. It is a wide concept, which comprehends the knowledge possessed by the single agents of the workforce through their skills, and also the competences, i.e. cumulative knowledge of the group. In particular competences are seen as strictly related to the entity they belong to, as they are strictly interrelated.

The great role of Penrose's analysis is given by the focus on knowledge, therefore, implicitly, on intangibles (considered as knowledge-based resources), as fundamental elements to cope with uncertainty.

2.5 Routines, skills and organisational capabilities: the evolutionary theory of the firm

Evolutionary theories can be considered a breakthrough in the study of the firm and a shift towards the economic study of intangible resources. Developing the contributions of Knight (1921), Penrose (1959) and of the behaviouralists approach, evolutionary theory rejects the neoclassical theory assumptions, which have for long taken away attention from intangible resources, and builds a theory of the firm capabilities and behaviour in an environment characterised by continuous technological change.

Evolutionary exponents consider progress as an endogenous factor and see growth as the effect of the process of learning and discovery. The firm, like its constituencies, is characterised by bounded rationality and aims at satisfying aspiration levels as in the behavioralist approach. The novelty, here, is the focus on the mechanisms that allow the firm to reach its goals.

Nelson and Winter (1982), founders of the theory, see the firm as “a hierarchy of activities governed by rules or ‘routines’” (Clement et al. 1998, p. 7) and argue that routines, skills and capabilities are the key factors that allow the firm to survive in the market competition. A clarification is necessary about the terminology, although, as Nelson and Winter (1982) themselves admit, the level of intertwines between the elements is so strong that sometimes it is hard to understand where one ends and the other begins.

Routines are “capability of a smooth sequence of coordinated behaviour” (Nelson and Winter, 1982, p. 73). They belong to the organisation (organisational routines) or to the single individual (skills). Routines are quasi-automatic, regular and predictable behaviours. They do not have a specific purpose; their purpose can be understood only when they are inserted into a context. Capabilities are, instead, the “know-how that enables organisations to perform activities” (Dosi et al., 2000, p. 1). They have an intentional nature: given a purpose, there is a capability that generates an outcome related to the purpose. Therefore, routines are the building blocks (even though not the only ones) of capabilities that represent what the firm can do.

Much of the evolutionary analysis is focused on routines, that allow the firm to perform single activities, and on their role in the firm’s process of development, which is assimilated to the one of mutation described by biological evolutionary theory (Montresor, 2002). Routines are like genes: they are the memory of the firm. They are durable, since they can be replicated an infinite amount of time, but they are also dynamic. When the firm does not reach a satisfactory result in relation to its aspiration level, the firm, through search-routines, starts changing the routines that have failed. In this way, the firm can learn and adapt to changes in the economic environment and in aspiration levels. There is a selection process operated by the market on the firm’s routines, and routines are the key factors that allow the firm to survive.

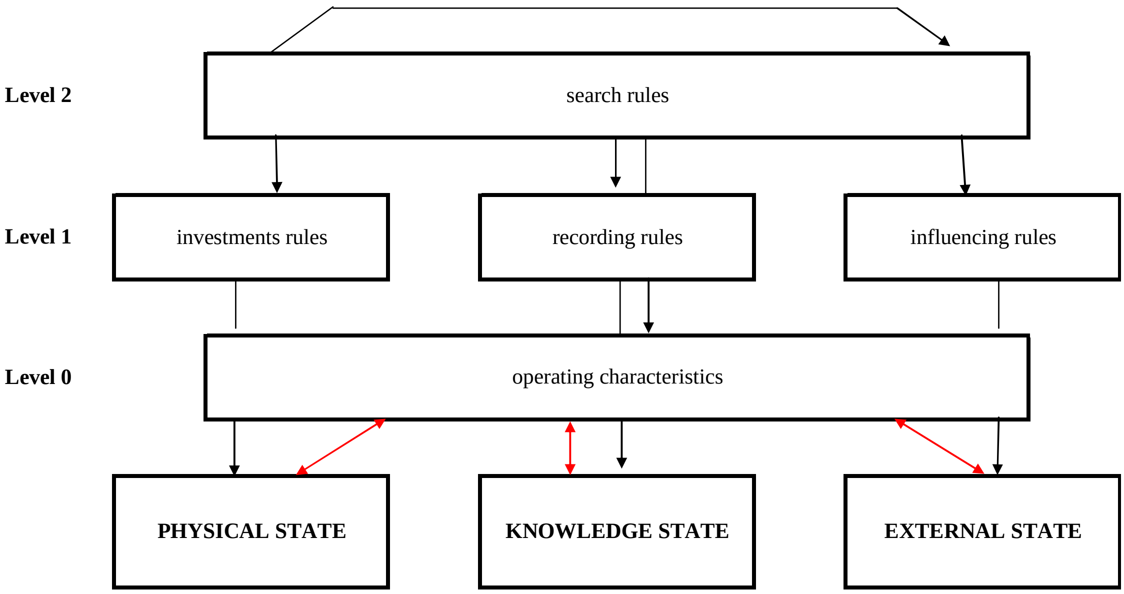
Nelson and Winter (1982) also underline the fact that capabilities, routines and skills are hard to imitate, due to the fact that the underlying knowledge is hard, and sometimes impossible to codify. Even when the knowledge can be codified, this process is very costly. As a result, much knowledge remains in its tacit form.

For the first time, intangibles such as skills, capabilities and routines, are identified as the main resources of the firm. Furthermore, the theory embraces the Shumpeterian view of innovation, considered as change in the firm's routines, underlying the role of intangible resources in the innovation process. The focus is on knowledge, a peculiar intangible, which is embodied in organisational routines and skills that determine the behaviour of the firm (Montresor, 2004). On the basis of Penrose's analysis (1959), knowledge is idiosyncratic and strictly context-related; it is also tacit and not easily codifiable as users cannot completely articulate it.

The evolutionary theory, in its dynamic approach, also analyses the mechanisms that govern the acquisition and expansion of organisational knowledge. Nelson and Winter (1982) describe the firm in term of states. The physical state represents the physical capital, while the information state represents the "contents of file drawers and human memories" (op. cit., p. 20). Routines are classified in operating characteristics (related to every day activities), investment rules (aimed at modifying the stock of capital), recording rules (aimed at changing the knowledge possessed by the firm) and search rules (related to the modification of existing rules); change is generated through the transformation from one state to the other.

Clement et al. (1998) start from Nelson and Winter's dynamic model, expand it and adapt it to the study of intangible investments on the consideration that it is necessary to distinguish between stocks and flows and focus on the classification of the latter, i.e. investments intangibles that modify the stocks. Their model adds a third state (external state) to include the external relationships that the firm has with the environment. As a consequence, a further type of rules (influencing rules), regulating the relationship with the firm and the external environment, is also added. The "information state" is substituted with the "knowledge state", to include also that part of knowledge that is implicit, hard to codify and transfer. Finally, rules and activities (and related costs) are related and divided in three levels. The first level (level zero) is "current expenditure" and corresponds to Nelson and Winter's operating characteristics; the second and third level (level one and level two) represent "tangible and intangible investment" (figure 2.1)

Figure 2.1: The firm state: an extended view



Source: Adapted from Clement et al. (1998, p.12)

Through this scheme, investments can, in this way, "be classified according to the state level". Even though a strict distinction among different types of activities is not always possible, intangible investments are identified as the costs associated to recording activities and to the combination of investment and search activities. Recording activities aim at the acquisition of the existing knowledge, or information, from the external environment and generate a quantitative change. The joint combination of investment and search activities aims at the internal creation of new knowledge and generates a qualitative change. Based on this model, the majority of intangible investments are classified as related to the knowledge state, further dived in technological knowledge and economic competences. The only intangible investments outside the knowledge state relate to the external state and are, namely, investments in advertising and investments in public relations.

This classification also offers a clear definition of software investments. Software systems are considered as the basic functioning of a computer, therefore classified as tangible investments. Only application software can be considered intangible investments, since they generate a quantitative increase in the knowledge state.

Even though the perspective of this model is strictly dynamic and focuses on investments, the authors recognize the importance to also measure the stock of intangibles, as represented by the level and benefits of the investments, at a given point in time. This is identified as the most complex task due to the problems outlined above.

The model is explicitly recognized as hard to apply in reality by the authors themselves; though characterized by abstractness and practical problems, it offers a clearer classification criterion for investment in intangibles and proposes a possible theoretical framework.

On the basis of the above considerations, evolutionary theory could provide an ideal framework for the development of an economic theory of intangibles. However, even though it has developed in the field of economic theory (Nelson and Winter, 1982), it has been followed and quoted more by scholars belonging to the strategic management field, due to its direct strategy implications (Hodgson, 1998) while economists do not seem to have considered it in detail. Only Edvinsson (2000, p 14) seems to recall the theory when stating "it might be more relevant to visualize the new economical sphere from a biological perspective, as a nervous system with energy flows and cells being split, mutated and evolving. It describes life, renewal and movements".

This part of the analysis has attempted to demonstrate that many of the issues related to intangibles resources have a long and complex history in the economic literature whose development of certain research patterns has led to the 'discovery of intangible resources' and their consequent, even though still indirect and incomplete, analysis. In particular, it has emerged that an economic theory for intangible resources needs to abandon certain assumptions, and recognize the limited rationality of individuals, the uncertainty of the world, the dynamic phenomena related to learning and development and that the scarcity of certain resources (intangibles) does not imply the impossibility to improve and expand them. The analysis of intangible resources finds a reasonable place within a theory of the firm that analyses the internal functioning mechanisms related to the production process, since the study of intangibles, from the economic point of view is justified in reason of the special role they have in helping the firm to succeed. In this last respect, it is fundamental to focus on the features that are peculiar to these types of resources, and the implications they have. The resource-based view of the firm has addressed these issues, building up on the heterodox approaches to the theory of the firms and, in particular, on the evolutionary theory.

2.6 Intangible resources analysis through the resource-based view

2.6.1 The resource-based view and knowledge-based view approach

The resource-based view (RBV), also called “capabilities” or “competence-based” view, groups together a wide class of heterodox contributes (evolutionary theory included) to the theory of the firm (Hodgson, 1998). This approach is not yet a theory, from a formal point of view, probably due to the fact that its proponents belong to different disciplines (such as strategic management, technology analysis, organizational studies and economics) and focus on different aspects. This lack of homogeneous approach has originated a sort of “terminological soup” (Montresor, 2002, p. 15) regarding the real meaning of competences and capabilities (often labeled differently), similar to the one that characterizes intangibles[9].

Even though it is not yet a formal theory, since many aspects still need to be clarified; even though only few of the scholars analyzed in this research have referred to it as a possible theoretical framework for intangibles, the RBV seems to offer a possible theoretical background for the analysis of intangible resources (Canibano and Sanchez, 2002).

As already said, the approach still needs to develop in a theory; nonetheless, the aim, here, is not to focus on the problems related to the status of the approach, but to hint at the crucial inputs offered by the view to improve the understanding and the analysis of intangible resources. It is therefore useful to briefly analyse the main points of the approach.

The RBV considers the firm as a “unique bundle of idiosyncratic resources and capabilities” (Grant, 1996b, p.110) that the firm has to efficiently exploit and regenerate to stay competitive. As a result, the resources of the firm, tangible and intangible, are the main factors that let the firm pursue a market strategy and achieve results.

[9] Nonetheless RBV advocates belong to different disciplines, the main field has to be considered given by managerial sciences. An attempt to intregate economics and managerial contributes has been done in

While the strategy model of Porter focuses on the analysis of environment and strategy, considering resources fixed and highly mobile, the RBV focuses on the resources, heterogeneous and imperfectly mobile, which determine the strategy (Barney, 1991). Resources are the factors that create the difference between firms; as a consequence, the emphasis is on the features that resources must posses in order to generate competitive advantage and on the mechanisms that help develop them (Montresor, 2004).

A set of key features are common to all resources, competences and capabilities of the firm. They are described as “dynamic”, “imperfectly or non contractible”, “interrelated and organisational” (Montresor, 2002). The resources of the firm, tangible and intangible, allow the firm to accomplish different tasks. Due to the uncertainty of the world, the firm cannot anticipate the activities that it will be required to accomplish; however, building up resources will provide the flexibility and the capacity to adapt to different situations, reducing the level of uncertainty[10]. This is why the resources of the firm have to be dynamic. A particular type of “superior” organisational capabilities guides the dynamic processes within the firm. These are the search routines in Nelson and Winter’s model (1982) or the “core competences” in Teece and Pisano’s (1994) model. These superior organisational capabilities are particularly unique and inimitable, compared to the other resources of the firm.

Resources are mainly organisational, pertain to the organisation as a whole and are the result of complex social phenomena that render them strictly interrelated and idiosyncratic. As a consequence, the value the resources have, if taken individually, is not the same as the value they have inside the organisation since, in the latter case, the synergies and relationships that develop among them create further value (Montresor, 2002). The strong ties and interrelations among the resources render them hard to imitate and replicate by competitors, but also render them imperfectly contractible.

The internally-oriented approach of the RBV has therefore helped first, in shifting the attention on the firm resources; secondly in identifying the main features that resources must posses in order to generate competitive advantage: inimitability and

[10] These concepts are already analysed in Knight (1921), Penrose (1959) and Nelson and Winter (1982) considered precursors of this view (Hodgson, 1998).

uniqueness, firm-specificity and interconnectivity, among others. A special type of resource, in particular, seems to posses all these features: knowledge.

It is important to outline that knowledge is different from information, since it is "a qualified transformation of the information resources of the firm" (Montresor, 2002, p.3). In order to become knowledge, information needs to be transformed through cognitive processes that are complex, different from individual to individual and uncertain with respect to the outcome. Knowledge and information, however, have something in common with respect to transactions. The value of information and knowledge cannot be known until the purchase has been made. Furthermore, in case of knowledge-based transactions, there is a further obstacle due to the fact that knowledge is hard to articulate and transfer into a physical support.

There are different types of knowledge (Loasby, 1999). The most relevant distinction for the firm is probably the one between codified and implicit knowledge, distinction represented by "knowing about" and "knowing how" (Grant, 1996b). The problems related to the different types of knowledge are the research area of that stream of the RBV – the knowledge-based view (KBV) - that considers knowledge as the most strategically important of the firm resources and focuses on the mechanisms through which knowledge is created and integrated (Grant, op. cit.).

The problems related to knowledge transmission and integration create barriers that have strategic importance. While knowledge integration can be easy and can be done through the diffusion of "written manuals" when knowledge is codified, it becomes extremely complex when knowledge is in tacit form. In this latter case the transfer and integration can only be done through organisational routines, informal processes and learning by doing, that require time (Grant, 1996a). The organisational culture and sharing of a common language can facilitate the transfer by improving the ability of the recipient to receive new knowledge (Cohen and Levinthal, 1990), in so expanding the knowledge capacity for aggregation. The process that integrates knowledge needs to combine different complementary types of knowledge in order to generate complex capabilities that are hard to be disentangled by competitors.

If the collective knowledge is owned by the firm, while the specialised knowledge is owned by individuals, then the firm has to integrate the latter and transform it in knowledge that belongs to the organisation. According to some authors, the process of codification is then essential (Sullivan, 1999, Nonanka et al. 2000). The process of codification is costly and not always possible because knowledge is implicit and there is only a part of it that can be codified (Spender, 1996). However, the cost of codification and the extent to which knowledge is implicit strongly depends on the context. Sometimes knowledge is only apparently implicit, because the organisation has embedded the codified knowledge to such an extent that it seems to operate without a "codified manual"; in this case the cost of codification is not too high. The presence of a common language is also responsible for the cost of codification; if a common language is present, then the high costs of creating one will not have to be afforded (Cowen et al., 2000).

The codification of knowledge, however, transforms it into a public good, available to competitors. Once knowledge gets codified, then the imperfect mobility and causal ambiguity protection mechanisms are lost. The trade off is then between the need to protect knowledge (leaving it in its tacit form), and the need to transfer it through different parts of the firm, while integrating the specialised knowledge of the single employees (through the codification process).

Throughout all this analysis, whose main object has been intangibles, knowledge has been mentioned and recalled with a certain frequency. Webster and Jensen (2006) describe the process of creating intangible capital as the creation of knowledge, tacit or codified, individual or collective, and outline the importance of the role that learning and existing capabilities have in the process. Rastogi (2003) refers to intellectual capital as the capacity to use and generate knowledge. Bianchi and Labory (2002) define knowledge as the common denominator to all intangibles. According to Canibano and Sanchez (2002, p. 4) "Knowledge is the main driver of growth". Bontis et al. (1999) argue that knowledge and its management are the keys to success. And I could quote others.

The analysis of the heterodox approaches to the theory of the firm has pointed out the great role of knowledge for the firm. Knight (1921), Penrose (1959) and Nelson and Winter (1982) all focus on the role of knowledge, embedded in the organisation, as the key factor for the functioning of the firm, just to mention a few, as knowledge has been recalled since the early work of classical economists such as Smith and Ricardo.

Knowledge is the "intangible by definition" and it is the common denominator of all intangibles. As the knowledge base of intangibles increases, those features that render intangibles key factors for success reach extreme levels; this is the case especially for competence and capabilities which are extremely firm-specific, tacit, inimitable and non contractible. Knowledge resources are not only idiosyncratic i.e. strongly context-dependent and interrelated, but also tacit i.e. hard to express in an explicit formula (Montresor, 2002). As already seen in chapter 1, these are all features that strongly characterise intangible resources, key factors for competitive advantage. The RBV analyses them in more details compared to that part of the literature that mainly focus on classifications, definitions, and measurement and management systems. Only a few, among the "scholars of intangibles", deeply investigate these features. This seems to be a weakness of those approaches, since a deeper understanding of the key features can possibly provide, at least, a classification framework and, hopefully, open the way to possible solutions to problems.

Concluding, by outlining the role of firm resources, the RBV has helped identify the main features that resources must have to generate competitive advantage; this has led to the recognition of the role of knowledge, a resource that possess all the key features for competitive advantage at the highest level. By focusing on knowledge, the KBV has underlined the important role of the organisational culture in its transmission and in the generation process of new knowledge. The joint contributions of the RBV and the KBV have therefore provided interesting insights in the study of intangible resources that form the knowledge capital of the firm. In the following section, classifications of intangibles based on the RBV are presented.

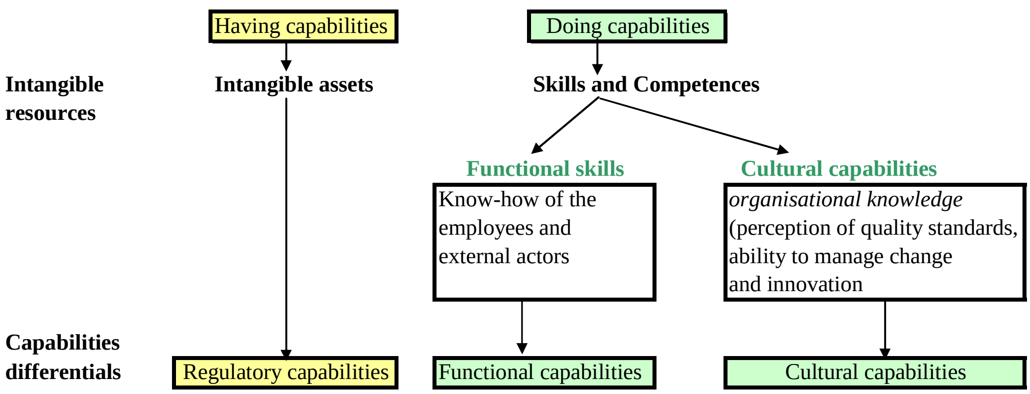
2.6.2 The resource-based view classifications of intangibles and the rational for their importance

Hall (1992, 1993) develops a specific model for the analysis of intangibles as a key factor for competitive advantage and classifies intangibles as 'Having' capabilities (intangible assets) and 'Doing' capabilities (skills and competences), 'People Dependent' and 'People Independent', legally protected and legally non-protected.

The 'Doing Capabilities' (or competences) are divided in 'Functional Skills', represented by the know-how of employees and external actors related to the firm, and 'Cultural Capabilities', represented by capabilities such as the perceptions of quality standards, the ability to manage change and innovate (Hall, 1993). The possession of one or more of the four capability differentials gives sustainable competitive advantage and the four capability differentials are strictly linked with the possession of intangible resources.

As a result of this classification, 'regulatory capability' differential is given by legally protected resources and 'positional differential' is given by the previous history and past actions taken by the firm. The two other capability differentials are given by competences. 'Functional capability' represents the "ability to do specific things" (op. cit., p. 610) and it is given by skills and knowledge of the workforce and external actors, while 'cultural capability' is given by organisational knowledge. Hall concludes that each intangible resource is a source of sustained competitive advantage, since "feedstock" of different capability differentials. A graphical representation of the classification model is presented in fig. 2.2.

Figure 2.2: A classification of intangible resources based on their capacity to generate competitive advantage

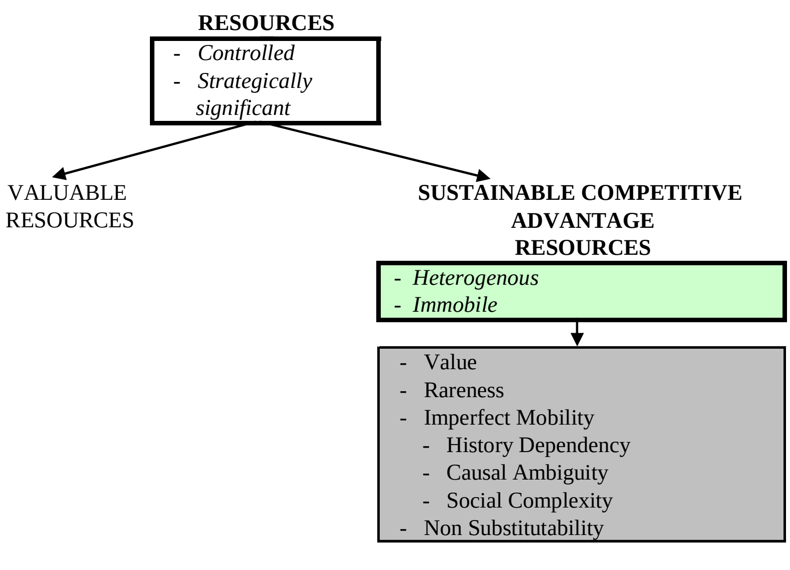


Source: Adapted from Hall (1993)

According to Hall (1992, 1993) all intangibles are therefore important for firm performance as they generate capability differentials; in particular, organisational knowledge and functional skills generate the most difficult capabilities differential to build and imitate, as strictly embedded and firm-specific. Through the creation of capability differentials, intangibles generate competitive advantage, which provides a justification for their importance with respect to firm performance.

Barney (1991) outlines the difference between the notion of competitive advantage and the notion of sustained competitive advantage: a firm has competitive advantage when its strategy is not implemented by any other firm. Sustained competitive advantage, instead, means that not only are there no other firms implementing the same strategy, but also that the particular strategy cannot be imitated by anybody else. Barney (op. cit) defines the position of sustained competitive advantage as an 'equilibrium condition' that can be changed only by external shocks, not by competitors. Only resources with particular features can guarantee sustained competitive advantage. Based on this distinction, a model is created (figure 2.3), able to identify resources that can guarantee sustainable competitive advantage.

Figure 2.3: A classification of resources based on their capability to generate sustained competitive advantage



Source: adapted from Barney (1991)

This model makes a distinction between the resources possessed by the firm: valuable resources are controlled and strategically significant; sustainable competitive advantage resources are not only controlled and strategically significant, but also heterogeneous and imperfectly immobile.

Four conditions have to be satisfied to be classified as heterogeneous and imperfectly immobile resources. First of all, resources have to be valuable in the strategy perspective; secondly, they have to be rare, meaning that only a firm, or very few firms, can posses them.

Resources have to be imperfectly imitable; this condition is verified, for example, when they are the results of unique historical conditions and past actions taken by the firm in developing them. This is a timeless process that cannot be easily replicated by competitors. The imperfect mobility condition can also be generated by the causal ambiguity that relates resources to the strategy. It is important that the level of causal ambiguity is equal for both the firm that owns the resources and for the firm that tries to imitate them, otherwise the latter can engage in activities aimed at decreasing the level of knowledge asymmetry, and gain access to the knowledge required to replicate the resource. Finally, social complexity generates imperfect mobility; this situation is verified when resources are dependent on complex relationships that the firm itself cannot completely influence.

The last condition to be classified as a resource that generates sustained competitive advantage is the non substitutability, verified when there is no alternative resource that can implement the same strategy. Substitutes can be similar, but also very different, as long as they absolve the same function.

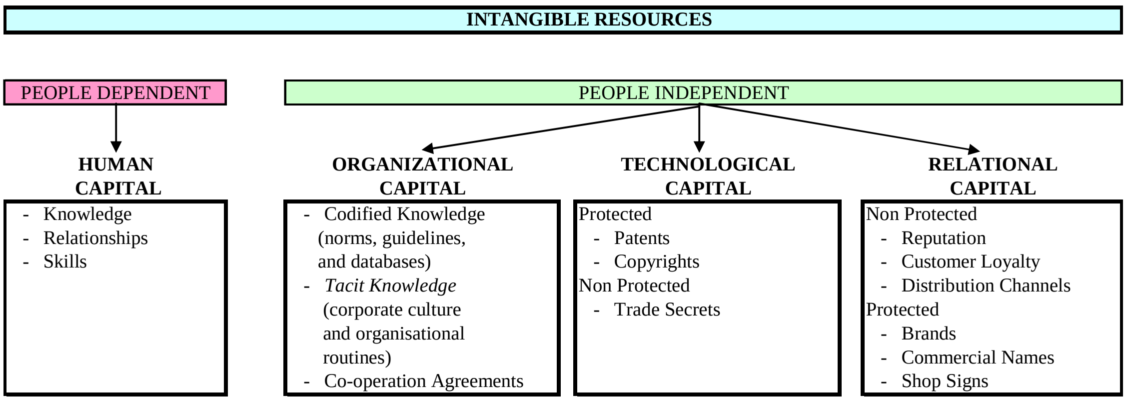
Barney’s model is not specifically designed to classify intangibles; however, it seems to indicate them as the main source of sustained competitive advantage. All intangibles can be, in general, valuable to the firm’s strategy. The requirement of control is trickier to satisfy, due to the appropriability problems already seen. However, if it assumed that the notion of control adopted is not a strict one, the firm can have some, (although imperfect) mechanisms to control intangibles.

The distinction that emerges from the application of Barney’s model is the existence of two types of intangibles: the ones that provide competitive advantage and the ones that provide sustained competitive advantage. As he points out, resources responsible for sustainable competitive advantage are related to “a broad range of organizational, social and individual phenomena within the firm" and that "firm cannot expect to purchase sustained competitive advantages in open market" but that "such advantages must be found in the rare, imperfectly imitable and non-substitutable resources already controlled by the firm" (p. 116-117).

In both Hall's and Barney's model, intangibles are considered crucial for firms performance; however, the inclusion/exclusion criteria in order to be considered a key resource are different; Hall refers to competitive advantage; Barney refers to sustained competitive advantage, identifying stricter criteria.

Fernandez et al. (2000) propose a resource-based classification framework for intangibles, based on the one proposed by Hall (1992, 1993). I have readapted their framework as showed in figure 2.4.

Figure 2.4: A classification of intangible resources based on the resource-based view



Source: Adapted from Fernandez et al. (2000)

Intangibles can be people dependent and people independent. People dependent intangibles are identified with the skills, relations and knowledge of the workforce that form the human capital.

People independent intangibles comprehend organizational, technological and relational capital.

The single components of organizational capital are divided in three sub-groups. The first sub-group, - here named "codified knowledge" - , comprehends the stock of codified knowledge represented by written norms and guidelines that regulate the activity of the firm. I also included databases, based on the consideration that they are not simple information, but consist of organised information that reflects the "internal structure of relations" of the firm (Fernandez et al, 2000, p. 82). The second sub-group – here named "tacit knowledge" – is formed by organisational routines as "regular and predictable patterns of activity"[11] (op. cit, p. 82) and corporate culture given by the values, vision and principles of the organisation. The last sub-group includes cooperation agreements established with suppliers and competitors, which are protected and regulated, even though only in a partial way, due to their incompleteness and consequent opportunism problems.

Technological capital represents the "knowledge related to the access, use and innovation of production techniques and production technology" (op. cit., p.84). I have grouped its components in two sub-groups, using the legal protection criterion.

Finally, relational capital includes intangibles related to the market. Even in this case I have grouped the components as legally protected and non-legally protected.

Fernadez et al. (2000) analyse the features of each subcomponents and identify ad-hoc mechanisms to appropriate the benefits deriving from the exploitation of intangible resources. I have divided the mechanisms in two groups according to their property to be features of intangible themselves or legal system derived. It is worth to notice that these mechanisms have a double function; not only do they protect the benefits deriving from intangibles, but they also protect intangibles themselves from imitation and appropriation by competitors.

The first group is formed by causal ambiguity and imperfect mobility. In the presence of causal ambiguity the link between the resources and the strategy is so complex that imitators, and the owner of the resource himself, cannot "crack the code" to reproduce them. Causal ambiguity manly characterises those resources that are the result of complex interactions among different agents and elements and can, therefore, be grouped under the sub-group of organisational capital named "tacit knowledge".

Imperfect mobility is strictly related to the fact that intangibles require time to build up. They are different from physical factors that can be bought in the market, and therefore do not require necessarily a continuous investment activity. For example, a firm

[11] This definition of organizational routines reflects the one provided by Nelson and Winter (1982) and outlines the strong link between resource-based view and evolutionary economic theory.

can invest and renovate machinery and equipment in a short time, but cannot as fast generate capabilities and competences to exploit them. Fernandez et al. (2000) outline that the process of accumulation of intangible resources is characterised by diseconomies of time compression, meaning that a constant level of investment through time generates more results than a double amount of investment realised in half time. Imperfect mobility therefore cover "tacit knowledge" but also the technological knowledge of the firm intended as idiosyncratic, context specific and history dependent capability to generate technological innovation.

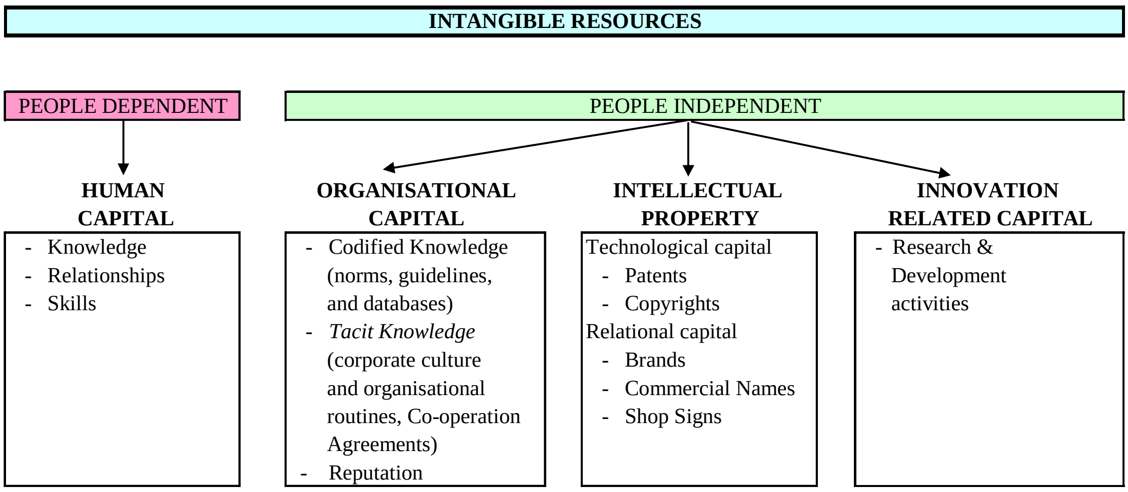
The protection mechanisms deriving from the legal system are called "Contracts" and protect those intangibles included in the "protected" sub-groups. They also protect co-operation agreements; however, as already underlined, property rights are weak for intangibles, therefore legal mechanisms can be considered a second best solution, with the result that intangibles protected through them are the easiest to imitate.

Human capital is a peculiar class of intangibles since it belongs to employees; contracts can, however, help minimise turnover if they offer a proper incentive system.

Two other mechanisms are proposed; their classification as protection mechanisms raises, however, some doubts. The first mechanism is "stability of co-operation agreement"; but this is the result of the capacity of the firm and its personnel to build up trustful relationships with competitors and suppliers, therefore seems more the effect of the skills of human capital and organisational knowledge of the firm. The second one is "first-mover advantage" but again, this seems the result of the stock of knowledge and capabilities that has allowed the firm to innovate and become a first actor in the market place.

The classification provides a good framework for the analysis of intangible resources by identifying their properties, protection mechanisms and the main components of each class. Possibly, some improvements could be made. A modified intangible resource classification is presented in table 2.5.

Figure 2.5: Classification of intangible resources: a proposal



On the basis of the proposed classification, intangibles are divided in four groups: Human capital, Organization capital (OC), Intellectual property and Innovation-related capital

The first group, human capital represents individual-related knowledge, as in Fernandez et al (2000).

The second group is represented by Organizational capital and, with respect to Fernadez et al (2000), includes also reputation. Chapter 1 has shown that there is no consensus on the OC definition and on what its main components are. However, by the joint analysis of different contributions, some common points can be outlined. OC is the structure of the firm when it provides an efficient way to operate (Lev, 2005); is "everything that remains in the office after 5 o'clock", in Edvinsson words; it includes relations with the external environment, values, leadership corporate culture, technology, information and communication systems (Lev, 2005, Bontis et al, 1999). Joining and comparing these definitions with Fernadez et al. (2000), OC has been defined as in figure 2.5. Our definition of OC also includes knowledge embedded in the relationships, internal and external, as the capacity to establish relationships depends on the culture of the organization, part of OC. Also reputation is included in OC; reputation is, in fact, the result of the tacit organisational knowledge and capabilities of the firm and its ability to produce and deal with the market.

The third class of intangibles is represented by intellectual property. The last – and new – class of intangibles is represented by innovation related capital – mainly R&D activity. Each class is characterised by a particular feature: human capital is individually related; OC is strictly context-dependent and firm-specific; Intellectual property is legally protected and Innovation related capital strictly relates to the production of scientific and technological knowledge.

Barney's model can be applied to this classification to identify the most crucial intangible resource for firm performance, able to generate not only competitive advantage, but also sustainable competitive advantage.

Human capital can be a source of sustainable competitive advantage but only if considered as a whole, not as the knowledge and skills of a single individual, otherwise the control condition to qualify as a resource fails. However, considering the organisational dimension of human capital is equal to considering the workforce as a whole, working together in teams through competences and organisational routines; in a word, OC.

Codified organisational knowledge and intellectual property seem to fail the criterion of imperfect mobility, being in an explicit form and therefore somehow accessible to competitors. Also innovation-related capital seems to fail the requisite of imperfect immobility as it can be imitated by competitors who can discover secrets or study the commercialised results of R&D stock. Reputation is a source of sustained competitive advantage; however, as already noticed is the result of OC. Co-operation agreements seem to fail the condition of rareness, since they involve other firms with which knowledge is shared. Furthermore, they seem to be substitutable, since competitors can subscribe similar co-operation agreements with the same, or other, economic actors.

I would conclude that the main source of sustained competitive advantage is then the tacit organisational knowledge of the firm, component of OC. It is however extremely hard to separate tacit organisational knowledge from codified organisational knowledge as the degree of intertwining between the two is very high, and OC is, altogether, given by the interaction of its single components. We therefore conclude that OC, given its special features, is a controlled, strategically significant, heterogeneous and imperfectly immobile resource; OC is thus the most important intangible for firm performance, able to generate sustained competitive advantage.

The application of this model seems to provide a good analytical tool to identify the relevant economic features of intangibles, even though the conclusion reached could be proven wrong, or dependent on the context of analysis.

This application of Barney's model to intangibles does not expect to provide a final solution to the classification and identification problems. However, the analysis has showed that referring to a "theoretical framework" can provide, at least, a tool to facilitate the analysis of such complex phenomena, by outlying the critical features in a perspective of competitive or sustained competitive advantage. Through such a framework, it seems possible to outline which criteria should be relevant to be classified as intangible resources, even though this may imply losing generality. If the focus is on those intangibles that have a positive effect on performance through the creation of sustained competitive advantage, then the intangibles that are relevant and have to be analysed in more details, are those that satisfy the conditions of Barney's model – mainly OC, according the results of this analysis. An assumption therefore has to be made for such a model to hold: firms must pursue sustained competitive advantage. It does not seem to be an overly unrealistic assumption, given the condition of the economic environment, characterised by fierce competition and continuous change. In this situation a competitive advantage would seem to be too temporary and in a fragile state.

2.7 Intangible resources: a second set of conclusion

Even though several authors lament the lack of a "theory of intangibles", the majority of them do not refer to a "theory" in their analysis. Only few (e.g. Hall, 1992, 1993, Clement et al., 1998, Fernandez et al., 2000) analyze intangibles in the context of frameworks related to the "heterodox" approaches to the economic theory of the firm. This chapter has carried out an indirect analysis of intangibles through the theories of the firm, their critique and development and reviewed some of the most representative contributions that have helped to uncover the importance of intangibles, their features and the way in which they interact with other tangible resources to improve firm performance.

Traditional and neoclassical economic theories do not appear to offer a coherent framework for the analysis of intangibles and has for long neglected this type of resource, due to their peculiar features that make them non-tradable goods. The neoclassical theory of the firm relies on assumptions that do not allow the treatment of intangibles and perceives knowledge as fixed, publicly available and equal to information. It is through the critic of these assumptions that intangibles slowly enter into the economic theory of the firm. The recognition of the existence of market failures, imperfect information and bounded rationality of individuals (contractarian approach), the observation that firms, as formed by individuals, are characterized by bounded rationality (behavioralist approach), the introduction of uncertainty and the need to cope with it (Knight, 1921) open the way to the development of a theory of the firm that includes intangibles, mainly in the form of tacit knowledge, skills and competences (Penrose, 1959). On this ground, Nelson and Winter (1982) have developed the evolutionary theory of the firm, which sees those intangibles such as routines, skills and capabilities as the main factors to survive in the market competition (Hodgson, 1998).

While the evolutionary theory provides a dynamic framework that fits well the representation of the "flows" (investments) in intangibles, the resource-based view, static approach, offers a possible model for the analysis of the stock of intangible resources. The resource-based view sees the firm as a bundle of tangible and intangible resources and focuses on the features that the resources must posses in order to confer competitive advantage. By outlining the role of firm resources, the RBV has helped identify the main features that resources must have to generate competitive advantage; this has led to the recognition of the role of knowledge, particularly analyzed by the KBV that has underlined the important role of the organisational culture in its transmission and in the generation process of new knowledge.

Three classification-identification models for intangibles based on the RBV have been presented (Hall, 1993; Barney, 1991 and Fernandez et al, 2000). These three models identify features that render intangibles able to generate competitive advantage or sustained competitive advantage; on their bases, we have proposed an eclectic classification model for intangibles. The classification proposed groups intangible resources in human capital, OC, intellectual property and innovation related capital. Barney's model has been applied to the proposed classification to identify the most important intangible for firm performance. We have concluded that OC, given its special features, is a controlled, strategically significant, heterogeneous and imperfectly immobile resource; OC is thus the most important intangible for firm performance, as it is able to generate sustained competitive advantage.

The importance of intangible resources as key factors for firm performance has thus been justified at the theoretical level; in the following chapter we analyze the empirical evidence for this relationship.

Chapter 3: On the empirical relationship between intangible resources and firm performance

3.1 Intangible resources and firm performance in empirical studies

The aim of this chapter is to review some of the literature on the relationship between intangible resources and firm performance. The work in this field belongs to different areas of studies and focuses only on certain specific intangible resources, telling only "part of the whole intangible resource effect" on performance.

One of the most controversial problems regarding the measurement of the effect of intangible resources (also called collectively knowledge, intellectual, or technological capital by the literature) relates to the identification of good proxies for their measurement, given the fact that such capital is not directly observable and it is highly heterogeneous.

The review of the theoretical literature of Chapter 1 has shown the issues related to the controversial and not universally agreed definition of what is to be included among intangible resources. The same issues reappear in the empirical literature, aggravated by the fact that, besides theoretical problems, studies that focus on the measurement of the effect of intangibles on performance also have to deal with the availability of data that influences what is to be considered intangible resources, and the availability of econometric tools.

As already discussed, there are various types of intangible resources; the empirical literature has first analyzed the effect of intangibles as a residual factor of the production function, most likely due to the problems related to their definition and measurement (Mairesse and Sassenou, 1991). Further developments have then mainly focused on Research and Development, patents, human capital, ICT and advertising. The studies of this relationship have been taken at different levels: firm, sector, industry, and country level; this survey mainly focuses on firm level studies.

Even though organizational capital (OC) has been identified as the most important intangible for firm performance (Chapter 2), empirical studies on the relationship between OC and performance have been uncoordinated and sporadic. It is therefore important to analyze how the causal relationship mechanisms, measurement and econometric problems have been treated with respect to other types of intangible resources.

Before continuing, it has to be underlined that a “true comparison” of the findings is almost impossible as the proxies used to represent intangibles are different, as are the methodologies and samples used; the present review thus aims more at presenting a selective sample of methods used than at comparing their results.

In this chapter, a review of the literature on the relationship between intangible resources and firm performance is examined. A critical analysis of the methodologies used in recent research to (a) build measures of intangible resources and (b) determine the association between intangible resources and firm performance is presented.

3.2 Intangible resources as Innovation capital: effect on performance

3.2.1 R&D and firm performance

Research and Development (R&D) capital has been one of the first definitions of intangible resources used by the empirical literature.

R&D comprehends basically three types of activities: basic research, which creates new knowledge without aiming at a particular use or application; applied research, which, instead, aims at creating new knowledge with a practical aim; and experimental development, which builds on existing knowledge to create, or improve, new products or processes (OECD, 1993).

The focus on R&D as a proxy for intangibles has, first of all, a theoretical justification: R&D activities represent the knowledge available to the firm, knowledge that is able to affect performance by allowing for the introduction of new products or processes (Aiaello & Cardamone, 2005). R&D is therefore a source of invention, technological change, economic efficiency and, finally, a factor of economic growth that improves performance (Guellec, 2000). Besides theoretical reasons, as many authors have noticed (e.g. Mairesse & Sassenou, 1991), the use of this proxy is justified by the practical reason of the availability of data: R&D expenses are directly observable from firms’ financial statement.

The use of this proxy to measure the entire intangible endowment of the firm is far from perfect. First of all, the definition of intangibles related to it is too restricted, as it does not take into account all the different dimensions related to intangible resources (Griliches, 1979) such as organizational capabilities, human capital, advertising and so on. The effect of R&D activities is often embodied in employees' knowledge, patents, blueprints, and in physical capital, therefore the aggregation of such diverse items in the definition of R&D capital as determined uniquely by R&D expenditures is reductive (Griliches, 1979).

Problems arise even when accepting R&D as the only intangible resource of the firm. The use of R&D expenses, in fact, first, does not include R&D activities performed outside the firm; secondly, it does not take into consideration the uncertainty of the R&D process, taking for granted the fact that higher R&D expenses equal higher technological capacity (Aiello, Pupo, 2004). This last objection could be moved to all the proxies for intangibles that use firms' expenditures; it could however be overruled if one considers that even when R&D projects do not reach the direct object for which they are carried out, they still result in the production of knowledge, that will generate a positive effect on performance, even though not immediately.

Another problem that characterizes the use of R&D expenses is the level of discretion in reporting R&D as expenses or as assets, especially in certain accounting systems (e.g. Italy, UK, and Belgium). Measures of R&D stock based on R&D expenses can therefore be biased when part of the R&D is capitalized (Kafourous, 2005). It can thus be said that R&D expenditures are available and directly observable, but only to a certain degree. Finally, models using R&D expenditures are often affected by the problem of "double counting" (Mairesse and Sassenou, 1991; O'Mahony and Vecchi, 2000) caused by the fact that other variables included in the model (i.e physical capital, value added, labour) are not corrected for the cost of R&D materials and personnel, inputs that increase R&D stock, not the firm's output. This generates a downward bias in the R&D estimates, as shown by studies that have the availability of data to allow for the correction of such measurement errors (e.g. Mairessse and Hall, 1996; Aiello, Pupo, 2004).

Besides some of the above mentioned problems, as the literature as shown, the use of R&D expenditures can capture at least part of the effect of intangible resources on performance, in particular the effect that this type of investment has in improving the firm's knowledge in a special area (Griliches, 1979). Furthermore, they represent a quantitative, observable proxy, a financial data that is not subject to personal analysis bias of the researcher or respondent as is often the case for proxies based on qualitative surveys.

A review of several studies that have analyzed the relationship between intangible resources and firm performance focusing on R&D expenses (e.g. Griliches, 1979, Griliches and Mairesse, 1981, Mairesse and Sassenou, 1991, Kafouros, 2005) shows that the model generally used for these studies is an extended Cobb-Douglas production function, in different specifications, that relates three independent variables, capital, labour, and R&D, with a performance measure of output, usually sales or value added. Additional control variables are then added to control for other variables that affect firm's performance.

The stock of R&D capital is generally measured through the perpetual inventory model with declining balance depreciation applied to R&D expenses (e.g Griliches and Mairesse, 1981, Hall, 1990, Mairesse and Sassenou, 1991). This model assumes that the present stock of R&D depends on R&D current and past expenses and that it needs to be depreciated, as any other type of capital. Therefore, the gross R&D stock, given by the sum of previous R&D expenses, is then depreciated and transformed into net R&D capital.

R&D stock is derived based on the research conducted by Griliches and Mairesse (1981) who state: "We think of the unobservable research capital stock as a measure of the distributed lag effect of past R&D investments on productivity." (op. cit, p. 3). The formula generally used is:

$$K_{it} = \sum_{\tau} w_{\tau} R_{i(t-\tau)} \tag{3.1}$$

where R is a measure of the R&D expenditure (deflated) in a period, and the subscripts $t, (t-\tau)$, and i stand for current year, lagged year and firm, respectively. The lag structure w_{τ} should be determined from the data which should give an estimate of the rate of R&D obsolescence and the average time lag between R&D expenditure and its impact on productivity. Given the fact that data are often not informative enough, the suggested solution is a constant rate of obsolescence of 15% per year, and a lag structure defined as geometrically declining weights $w_\tau = (1-\delta)^\tau$.

R&D capital needs to be depreciated as it is subject to obsolescence, like physical capital. New products and processes become available and the knowledge related to R&D activities loses specificity; furthermore the majority of R&D activities are carried out with a short term objective. The identification of a proper depreciation rate is still problematic, but there seems to be consensus around the use of 15%[12].

A recent study (Bitzer and Stephan, 2007) has questioned the validity of the perpetual inventory model to calculate R&D stock on the ground of the assumption made about the depreciation rate. The perpetual inventory model assumes that R&D capital follows the same path as physical capital and that depreciation takes place automatically. This leads to the conclusion that, if the firm stops investing in R&D, its knowledge capital (as proxied by R&D stock) paradoxically converges to zero. However, as the Schumpeterian notion of creation destruction suggests, knowledge becomes obsolete when new knowledge becomes available. On this ground, the authors (op. cit.) propose a Schumpeter-inspired method where every R&D investment increases R&D stock, while decreasing it at the same time, and where the depreciation rate is not constant, but linked to the amount of research activities carried out. The knowledge creation process is given by the accumulation of past expenditures. To model the knowledge destruction process, current R&D expenditures are weighted by a displacement factor "which captures the substitution rate of newly generated knowledge for old" (op. cit., p. 181). The displacement factor, therefore, substitutes the depreciation rate of the perpetual inventory model. As the latter, the displacement factor is not directly observable; it can however be estimated econometrically, when assumed to be constant. This is not an unreasonable assumption when considering that the majority of R&D activities generate incremental knowledge.

The results of the study, carried out at the country level, show that this new method generates better and more robust results when compared to the perpetual inventory method; furthermore, if R&D investments stop, the knowledge capital

[12]Some authors (Hall, 1990, Crepon, Duguet and Mairesse, 1998) also state that the choice of depreciation rate does not seem to seriously influence their results.

converges to a positive constant, instead of converging to zero. The method is definitely a valid attempt to improve the measurement of R&D stock, especially for the validity of the theoretical assumptions it relies on; however more evidence is needed, especially at the firm level, in order to confirm its superiority with respect to the perpetual inventory method.

Another problem related to the application of the perpetual inventory model is that it requires a sufficiently long series of R&D expenditure, which is not always available. There is no consensus regarding the length of the series required to reach a good approximation of R&D capital stock, or the appropriate lag structure required to see the effect on performance. Griliches (1979) suggests the use of a lag structure with effect in 3-5 years and no, or limited, effect after 10 years. However, time series availability is usually short, and the majority of the studies do not attempt to investigate the lag structure of R&D efforts, or they cannot reach any firm conclusions (Griliches and Mairesse, 1981, Hall, 1990).

The perpetual inventory model also needs appropriate deflators in order to transform the nominal into real value of R&D expenses; however, appropriate deflators are not always available (Griliches, 1979).

As the perpetual inventory formula shows, the initial year conditions have to be specified, together with a method to account for the problem encountered when some of the years in the series have missing values for R&D expenses. For example, Hall (1990) calculates the initial R&D stock from initial year R&D expenditures divided by 0.23 (given by the sum of a pre-sample growth rate of 8% and a depreciation rate of 15%). Crepon, Duguet and Mairesse (1998), instead, use a pre-sample growth rate equal to 5% (as in Mairesse and Hall, 1996); when firms do not have R&D expenses in the initial year or in later years, R&D expenditures values are assumed to be zero. Griliches and Mairesse (1981) exclude firms that have more than 3 years missing values for R&D expenses in the period considered.

The lack of R&D expenditures, therefore, is often the cause of some selectivity bias, as firms have to perform R&D activities with a certain regularity to be selected in the sample (Mairesse and Hall, 1996). In order to limit this problem, studies that use R&D expenses mainly focus on the manufacturing sector or, in general, on particular

R&D intensive sectors where R&D activity most occur (O'Mahony and Vecchi, 2000) due to the fact that using this proxy for intangible resources implies the absence of such resources when R&D is not performed.

Medda, Piga, and Siegel (2006) use a two-stage model to account for the fact that the decision to invest or not invest in R&D is endogenous. To limit the selection bias problem caused by the fact that many firms report zero R&D expenses, they model the decision to invest in R&D expenditures, and then use the results in the estimation of the impact of R&D on productivity, using all firms in the sample.

Studies that use R&D stock as a proxy for intangible resources of the firm and analyze the effect of this proxy on firm performance, generally estimate R&D elasticity with respect to output or productivity. Based on a sample of 133 US firms in the period between 1966-1977, Griliches and Mairesse (1981) find R&D elasticity estimates to be around 0.06; this estimate is slightly higher compared to similar studies, where the R&D elasticity with respect to output appears to range from 0.05 to 0.02 (Mairesse and Sassenou, 1991). One of the most recent studies in this area is the one performed by Kafouros (2005) on a panel of 78 UK firms spanning from 1989 to 2002; here the R&D elasticity is estimated to be an average of 0.04.

Another stream of empirical research has focused on the determination of the returns to R&D investment (the increase in output associated to a $1 increase in R&D stock), rather than the elasticity of R&D stock (the percentage increase in output associated to a 1 percent point increase in R&D stock). This method avoids some of the problems involved in the calculation of R&D stock from R&D expenses as it focuses on R&D intensity calculated as the ratio of R&D expenditures over sales or value added. The model is based on a transformation of the Cobb-Douglas production function that relates a performance measure to a flow variable instead of a stock variable.

Some of the problems that affect the calculation of the R&D stock, however, also affect this apparently simple approach. First of all, the rate of return so calculated is a gross rate of return, and a depreciation rate is still needed, as for the calculation of the R&D stock. While R&D elasticity estimates do not seem to be seriously affected by the choice of the depreciation rate, the rate of return appears to be more sensitive to the rate of depreciation used (e.g. Mairesse and Sassenou, 1991). Some authors (e.g Wakelin, 2001, Mate and Rodriguez, 2002) face this problem by simply providing gross estimates of the rate of return, based on the consideration that the difference between the gross and net rate of return is negligible when the R&D depreciation rate is comparatively small with respect to the R&D expenditure growth rate.

Wakelin (2001) estimates the rate of gross return of R&D expenditures on a sample of 170 UK firms between 1988 and 1996; R&D effect on performance is estimated to be 27%. Another study (Maté and Rodriguez, 2002) based on a sample of 1,265 Spanish manufacturing firms between 1993 and 1999 estimates R&D rate of return around 23%. In general, the R&D rate of return appears to range between 0.2 and 0.5 and to be higher than the tangible capital rate of return, which ranges between 0.05 and 0.1.

Some factors should however be considered when interpreting this result. First, the high rate of return could be influenced by the risk premium involved in investing in R&D activities. Second, R&D expenses only represent one type of investment in intangible resources; taking into account the cost of complementary investments required to enact R&D efforts (such as marketing and reengineering, for example) would probably lower the R&D rate of return (Guellec, 2000). Last but not least, when the depreciation rate is taken into account, the R&D rate of return appears to be lower. Aiello and Pupo (2004), in their study based on a sample of Italian manufacturing firms, shows that the estimated R&D rate of return drops from approximately 20% to 5-7% when a 15% depreciation rate is taken into account.

When measuring the relationship between intangibles and performance, other factors have to be taken into account. Wakelin (2001) shows that the "innovation history" of the firms influences the rate of return of R&D; in this study in fact, the R&D rate of return is positive and significant for firms classified as innovators, while it is not significant and negative for firms that are not innovators.

Several studies have found that the sector influences the estimates of R&D effect on performance; one method used to account for these differences has been the inclusion of sector dummies. Kafourous (2005 finds that R&D elasticity is about 0.11 in high-tech sectors, while it is not significant in low-tech sectors. A reason behind the higher estimates in high-tech sectors is possibly the better absorptive capacities that firms have due to the innovative nature of their work and their higher skilled labour force; if this assumption is correct, then the R&D stock captures a wider definition of intangible resources: namely R&D capital, absorptive capacity, and human capital.

Another reason behind sector effects is that the knowledge capital of the firm depends not only on internal investment in R&D, but also on the external capital, generated by other organizations, i.e. from the effect of R&D spillovers (Griliches, 1979). In high-tech sectors, firms are more subject to spillover effects than firms in low-tech sectors; for this reason, the effect of R&D is upward biased, as it captures effects due to the external knowledge present in the sector. When knowledge spillovers are not taken into consideration, the estimates of the R&D effect may capture the effect of the knowledge capital of the firm as given by the internally and externally generated knowledge (O'mahony and Vecchi, 2000). On this ground it has been pointed out that the production function should include a measure of external knowledge available to the firm, such as sector R&D intensity, to capture spillover effects with better results than sector dummies (Mairesse and Sassenou, 1991). A strong assumption of such method is that it assumes that firms have the same absorptive capacity.

Several studies (e.g. Wakelin, 2001, Aiello & Cardamone, 2005; Meda, Piga, & Siegel, 2006) have taken into account the effect of R&D expenditures of other firms, thus accounting for externalities in research.

Aiello and Cardamone (2005) base their study on a balanced panel of 1,017 Italian manufacturing firms covering the period 1995-2000. They argue that spillovers can be obtained by questioning whether all the investment efforts made by others are relevant for a given firm. Following Griliches (1979), to determine the share of technology produced by others and used by a firm, they utilize a method that incorporates (a) the amount of research expenditures performed by other firms, and (b) a weighting scheme based on the extent to which a firm could "take advantage" of the research expenses of other firms. The estimated R&D elasticity is 0.057 and the impact of R&D spillovers within a sector (0.007) is higher than that of spillovers from other sectors (0.002).

R&D spillovers are also investigated by Medda, Piga, and Siegel (2006). However, their approach differs from that of Aiello and Cardamone (2005) in that the spillovers of only collaborative research efforts are analyzed. Medda, Piga, and Siegel (2006) distinguish "internal" R&D activities (unique to each firm) from "external" R&D

activities, given by collaboration with other firms, with universities and with research centers. The notion of external knowledge available to the firm therefore implies the involvement of the firm itself in the R&D activity. The results for their sample (Italian manufacturing firms for the period 1992-1997) show that both types of research activities significantly affect performance; however, when distinguishing among different types of "external" R&D activities, only research conducted with other firms appears to strongly influence performance.

Most of the studies on the impact of R&D on performance have been based on a Cobb-Douglas production function model extended to include R&D as an input (Mairesse and Sassenou, 1991). Nonetheless the strong assumptions made by this model - factors that concur in the determination of the dependent variable are independent from each other and output elasticity is constant (O'Mahony and Vecchi, 2000) -, all the studies here presented have used this method.

The estimated R&D effects have exhibited important differences across studies. Moreover, results have been reported in terms of elasticities and in terms of returns to investments, using measures of R&D capital based on R&D stock calculated through the perpetual inventory model or based on R&D intensity; this causes difficulties in the comparison. Recalling some of the results presented, Kafouros (2005) finds an average R&D elasticity of 0.04, Griliches and Mairesse (1981) find R&D elasticity estimates to be around 0.06; Aiello and Cardamone (2006) find an elasticity ranging from 0.057 through 0.09, depending on the model specification. Maté and Rodriguez (2002), on the other hand, estimate the impact of R&D expenses as a return. They find that the return to R&D expenditure is 22%, slightly lower than the 29% found by Meda, Piga, and Siegel (2006). Similarly, Wakelin (2001) finds that the return to R&D expenditures is 27%. Therefore, there does not seem to be a widespread agreement of the effect of R&D on performance.

Estimates vary, first of all, according the different samples used, depending on country, period of time and sector. They also vary according to the measure of performance; some author use sales (e.g Kafourous, 2005, Medda, Piga, and Siegel, 2006; Wakelin, 2001), others use value added (e.g. Mate and Rodriguez, 2002, Aiello and Cardamone, 2005). The different measures of performance adopted can therefore impact the estimated effect of R&D, with higher estimates when value added is used (Mairesse and Sassenou, 1991, Mairesse and Hall, 1996).

The estimation method also influences results: different studies use different techniques such as, among others, Ordinary Least Squares (OLS) (e.g Kafouros, 2005, Wakelin, 2001), and Generalized Method of Moments (GMM) (e.g. Mairessse and Hall, 1996, Aiello and Cardamone, 2005, Maté and Rodriguez, 2002). The main advantage of using GMM is that this method is robust to heteroskedasticity across firms and to correlated error terms across time, which is especially important when estimating panel data. However, in spite of these advantages, GMM tends to produce unusually large standard errors for the coefficients, which may lead to the incorrect conclusion that a given variable is not significant (Ballot et al., 2001). The instrumental variable estimator is another technique that can be used to solve the simultaneity and causality problem that affects R&D investments, i.e R&D investments generate future output but, at the same time, are determined by previous output and current output. However, the identification of the proper instruments is quite problematic (Griliches, 1979).

This brings about the limits that econometric tools pose on studies that try to assess the relationship between intangibles and performance. Econometrics tries to simplify very complex phenomena and there is only so much that can be asked of the data (Mairesse and Sassenou, 1991). The effect of intangibles on performance is indeed a complex phenomenon: there are different types of intangibles that are interdependent, hard to identify and measure. Thus, when trying to measure this relationship, there are necessarily strong and restrictive assumptions that have to be made. Besides the several limitations outlined, studies that have focused on R&D stock have managed to prove the positive effect that it has on performance. The strongest limit is probably the fact that the knowledge capital of the firm is assumed to be formed only by the R&D intangible resource.

3.2.2 Patents and firm performance

As seen in the previous paragraph, a stream of literature has proxied knowledge capital and intangible resources using R&D capital. This view focuses particularly on one of the reasons that justify the effect of intangibles on performance, namely the capacity to generate innovation. The notion of knowledge capital adopted is, therefore, directly linked to the notion of innovation capital.

Other intangible resources have been used to measure the effect of knowledge-innovation capital; besides R&D, patents are probably the most widely used.

Patents are legal rights granted by public authorities to the inventor that assure him a temporary monopoly on the production, or use, of a specific new device or process; the theoretical reason that justifies the assumption of a positive effect on performance is basically included in their definition: they guarantee monopoly profits.

As for R&D, practical reasons, related to the availability of data, are behind their use as a proxy for firm knowledge: patent data are, somehow, more available with respect to data for other intangible resources; also, patent data are quite stable over time. As for R&D data however, the use of patent data has some problems.

The first problem relates to their economic value that greatly varies; patents are, in fact, issued based on criteria of novelty and capacity to generate utility. The level of these two criteria, requested to receive the patent, is, however, not high; thus, some patents have great economic value, while others do not. Differentiating between the valuable and non valuable patents is practically very problematic.

The second problem relates to what the patent actually represent: they can be considered a knowledge input or a knowledge output (Griliches, 1990).

In same cases they are considered a proxy for the entire knowledge capital of the firm (e.g. Crepon et al, 1998; Nesta, 2007). Nesta (2007) examines the relationships between a firm's knowledge stock and productivity on a sample of 156 of the world's largest corporations in the period 1986-1996, using panel data regression models. Knowledge capital is calculated, through the perpetual inventory method, as the cumulated stock of past patent applications, using a depreciation (obsolescence) rate of 15% per year. Results show that knowledge capital has a positive and significant effect on productivity (0.04).

The positive and significant effect of knowledge on performance is also confirmed by Crepon et al (1998) who also use patents to measure knowledge capital; the effect on performance is higher (0.09) than the one estimated by Nesta (2007).

The main objection that can be raised against the use of patents as a proxy for the firm's knowledge capital relates to the fact that not all types of knowledge can be covered by patents and, even when knowledge can form the content of a patent, different firms, in different sectors, have different propensities to patent (Griliches, 1990). However, to a certain extent, patents can represent the knowledge capital of the firm; in particular, the knowledge capital that is more likely to have commercial success.

Studies that recognize that innovation resources are not the only intangibles of the firm, and that measuring the effect of intangibles on performance using only innovation-related proxies can be reductive, include other proxies of intangible resources. In these cases, patents do not represent the entire knowledge of the firm, but only a part of it. When data refer to patents granted or applied, they represent the internal innovative capacity; when data refer to patents purchased, they can be considered a measure of the external knowledge acquisition (Tsai and Wang, 2008)

Patents can also represent intangible resources intended as inputs that, together with other factors, contribute to the creation of the total knowledge capital of the firm proxied by an innovation related variable, usually share of innovative sales. The effect of patents on performance is, in this case, indirect. This stream of studies assumes that innovation output, not input, affects performance; the studies however differ with respect to what forms innovation input and what forms innovation output.

While R&D is generally considered an innovation input, patents are considered, alternatively, innovation inputs (Loof and Heshmati, 2002, Hesmati et al, 2006) or innovation output (Crepon et al, 1998).

The general framework (Crepon-Duguet-Mairesse model, or CDM model) used by these studies consists in a system of equations linking innovation inputs to their determinants, innovation input to innovation output and, finally, through a productivity equation - usually an augmented Cobb-Douglas -, performance to innovation output and other independent variables.

In Crepon et al (1998) the only innovation input is R&D capital, which appears to be determined by the firm's market share, diversification strategy demand and technology opportunities. Results show that R&D intensity affects knowledge capital; R&D elasticity with respect to knowledge capital is 0.9 when knowledge capital is proxied by patents.

Knowledge capital affects performance: the elasticity of knowledge capital with respect to output is 0.09 when proxied by patents; 0.06 when proxied by innovative sale.

Another similar study (Loof and Hesmati, 2002) based on 600 Swedish firms in the period 1994-1996, reaches similar conclusions but considers patents as an input. Patents, together with sources of internal knowledge and market relationships, positively affect the decision to engage in innovation activities; the extent to which firms engage in innovation activities, instead, is found to be positively affected by sources of knowledge within the firm and customers capital. Knowledge output (shares of innovative sale) is positively affected by knowledge inputs, internal ideas and cooperation agreements. Besides the difference in the value assigned to patents, the present study differs from Crepon et al (1998) in the breadth of the knowledge inputs category; not only R&D, but also other intangible resources, such as market relations, cooperation agreements, knowledge sources within the firm, are in fact included. The study confirms the positive effect of innovation inputs on knowledge capital and the positive effect of knowledge capital on performance: the estimated output elasticity of knowledge capital is 0.05, slightly lower than what estimated by Crepon et al (1998).

Similarly to Loof and Heshmati (2002), a more recent study (Heshmati et al, 2006) on a sample of Korean firms confirms these results: the knowledge capital (innovative sale percentage) is affected by size, patents and sources of knowledge within the firm; knowledge capital strongly affects performance (output elasticity is 0.7).

It is worth to notice that the just mentioned studies find knowledge capital effect on performance to be within the interval estimated by studies that measure knowledge capital by solely R&D stock (see 3.2.1).

The introduction of a wider variety of intangible resources that positively affect (indirectly) performance in Loof and Heshmati (2002) is noteworthy and validates objections advanced to studies that only focus on R&D activity as proxy for knowledge capital. A weakness of the study consists on the qualitative nature of data used to proxy the new intangible resources used. Intangible resources can be measured through objective and measurable indicators, but also through subjective assessment, company's own ranking on a given index. The first methodology is probably preferable; on one side, in fact, the perception that firms have of their own intangible resources and their importance is often blurred; on the other side, qualitative data can be subject to interpretative bias.

Patents can therefore be used to proxy knowledge input or output; they are also used to measure the effect of knowledge quality on performance.

Nesta (2007) uses patent qualitative information to measure the effect on performance of two qualitative dimensions of knowledge: diversity and relatedness. Knowledge diversity represents the extent of the firm knowledge base and it is proxied by the number of technology classes in which the firm is granted patents over a certain period of time. Knowledge relatedness indicates the complementarity of the services rendered by two different technologies and it is estimated based on the comparison of the frequency with which two technologies are used together, compared to the expected frequency. Only knowledge relatedness has a positive and significant effect on performance; this is justified by the fact that coordination costs increase when a firm diversifies in different, unrelated activities.

The conclusions that can be drawn from the analysis of studies based on patent proxies are similar to the ones drawn from the analysis of studies that focus on R&D. The positive effect of patents on performance has been somehow confirmed; however, the magnitude of the effect has not. Also, the value assigned to patents (knowledge input, knowledge output) varies together with the nature of the link, direct or indirect, they are assumed to have on performance.

Studies that focus only on patents, R&D, or innovation related measures account only for a part of the intangible resources effect on performance. Considering innovation and knowledge as synonyms does not take into consideration the effect of other important intangibles such as human capital, marketing activities that build up brand and reputation, alliances and organisation capital. In the following section some methodologies to measure these intangibles and their effect on performance are analysed.

3.3 Beyond innovation related intangibles: Human Capital, Information Technology and Advertising and their effect on firm performance

3.3.1 Human capital

Human capital, the knowledge embodied in employees, has been one of the first non-innovation related intangibles whose effect on performance has been analyzed. The theoretical reasons behind the assumed positive effect of human capital on firm performance relate to the better capacity of the firm to organize and make efficient decisions. Furthermore, a highly qualified labour force can benefit more from the learning by doing process, in so generating more knowledge capital and a higher effect on performance (Ballot et al., 2001)

Human capital has often been analyzed together with R&D or innovation (e.g Crepon et al., 1998, Loof and Heshmati, 2002); this is due to the fact that investment in R&D activities and the innovation capacity of the firm are strongly affected by the quality of labour force.

Different proxies have been used for human capital; the most common are labour costs, level of education and level of training.

The use of labour costs has the advantage to offer a relatively available proxy; Lin (2007) uses the labour cost proxy and finds a positive relationship between human capital and firm performance. The main critique that has been moved to this method relates to the fact that wages and benefits of employees do not always reflect their real productivity and value; furthermore there are differences in the level of retribution among the sectors (Kafourous, 2005)

Level of education is potentially a better proxy, even though less available. Aiello and Pupo (2004) proxy human capital by the average education level of employees and find a positive effect on productivity. This result is also verified by Crepon et al (1998) and Loof and Heshmati (2002) who measure human capital as the ratio of engineers and administrators to total number of employees.

In these first set of studies, human capital is a type of intangible resource that directly affects performance; Heshmati et al (2006) instead see it also as a determinant of the innovation capital of the firm. Human capital, proxied by n. of researchers, is found to negatively affect the probability to engage in R&D activities and positively affect the amount of innovation investments performed by the firm. Contrary to that predicted by the theory, the effect on performance as proxied by productivity is estimated to be negative.

The level of training has also been used to measure human capital; this type of data, however, is hard to find as firms hardly track training expenses. Another limit that affects this proxy is, obviously, the fact that it implies the absence of human capital when firms do not carry out training programs. Training related proxies can therefore be a solution to the human capital measurement problem when the analysis is carried out on large companies that have the resources and, usually, engage in training programs, contrary to small firms.

Ballot et al. (2001) use firm-sponsored training to examine the effect of human capital on performance in a sample of 90 large French and 272 large Swedish firms in the period 1987-1993. Human capital is measured by the percentage of the wage devoted to continued training and by the hours of training paid by the firm. This data is then used to build two human capital flow variables: an indicator of annual training expenditure and an indicator of annual training hours. These flow variables are then converted into stocks, by summing them over the previous seven years, through the perpetual inventory method used to build R&D stock from R&D expenses. The equivalent of the "depreciation rate" in the case of human capital is the "separation rate". This is the proportion of workers that leave the firm in a year, thus producing a loss of human capital, and it is calculated to be 19%. Results show that, besides R&D capital, also human capital has a significant and positive effect on performance. The human capital return is indeed extremely high: 288% for France and 441% for Sweden.

Human capital also has been measured by both training and education related data; Lybaert et al (2006) uses the share of highly educated personnel and the percentage of personnel involved in training programs to measure the effect of knowledge capital on a sample of 259 Belgium firms. The results strongly depend on the measure of performance used and only education level appears to positively affect performance; conclusive results cannot be reached for training levels.

It is noteworthy to underline that in this study education level and training do not proxy human capital; the authors define them as the components of intellectual capital as opposed to innovation capital, proxied by innovation related intangibles.

Level of education is more individual-related than level of training, and measures the knowledge that the single employee can take away from the firm at any time. Level of training measures something more firm-specific; through specific training programs the firm can decide what types of skills and competences to create in the labour force and render it context-dependent. Training related data seems therefore appropriate proxy more for organisational knowledge than for human capital; the knowledge product of firm-specific training activities, in fact, is likely to become firm-specific, organisational and not strictly related to the individual.

The theoretical reasons that postulate a positive effect of human capital on firm performance are conceptually solid; however, conclusive results cannot be reached at the empirical level. While some studies find a positive effect (e.g Crepon et al., 1998, Loof and Heshmati, 2002, Ballot et al, 2001), others find a negative effect (e.g. Heshmati et al., 2006, Lybaert et al, 2006).

The lack of robustness of empirical evidence is likely due to the quality of the proxy used; measuring ability and knowledge in fact, has, for long been a tedious problem for econometricians as these factors are not observable.

The measurement method for output could also justify the lack of robust empirical evidence; intangibles often generate an effect on performance through qualitative improvements and measures of performance based on sales or other financial indicators may not be able to capture such effect. It is likely possible that improvements of output or input measures will, in the future, provide more solid evidence, as it has happened for another type of intangible: Information technology.

3.3.2 Information technology

Information technology has attracted the attention of scholars as one of the factors able to influence firm performance. Early studies define Information Technology (IT) as computer capital, proxied by n. of computers per employees. More recent studies have used a broader definition that also includes telecommunication structure and information processing equipment (Brynjolfsson and Yang, 1996).

IT can affect performance as it allows automating processes and substituting labour for capital; more importantly, it can increase information flows and their management, allowing for more efficient decision making processes. IT can therefore be seen as technology for coordination: through improvements in IT, business processes and organisation structure of the firm can be re-designed to reduce coordination costs (Dedric et al., 2003). It is this last aspect that allows for the inclusion of IT in the intangible resource category. Computer capital is an important resource of the firm but it can easily be purchased in the market and therefore imitated by competitors; in this sense, it is a more a tangible resource than an intangible one. When looking at the telecommunication and information processing structure of the firm as a whole, as the coordination structure embedded in the organisation, that includes not only computers but also databases and technology management systems, the intangible dimension then appears “more visible”. IT has therefore both aspects of tangible and intangible capital (Dedric et al., 2003); when proxied only by the number of computers, the intangible aspect, the most important for performance, is neglected and often not captured.

The type of proxy used to measure technology-related resources of the firm has been crucial to verify the effect on performance. Early studies in the 80’s have identified firm technology solely with hardware and software and have not been able to provide evidence of a positive impact on performance, generating the so called “productivity paradox” (Matteucci and Sterlacchini, 2005). The use of this strict definition of IT has been dictated by the availability of data. Since the 90’s, data for IT outlays has become more available from sources such as market research companies, firm’s surveys and financial information; furthermore, the increase in IT investments has allowed researchers to better identify their contribution (Dedric et al., 2003).

Lack of IT data is still a problem for empirical studies, especially at the firm level and for countries different from the US; however, even though evidence of the positive impact is not as robust as for R&D capital, the productivity paradox has been overcome (Matteucci and Sterlacchini, 2005).

Similar problems seen for the measurement of R&D capital and its effect on performance affect IT. As any other type of resource, IT is subject to obsolescence; however, as for R&D, the calculation of the exact obsolescence rate is problematic (Dedric et al., 2003). Furthermore, the determination of the time lag for the realisation of the IT effect on performance is another problem to take into consideration; not every IT investment will have the same lag on performance. When a sufficiently long series of data is obtainable, the solution is given by the inclusion of IT lagged values or performance lagged values; unfortunately, the unavailability of such types of data is often a constraint (Brynjolfsson and Yang, 1996).

Another issue relates to the use of IT outlays related expenses as a proxy for IT effect. This proxy could overestimate the returns of IT due to the fact that the cost of organisation capital adjustments (such as training and process re-engineering) would not be taken into account; on the other side, it could underestimate the effect, when it only includes computer related costs.

Firm level studies usually estimate the effect of IT on performance using a production function approach, including IT capital investments among traditional inputs. Matteucci and Sterlacchini (2005) study the effect of IT and R&D on performance for a sample of Italian firms in the period 1998-2000. IT is computed by the cumulative investment in hardware, software and communication equipment. Due to the lack of a sufficiently long series of data, the authors use IT intensity given by IT investments over value added. Results show that, besides R&D capital, IT also has a positive impact on total factor productivity changes; however, IT is significant only when inserted with a lag. In this case the effect of IT on performance is even greater than the effect of R&D (79% versus 5%). The breakdown of IT components also shows that communication investments have higher impact on performance than software and hardware investments, which suggests the existence of a strong link between IT and organization capital; IT investments, in fact, also need “complementary organizational changes and investments in intangible assets” (op. cit. p. 2).

Lin (2007) computes the level of IT capability of a firm using a ranking obtained from Information Week’s 500 survey, published annually from 1995 through 1999 (as Lev and Radhakrishnan, 2005). These rankings are determined on the basis of the number of personal computers, LANs, and mainframe computers that firms interviewed had currently installed or planned to purchase. The knowledge capital of the firm is proxied by IT and HC, identified as the most important intangibles for the firm. The analyses consists of a series of ordinary least squares regressions on several measures of performance (productivity and profitability). Results show the positive relationship between IT capability and performance on all the different performance measures used.

Despite concerns about statistical tools, quality of data and measurement errors the evidence of a positive relationship between IT investments and performance is relatively robust; less consistent evidence has been found when performance has been measured through financial profitability measures (Dedric et al., 2003).

3.3.3 Alliances and advertising

Two other types of intangible resources have been analyzed with respect to their effect on performance; although not to the same extent of R&D, patents, human capital: advertising and alliances. The following paragraphs outline some of the main findings from a sample of research in this field.

Alliances can improve performance as partnering with other firms with technical knowledge expertise may allow organizations to leverage their skills and increase their competitiveness (Tsai and Wang, 2008). One of the main problems related to the measurement of knowledge capital deriving form alliances is probably due to the lack of consensus on the definition of knowledge alliances. Contributions vary with respect to what they consider to be knowledge producing alliances.

Gambardella et al (2000) measure the impact of alliances and firms' strategy on 47 Fortune 500 worldwide chemical companies in the period 1990-1996. Three different performance measures are used: market value and net profit over sales as measures of profitability; sales growth as measure of productivity. Their intangible capital definition corresponds to R&D capital; however, they also include control variables that account for what a part of the literature would call relational capital: namely joint ventures, mergers, alliances, acquisitions and globalization strategies. Results show that, besides R&D, expected profitability is also positively affected by globalization strategies, alliances and acquisition; only globalization strategies appear to have a positive impact on productivity growth but no conclusive results can be reached for what concerns current profitability. The type of alliances considered by Tsai and Wang, (2008) is more restrictive than those considered by Gambardella et al (2000). The authors only consider innovation related alliances, such as joint research and development agreements, and technology sharing programs. The focus is therefore still on innovation related intangibles. Results are not conclusive; even though coefficients are positive, they are not significant.

Advertising and marketing investments are carried out in order to improve reputation, brand recognition and therefore firm performance.

Based on consolidated company account information on 16,000 worldwide companies from ‘88 to ’97, O’Mahony and Vecchi (2000) measure the effect of two intangible resources: R&D capital and other intangible assets. The latter are defined as other assets not having physical existence, whose value lies in their expected future returns. Other intangibles are proxied using the corresponding balance sheet item which mainly refers to capitalised intangibles, including licenses of no specific duration and capitalised advertising costs. Results show that R&D and other intangibles, mainly considered as proxy for advertising capital, influence productivity; however, with respect to profitability, evidence for other intangible assets effect is not robust across the different specifications of the model and varies across countries and sectors. R&D capital appears to have a higher effect than advertising capital with respect to productivity; when considering profitability, instead, even though results are not robust, the effect of other intangibles seems greater than the effect of R&D capital. According to this study, there is no evidence of the higher effect of intangible resources on performance, when estimates are compared to physical capital.

Even though results are not conclusive, the study has the merit to further extend the class of intangible resources, including balance sheet data that could proxy other aspect of intangible resources such as reputation deriving from advertising and marketing expenses. The problem related to this method is due to scarce data availability that can generate selectivity bias. The initial database, in fact, included 16,000 companies; due to the necessity of R&D data and Other Intangible data, the sample has then be reduced to

783 firm; the final sample, including only firms with all years data, resulted in only 404 firms.

3.4 Further issues: interdependence of intangible resources and dependence of results on performance measure used

The majority of the studies on intangible and firm performance focus on one or two intangible resource proxies that represent the type of knowledge capital they are interested in studying and utilise a production function approach.

Recently, studies have also investigated the effect that the interactions of different intangible resources have on firm performance on the basis of the consideration that, in order to improve performance, the different streams of knowledge owned by the firm need to be integrated, as postulated by the RBV (e.g Tsai and Wang, 2008, Ballot et al., 2001, Lin, 2007).

Tsai and Wang (2008) focus on the interaction among different types of innovation related intangibles: external knowledge acquisition and internal development capability. They argue that the extent to which the acquisition of external technological knowledge affects a firm's performance may also depend on internal R&D investment and suggests that the greater the level of a firm's internal R&D efforts, the stronger the positive effect of external technology acquisition on a firm's performance. Results of their study, based on a longitudinal sample of 341 Taiwanese firms in the electronics manufacturing industry in the period 1998-2002, show that returns to externally acquired technological capital are positively associated with the stock of R&D held by firms. These results underline the dual role of R&D capital: stimulating innovation but also strengthening absorptive capacity. The authors therefore suggest that “existing studies may underestimate the economic returns of R&D by failing to account for R&D-based absorptive capacity” (op. cit, p. 102). The fact that external technology acquisition is not significant, when not considered in relationship with other intangibles, underlines how the process of embedding and relating the different intangibles within the firm is crucial to improve performance, and how the organizational dimension of the analysis can provide better insights on how firms benefit from intangibles.

Ballot, et al (2001) examine the interaction effects of human capital and R&D capital on productivity; interactions between R&D stock and training stock are found to positively affect performance; this suggests the existence of complementarities between these two types of intangible assets.

Based on a cross-sectional sample of 155 banking firms, Lin (2007) investigates the interaction effects of IT capability and human capital investment. IT investments by themselves do not necessarily reflect the level of IT capability of the firm; it is therefore important to study the capability of the firm to use IT resources together with other types of resources. Results show a negative and significant interaction effect between human capital investments and IT capability on firm performance, implying that "IT and human capital can, to some degree, substitute for each other" (op. cit. 102). This is also suggested by the lower marginal benefits of IT capability found in firms with high-quality human capital. The results of this study confirm, again, the RBV of the firm: valuable knowledge assets of the firm are not easily codified and replaced with IT; IT is one if the elements of the organization that forms its knowledge capital. IT capability is essential to create value and it is not simply a business infrastructure that makes business more efficient.

As noticed for studies focusing on R&D capital, the effect of intangible resources varies not only with respect to the methodology used to measure them, but also according to the measure of performance used. The different measures of performance that have been used in the literature can be grouped in three classes: productivity measures, output measures and profitability measures.

Productivity and output growth are crucial measure of performance as firms with higher output growth and productivity are more likely to survive in the competitive environment (Loof and Heshmati, 2002). Some authors focus on labour productivity growth - the efficient use of resources to create value - measured either as value added over n. of employees (Crepon et al, 1998; Loof and Heshmati, 2002) or sales over n. of employees (Nesta, 2000, Heshmati et al, 2006). Others use growth in sales, total assets (Lybaert et al, 2006), or value added (Tsai and Wang, 2008; Ballot et al, 2001).

Firms that are more productive and have higher levels of output growth are likely to enjoy a higher profitability, another important measure of firm performance (Dedric et al, 2003).

Even though studies have not reached agreement over the magnitude of the effect, the existence of a positive effect of intangibles on productivity has been proven more extensively compared to their effect on profitability; this is especially true for innovation related intangibles, such as R&D.

Findings on the effect of other types of intangibles on productivity and output growth have appeared to be less robust. This phenomenon is likely due to the fact that intangibles often do not appear in quantifiable output measures; their effect on performance is of a qualitative type. Instead of increasing the amount of output, they improve the quality, the delivery and help satisfying customers' expectations (Brynjolfsson and Yang, 1996).

When using profitability financial measures, fewer studies have managed to reach conclusive results.

Gambardella et al. (2000) use both productivity and profitability measures; while they manage to show evidence of the effect of intangible resources on productivity, same results cannot be reached when the effect is analysed with respect to profitability, measured as market value and net profit over sales.

Lin (2007) uses five measures of performance: return on Equity (ROE), defined as net operating profit after taxes divided by the value of equity; Economic Value Added (EVA), defined as net operating profit after taxes minus a capital charge for the invested capital employed in the business (based on the weighted average cost of capital); Market Value Added (MVA), defined as the market value of equity minus a capital charge for the invested capital employed in the business; Market-to-book value ratio; Tobin's *q*. In this case the positive effect of intangibles (IT capital) is confirmed with respect to all the different measures used.

The reason behind the weaker evidence for the intangible effect on financial performance is likely due to the fact that when examining the relationship with financial measures, dynamics become even more complicated than with respect to productivity and a wider range of factors enter into the picture.

Furthermore, as for productivity, there is the chance that financial measures are not able to capture the effect of intangibles, particularly of those intangibles associated with the quality of output of the firm (such as customer service) and, only indirectly financial performance. Brynjolfsson and Yang (1996) suggest the use of market share and market value as better proxies. Market share could, in fact, capture the intangible effect on performance associated with the quality of output and improvements in the customer base; the use of market value instead is based on the assumption that investors are able to approximate the real value of intangibles beyond their effect on traditional financial measures of firms' financial statements.

3.5 Organisation capital and firm performance

The theoretical analysis of chapter 2 has concluded that, due to its features, Organisation Capital (OC) is the most important intangible resource of the firm.

The empirical evidence analysis performed in this chapter has shown that studies focusing on the impact of intangibles on performance have focused mainly on R&D and innovation related intangibles. More recently, other dimensions of firm's intangibles have been analysed: human capital, IT and advertising. The attention on these types of intangibles is due to the fact that there is relatively no consensus in the academia about their definition, even though different proxies are used to measure them.

As illustrated in chapter 1, OC is a type of resource that is formed by the interaction of different components; however, there is no consensus about what these components are. In chapter 2, OC has been mainly defined as the stock of codified knowledge (written norms and guidelines, databases), tacit knowledge (organisational routines and corporate culture, values, vision and principles of the organisation and cooperation agreements) and reputation, and has been indicated as the most valuable resource for sustainable competitive advantage, hence for firm performance. Notwithstanding this importance, to date, general empirical analysis on its contribution have been uncoordinated and sporadic (Black and Lynch, 2005) and have not reached firm conclusions.

The problems related to the different definitions of OC present in the literature have hindered the empirical proof of OC importance. As Black and Lynch (2005) argue, the proof that OC contributes to performance is problematic due to lack of consensus about what OC is, how to measure it and what the performance measure is that can capture it. While this proxy problem and the output problem also characterise the other types of intangibles analysed here, it can be said that for R&D, HC, Patents, advertising and IT, there is, at least, some sort of consensus regarding their definition. OC, as composed by the interaction of different firm resources at the organisational level, is more problematic to define. In short, it could be said that the problems seen when trying to define the category "intangibles" as a whole, reappear for OC.

As a result of the lack of an OC definition, researchers have chosen to proxy OC using data related to its elements: mainly information and communication technologies (ICT), training, Human Resource Systems (HRS) and workplace practice.

As seen in 3.3.2, some contributions focus on one of the components of OC: information and communication technologies. ICT is generally found to have a positive effect on performance, even though the magnitude varies across countries (e.g. Matteucci et al., 2005, Matteucci and Sterlacchini, 2005, Lin, 2007).

Level of training, also used to proxy human capital, is an appropriate proxy for organisational knowledge, even though it is not easily available as firms hardly track training expenses. Through specific training programs, in fact, the firm can decide which types of skills and competences to create in the labour force, render it context-dependent and generate organisational knowledge. Training level has been proven to positively influence firm performance (e.g. Ballot et al., 2001), even though results have not been as robust as for other intangible investments.

A consistent portion of empirical studies also proxy OC focusing on HRS and workplace practice. Early studies in the 80's mainly focused on HRS defined as quality-of-work-life and did not find a positive relationship with performance, probably due to the fact that quality of work life is not the main component of HRS that has an effect on organization. More recently, also thanks to better availability of data, studies have "re-defined" HRS as formed by flexible and team working job structures, cross-training, and incentive pay systems, and have managed to prove their positive effect on performance (e.g. : Bresnahan et al, 2002, Macduffie, 1995, Black and Lynch, 2004**).** These studies mainly use data collected in questionnaire surveys[13] based on questions related to peer-review of employee performance, job rotation, Total Quality Management, types of workers involved in training activities and level of employees' involvement in the decision process (Black and Lynch, 2005).

Macduffie (1995) focuses on HRS defined as employees knowledge embedded in routines and social interactions, and study the positive effect they can generate on performance by creating extremely hard to imitate organizational capabilities; HRS are therefore used as a proxy for OC. The study, based on an international data set of 62 automotive assembly plants in the period 1989-90, tests the effect of three indices representing different HRS practices on performance. Results indicate that flexible production systems, coordinating different HR practices and integrating them in the organization, outperform other systems, in so confirming the positive effects of HR systems on performance.

Black and Lynch (2005) define OC as workforce training, employee voice and work design. Employee voice represents a flexible organisation structure that gives autonomy and involves employees in the decision process[14], while work design includes management systems, monitoring, job rotation, and introduction of new IT. Results of their study, based on the manufacturing sector in the period 1933-1996, show that OC accounts for approximately 30% of output growth (Black and Lynch, 2004).

Other studies have attempted to measure OC as proxied by the entire organizational knowledge of the firm. DeCarolis and Deeds (1999) proxy organizational knowledge as generated by knowledge stocks and flows and test its effect in the biotechnology industry. Three proxies measure knowledge flows: alliances, R&D expenses and external knowledge, represented by an index built on the knowledge features of the geographical area. The two proxies measuring knowledge stocks are "products in the pipeline" and "firm citation", representing organizational knowledge in the form of intellect and research ability. Results show that external knowledge, products

[13] Some examples are: the Bureau of Labor Statistics Survey of Employer Provided Training; the EQW National Employers Survey; the British Workplace Industrial Relations Survey and the REPONSE (Relations Professionnelles et Negociations d'Entreprise) (Black and Lynch, 2005).

[14] Some examples of the practices that form this classt are: employees suggestion box, individual job enrichment schemes and self managed teams (Black and Lynch, 2005)

in the pipelines and firm citations significantly affect performance, in so confirming the importance of the management of stocks and flows of knowledge at the organizational level.

Finally, another branch of studies, instead of focusing on the single components of OC, analyzes the effect of OC focusing on the synergies among its different components (e.g. Lin, 2007).

Concluding, to date, efforts of researchers who have attempted to measure dimensions of OC have been "uncoordinated and sporadic" (Black and Lynch, 2005). There is evidence that ICT, training level, HRS and workplace organization matter, but there is no consensus about the definition, and measurement of OC.

The majority of the studies have been based on surveys; the methodology of collecting the answers, though, is very different across studies. Besides confusion on what to measure (and therefore what to ask), the identification of who to interview within the firm and how to formulate the questions in an understandable way also generate confusion. Finally, there is always the bias caused by personal interpretation of respondents and researchers and low response rate. For these reasons, the lack of solid empirical evidence for the effect of OC on performance is considered due more the scarce quality of data and to the limitations of the models used, than to wrong predictions of the "theory". We therefore believe that OC is a source of competitive advantage and that it has positive effect on performance based on theoretical considerations; we also believe that empirical evidence for this relationship, up to date, can be shown with better models and data availability.

The fact that, unlike physical capital, OC value does not appear in firm's balance sheets, and that investments in OC are usually treated as expenses and not as increases in firm's assets, has prevented the use of an OC proxy based on financial data, that could, in part, solve problems related to proxies based on survey answers (Black and Lynch, 2005).

In the following chapter, building on two recent studies (Lev and Rdhakrishnan, 2005, De and Dutta, 2007), I present a model that tries to measure OC's effect on performance using an income statement proxy that contains expenses made to build OC.

Chapter 4: Organization capital and firm performance. Empirical evidence for European firms

4.1 Organization capital and income statement: in search for a possible proxy

The previous analysis has shown the problems of definition and measurement that characterize intangible resources and, in particular, organization capital (OC). The accounting discipline considers physical capital as an asset, and therefore records it in the balance sheet; investments in intangible resources, instead, are generally recorded as expenses in the income statement, unless they satisfy the strict requirements imposed by the accounting standards. A methodology proposed by the literature to measure intangible resources has been based on the assumption that investments in intangible resources can be inferred from expenditure data, by capitalizing annual expenses through the perpetual inventory method and so obtaining a stock measure for intangibles. While this technique has been applied, and it is widely accepted - even though with the limits outlined in 3.1 - for what concerns the measurement of R&D stock, its application to other types of intangible resources has been more limited, probably due to the fact that R&D capital and expenses are easier to define and identify than other intangibles. Investments in OC, in particular, generally expensed in the income statement, are hard to identify and track as they relate to a variety of items whose expenses are recorded in different income statement items. This phenomenon has forced researchers aiming at measuring OC to search for proxies different from accounting data, based on indexes, qualitative data and survey answers.

Measuring OC on the basis of an accounting proxy would be particularly appealing as, if valid, would provide a relatively “objective” methodology for its measurement and the study of its effect on firm performance. It presents however, above all, the solution of the difficult problem related to the identification of the items to be taken as proxy for OC, as this resource is, at least, heterogeneous and collective – not to mention tacit. Besides the fact that a widely accepted definition of OC does not exist, investments (or expenses, to speak with the accounting discipline) in OC are often aggregated to other general expenses and not properly tracked. Nonetheless, two recent studies (Lev and Radhakrishnan, 2005; De and Dutta, 2007) have applied this technique to OC and have identified income statement items that could be a proper proxy for this intangible.

In order to justify the use of these proxies, it is necessary to consider how the authors define OC. Lev and Radhakrishnan (2005) define it as:

> "unique systems and processes employed in the investment, production, and sales activities of the enterprise, along with the incentives and compensation systems governing its human resources." (op. cit., p. 73);
> "agglomeration of technologies - business practices, processes and designs, and incentive and compensation systems – that together enable some firms to consistently and efficiently extract from a given level of physical and human resources a higher value of product than other firms find possible to attain." (op. cit., p.75)

The definition adopted by De and Dutta (2007) is similar; OC is

> "business processes, management structures and organisational systems specifically designed to maximise the value of output given available physical and human capital… (including)…quality management systems, supply chain management solutions and innovative processes for product development" (p.75).

According to these two definitions, the main components of OC are business processes, practices and systems for the everyday firm's activities, generated by investments (mainly, not exclusively) in:

- organizational practices
- information technology
- reputation enhancement;
- human resources
  - employee training (formal training, on-the-job training, mentoring programs)
  - incentive compensation systems

Besides this first definition, mainly formulated through the description of its main components, Lev and Radhakrishnan (2005) provide also a definition of OC through its main features. First of all, OC is collective in nature, due to the fact that it is generated by the interaction of human capital and physical capital and, therefore, belongs to the firm as an organization as a whole. The collective nature of OC renders it idiosyncratic, specific to the firm, and hard to transfer, as competitors cannot completely imitate it. For these reasons, it is a source of competitive advantage, can generate growth, and improve firm performance. The definitions used by Lev and Radhakrishnan (2005) and De and Dutta (2007) are similar and can represent the "operationalisation" of the definition of OC presented in chapter 2.

Even though Lev and Radhakrishnan (2005) and De and Dutta (2007) start from the same assumption – OC can be represented through an income statement proxy – and the definitions of OC proposed are similar; they reach different conclusions for what concerns the choice of the income statement item to use for the measurement of OC and the models used to measure its effect on company's performance.

Lev and Radhakrishnan (2005) choose Selling General and Administrative (SGA) expenses, based on the fact that this item includes many of the expenses that generate OC, such as employee training costs, brand enhancement activities, payment to systems and strategy consultants, IT outlays. De and Dutta (2007), instead, choose administrative expenses, which is defined as a "more focused variable" (op. cit., p. 75). This is based on the consideration that SGA expenses include a wide variety of items that do not concur to the creation of OC, while administrative expenses, a sub-class of SGA expenses, is a more precise variable. Although different, the two income statements can be said to be "of the same type"; they belong to the same class of expenses, with the difference that one is more comprehensive than the other. As the authors themselves admit, SGA expenses include items that do not concur to the creation of OC, such as strike expenses, distribution expenses, foreign adjustment costs; however, administrative expenses are also plagued by the same problem and may be too restrictive, excluding OC expenses that are instead considered by SGA expenses. An advantage of using SGA instead of administrative expenses is related to the availability of data; as the latter is a sub-item of the former, data retrieval can be harder. OC expenses, in fact, may be reported only at the "aggregated level" under SGA expenses, especially in worldwide databases that reorganize firms financial statements based on different accounting standards and templates. The limits of the proxies just outlined, however, do not jeopardize the novelty and validity of this method. Both income statement items, in fact, do include the bulk of the expenses that concur to the creation of OC, as above defined; both have its own pros and cons. SGA expenses are more available and comprehensive compared to administrative expenses; the former variable is likely to include more items that do not concur to the creation of OC; the latter includes the majority of OC expenses but risks to disregard OC expenses included in the former.

Selectivity bias can affect studies based on this method; when firms do not have data for the income statement item chosen to represent OC, in fact, this method brings to the paradox that the firm does not have any type of OC. This problem, however, also characterizes methodologies based on R&D expenses to proxy the innovation capital of the firm, which have been widely used in the literature.

The identification of an income statement proxy is only the first obstacle that has to be overtaken; once the proxy is identified, it has to be transformed into an OC measure, and placed into a model that can analyze its effect on firm performance. In the following, two different measurement methods and models will be illustrated; drawbacks and advantages will be identified and discussed. On the basis of this consideration, a new eclectic model to measure OC will be presented.

4.2 Organization capital and firm performance: two alternative methods based on income statement proxies

Following several studies that estimate the effect of intangibles on firm performance, to estimate the effect of OC, Lev and Radhakrishnan (2005) start with a production function in a Cobb-Douglas form, which assumes constant output elasticities, constant returns to scales and elasticities of substitution equal to 1, modeled as follows[15]:

$$Y_{it} = A_{0it} C_{it}^{b_c} R_{it}^{b_r} L_{it}^{b_l} u_{it} \qquad (4.1)$$

Where Y_{it}, C_{it} , R_{it} and L_{it} represent respectively revenues, physical capital, R&D capital and labour of firm i at time t, b_j with ($j = c, r, l$) represent the elasticities of output with

[15] In reality Lev and Radhakrishnan (2005) specify eq. 4.1 as follows: $Y_{it} = A_{0it} C_{it}^{b_{ct}} R_{it}^{b_{rt}} L_{it}^{b_{lt}} u_{it}$, therefore assuming time-varying output elasticities. However, they estimate the model in first difference which implies assuming that output elasticities are constant through time. For this reason, the model should therefore be written as in eq. 4.1.

respect to input j and u_{it} is a random error term. OC is represented here by A_{0it}. Taking the logarithm of expression 4.1 the production function is expressed in the following terms:

$$\log(y_{it}) = \log(a_{0it}) + b_c \log(c_{it}) + b_r \log(r_{it}) + b_l \log(l_{it}) + u_{it} \tag{4.2}$$

By estimating equation 4.2, OC is thus represented by the residual of the production function; this method, however, produces “black-box” estimates of OC. The residual is, in fact, a measure of Hicks-neutral efficiency that could measure the OC effect, but it is, more generally, an overall measure of production efficiency and technical progress change. On this ground, the authors model OC as follows:

$$\log(a_{0it}) = b_{0t} + b_{0s} \log(s_{it}) \tag{4.3}$$

Where s_{it} represents SGA expenses of firm i at time t. The total OC is therefore decomposed in two types of capital: b_{0t}, common OC, and $b_{0st} \log(s_{it})$, firm-specific OC. The firm SGA expenses are assumed to be an endogenous variable depending on current revenues as revenue increases generate increases in firm size to which the firm adjusts by increasing SGA expenses. SGA expenses are also assumed to depend on SGA expenses of the year before, as many investments in OC are multiyear programs. SGA expenses are therefore modeled as follows:

$$\log(s_{it}) = g_{0t} + g_{1t} \log(y_{it}) + g_{2t} \log(s_{it-1}) + u_{it} \tag{4.4}$$

For this reason, the estimation method used is a two-stage least square regression with a one-year lag for SGA expenses as an instrumental variable. Practically, s_{it} is estimated through equation 4.4, and its fitted value is used to estimate the production function (eq. 4.2). In order to eliminate the effect of unobserved firm heterogeneity, the variables are transformed in growth rate form; thus the system of two equations to be estimated looks like the one shown in equation 4.5 and 4.6, with an extended Cobb-Douglas production function that includes R&D stock and OC.

$$\log\left(\frac{y_{it}}{y_{it-1}}\right) = b_{0t} + b_{0s} \log\left(\frac{s_{it}}{s_{it-1}}\right) + b_c \log\left(\frac{c_{it}}{c_{it-1}}\right) + b_r \log\left(\frac{r_{it}}{r_{it-1}}\right) + b_l \log\left(\frac{l_{it}}{l_{it-1}}\right) + \Delta u_{it} \tag{4.5}$$

$$\log\left(\frac{s_{it}}{s_{it-1}}\right) = g_{0t} + g_1 \log\left(\frac{y_{it}}{y_{it-1}}\right) + g_2 \log\left(\frac{s_{it-1}}{s_{it-2}}\right) + \Delta u_{it} \tag{4.6}$$

The second stage of the model aims at producing an estimate of the annual monetary contribution of OC. This is done by using the results provided by the estimated eq. 4.5. The annual monetary contribution of OC is in fact estimated by the difference in predicted revenues with and without OC (as measured by SGA expenses) as described in the following equations:

$$OC_{it} = y_{it}* - y_{it}** \tag{4.7}$$

where OC_{it} represents the estimated annual monetary contribution of OC, $y_{it}*$ represents expected revenues with OC and $y_{it}**$ represents expected revenues without OC, that is

$$y_{it}* = y_{it-1} \exp\left[\hat{b}_{0t} + \hat{b}_{0s} \log\left(\frac{s_{it}}{s_{it-1}}\right) + \hat{b}_c \log\left(\frac{c_{it}}{c_{it-1}}\right) + \hat{b}_r \log\left(\frac{r_{it}}{r_{it-1}}\right) + \hat{b}_l \log\left(\frac{l_{it}}{l_{it-1}}\right)\right] \tag{4.8}$$

$$y_{it}** = y_{it-1} \exp\left[\hat{b}_c \log\left(\frac{c_{it}}{c_{it-1}}\right) + \hat{b}_r \log\left(\frac{r_{it}}{r_{it-1}}\right) + \hat{b}_l \log\left(\frac{l_{it}}{l_{it-1}}\right)\right] \tag{4.9}$$

Lev and Radhakrishnan (2005) argue that OC represents an unmeasured resource that is not reflected in a firm's book value. Accordingly, for this to be a good measure of OC, it should be significantly related to the difference between book value and market value. To be sure, as several OC items rely on IT infrastructure, it should also be related to IT expenses. The co-authors test these two hypotheses to back up the validity of their results.

The model illustrated above is tested on a sample of 90,237 US large firms (annual sale and total assets greater than $5 million) divided in firms with R&D capital (32,979) and firms without R&D capital (57,258) over the period 1978-2002. Results show that all the independent variables have a positive effect on dynamic performance, but firm-specific OC has the highest elasticity. In firms without R&D, the effect of the firm-specific OC growth is higher than in firms without R&D (58% versus 41%); this suggests, according to the co-authors, that firms without R&D stock use OC to compensate for the absence of R&D to sustain their competitive advantage. The average contribution of OC to sales growth is estimated to be $96 million, which is 4% of average sales and almost 100% of mean annual change in sales.

These results back up the view that sees OC as the main intangible of the firm, the resource that is mainly responsible for superior firm performance. Some remarks, however, have to be made regarding the assumptions on which the model and the estimation method rest.

Assumption n.1: firm's OC is measured by the production function residual

At first, the model assumes that OC is estimated by the production function residual (eq. 4.2); but the residual is a measure of Hicks-neutral efficiency that measures production efficiency and technical progress change and therefore provides "black-box" estimate of OC. For this reason, OC is decomposed into OC common to all firms and firm-specific OC, as proxied by SGA expenses. However, this is only an apparent solution; in fact, even in this second methodology, OC is still measured by the production function residual (Bresnahan, 2005). Firm-specific OC is the part of the residual explained by SGA expenses; common OC is the part of the residual not explained by SGA expenses. Therefore, the objections raised to the specifications of eq. 4.2 are similar to the ones that can be raised to the model as specified in eq. 4.5. The residual estimate may well include OC; but we cannot take it as a pure measure for OC, as we cannot isolate the effect of the other factors as well included. As outlined by Abramovitz (1956), the residual measures the shift in the production function given a certain level of inputs, and has been mainly identified with technical change. Given this interpretation, the use of the residual to estimate OC would provide a measure that includes only costless improvements in the way inputs are transformed into output and, more than an OC measure, it would be a measure of the overall technological change and production efficiency improvements due not only to OC, but also to other factors. Furthermore, as outlined by (Solow, 1957) besides being a measure of technical efficiency, the residual also includes "unwanted" effects (Hulten, 2001) due to measurement errors, aggregation bias and model misspecification, in so resulting in a "Measure of our ignorance" Abramovitz (1956)[16].

[16] The infinite debate on what the residual actually measures also has advocates of the idea that the residual is actually a good measure of technological efficiency when the model is well specified and does not include measurement errors (Jorgenson and Griliches, 1967, 1972); however other studies (e.g. Deninson,

This remark obviously casts doubts also with regards to the estimation of the annual monetary contribution of OC, which is based on the estimates of eq. 4.5. Even accepting the validity of this method, it is not clear how the difference for the sample with R&D and without R&D is taken into consideration. There is only one estimate of OC that is provided; but this estimate is derived from eq. 4.5, which has different results according to the sample taken into consideration. OC annual monetary contribution should therefore be calculated considering the different effect that the production factors have for firms with and without R&D, as should any comparison between OC annual monetary contribution, average sales and average annual sale increase.

Assumption n. 2: the elasticity of organization capital is equal to 1

The estimates of eq. 4.5 produce the elasticities[17] of the production function inputs; but do not provide the elasticity of OC. The coefficients b_{0t} and b_{ost}, in fact, are not the elasticities of OC, which is instead, evidently, assumed to be equal to 1. This appears clearly from eq. 4.1, as the exponent of A_{0it} - which measures OC - is actually equal to 1. This assumption lacks a theoretical foundation and cannot be justified; furthermore, it implies assuming that the production function has increasing returns to scale, which should be tested and however contradicts the authors' statement that the model assumes "constant returns to scale" (op. cit., p. 77).

Assumption n. 3: current SGA expenses depend on current sales and previous SGA expenses

The estimation method rests on the hypothesis, not tested, that current SGA expenses are endogenous and depend from current sales and previous SGA expenses.

The positive relationship between current level of output and current level of SGA expenses is justified by the fact that when revenues increase, "business processes and practices need to be scaled up to accommodate the delivery of products and services for the larger base of customers" (Lev and Radhakrishnan, 2005, p. 79); the implicit

1972) have tried to demonstrate that this conclusions were due to peculiarities of the samples considered such as time effects and business cycles (Hulten, 2001).

[17] Lev and Radhakrishnan (2005) mistakenly refer to them as marginal productivities. Marginal productivity measures the unit change in output deriving from a unit change in input $(\partial Y / \partial X)$; elasticity, instead, is the percentage increase in output resulting from a 1% increase in input $(\partial Y / \partial X)(X / Y)$; here, taking as an example R&D stock, marginal product is: $b_r a_{0it} c_{it}^{b_c} l_{it}^{b_l} r_{it}^{(b_{cr}-1)}$; elasticity is b_r.

assumption behind this hypothesis is that an increase in revenues generates a contemporaneous increase in firm size to which the firm immediately adjusts by increasing SGA expenses. This can be true for certain items included in SGA expenses but not for all of them. For example, it is reasonable to believe that distribution expenses, included in SGA expenses, obviously increase with increase in revenues. It is reasonable to assume that revenue increases require adjustments in the organization brought about by more flexible business processes and design; investments in the latter are, in fact, investments expensed in SGA expenses. Some perplexity comes from the fact that it is plausible to assume that the firm would operate such adjustments at least with one lag with respect to the increase in revenue, and not immediately. Finally, it could be possible that an increase in revenue could generate an immediate increase in training expenses, another fundamental aspect of SGA expenses. An increase in revenue can require an increase in training from a qualitative point of view, as the introduction of new business processes and design, required by an organization that has to deal with a greater production scale, may require further training of the existing workforce; and/or from a quantitative point of view, as the new organization may require a larger workforce that needs to be trained. However, this contemporaneous relationship would require a great adjusting capacity of the firm. It can be concluded that current SGA expenses could be in fact endogenous, given their nature; but it could also be the case that this relationship would require some lags to be verified. The conclusion of this argument is that the endogeneity should be tested and not assumed. A last note has to be made. This does not necessarily jeopardize the inverse relationship, i.e. that current SGA expenses determine current sale, as in this case there is no assumption to be made about the capacity of the firm to immediately adjust to changes.

The second relationship that is assumed is between current SGA expenses and SGA expenses of the year before. This is due to the fact that organization changes may take time; therefore including the effect of SGA expenses of the previous year provides a better estimate of current SGA expenses. From a logic point of view, the relationship between current and previous SGA expenses could be reasonable; many investments in OC are in fact multiyear programs. The effect of previous SGA on present SGA expenses is fundamental to estimate this model with the two-stage least square procedure. If we look at the way in which current SGA expenses is constructed (eq. 4.4), it is apparent that a non significant s_{it-1} would generate multicollinearity in the estimation, as s_{it} would be a linear combination of the regressors present in the production function. The results of Lev and Radhakrishnan (2005) show that, for both firms, with R&D and without R&D stock, s_{it-1} is significant (R&D firms .21; non R&D firms .18), and this eliminates the multicollinearity problem. In case s_{it-1} would not be significant, if we had to keep the assumption that current revenues determine current SGA expenses, we would need an alternative method to estimate the model[18].

Consider eq. 4.2, which is reproduced here for the ease of the reader:

$$\log(y_{it}) = \log(a_{0it}) + b_c \log(c_{it}) + b_r \log(r_{it}) + b_l \log(l_{it}) + u_{it} \qquad (4.2)$$

If SGA expense is, as assumed, an endogenous variable, the elasticities will be composed by two separate effects: the effect that the single variables have on output, and the effect that the variables have indirectly on output, through their effect on SGA expenses. As we are interested in identifying the direct effect of each single variable on output, we could decompose the elasticities as follows. After estimating elasticities of equation 4.2 we could estimate eq. 4.4 (i.e. $\log(s_{it}) = g_{0t} + g_1 \log(y_{it}) + g_2 \log(s_{it-1}) + u_{it}$) and obtain estimates of current SGA expenses, after taking into consideration the effect of revenues and SGA expenses of the previous year. In case of multicollinearity, the substitution of eq. 4.2 into equation 4.4 would obtain a non significant coefficient for SGA expenses at *t-1*; eq. 4.4 could therefore be rewritten as in the following:

$$\log(s_{it}) = \alpha_{0t} + \alpha_c \log(c_{it}) + \alpha_r \log(r_{it}) + \alpha_l \log(l_{it}) + u_{it} \qquad (4.10)$$

Eq. (4.10) would give the elasticities of SGA expenses with respect to other inputs, and the estimated $\log(s_{i,t})$. After estimating equation 4.2 and 4.10 we could estimate the equation of interest:

$$\log(y_{it}) = \beta_{0t} + \beta_c \log(c_{i,t}) + \beta_r \log(r_{i,t}) + \beta_l \log(l_{i,t}) + \beta_s \log(s_{i,t}) + u_{it} \qquad (4.11)$$

[18] Acknowledging the weaknesses of the model of Lev and Radhakrishnan (2005), I have nevertheless applied their methodology to the dataset. Results have, in fact, showed the presence of multicollinearity caused by a non significant effect of previous SGA on current SGA expenses.

where the coefficients β_j *(j = c, r, l, s)* represent the elasticities of revenues with respect to inputs, after taking into consideration the correlation between SGA expenses and revenues. By substituting the equation 4.10 into equation 4.11 we would obtain:

$$\log(y_{it}) = (\beta_{0t} + \beta_s\alpha_{0t}) + (\beta_c + \beta_s\alpha_c)\log(c_{i,t}) + (\beta_r + \beta_r\alpha_r)\log(r_{i,t}) + (\beta_l + \beta_l\alpha_l)\log(l_{i,t}) + u_{it} \tag{4.12}$$

where $\log(a_{0it}) = (\beta_{0t} + \beta_s\alpha_{0t}),\ b_c = (\beta_c + \beta_s\alpha_c),\ b_r = (\beta_r + \beta_r\alpha_r),\ b_l = (\beta_l + \beta_s\alpha_l)$. We would therefore be in front of a linear equation system in four equations and five unknown variables that would force us to add a further condition in order to reach a solution. We could assume a production function with constant returns to scale (i.e: $\beta_c + \beta_r + \beta_l + \beta_s = 1$); by adding this condition we would be able to solve the system and analyze the elasticity of output with respect to inputs, without worrying about the multicollinearity problem caused by the relationship between current revenues and current investment in OC. This methodology, presented just to show that even in case of multicollinearity the model could still be estimated, has a weak point however: it relies on the assumption that the production function has constant returns to scale, which can't be taken for granted and therefore should be tested[19].

Assumption 4: firm heterogeneity is constant over time

The estimated model is in first difference. The assumption behind the model in first difference is that the error term of the correspondent model in level is a composite error given by a systematic error representing firm heterogeneity and assumed constant over time, and by a time-varying error. By taking the logarithms of annual changes, the systematic component of the error gets "differenced away" and therefore eliminates the possible bias present in the models in levels, due to unobserved firm heterogeneity. In order for this model to hold, it must be assumed that the composite error is uncorrelated with the regressors, therefore that the idiosyncratic error u_{it} is uncorrelated with the regressors at time *t* and *t-1*. This is not necessarily reasonable, however, as there is also

[19] Besides the fact that the model is based on an assumption – constant returns to scale – that I believe should be tested, results obtained from the application to this model to the dataset have been inconclusive and indicated the inappropriateness of the model to describe the relationship under investigation.

the possibility that the condition would not hold, in which case the estimators would be biased.

In spite of these methodological problems, the results of Lev and Radhakrishnan study confirm the view according to which OC is indeed the most important intangible for firm performance; the weaknesses of the model just outlined cast doubts on the possibility to draw firm conclusions. The test performed to back up results gives a positive outcome: the annual monetary contribution of OC is indeed correlated with IT expenses and market to book value; however this cannot be taken as a true validation of the test as the correlation could be generated by other factors and flows of causation besides OC.

A second recent (De and Dutta, 2007) study has proxied OC using an income statement item similar to SGA expenses; however it has modeled OC and studied its effect on performance using a different measurement method and model in the attempt to improve the model of Lev and Radhakrishnan (2005)

De and Dutta (2007) start from an assumption similar to Lev and Radhakrishnan (2005): OC is, in fact, proxied by expenses in OC. Besides the fact that the chosen income statement item differs from SGA expenses, used by Lev and Radhakrishnan (2005), the main novelty of their methodology is the way in which OC stock is calculated. Administrative expenses – the proxy used for OC – are capitalized using the perpetual inventory method through a methodology similar to the one adopted to derive R&D stock from R&D expenses. The authors consider the fact that only a small percentage of administrative expenses concur to the creation of OC capital and that this process requires time; on this ground, they create two measures of OC stock. The first measure is built by capitalizing 10% of annual administrative expenses and using a 20% depreciation rate; the second measure instead capitalizes 20% of annual administrative expenses using a 10% depreciation rate. They use the measure so obtained to estimate a “new economy production function” in the Cobb-Douglas form, extended to include the effect of intangibles – namely OC and brand capital:

$$Y_{it} = A_{it} K_{it}^{\kappa} H_{it}^{\alpha} B_{it}^{\beta} OC_{it}^{\psi} \tag{4.13}$$

where Y_{it} represents sales of firm *i* at time *t*, K_{it} is physical capital, H_{it} is human capital, B_{it} is brand capital and OC_{it}, A_{it} represents time and firm specific technology and productivity factors. The intangibles here considered are different from those included in Lev and Radhakrishnan model (R&D stock and OC). Instead of R&D stock, De and Dutta model includes, besides OC, another type of intangible, brand capital, defined as "the intangible resulting from advertising and marketing expenditures that result in a positive image of the firm in the market and help it secure future orders" (De and Dutta, 2007, p. 75). Brand capital is built using the same methodology used to build OC; half of annual marketing and advertising expenses are capitalized with the perpetual inventory method using a 60% geometric depreciation rate, on the basis of the documented short service life of advertising. Wages are used to proxy human capital; this is justified by the nature of the industry under exam, where it has been documented that wages well reflect the experience and talents of individuals. The exclusion of R&D stock from the model is also justified by the features of the industry that does not invest in R&D. The model, that includes besides physical capital, three types of intangibles – OC, brand capital and human capital - is tested on a sample of 165 Indian firms belonging to the IT software industry, using firm-level panel data spanning from 1997 to 2005.

Results show that OC has a strong effect on output, measured as sales: elasticity is around 1.00, higher than elasticities of other inputs (physical capital is about 0.08, brand capital 0.03 and human capital 0.18). Results are quite robust across the different specifications (level and difference) and estimation methods used (GMM and OLS).

In De and Dutta (2007) model, unlike in Lev and Radhakrishnan (2005), OC is considered a factor of production, not a production function residual. The main concerns relate to the main novelty of the study: the measurement of OC through the perpetual inventory method. This has been widely done in the literature for R&D stock (e.g. Griliches, 1979, Griliches and Mairesse, 1981, Mairesse & Sassenou, 1991, Hall, 1990) another intangible resource; therefore, in principle, there should be no objections to its application to OC. The same problems that this method creates with regard to R&D stock (outlined in 3.1) however, arise also with respect to OC; to our knowledge, this methodology has been used only by De and Dutta (2007), therefore the usual worries about proper obsolescence rate, length of the series of expenses to use, lag, are exacerbated as not deeply studied yet. While the application of the perpetual inventory method to R&D expense to build R&D stock has been tested in different versions (for example different obsolescence rates and R&D expenses series length) by several studies, similar efforts have not been done for OC. The percentage of administrative expenses to capitalize is therefore chosen somehow in an arbitrary way by De and Dutta (2007) as it is the obsolescence rate to use. However we think that this choice is acceptable on an empirical ground; the obsolescence rate of 10% and 20% are similar to the ones normally used for R&D stock, which can be a reasonable assumption given the similar properties of the two different intangibles. More doubts regard the percentage of expenses to capitalize and further studies could clarify better the nature of these expenses and provide a better idea about the true OC expenses percentage included in administrative expenses.

In brief, the model by De and Dutta (2007) seems more sound than the one adopted by Lev and Radhakrishnan (2005); De and Dutta start from a measure of OC stock and then estimate elasticity of output using a Cobb-Douglas production function; Lev and Radhakrishnan (2005) instead do not reach a measure of OC stock, assume elasticity of OC equal to 1 and do not consider it a factor of production as they estimate it from the production function residual. Both studies however have the merit to attempt to estimate the effect of OC using financial statement data.

In the following, building on these studies, I formulate a model and measure the effect of OC capital on firm performance on a sample of European firms. The new model here proposed is somehow an eclectic version of the two models just described, and attempts to integrate their strengths. Briefly, we borrow the proxy to measure OC (SGA expenses) from Lev and Radhakrishnan (2005) and we test for the presence of endogeneity of OC, assumed by the authors; we consider OC an input of the production function and we measure it by applying the perpetual inventory method to part of OC expenses as in De and Dutta (2007). The new model here presented, however, proposes a more flexible production function with respect to the Cobb-Douglas, which has the advantage of imposing less strict assumptions on the production process. In 4.3 the variables, the model and the estimation method are described, commented and a rationale is provided; 4.4 analyses the dataset and results are reported and commented in 4.5. 4.6 sums up the main conclusions and final comments.

4.3 Organization capital and firm performance on a sample of European firms: Organization capital measurement, model and estimation method

4.3.1 Measurement of variables

To measure OC, we follow the recent trend that measures intangible stock from income statement proxies (i.e. expenditure data). Between the two proxies proposed and described in 4.1, SGA expenses and administrative expenses, I chose the former on the ground that SGA expenses is more comprehensive; using only administrative expenses could exclude other investments in OC. As previously explained, in fact, the two measures differ as administrative expense is a sub-class of SGA expenses. Administrative expenses is surely the item that include the majority of OC expenses; SGA expenses includes administrative expense but also selling expenses, that refer mainly to distribution expenses and therefore do not generate OC. However, general expenses, the other type of expenses included in SGA expenses, is a heterogeneous class that includes different items; the criteria to classify expenses under general or administrative are often subject to different interpretation, and therefore we believe that taking only administrative expenses could exclude important expenses related to the creation of OC. To partially limit the OC measure bias due to the fact that SGA expenses also include expenses that do not generate OC, I take only a percentage of SGA annual expenses. We believe that SGA expenses are a better proxy also for a second order of reasons related to the availability of the data. As administrative expenses are a sub-item of SGA expenses, it is in fact harder to retrieve this data due to the fact that databases often report only the aggregated SGA expenses (or its correspondent in income statement templates that use different denominations).

Based on De and Dutta (2007) we consider only 20% of SGA expenses through the perpetual inventory method with an obsolescence rate of 10%. We believe that considering only the 20% of SGA expenses is appropriate and allows to take into consideration the fact that only part of SGA expenses actually contribute to the creation of OC and that this process takes time (as observed by De and Dutta, 2007). The obsolescence rate of 10% is preferred to the 20% (other obsolescence rate proposed) based on the comparison with the obsolescence rate used to calculate R&D stock. R&D stock, the other intangible included in the model, is in fact computed using a 20%

depreciation rate (as in the literature, e.g. Lev and Radhakrishnan, 2005); even though R&D stock and OC have similar properties that justify the application of a similar methodology to measure them, we believe that OC is more tacit, firm-specific and harder to imitate. For this reason, in order to differentiate the two different intangibles, a lower depreciation rate (10% instead of 20%) is considered more appropriate for OC[20].

I test the effect of OC, measured as described above, on two different measures of firm performance: output and profitability. To proxy firms' output I use firm's sales; firm's incomes are used as proxy for profitability. The analysis of the effect on profitability helps to understand the effect of OC in a more comprehensive way; while output and output growth are, in fact, proxies for firm performance that are strongly influenced by firm structural factors, profitability is not, or, at least, not in the same measure. The effect of OC on output is analyzed also by De and Dutta (2007) and Lev and Radhakrishnan (2005); the analysis with respect to profitability represents an improvement with respect to these two models.

4.3.2 The model and estimation procedure

We consider a production function process that uses four inputs to produce output:

$$Q_{it} = A_{it} f(K_{it}, L_{it}, R_{it}, OC_{it}) \tag{4.14}$$

where Q_{it} is the *i*th firm's output at time *t*, A_{it} captures unobservable differences in production efficiency and time effects, K_{it} represents physical capital, L_{it} represents labour, R_{it} is R&D stock and OC_{it} is OC. We model the production function in the Cobb-Douglas form:

$$Q_{it} = A_{it} K_{it}^{\beta_1} L_{it}^{\beta_2} R_{it}^{\beta_3} OC_{it}^{\beta_4} \tag{4.15}$$

Taking the logarithm of equation 4.15, the final model is:

$$q_{it} = a_{it} + \beta_1 k_{it} + \beta_2 l_{it} + \beta_3 r_{it} + \beta_4 oc_{it} \tag{4.16}$$

[20] De and Dutta (2007) shows that the two different measures of OC proposed produce fairly robust results and that the pronounced difference between them disappears once the variables are expressed in log form. Even though both measures are indicated as appropriate, we have chose to capitalize 20% annual SGA expenses with a 10% obsolescence rate for the conceptual reason explained above.

where q_{it} is the log of output, a_{it} is the log of time and firm-specific effects, k_{it} is log of physical capital, l_{it} is log of labour, r_{it} is log of R&D stock and oc_{it} is log of OC. The coefficients β_n *(n = 1, 2, 3, 4)* represent the elasticities of output with respect to inputs, i.e. the percentage change in total output when the amount of input changes by 1%.

The Cobb-Douglas functional form (Cobb and Douglas, 1929) has been proven to be a good description of technology and satisfy the properties usually required for the production function, such as diminishing marginal productivities (Hayashi, 2000).

In this specification returns to scale are given by the sum of the coefficients β_n. Two major assumptions are implied by such a model: returns to scale do not change with the level of production and the elasticity of substitution is constant and equal to one.

The literature has also modeled the production function in more flexible forms, such as the transcendental logarithmic (or translog) functional form, first introduced by Berndt and Christensen (1973). The translog is a useful generalization of the Cobb-Douglas that has both linear and quadratic terms; it is conceptually simple and has been widely used in empirical analysis to study technical change and productivity growth (May and Denny, 1979; Humphrey, Moroney, 1975), input substitution (Berndt and Christensen, 1973) and returns to scale (Kim, 1992). With respect to the Cobb-Douglas, the translog does not impose restrictions on output elasticities and elasticities of substitutions; the former, in fact, are not assumed to be constant but depend on levels of inputs and the latter are not assumed to be equal to one. For these reasons we also model the production function in the translog form and we compare the results reached with the two different specifications.

The general form of the translog function

$$\ln y = A_o + \sum_{i=1}^{N} \beta_i \ln x_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} \ln x_i \ln x_j \quad (4.17)$$

here becomes, taking the logs

$$\begin{aligned} q_{it} &= a_{it} + \beta_k k_{it} + \beta_l l_{it} + \beta_r r_{it} + \beta_o oc_{it} + \gamma_{kk}(k_{it})^2 + \gamma_{ll}(l_{it})^2 + \gamma_{rr}(r_{it})^2 + \gamma_{oo}(oc_{it})^2 \\ &+ \gamma_{kl}(k_{it}l_{it}) + \gamma_{kr}(k_{it}r_{it}) + \gamma_{ko}(k_{it}oc_{it}) + \gamma_{rl}(r_{it}l_{it}) + \gamma_{ro}(r_{it}oc_{it}) + \gamma_{lo}(l_{it}oc_{it}) \end{aligned} \quad (4.18)$$

where the dependent and independent variables are expressed in log form. In eq. 4.18, the individual parameters of the translog function are not readily interpretable and do not represent elasticities as in the Cobb-Douglas. Indeed, given that the elasticities are given by the partial derivatives of output with respect to input

$$\frac{\partial q}{\partial X_i}\frac{X_i}{q} = \frac{\partial \ln q}{\partial \ln X_i} \quad (4.19)$$

in this model elasticities are therefore given by the following four equations:

$$\varepsilon_{kt} = \beta_k + 2\gamma_{kk}k_{it} + \gamma_{kl}l_{it} + \gamma_{kr}r_{it} + \gamma_{ko}oc_{it} \quad (4.20.a)$$

$$\varepsilon_{lt} = \beta_l + 2\gamma_{ll}l_{it} + \gamma_{kl}k_{it} + \gamma_{rl}r_{it} + \gamma_{lo}oc_{it} \quad (4.20.b)$$

$$\varepsilon_{rt} = \beta_r + 2\gamma_{rr}r_{it} + \gamma_{kr}k_{it} + \gamma_{rl}l_{it} + \gamma_{ro}oc_{it} \quad (4.20.c)$$

$$\varepsilon_{ot} = \beta_o + 2\gamma_{oo}oc_{it} + \gamma_{ko}k_{it} + \gamma_{ro}r_{it} + \gamma_{lo}l_{it} \quad (4.20.d)$$

Due to the nature of the model, including R&D stock, and to the fact that not all firms in the sample report R&D expenses, we divide the dataset in two sub-samples: R&D firms and non R&D firms. The model is estimated separately on the two sub-samples.

I start by estimating the effect of OC and production function inputs on firm's productivity.

I estimate eq. 4.16 in levels (year 2006) with the OLS procedure; in order to justify the use of this estimator some conditions have to hold. The linearity condition is obviously satisfied by taking the logs of variables. The assumption of no correlation in the error terms of different observations could be made false in principle presence of knowledge spillovers among closely located firms; however, due to the wide geographical area considered, its inter-industry nature, and the dispersion of the firms, spillover effects are not expected to invalidate this assumption.

For what concerns the strict exogeneity assumption, it seems reasonable to assume, given the cross-section nature of the data, that x_i is independent from u_j for $i \neq j$. Problems instead arise concerning the assumed independence of x_i and u_i as this would imply that input quantities are chosen with no regard to the firm level efficiency. For the same reason output could be endogenous: this would be the case if level of output would depend on firm efficiency. Finally, there is no a priori reason to assume that errors are identically distributed. Heteroskedasticity does not generate inconsistent or biased estimators; however, it would render inference useless, as the standards errors and *t* statistics would be miscalculated (Wooldridge, 2003).

In order to check the strict exogeneity assumption I estimate eq. 4.16 instrumenting regressors through log of physical capital, labour and R&D stock of the previous year and SGA expenses of the previous year. In order to control for sector and country effects, dummies are included in the regression; results report only significant dummies, selected through the Wald test. The Cook-Weisberg test is performed on the residuals of the regression in order to check for the presence of heteroskedasticity; if the null hypothesis is rejected (i.e. errors are heteroskedastic), we re-estimate the regression using the OLS robust procedure (White variance-covariance estimators)[21]. The true model is then compared to the instrumented model through the Hausman test. Results show that we can confirm the strict exogeneity assumption; therefore we can rely on the estimates of the true model without the need to use instrumental variables.

The descriptive statistics of the dataset show the likely presence of severe outliers; for this reason I also estimate eq. 4.16 with Huber and Tukey biweights to control for the influence of outliers; results are compared.

As the Cobb-Douglas form imposes restrictions on the elasticities of output and elasticities of substitutions, we estimate the more flexible translog model (eq. 4.18). Also in this case results of the Cook-Weisberg test establish whether or not perform a simple OLS regression or a robust OLS regression; country and industry significant effects are selected through the Wald test on the regression dummies. If the log-quadratic and interaction terms are not significant, the translog goes back to be a simple Cobb-Douglas and its estimation is useless; through a Wald test on the log quadratic and interaction terms we are able to determine whether or not the translog function is preferable and captures effects that the Cobb-Douglas form is not able to capture. The Wald test almost always rejects the null hypothesis of joint non significance of the log-quadratic and interaction terms; therefore we can conclude that the translog function is a better model.

Elasticities of output are calculated using eq. 4.20.a-d. In search for the best model, we use the Wald test to identify a simplified version of the translog that only includes significant log-quadratic and interaction terms; once these are selected, the new version of the translog function is re-estimated and the corresponding elasticities of output are calculated and reported. The same procedure is performed on the translog function estimated using Huber and Tukey biweights to control for the influence of outliers.

It should be stressed that the results so obtained from level-estimates could be biased due to the presence of unobserved firm-heterogeneity. We assume that firm-heterogeneity is constant over time and that the u_{it} and u_{it-1} are not correlated; we then estimate eq. 4.16 in first difference, and "difference away" firm-heterogeneity that could be a cause of bias estimates in the model in levels. Results of the model in first difference can then be used to back up the validity of the overall model and estimates. The model in difference is again estimated using OLS and therefore the conditions required by this estimator need to be verified. As seen for the model in levels, the more problematic assumptions concern the strict exogeneity and homoskedasticity. Problems of data availability do not allow us to check for the endogeneity of physical capital and labour; however, based on results of the model in level, we can exclude that regressors are endogenous. Some doubts are related to the endogeneity of OC stock, due to the nature of current expenses of the proxy on which the stock is built on; as a matter of fact, SGA expenses are taken as endogenous variable by Lev and Radhakrishnan (2005). We therefore estimate eq. 4.16 in first difference by instrumenting OC through SGA expenses from the period 2000-2004; the Cook-Weisberg test on the residuals of the regression indicates whether or not use the OLS robust procedure. The instrumented model is compared with the true model using the Hausman test; also in this case we can conclude that OC is not an endogenous variable and therefore we can rely on the true model estimates. Using the same methodology described for the model in levels, the first difference Cobb-Douglas production function is compared to the first difference translog function; the translog function is simplified by including only the significant log-quadratic and interaction terms selected with the Wald test and elasticities of output are calculated. The first difference Cobb-Douglas and translog production functions are also estimated using Huber and Tukey biweights to control for the influence of outliers. Results in the different specifications are compared.

In addition to the effects of OC on firm's output, we check whether or not the same conclusion holds with respect to profitability by regressing inputs on income, using eq. 4.16 (Cobb-Douglas form) and eq. 4.18 (translog form) and the same *modus operandi*. OLS is still the estimation method preferred, and the Cook-Weisberg tells us whether or not to adjust for heteroskedasticity in the residuals. In this case there is no reason to believe that the strict exogeneity assumption is not respected, given the different dependent variable used; the model is also estimated controlling for the presence of outliers. Unfortunately, due to missing income values for the year 2005, the model can only be tested in levels, therefore results could be biased due to unobserved firm heterogeneity effects.

In brief, we measure OC by capitalizing 20% of annual SGA expenses and an obsolescence rate equal to 10%. OC effect on output is then measured using an extended Cobb-Douglas production function that includes, besides the traditional input of physical capital and labour, intangible resources, namely OC and R&D stock. A more flexible functional form is then proposed: the translog function, which does not impose restrictions such as constant output elasticities and elasticity of substitution equal to one assumed by the Cobb-Douglas form. The two models are estimated first in levels, then in first difference, in order to control for the possible presence of unobserved firm heterogeneity in levels; results are compared. OC effect is then tested, using the same model – Cobb-Douglas and Translog function – on firm profitability as proxied by income.

4.4 Data collection and analysis: the OC of the Compustat Global

The dataset of this study has been built up by drawing on Compustat Global dataset. Compustat Global provides financial data on over 28,500 worldwide publicly traded firms that represent more than 90% of the world's market capitalization; it includes more than 6,340 European[22] companies that correspond to 95% of the European market capitalization. Created in 1999, this database is unique in that it provides

[22] Besides the countries selected in this analysis, the European area for the Compustat Global general database includes the following countries: Czech Republic, Estonia, Hungary, Iceland, Liechtenstein, Lithuania, Malta, Monaco, Norway, Poland, Romania, Russia, Slovakia, Sweden, Switzerland, and Turkey.

normalized templates for global companies. Instead of adopting one country's set of accounting principles as the standard for data collection, the database examines financial statements of different countries, identifies items widely reported and creates a consistent set of financial data items. Based on this identified uniform template, data are normalized to local accounting principles, disclosure methods and data items definitions. This allows meaningful comparisons across a wide variety of global firms using different accounting standards and practices. From this database, we selected firms belonging to the Euro currency area, extended to include also United Kingdom and Denmark. These two countries were included, even though they are not in the Euro zone, because their weight within the European Economy has been considered crucial for an analysis that aims to be at the "European level". I have restricted the analysis to this geographical area mainly for two reasons. First of all, firms attitude towards investments in OC is particularly influenced by cultural factors and organizational structures; selecting a quite homogeneous area for what concerns the business culture and the economic and legal infrastructural system, such as the one under analysis, can therefore help avoiding bias due to cultural differences existing among firms belonging to other less homogeneous geographical areas. Second, to our knowledge a study that analyzes the effect of OC, as proxied by an income statement item, has not been performed at the European level, but only for North American (USA) (Lev and Radhakrishnan, 2005) and Asian (India) (De and Dutta, 2007) firms.

Currency data that were not expressed in Euros have been converted by Compustat Global. Given the nature of the study, only firms reporting Selling General and Administrative expenses for the years 2000 - 2006 have been selected. The initial sample consists of 1,309 firms; 562 firms have R&D expenditures and 747 do not.

Based on the study of Lev and Radhakrishnan (2005), who also use Compustat dataset, I have obtained the following variables: Company Name, yearly Revenues, Yearly Incomes, Yearly Selling General and Administrative expenses (SGA), yearly Property Plant and Equipment (PPE), yearly R&D expenses (R&D), yearly n. of employees, SIC codes, and Country. Table 4.1 summarizes the collected items, the variables for which they have been used as proxy, and the years for which the items were collected.

Table 4.1: Compustat Global proxy items and study variables

Proxy item from Compustat Global	Variable	Year
Company Name	Firm *i*	
Yearly Revenues	Firm performance: output measure	2006-2005
Yearly Incomes	Firm performance: profitability measure	2006-2005
Yearly SGA expenses	Intangible resource: Organization Capital	2006-2000
Yearly R&D expenses	Intangible resource: R&D Stock	2006-2000
Yearly PPE	Physical Capital	2006-2005
Yearly n. of employees*	Labour	2006-2005
SIC code	Industry	
Country	Country	

Notes: *N. of employees has been obtained from 3 different sources: Compustat Global, Amadeus and company websites

Yearly revenues and yearly incomes represent the performance measures used: the former is assumed to be an index for output whiles the latter for profitability. Tangible capital is proxied by Property, Plant and Equipment; labour is proxied by n. of employees. Intangible resources are represented by innovation related capital and OC. Innovation related capital is proxied by R&D stock, derived from a series of R&D expenses from 2000 to 2006 through the perpetual inventory method. The depreciation rate is equal to 20%. The effect of OC on firm performance is proxied by the income statement item Selling General and Administrative Expenses (SGA) as in Lev and Radhakrishnan (2005). Following De and Dutta (2007), 20% of firm SGA expenses is capitalized and taken as investments in OC. The perpetual inventory method is applied to these investments using an annual depreciation rate of 10%. The rational for this method has been provided in 4.3.1. Industry codes are grouped under the classification scheme of Fama and French (1988, 1997), below presented in table 4.2

Table 4.2: Industry classificassion

Industry	Sic code
Consumer Non-Durables: Food, Tabacco, Textile, Apparel, Leather, Toys	0100-0999, 2000-2399, 2700-2749, 2770-2799, 3100-3199, 3940-3989
Consumer Durables: Cars, TVs, Furniture, Household Appliances	2500-2519, 2590-2599, 3630-3659, 3710-3711, 3714-3716, 3750-3751, 3792-3792, 3900-3939, 3990-3999
Manufacturing: Machinery, Trucks, Planes, Office furniture, Paper, Commercial Printing	2520-2589, 2600-2699, 2750-2769, 3000-3099, 3200-3569, 3580-3629, 3700-3709, 3712-3713, 3715-3715, 3717-3749, 3752-3791, 3793-3799, 3830-3839, 3860-3899
Energy, Oil, Gas, and Coal Extraction and Products	1200-1399, 2900-2999
Chmicals and Allied Products	2800-2829, 2840-2899
Business Equipment: Computers, Software and Electronic Equipment	3570-3579, 3660-3692, 3694-3699, 3810-3829, 7370-7379
Telecom, Telephone and Television Transmission	4800-4899
Utilities	4900-4949
Wholesale, retail, and Services (Laundries, repair shops)	5000-5999, 7200-7299, 7600-7699
Healthcare, Medical Equipment and Drugs	2830-2839, 3693-3693, 3840-3859, 8000-8099
Money, Finance	6000-6999
Others: Mines, Construction, Building Materials, Transportation, Hotels, Business Services, Entertainement	All other Sic codes

(Source: Lev and Radhakrishnan (2005) based on Fama and French (1988, 1977)

Firms with data for Property Plant and Equipment, and/or n. of employees, and/or revenues equal to zero were excluded as considered not reliable; data were not cleaned behind these requirements, in order to avoid selectivity bias. At the end of the cleaning procedure, the final sample consisted of 828 firms, 418 with R&D stock and 410 without R&D stock.

Table 4.3 provides data analysis for the variables in levels. The sample represents a variety of firms of all sizes; the wide range between maximum and minimum values for all variables, in both sub-groups, suggests that the sample covers both large and small firms.

In the first sample – R&D firms – the mean is larger than the median for all the variables, which indicates that the distribution is skewed, with slim tails (kurtosis always greater than zero); the sample is affected by severe outliers at the high end which make up, on average, 13% of the sample for each variable. 75% of R&D firms have revenues below 1,363.8 million Euros, which is lower than the mean (5,254.5 million) and only 13.6% of firms have revenues above the mean. When looking at incomes, the situation is similar: 75% of firms have incomes lower than 81 million, value again lower than the sample mean (322.3), and only 12% of observations are above the mean. More than 75% of firms have values for physical capital, R&D stock, labour and OC below the mean;

approximately only 16% of firms have values for labour and OC above the mean and 11.2% have values for physical capital and R&D stock above the mean.

Table 4.3: Variables Analysis (levels) - year 2006

R&D Firms

	Obs	Mean	Std. Dev.	Min	1st Q	Median	3rd Q	Max	Iqr	Kurtosis
Revenues (€ million)	410	5254.45	20992.37	0.40	45.92	229.76	1363.76	254114.30	1317.84	79.75
Incomes (€ million)	410	322.25	1582.44	-7281.54	0.72	11.17	81.01	20276.86	80.28	99.89
Physical Capital (€ million)	410	1685.37	7581.66	0.09	4.46	30.08	288.90	76594.86	284.44	62.23
OC (€ million)	410	693.74	2089.52	0.80	12.75	43.53	241.98	16016.71	229.23	25.06
Labour (thousand)	410	16.66	49.03	0.01	0.26	1.11	8.13	472.50	7.88	36.89
R&D stock (€ million)	410	588.67	2335.24	0.02	2.99	19.74	96.04	20754.48	93.05	40.42

Non R&D Firms

	Obs	Mean	Std. Dev.	Min	1st Q	Median	3rd Q	Max	Iqr	Kurtosis
Revenue (€ million)	418	1404.69	6453.54	0.29	45.32	177.14	543.31	77901.06	497.99	89.19
Income (€ million)	418	55.67	213.55	-161.50	0.74	5.98	24.64	2761.92	23.91	80.14
Physical Capital (€ million)	418	387.25	1825.10	0.01	3.52	23.70	134.02	25182.19	130.49	99.49
OC (€ million)	418	224.48	967.72	0.29	7.23	22.04	82.16	12075.20	74.94	87.53
Labour (thousand)	418	7.15	32.54	0.00	0.22	0.71	3.01	456.30	2.79	118.31

Mean revenues, incomes and R&D stock are, on average, about 26 times larger, mean OC and labour 15 times larger and mean physical capital about 56 times larger than the respective medians. This is due to the presence of "giants" such as Siemens, Volkswagen and Royal Dutch, among others. The mean appears thus to be drastically affected by outliers. For this feature of the data, the median and the inter quartile range provide a better description than the one provided by the mean and standard deviation.

The magnitude of OC is considerable: median OC is higher than median R&D stock (43.53 versus 19.74). Median OC appears to be also greater than physical capital (43.53 versus 30.08), although when comparing the means, the reverse is true. OC therefore appears to be perceived as an important factor by the firms in the sample, which invest more heavily in this intangible that in physical capital. This also shows that measuring firm's capital only through R&D stock may provide a distorted picture of firms' attitude towards intangible investment strategy. In this case, for example, considering only R&D stock, would lead us to wrongly conclude that firms still do not understand the importance of intangible resources and under invest in them. The fact that mean physical capital values are higher than mean OC values does not invalidate the conclusion just reached; it only indicates that a minority of firms in the sample still invest more in physical capital and affect the mean distribution. Furthermore, it does not imply that these firms overvalue physical capital with respect to OC; they could simply belong to sectors where physical capital requires a great amount of investments. We have to recall, also, that OC and intangibles are important for firm performance, but only when interacting with other firms factors, such as physical capital and labour which therefore require a sound investment strategy as well.

Similar considerations apply to the non R&D sample. The distribution of the variables is skewed with slim tails and it is affected by severe outliers on the high end, which make up on average 10% of the sample. The mean is again larger than the median for all the variables, although, here, the difference between the two values is less pronounced (even though still considerable) than in the R&D sample. Mean revenues, incomes, labour and OC are, on average, about nine times greater than the respective medians. Physical capital is still the variable showing the greatest difference between mean and median as in the R&D sample: mean physical capital is about 16 times greater than its median. Also for this group the presence of very large firms, such as Carrefour, Tesco and Sainsbury, strongly affects the variable means.

The comparison between the two groups seems to suggest that firms investing in R&D are significantly larger, profitable and have higher values of output than firms that do not report R&D expenses. Even though the two groups are composed by almost the same number of firms (410 R&D firms versus 418 non R&D firms), R&D firms generate 78% of revenues and 85% of incomes of the entire sample. Their physical capital, OC and labour represent respectively the 81%, 75% and 69% of the entire sample. Results of the Wilcoxon-Mann-Whitney test show that there is a statistically significant difference between the underlying distribution of all dependent and independent variables between the two groups, and that mean values for R&D firms are significantly greater than mean values for non R&D firms. Mean revenues and OC of R&D firms are about 4 times greater than those of non R&D firms; mean physical capital is 6 times greater and mean labour is 3 times greater. The median test instead reveals that only values of OC, incomes and labour are significantly different, with R&D firms showing again median values greater than those of non R&D firms; median revenues and physical capital, instead are not significantly different ($p = 0.13$ and $p = 0.45$).

Within the R&D sample, firms appear to be committed to the creation of innovation related capital; over the seven-year-interval analyzed, the majority of firms have reported R&D expenses for at least 5 years, with only 10% reporting expenses for only 1 year and 25% reporting expenses for all the 7 years. Looking at the mean values, R&D expenses have been slowly increasing between 2000 and 2006, with 2004 representing the year with the highest mean investment (167.4 million Euros). Also in this case, however, the mean is strongly affected by the presence of positive outliers. The median for the year 2006 is, in fact, 4.9 million, a value 33 times smaller than the respective mean of 165.9 million; in the year 2006, 75% of firms have invested less than 28.4 million in R&D.

The same level of commitment is showed with respect to investments in OC: 75% of R&D firms have reported SGA expenses for seven years, with a minimum of 3 years reported only by the 5% of firms; the average number of years is 6.44.

On average, mean annual R&D expenses represent the 24% of mean annual investment in OC over the period 2000-2006; even considering that the method used to build up OC capitalizes only 20% of SGA expenses, it can be said that the mean annual investment in OC is higher than the mean annual investment in R&D capital. Once again, however, the mean is strongly affected by positive outliers, and median values for SGA expenses are significantly lower (for the year 2006: mean SGA expenses is 760.1 million while median SGA expenses is 45 million). When comparing median values of SGA and R&D expenses over the years, the former appears still higher, even though not in the same proportion provided by the comparison of the means: R&D expenses represent between the 7% and the 14% of the annual median investment in OC, depending on the year considered.

With respect to continuity in OC investments, non R&D firms do not differ from R&D firms. Only 5% of firms have reported SGA for only three years, while the majority of firms have reported more than 5 years of investment activity, with an average equal to 6 years. The investment strategy towards intangibles is, therefore, similar for both samples of firms. Once again this shows that using only R&D related proxies to measure intangibles provides a reductive view of firms' knowledge capital. It also suggests that R&D capital is only one type of intangible, and not the main one; according to the industry or sector in which they operate, firms may need or may need not to invest in R&D. Independently from their business area, instead, all firms need OC and invest in it; firms therefore understand the importance of knowledge capital; they just chose the type of intangibles in which to invest according to their needs. The fact that some of the firms in the sample do not have R&D investments does not necessarily mean that these firms undervalue the importance of R&D capital; this behavior towards investment in R&D may be simply due to the fact that the area in which the firm operates does not require investment in this specific intangible.

A significant difference between the two samples is recorded for what concerns the amount of investments in OC. The comparison between the two groups shows that firms that invest in R&D capital also invest significantly more in OC; this is probably due to the fact that R&D firms are on average bigger and have greater availability of resources, not that much to the presence of collinearity between the two types of investments. Also firms belonging to the non R&D sample have been increasing the amount of investments in OC over the years, with mean SGA expenses going from 181.8 million of the year 2000 to 239.8 million of the year 2006. Once again, however, the mean is strongly affected by positive outliers and offers an upward biased value of the average investment in OC. For the year 2006, for example, median SGA expenses are reported to be 28.1 million, with only 25% of firms reporting more than 100 million, value still lower than the mean for that year.

It is interesting to analyze the rate of growth of the data, as presented in table 4.4. Even when considering the growth rates, all the variables, for both sub-groups, present mean values larger than median values, from which it can be inferred that the distribution is again skewed, with slim tails (kurtosis always greater than zero). Also the growth rates are thus affected by outliers. In the R&D sample, severe outliers make up on average 2.93% of the distribution on the high end and 0.86% on the low end. In the non R&D

sample the weight of the outliers is similar: they represent the 2.24% of the distribution on the high end and the 1.32% on the low end. In both samples the growth rates of physical capital and revenues are the most affected by the presence of outliers; OC, instead, is the least affected. Outliers make up 1.87% on the high end and 0.27% on the low end of the OC growth rate distribution in the R&D sample; 0.88% on the high end in the non R&D sample.

Table 4.4: Variables Analysy (growth rate) - year 2005/2006

R&D Firms

	Obs	Mean	Std. Dev.	Min	1st Q	Median	3rd Q	Max	Iqr	Kurtosis
$\log(rev_t/rev_{t-1})$	375	0.13	0.40	-2.05	0.02	0.11	0.21	3.92	0.19	30.90
$\log(c_t/c_{t-1})$	375	0.05	0.45	-2.46	-0.08	0.01	0.13	3.87	0.21	29.91
$\log(OC_t/OC_{t-1})$	375	0.19	0.21	-0.69	0.09	0.15	0.23	2.69	0.14	56.79
$\log(l_t/l_{t-1})$	375	0.09	0.35	-1.01	-0.02	0.04	0.15	4.49	0.17	75.78
$\log(r_t/r_{t-1})$	375	0.09	0.43	-0.90	-0.12	0.04	0.21	3.62	0.33	26.68

Non R&D Firms

	Obs	Mean	Std. Dev.	Min	1st Q	Median	3rd Q	Max	Iqr	Kurtosis
$\log(rev_t/rev_{t-1})$	453	0.16	0.34	-1.87	0.04	0.13	0.26	2.35	0.22	13.33
$\log(c_t/c_{t-1})$	453	0.11	0.49	-5.08	-0.05	0.05	0.23	3.41	0.28	35.87
$\log(OC_t/OC_{t-1})$	453	0.24	0.21	-0.10	0.11	0.18	0.33	1.95	0.22	14.74
$\log(l_t/l_{t-1})$	453	0.13	0.34	-1.68	-0.02	0.07	0.22	3.28	0.23	25.11

Notes : rev represents firm's revenues; c, r, l and OC represent respectively physical capital, R&D stock, labour (n. of employees) and organization capital.
The subscripts *t* and *t-1* represent respectively the year 2006 and 2005.

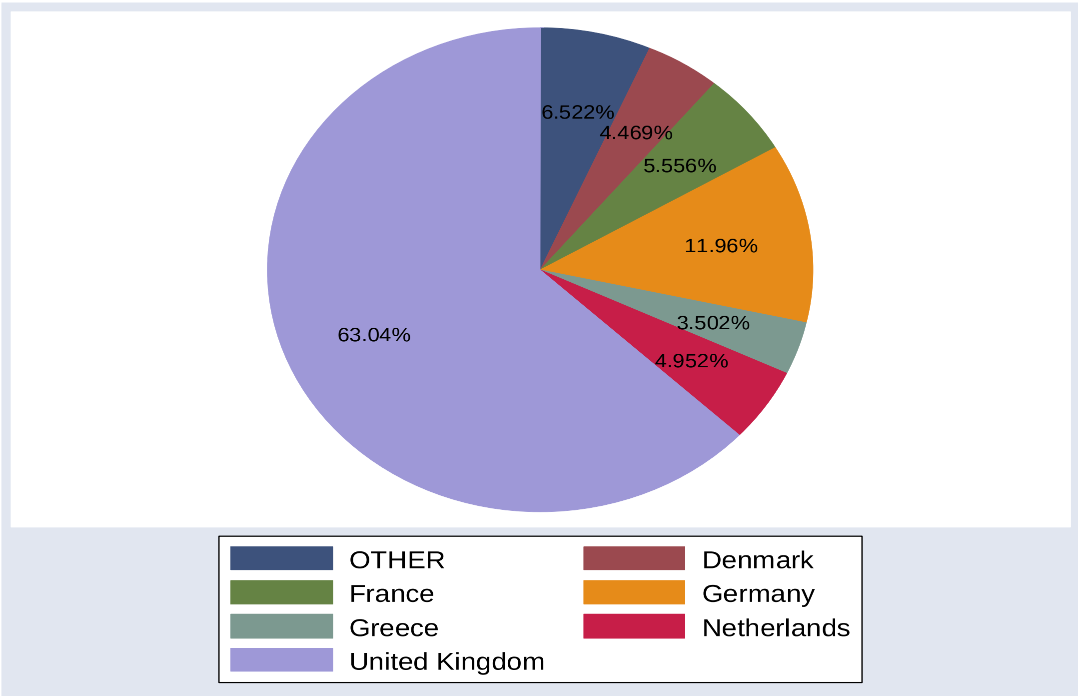
In both sample OC appears to have registered the highest increase in the period considered, with mean growth rate of 19% for R&D and 24% for non R&D firms. Revenues have registered the second highest increase (13% in the R&D sample; 16% in the non R&D sample), followed by labour (9% in the R&D sample; 13% in the non R&D sample), and R&D stock (9%). In both samples physical capital has recorded the lowest percentage increase: 5% in the R&D sample and 11% in the non R&D sample. This confirms what is observed for the variables in levels; while physical was once considered the main resource for firms, its commoditization has rendered it less important with respect to other factors, such as intangibles, on which firms now focus their investment efforts. Conclusions do not differ greatly when focusing on the analysis of the medians, even though the magnitude of the growth rates appears to be reduced. OC still registers the highest growth rate (15% in the R&D sample, 18% in the non R&D sample), followed by revenues (11% in the R&D sample, 13% in the non R&D sample), labour (4% in the R&D sample; 7% in the non R&D sample) and R&D stock (4%), and finally, by physical capital (1% in the R&D sample; 5% in the non R&D sample).

When analyzing variables in levels we have reached the conclusion that R&D firms appear to have a better performance. However, the comparison of revenue growth rates between the two groups leads to different conclusions. The Wilcoxon-Mann-Whitney test, in fact, rejects the hypothesis that the underlying distribution of the growth rates of revenues is equal only at the 1% significance level ($p = 0.06$) and shows that non R&D firms may have a mean percentage increase in revenues that is higher than the one of R&D firms ($z = 3.66$). Furthermore the percentage increase in the production function inputs is always higher in non R&D firms ($p = 0.00$). The median test shows that non R&D firms have higher percentage increases in revenues as well as in physical capital, labour and OC.

From the above analysis we can conclude that both types of firms, those that invest and those that do not invest in R&D, have recorded an increase in revenues, with the latter having recorded, in general, the highest percentage increase. This does not necessarily imply a slowing down effect of R&D stock on output growth; it may simply be due to other structural factors typical of R&D firms. For example, R&D firms are, on average, bigger than non R&D firms and therefore more subject to diseconomies of scale. It could also be due to macroeconomic factors; the majority of firms investing in R&D, in fact, belong to different industries with respect to non R&D firms. R&D intensive industries could therefore have been characterized by more economic shocks and by a slower output growth than non R&D industries. The investing strategy of both firms has been similar; intangible resources (here R&D stock and OC) – have recorded the highest growth rates, together with labour. Physical capital has recorded the lowest percentage increase, outlying the importance of intangible resources and the trend towards a dematerialization strategy of the production process. In particular, OC has recorded the highest percentage increase: 19% in R&D firms and 24% in non R&D firms. Despite the fact that R&D firms are larger and have the availability of more resources, the percentage growth rates of non R&D firms are higher.

The geographical distribution of firms in the sample (fig. 4.1) is the following; UK has the highest number of firms (63.04%), followed by Germany (11.96%), France (5.56%), Netherlands (4.95%), Denmark (4.47%) and Greece (3.50%). The rest of the countries, all together, represent only the 6.52% of the sample.

Figure 4.1: Sample distribution by country

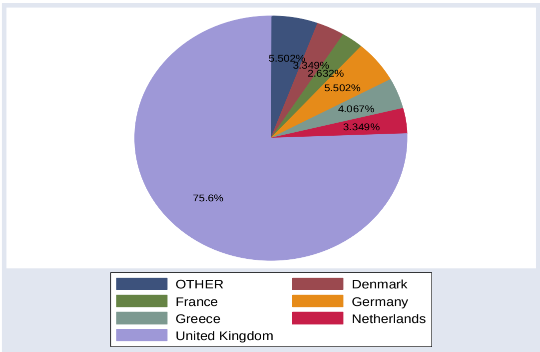


OTHER: Austria (0.845%); Belgium (0.845%); Cyprus (0.12%); Finland (1.328%); Italy (0.362%); Ireland (1.449%); Luxembourg (0.966%); Portugal (0.12%); Slovenia (0.241%); Spain (0.241%)

The strong presence of British, German, French, Dutch and Danish firms, representing by themselves almost 90% of the sample, reflects the composition of the main financial core of the European Economy. The dataset, in fact shows a concentration of firms in certain areas of Europe, mainly UK, Germany, France, Netherland, Denmark, Greece, which are only six out of the sixteen countries forming the “extended euro area” selected for the analysis. This is a close representation of the economic core of the area. The peculiar composition of the dataset could be due to some selectivity bias caused by the selection only of firms reporting SGA expenses for the year 2005 and 2006. Countries that are not, or very partially, represented, could, in fact, use different reporting rules that render the identification harder for these income items, resulting in their firms' exclusion from the database. The validity of the dataset is, however, not undermined; the countries represented form the core of the European economy and, besides the six major countries, the group "Others" also includes other countries with less economic weight and different business cultures. Results however have to be interpreted on the basis of the sample composition; this study therefore mainly reflects the effect of OC on firm performance in those firms belonging to the financial and economic core of Europe.

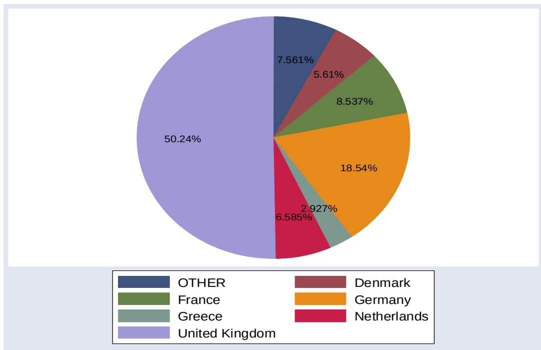
The proportions of the geographical distribution present small changes when examining the two sub-samples separately (fig.4.2 and fig. 4.3). United Kingdom (75.6% of non R&D firms; 50.24% of R&D firms) and Germany (5.5% non R&D; 18.54% R&D) are still the countries with the highest number of firms. In the non R&D sample, Greece follows with 4.07%, then Denmark and Netherlands (3.35% each), France (2.63%), and all the other countries together representing the 5.50%. In the R&D sample, France follows (8.54%), then Netherlands (6.59%), Denmark (5.61%), Greece (2.93%) and all the other countries together representing the 7.56% of the sample.

Figure 4.2: Non R&D sub-sample distribution by country



OTHER: Austria (0.478%); Belgium (0.239%); Cyprus (0.239%); Finland (0.000%); Italy (0.239%); Ireland (2.153%); Luxembourg (1.196%); Portugal (0.239%); Slovenia (0.478%); Spain (0.239%)

Figure 4.3: R&D sub-sample distribution by country



OTHER: Austria (1.219%); Belgium (1.463%); Cyprus (0.000%); Finland (2.682%); Italy (0.487%) Ireland (0.731%); Luxembourg (0.731%); Portugal (0.000%); Slovenia (0.000%); Spain (0.243%)

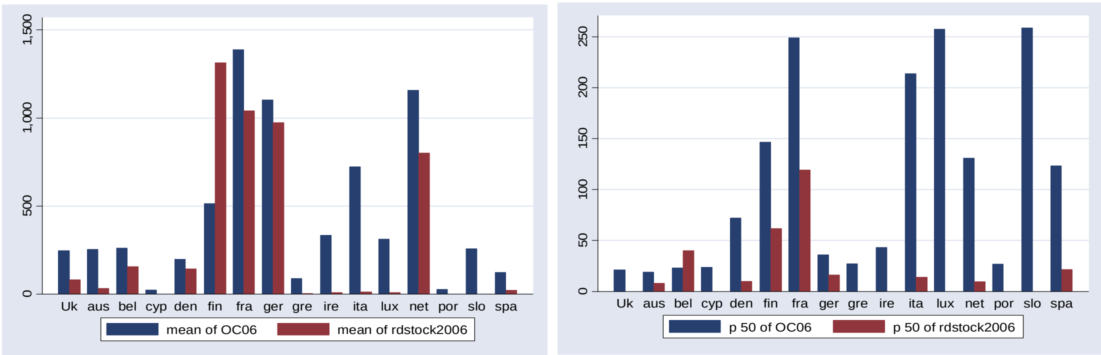
Figure 4.4 shows mean and median levels for OC and R&D stock by countries. With respect to mean OC levels (fig. 4.4.a), the sample can be divided in three groups: countries with high levels of OC (France, Netherlands, Germany and Italy); countries with medium levels of OC (UK, Austria, Belgium, Denmark, Ireland, Luxembourg and

Slovenia) and countries with low levels of OC (rest of the countries). With respect to median values (fig. 4.4.b) groups, composition presents differences with countries going from one group to the group at the higher or lower level. France and Italy are still among the countries with highest levels of OC; for Italy this is probably due to the high investment strategy in marketing and advertising (reputation investments partially captured by the OC proxy SGA expenses) pursued by Italian firms (O'Mahony and Vecchi, 2000). The main difference between mean and median OC values comparison is for Germany, which goes from the highest OC group to the lowest.

The country difference between median and mean values of OC seems to suggest that the level of investments in OC is not strongly influenced by countries effects within this homogeneous geographical area, and that, within each country, firms pursue different levels of investments in OC.

Figure 4.4: Mean and Median OC and R&D stock by Countries

a) Mean OC and R&D stock by Countries **b) Median OC and R&D stock by countries**

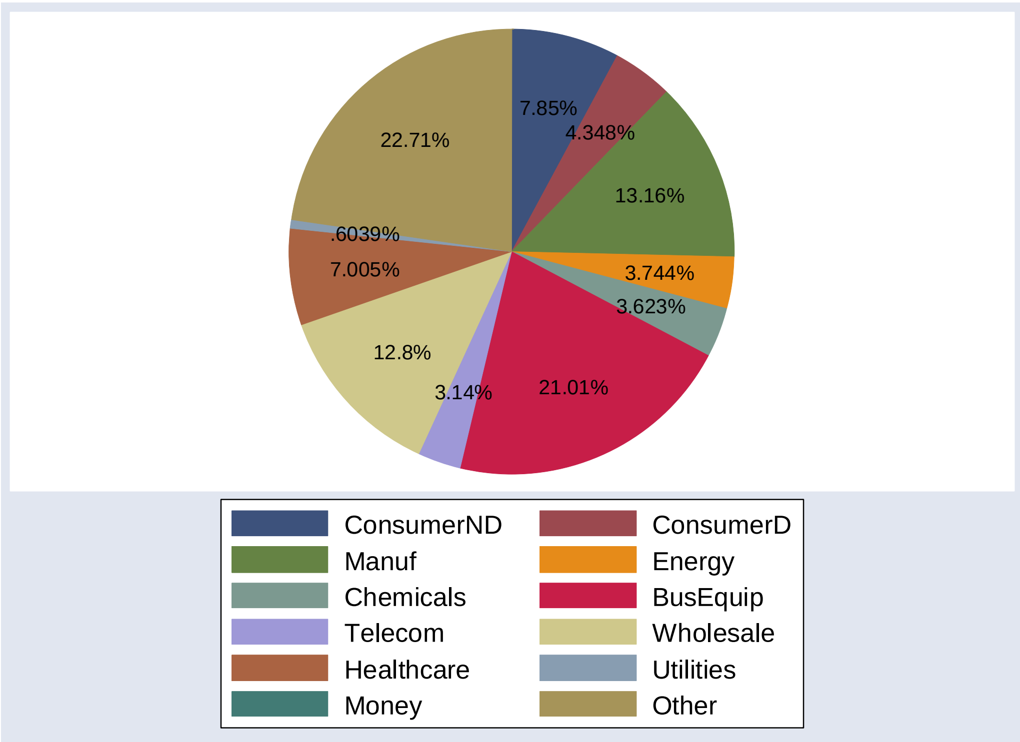


Notes : Uk = United Kingdom; aus = Austria; bel = Belgium; cyp = Cyprus; den = Denmark; fin = Finland; far = France; ger = Germany; gre = Greece; ire = Ireland; ita = Italy; lux = Luxembourg; net = Netherlands; por = Portugal; slo = slovenia; spa = Spain

With respect to R&D stock the sample can be divided in 2 groups: Finland, France, Germany and Netherlands, with high mean values (fig. 4.4.a); the rest of the countries with lower values. With respect to median values (fig. 4.4.b), the countries with highest R&D stock values are still France and Finland, as observed with respect to mean values; all the rest of the countries have lower values. The bulk of the low R&D stock countries is formed by Mediterranean countries (Cyprus, Greece, Italy, Portugal and Slovenia) which seems to suggest a country effect for R&D investment strategy. Even though British firms represent the majority of the R&D sub-sample, the level of R&D stock of these firms is particularly low when compared to firms belonging to other countries.

The firms in the sample represent a wide variety of industries (fig. 4.5); the majority belongs to Construction, Transportation and Entertainment - grouped under "Others"- (22.71%), Business Equipment (21.01%), Manufacturing (13.16%) and Wholesale (12.8%); the Utilities industry is the least numerous (0.6%). Firms belonging to the financial sector, grouped under "Money", are totally absent.

Figure 4.5: Sample distribution by industry



The presence of firms belonging to different industries and sectors renders the study original as the empirical literature that investigates the effect of intangible resources on firm performance focuses mainly on R&D capital and therefore has principally addressed sectors where this type of investing activity is conducted (e.g. manufacturing, chemicals, pharmaceutical, high-tech). This database, instead, includes almost all sectors, as shown in fig. 4.5

When looking at the industry representation of the R&D and non R&D samples separately, as shown in fig. 4.6 and 4.7, it can be inferred that sectors such as Business Equipment (which includes Computer and Software), Manufacturing, Healthcare (Medical Equipment and Drugs) represent the bulk of the firms investing in R&D (65.37%), as found by previous studies. Also industries such as Mines, Construction and Transportation (all together grouped under "Other") represent a conspicuous part of the R&D sample (around 10%). In the non R&D sample, the majority of firms belong instead to Other, Wholesale and Consumer non-durable (68.43%). It is interesting to notice that even R&D-intensive industries, such as Business Equipment, Manufacturing and Others, represent a conspicuous part of the non R&D sample. This is probably due to the system used to classify and group the numerous SIC codes of the single observations (see Table 4.2); if we look at the composition of the group "Others" for example, we can see how this includes sectors such as Hotels and Entertainment, which are not R&D-intensive, together with Mines and Building Materials, which are instead R&D intensive.

Figure 4.6: Non R&D sub-sample distribution by industry

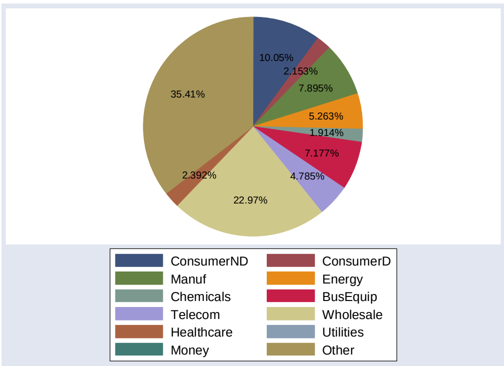


Figure 4.7: R&D sub-sample distribution by industry

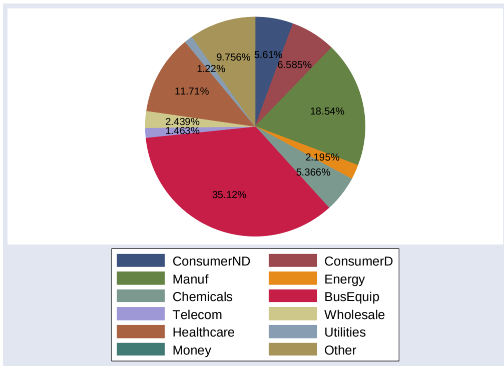
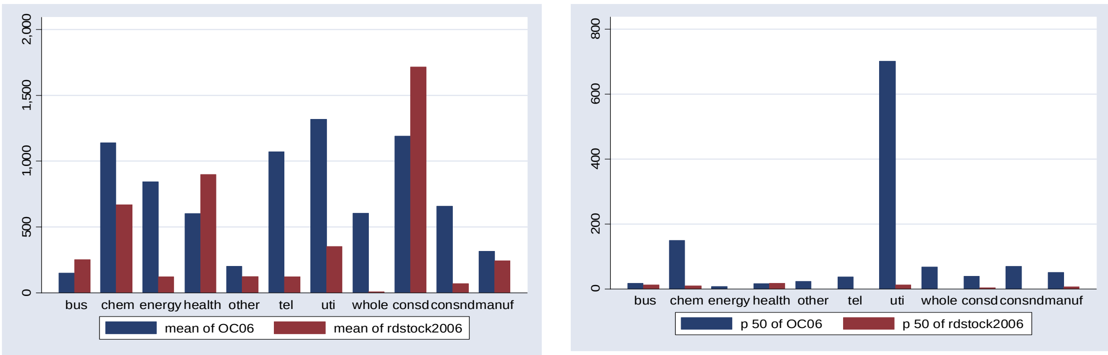


Figure 4.8 shows mean and median values for OC and R&D stock by industry. The industries with the highest mean levels of OC (fig. 4.8.a) are Utilities, Chemical, Telecom, Consumer durable and Energy; when looking at median values (fig. 4.8.b), only Utilities and Chemicals have values for OC significantly higher than the rest of the other industries. Mean values for R&D stock (fig. 4.8.a) are particularly high in Consumer Durables, Healthcare and Chemicals, with all the rest of the industries having values relatively in the same range. Median values of R&D stock (fig. 4.8.b) are more uniform

among the industries that have firms investing in R&D. It can be noticed that having the highest percentage of R&D firms implies having higher values for R&D stock only for Healthcare.

Figure 4.8: Mean and Median OC and R&D stock by Countries

a) Mean OC and R&D stock by Countries **b) Median OC and R&D stock by countries**



Notes: bus = Busequpment; chem = chemicals; Energy = Energy; health = Healthcare; other = Other; tel = Telecom; uti = Utilities; whole = Wholesale; consd = Consumer Durables; consnd = Consumer Non-Durables; manuf = Manufacturing

In all, the sample is basically divided in two halves represented by firms with R&D and firms with no R&D; it includes a wide range of firms of different dimensions that belong to different sectors and different countries and form a sample that describes, in particular, firms belonging to the financial and economic core of the European area considered. In the following, the estimation and the results of the model presented in section 4.3 are presented.

4.5 Results

4.5.1 Organization capital and firm output

The comparison between estimates of eq. 4.16 obtained with instrumented variables and with the actual regressors (see appendix n.1, table A1.1) leads us to conclude that the strict exogeneity assumption is likely to hold; estimates do not differ greatly and results of the Hausman test (R&D firms: p = 0.66; non R&D firms: p = 1.00) seem to confirm that regressors are not endogenous.

Results obtained from the estimation of eq. 4.16 are reported in table 4.5. Columns 1 report results for the OLS robust procedure; columns 2 report results using the Huber and Tukey biweights to control for the influence of outliers.

Table 4.5: Empirical estimates. Cobb-Douglas production function (levels)

	With RD		Without RD	
	Coefficient		Coefficient	
	(1)	(2)	(1)	(2)
Variables				
Intercept	3.54	3.54	3.20	3.06
	(0.20) ***	(0.12) ***	(0.18) ***	(0.17) ***
$\log(c_t)$	0.16	0.16	0.10	0.06
	(0.03) ***	(0.02) ***	(0.03) ***	(0.02) **
$\log(r_t)$	0.02	0.02		
	(0.02)	(0.01)		
$\log(l_t)$	0.56	0.56	0.37	0.42
	(0.06) ***	(0.03) ***	(0.05) ***	(0.04) ***
$\log(OC_t)$	0.30	0.29	0.47	0.50
	(0.06) ***	(0.03) ***	(0.04) ***	(0.03) ***
Control dummies				
Energy	0.76	0.75		1.08
	(0.19) ***	(0.16) ***		(0.19) ***
Wholesale			0.25	0.41
			(0.10) **	(0.11) ***
Telecom			0.49	0.78
			(0.16) ***	(0.18) ***
Manuf				0.35
				(0.15) **
Busequip				0.32
				(0.16) **
Other			0.20	0.39
			(0.09) **	(0.11) ***
France			0.50	
			(0.20) **	
Italy			-0.46	
			(0.12) ***	
Obs.	410	410	418	418

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. $\log(\text{revenues}_{2006})$)
2. Columns labeled (1) report OLS robust regression estimates; Columns labeled (2) report Huber and Tukey biweights regression estimates
3. Standard Errors in parentheses

For both samples of firms, labour and OC have the highest elasticities; surprisingly, R&D stock is not significant; results are confirmed even when controlling for the presence of outliers.

OC has a strong effect on output with elasticity ranging between 0.29 and 0.30 for the R&D sample, and between 0.47 to 0.50 for the non R&D sample, depending on the estimation procedure used; this is significantly higher than the elasticity of physical capital that is 0.16 for the R&D sample and ranges between 0.06 and 0.10 for the non R&D sample. OC output elasticity (0.30) is also higher than output elasticity of R&D stock (0.02), which is not even significant. Even though R&D stock does not appear to significantly affect output, it seems to influence the effect of OC on firm performance; OC elasticity with respect to output is in fact significantly higher for firms without R&D stock (t-statistics = 5.25 for the Huber and Tukey robust estimates; t-statistics = 2.42 for the OLS robust estimates). A first explanation for this result could be the presence of a structural difference between R&D and non R&D firms; also, the result could indicate that in non-R&D firms OC "compensates" the lack of R&D capital and substitutes it.

I then estimate the production function using the more flexible translog model. The Cook-Weisberg test rejects the hypothesis of homoskedastic residuals at the 1% significance level for both samples of firm (p = 0.00); therefore I estimate eq. 4.18 using an OLS robust procedure. Results are reported in table 4.6. The Wald test rejects the null hypothesis of joint non significance of the log-quadratic and interaction terms at the 1% significance level (p = 0.00), therefore we can conclude that the translog function captures effects not captured by the Cobb-Douglas production function and provides a better description of the production process. As we can observe in columns A, several log-quadratic and interaction terms are, however, not significant; we therefore try to reach a simplified version of the translog function by selecting only significant interaction effects through the Wald test on the log-quadratic and interaction terms. Results are shown in columns B, table 4.6.

The same procedure is performed on the translog function estimated with Huber and Tukey biweights to control for the presence of outliers; results are reported in table 4.7

Since the individual parameters of the translog function are not readily interpretable, we have calculated elasticities of output using eq. 4.20.a-d. These elasticities are evaluated at the sample mean of the data and are presented in table 4.8.

As variable means are greatly affected by the presence of outliers, as seen in the data analysis of paragraph 4.4, I have calculated elasticities also using variables median values (see Appendix n.1, table A1.2); output elasticities do not substantially differ.

Table 4.6: Empirical estimates. Translog production function (levels)

	With RD		Without RD	
Parameter	**(A)**	**(B)**	**(A)**	**(B)**
a	2.93	2.78	2.21	2.31
	(0.40) ***	(0.35) ***	(0.35) ***	(0.35) ***
β_k	0.05	0.15	-0.11	-0.14
	(0.11)	(0.03) ***	(0.09)	(0.09)
β_r	-0.12	-0.02		
	(0.08)	(0.02)		
β_l	0.24	0.07	0.22	0.31
	(0.19)	(0.09)	(0.15)	(0.09) ***
β_o	0.79	0.75	1.18	1.14
	(0.19) ***	(0.15) ***	(0.13) ***	(0.12) ***
γ_{kk}	0.01		0.06	0.06
	(0.01)		(0.01) ***	(0.01) ***
γ_{rr}	0.01	0.01		
	(0.01)	(0.00) ***		
γ_{ll}	-0.07	-0.10	-0.02	
	(0.04) *	(0.02) ***	(0.03)	
γ_{oo}	-0.07	-0.06	-0.07	-0.07
	(0.02) ***	(0.01) ***	(0.02) ***	(0.02) ***
γ_{kr}	0.01			
	(0.01)			
γ_{kl}	0.02	0.06	-0.04	-0.05
	(0.03)	(0.01) ***	(0.02) *	(0.02) **
	(0.03)		(0.03) **	(0.03) **
γ_{rl}	-0.03			
	(0.02)			
γ_{ro}	0.02			
	(0.02)			
γ_{lo}	0.08	0.08	0.12	0.10
	(0.05)	(0.02) ***	(0.04) ***	(0.02) ***
Control dummies				
Consumernd			-0.26	-0.25
			(0.09) ***	(0.09) ***
Consumerd			-0.35	
			(0.21) *	
Telecom			0.44	0.45
			(0.17) **	(0.17) ***
Energy	0.66	0.69		
	(0.15) ***	(0.15) ***		
Healthcare	-0.25	-0.23		
	(0.09) ***	(0.09) ***		
Belgium			0.51	0.54
			(0.17) ***	(0.17) ***
Cyprus			0.54	0.57
			(0.16) ***	(0.15) ***
Denmark			0.48	0.44
			(0.21) **	(0.21) **
France			0.80	0.80
			(0.24) ***	(0.24) ***
Germany			0.32	0.32
			(0.19) *	(0.19) *
Greece			0.51	0.53
			(0.22) **	(0.21) **
Ireland	-0.41	-0.41	0.59	0.61
	(0.17) **	(0.16) ***	(0.24) **	(0.24) **
Netherlands			0.74	0.70
			(0.24) ***	(0.24) ***
Portugal			0.33	0.35
			(0.16) **	(0.15) **
Spain	0.44	0.36	0.38	0.39
	(0.10) ***	(0.08) ***	(0.16) **	(0.16) **
Unitedkingdom			0.29	0.29
			(0.14) **	(0.14) **
Austria	-0.23	-0.25		
	(0.10) **	(0.09) ***		
R^2	95.2%	95.1%	86.6%	86.5%
Obs	410	410	418	418

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. log(revenues$_{2006}$))
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report a simplified version of the translog function after selecting only significant log-quadratic and interaction terms through the Wald test
3. Robust Standard Errors in parentheses

Table 4.7: Empirical estimates. Translog production function (levels) - Huber and Tukey biweights

	With RD		Without RD	
Parameter	**(A)**	**(B)**	**(A)**	**(B)**
a	3.43	3.52	2.67	2.99
	(0.31) ***	(0.24) ***	(0.27) ***	(0.21) ***
β_k	0.01	-0.02	-0.13	-0.20
	(0.09)	(0.03)	(0.08)	(0.06) ***
β_r	-0.03	0.02		
	(0.06)	(0.01) *		
β_l	0.34	0.37	0.20	0.39
	(0.15) **	(0.08) ***	(0.13)	(0.07) ***
β_o	0.53	0.48	1.09	0.97
	(0.14) ***	(0.11) ***	(0.12) ***	(0.10) ***
γ_{kk}	0.02	0.03	0.05	0.04
	(0.01) *	(0.00) ***	(0.01) ***	(0.01) ***
γ_{rr}	0.00			
	(0.00)			
γ_{ll}	-0.08	-0.07	-0.03	
	(0.02) ***	(0.01) ***	(0.02)	
γ_{oo}	-0.04	-0.03	-0.07	-0.07
	(0.01) ***	(0.01) **	(0.01) ***	(0.01) ***
γ_{kr}	0.01			
	(0.01)			
γ_{kl}	0.01		-0.02	-0.04
	(0.03)		(0.02)	(0.02) ***
γ_{ko}	0.00		-0.04	
	(0.02)		(0.02)	
γ_{rl}	-0.01			
	(0.02)			
γ_{ro}	0.00			
	(0.01)			
γ_{lo}	0.07	0.07	0.11	0.07
	(0.03) *	(0.02) ***	(0.03) ***	(0.02) ***
Control dummies				
Energy	0.69	0.66	0.65	0.68
	(0.15) ***	(0.15) ***	(0.19) ***	(0.18) ***
Wholesale	0.33	0.32		
	(0.15) **	(0.14) **		
Manuf	0.14	0.13		
	(0.06) **	(0.06) **		
Telecom			0.53	0.49
			(0.16) ***	(0.16) ***
Obs	410	410	418	418

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. log(revenues$_{2006}$))
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report a simplified version of the translog function after selecting only significant log-quadratic and interaction terms through the Wald test
3. Standard Errors in parentheses

Table 4.8: Translog function estimated output elasticities evaluated at the sample mean of the data (levels)

	With RD			
	(A)		(B)	
	(1)	(2)	(1)	(2)
Output elasticities				
Physical capital	0.19	0.17	0.18	0.07
	(0.03) ***	(0.02) ***	(0.03) ***	(0.02) ***
R&D stock	0.03	0.03	0.03	0.02
	(0.02)	(0.01) **	(0.02)	(0.01) *
Labour	0.48	0.57	0.51	0.58
	(0.06) ***	(0.03) ***	(0.05) ***	(0.03) ***
OC	0.33	0.25	0.31	0.25
	(0.05) ***	(0.03) ***	(0.05) ***	(0.03) ***
	Without RD			
Physical capital	0.04	0.04	0.04	0.05
	(0.03)	(0.02) *	(0.03)	(0.02) **
Labour	0.49	0.50	0.48	0.48
	(0.05) ***	(0.04) ***	(0.05) ***	(0.04) ***
OC	0.49	0.47	0.49	0.47
	(0.04) ***	(0.03) ***	(0.04) ***	(0.03) ***

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Elasticities are evaluated at the sample mean of the data
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report a simplified version of the translog function after selecting only significant log-quadratic and interaction terms through the Wald test
3. Columns labeled (1) report estimates obtained from the OLS robust procedure; columns labeled (2) report estimates obtained with Huber and Tukey biweights
4.Standard errors in parentheses

Elasticities of output are similar to those obtained using the Cobb-Douglas model and are quite robust across the different estimation procedures used. OC strong effect on output is confirmed: elasticity ranges between 25% and 33% for the R&D sample and between 47% and 49% for the non R&D sample. R&D stock elasticity is modest (average is 0.03) and significant only for Hubey and Tukey biweights estimation procedure. Also physical capital has a small effect on output (R&D sample: 0.07-0.19; non R&D sample: 0.04 – 0.05). Together with OC, labour is the other determinant input factor; its elasticity ranges between 0.48 and 0.58 in the R&D sample and 0.48 and 0.50 for the non R&D sample.

Based on the estimates in levels, a first set of conclusions can be reached. The first result relates to the strong effect that OC has on firm performance. OC average elasticity is 0.29 in R&D firms and 0.48 in non R&D firms; this is much higher than the average elasticity of physical capital (0.16 for R&D firms and 0.06 for non R&D firms). This seems to confirm the view that sees intangibles, and in particular OC, idiosyncratic, firm-specific, interrelated and hard to imitate, as the main factors of production.

The second result concerns OC and its relationship with physical capital. Estimates indicate that physical capital is not a key factor for success anymore; the development, globalization and commoditization processes have rendered it easily available and, therefore, not a factor on which build up the competitive strategy. Nonetheless, physical capital is still important, as shown by its positive and generally significant output elasticities. The interrelated nature of OC, in fact, also needs traditional factors of production, such as labour and physical capital, in order to generate some effects on performance. As results show, OC has a significant effect on output, but together with the significant effect of physical capital and labour.

The third results are somewhat unexpected; it concerns the low and non significant effect of R&D stock on firm performance. This could be due to the tedious double counting problem – which could be exacerbated in this study by the inclusion of OC among the production inputs - caused by the fact that physical capital and labour also include, respectively, materials used in R&D laboratories and researchers employed in R&D activities. Studies (Mairesse and Sassenou, 1991, O'Mahony and Vecchi, 2000) have demonstrated that this could produce R&D downward bias estimates. Furthermore, SGA expenses include, in certain cases, customer or government sponsored R&D expenses, and therefore part of the R&D stock effect could be captured by OC. In this case, the model would provide biased estimates for what concerns R&D stock elasticity and slightly overestimate the effect of OC on output.

The last main result to outline relates to the effect of OC in the two different sub-samples of firms. Even though R&D stock does not show to have a strong effect on firm performance, OC elasticity is higher in firms without R&D; this is probably due to the fact that firms without R&D stock operate in sectors where R&D stock is not essentially required and therefore OC can "compensate" for the absence of the R&D stock input.

The model in level could have produced biased estimates due to the presence of unobserved firm heterogeneity. In order to confirm the conclusions just reached, we estimate the same model in first difference, starting with the Cobb-Douglas production function. OC could be endogenous; to verify this hypothesis we instrument it using SGA expenses for the period 2000-2004. Results of the regression with instruments are compared with OLS estimates using the Hausman test (Appendix n. 1, table A1.3). For both sub-samples we can state that OC is not an endogenous variable, and therefore we can rely on estimates of the true model. Results are presented in table 4.9.

Table 4.9: Empirical Estimates. Cobb-Douglas production function (first difference)

	With RD				Without RD			
	Coefficient				Coefficient			
	(1)		(2)		(1)		(2)	
Variables								
Intercept	-0.01		0.03		-0.04		0.02	
	(0.02)		(0.01)	***	(0.02)	**	(0.01)	
$\log(c_t/c_{t-1})$	0.03		0.08		0.07		0.04	
	(0.04)		(0.02)	***	(0.04)	*	(0.01)	***
$\log(r_t/r_{t-1})$	0.05		0.00					
	(0.04)		(0.02)					
$\log(l_t/l_{t-1})$	0.66		0.60		0.31		0.43	
	(0.06)	***	(0.03)	***	(0.08)	***	(0.02)	***
$\log(OC_t/OC_{t-1})$	0.39		0.28		0.66		0.37	
	(0.10)	***	(0.05)	***	(0.09)	***	(0.04)	***
Obs.	375		375		453		453	

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it}/y_{it-1}(i.e. $\log(\text{revenues}_{2006}/\text{revenues}_{2005})$)
2. Columns labeled (1) report OLS robust regression estimates; Columns labeled (2) reports Huber and Tukey biweight regression estimates
3. Standard errors in parentheses

The strong effect of OC on firm performance is confirmed and it is slightly higher compared to the estimates of the model in levels: it ranges between 0.28 and 0.39 for the R&D sample and between 0.37 and 0.66 for the non-R&D sample; R&D stock is not significant, as in levels. Physical capital effect is small: 0.03-0.08 in R&D firms, 0.04-0.07 in non R&D firms. Results obtained with Huber and Tukey biweights show that outliers have a quite significant influence in the model in difference; estimates shown in columns 2 are more similar to those obtained for the model in levels.

Table 4.10 presents results for the translog function in first differences. On the basis of the Cook-Weisberg test, which rejects the hypothesis of homoskedastic residuals at the 5% significance level for both samples of firms (R&D sample: p = 0.027; non R&D sample: p = 0.021), I estimate eq. 4.18 using the OLS robust procedure. The translog function provides a better description of the phenomenon under analysis: the Wald test rejects the hypothesis of joint non significance of the log-quadratic and interaction terms at the 1% significance level (p = 0.00). Columns B report results of the simplified version of the translog function.

Table 4.10: Empirical estimates. Translog production function (first difference)

	With RD		Without RD	
Parameter	**(A)**	**(B)**	**(A)**	**(B)**
a	0.00	0.00	-0.03	-0.03
	(0.02)	(0.02)	(0.02)	(0.02)
β_k	0.41	-0.12	0.09	0.06
	(0.35)	(0.06) *	(0.12)	(0.04) *
β_r	0.29	0.06		
	(0.16) *	(0.04)		
β_l	-0.12	0.60	0.02	0.03
	(0.63) **	(0.11) ***	(0.13)	(0.10)
β_o	0.12	0.34	0.96	1.01
	(0.46)	(0.15) **	(0.16) ***	(0.15) ***
γ_{kk}	0.02	0.04	-0.01	
	(0.02)	(0.01) ***	(0.01)	
γ_{rr}	0.01			
	(0.01)			
γ_{ll}	-0.22	-0.09	-0.04	-0.04
	(0.10) **	(0.02) ***	(0.02) *	(0.02) **
γ_{oo}	0.09		-0.07	-0.06
	(0.07)		(0.02) ***	(0.02) **
γ_{kr}	-0.02			
	(0.03)			
γ_{kl}	0.15		0.02	
	(0.10)		(0.03)	
γ_{ko}	-0.10		0.02	
	(0.08)		(0.03)	
γ_{rl}	0.06			
	(0.06)			
γ_{ro}	-0.05			
	(0.04)			
γ_{lo}	0.02		0.09	0.10
	(0.13)		(0.04) **	(0.03) ***
R^2	65.97%	64.51%	44.99%	44.63%
Obs	375	375	453	453

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it}/y_{it-1}(i.e. log(revenues$_{2006}$/revenues$_{2005}$))
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report a simplified version of the translog function after selecting only significant log-quadratic and interaction terms through the Wald test
3. Standard Errors in parentheses

Estimates obtained when controlling for outliers are shown in table 4.11; also in this case the translog function is the preferred model as the Wald test rejects the hypothesis of joint non significance of the log-quadratic and interaction terms at the 1% significance level for the R&D sample (p = 0.000) and at the 5% significance level for the non R&D sample (p = 0.032).

Table 4.11: Empirical estimates. Translog production function (first difference) - Huber and Tukey biweights

	With RD		Without RD	
Parameter	**(A)**	**(B)**	**(A)**	**(B)**
a	0.03	0.05	0.02	0.02
	(0.01) ***	(0.01) ***	(0.01) **	(0.01) **
β_k	0.01	-0.05	-0.06	0.02
	(0.09)	(0.02) **	(0.04)	(0.02)
β_r	0.14	0.02		
	(0.05) ***	(0.02)		
β_l	0.69	0.57	0.09	0.06
	(0.16) ***	(0.03) ***	(0.06) *	(0.05)
β_o	0.00	0.12	0.76	0.74
	(0.15)	(0.06) *	(0.07) ***	(0.07) ***
γ_{kk}	0.01	0.02	0.01	
	(0.01) **	(0.00) ***	(0.00) **	
γ_{rr}	0.00	-0.01		
	(0.01)	(0.00) **		
γ_{ll}	-0.06	-0.07	-0.04	-0.04
	(0.02) **	(0.01) ***	(0.01) ***	(0.01) ***
γ_{oo}	0.04	0.01	-0.07	-0.06
	(0.02) *	(0.01) *	(0.01) ***	(0.01) ***
γ_{kr}	-0.01			
	(0.01)			
γ_{kl}	0.03		-0.04	-0.02
	(0.02)		(0.01) ***	(0.01) ***
γ_{ko}	0.00		0.01	
	(0.02)		(0.01)	
γ_{rl}	0.01			
	(0.01)			
γ_{ro}	-0.02			
	(0.01)			
γ_{lo}	-0.04		0.13	0.13
	(0.03)		(0.02) ***	(0.02) ***
Obs	375	375	453	453

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it}/y_{it-1}(i.e. log(revenues$_{2006}$/revenues$_{2005}$))
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report a simplified version of the translog function after selecting only significant log-quadratic and interaction terms through the Wald test
3. Standard Errors in parentheses

Estimates of elasticities of output (shown in table 4.12), evaluated at the sample mean, substantially confirm results reached when estimating the model in levels. Results do not differ when elasticities are calculated at the sample median (see Appendix n. 1, table A1.4).

OC and Labour are confirmed as the inputs with highest output elasticities; OC elasticities range between 0.23 and 0.39 for the R&D sample and between 0.31 and 0.57 for the non R&D sample. Physical capital is still the factor with the smallest impact on firm performance; its elasticity is the lowest and ranges between 0.09 and 0.16 for the R&D sample and between 0.02 and 0.09 for the non R&D sample. R&D stock elasticity is confirmed to be low and not significant; however, R&D firms still have higher values of OC output elasticities with respect the non R&D firms.

Table 4.12: Translog function estimated output elasticities evaluated at the sample mean of the data (first difference)

	With RD			
	(A)		(B)	
	(1)	(2)	(1)	(2)
Output elasticities				
Physical capital	0.13	0.09	0.16	0.11
	(0.10)	(0.02) ***	(0.09) *	(0.02) ***
R&D stock	0.08	0.00	0.06	-0.03
	(0.06)	(0.03)	(0.04)	(0.03)
Labour	0.49	0.56	0.50	0.49
	(0.15) ***	(0.03) ***	(0.12) ***	(0.03) ***
OC	0.39	0.26	0.34	0.23
	(0.13) ***	(0.06) ***	(0.15) **	(0.05) ***
	Without RD			
Physical capital	0.09	0.02	0.06	0.02
	(0.04) **	(0.02)	(0.04) *	(0.02)
Labour	0.37	0.43	0.38	0.43
	(0.07) ***	(0.03) ***	(0.07) ***	(0.03) ***
OC	0.55	0.31	0.57	0.31
	(0.09) ***	(0.05) ***	(0.09) ***	(0.05) ***

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Elasticities are evaluated at the sample mean of the data
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report a simplified version of the translog function after selecting only significant log-quadratic and interaction terms through the Wald test
3. Columns labeled (1) report estimates obtained from the OLS robust procedure; columns labeled (2) report estimates obtained with the Huber and Tukey biweights
4. Standard errors in parentheses

Summing up, compared to the Cobb-Douglas production function, the translog can be considered, in this case, a more adequate model to describe the production process (even though the two models produce similar estimates of output elasticities). In particular, I propose, as the best model, a simplified version of the translog production function. According to this model, OC elasticity estimated in first difference, to control for the possible presence of unobserved firm heterogeneity, ranges between 0.23 and 0.34 for the R&D sample and between 0.31 and 0.57 for the non R&D sample. The robustness of the results across the different estimated specifications lets us, quite confidently, conclude that, in the sample considered, OC has a strong effect on performance, especially when compared to the small effect of physical capital and to the small and non significant effect of R&D. Average OC elasticity is 0.30 for the R&D sample (ranging between 0.23 and 0.39) and 0.47 for the non R&D sample (ranging between 0.31 and 0.66), which confirms the importance of OC for firm performance.

Results also outline the interrelated nature of the intangible OC and firm resources in general, confirming the RBV postulates. OC, in fact, has a strong effect on output, but together with traditional resources: physical capital (average elasticity R&D firms: 0.13; average elasticity non R&D firms: 0.05) and labour (average elasticity R&D firms: 0.55; average elasticity non R&D firms: 0.42).

Even though significant only in levels, there is a difference in the elasticity of OC between R&D and non R&D firms, with the latter having a higher value. Given the fact that firms that do not invest in R&D belong to industries different from those of firms that invest in R&D, this result could imply, in our opinion, that in certain industries OC also takes up the role of R&D stock. It also seems to point to the existence of a structural difference between firms that invest and firms that do not invest in R&D.

The most unexpected result relates to the effect of R&D stock, generally very small and not significant, which is in contrast with the results of empirical studies that analyze the effect of this intangible on firm performance. In search of an explanation for this unusual result, I have tested the same model presented in 4.3 using a production function that only considers three inputs: physical capital, labour and R&D stock, as done by the majority of the studies that analyze the effect of innovation related capital. Results, presented in the Appendix 2, are quite robust across the different specification. Through the analysis of the estimated elasticities, we can observe how conclusions for R&D stock are different when the effect of OC is not considered in the production function.

The elasticities of physical capital and labour do not substantially change; the simplified version of the translog function, proposed as the “best model”, estimates physical capital elasticity in the range between 0.10 and 0.19 (Table A2.6.a) - similarly to that of the model including OC (0.11-0.16) - and labour elasticity in the range between 0.58 and 0.66, again similarly to that of the model including OC (0.49-0.50). The main difference relates to the elasticity of R&D, which is now always significant and higher – ranging between 0.03 and 0.11. Considering the results of the different specifications, R&D average elasticity is about 0.07, which is very close to that found by similar studies

(Griliches and Mairesse, 1981, Aiello and Cardamone, 2006). This seems to suggest that studies that do not include the effect of OC in the production function, could be misspecified and overvalue elasticity estimates for R&D stock. On the other side, the same consideration could apply to the model presented here. Including OC stock could in fact capture the effect of R&D stock, which would be an explanation of the non significant R&D elasticity observed.

Compared to the estimates obtained by De and Dutta (2007), who use a similar model, our elasticity estimates for OC are somewhat lower; however both studies confirm the importance of OC for firm performance. Given the robust, quite stable and reasonable nature of the estimates obtained, the inclusion of the OC measure appears to be justified, not only at the theoretical but also at the empirical level. The model seems to perform well overall, with the exception of R&D elasticity estimates whose non significance has been justified. Contrary to De and Dutta (2007), even with the inclusion of OC, we can exclude that the production function has increasing returns to scale (as shown in Appendix 1, table A.5 and A.6)

4.5.2 Organization capital and profitability

The effect of OC on performance proxied by output has been confirmed; we now test the same hypothesis on profitability using the same methodology but a different dependent variable: incomes. For the reasons explained in 4.3, the model is tested only in levels. For both sub-samples, the Cook – Weisberg test performed on the residuals of the OLS regression of eq. 4.16 (with income as dependent variable) rejects the null hypothesis of constant variance in the residuals; the Cobb-Douglas function is thus estimated using the OLS robust procedure and results are presented in Table 4.13 columns 1. Columns 2 report the estimates obtained when controlling for the presence of outliers with Huber and Tukey biweights.

Table 4.13: Empirical estimates. Cobb-Douglas (levels) - Profitability

	With RD		Without RD	
	Coefficient		Coefficient	
	(1)	**(2)**	**(1)**	**(2)**
Variables				
Intercept	-0.08	-1.34	-0.08	-0.20
	(0.42)	(0.50) ***	(0.33)	(0.27)
$\log(c_t)$	0.31	0.26	0.29	0.28
	(0.06) ***	(0.05) ***	(0.05) ***	(0.04) ***
$\log(r_t)$	0.05	0.09		
	(0.03) *	(0.03) ***		
$\log(l_t)$	0.15	0.09	0.29	0.24
	(0.13)	(0.08)	(0.09) ***	(0.07) ***
$\log(OC_t)$	0.44	0.53	0.32	0.38
	(0.12) ***	(0.07) ***	(0.07) ***	(0.06) ***
Control dummies				
Energy	0.75	0.86	1.07	1.56
	(0.20) ***	(0.33) ***	(0.50) **	(0.32) ***
Manuf	-0.26			
	(0.16) *			***
Consumerd	-0.51			
	(0.30) *			
Consumernd				0.39
				(0.20) *
Chemicals	-0.56	-0.44		
	(0.23) **	(0.22) **		
Wholesale	-0.33			
	(0.14) **			
Busequip			0.86	0.97
			(0.26) ***	(0.26) ***
Telecom			1.03	0.96
			(0.20) ***	(0.34) ***
Healthcare			-0.92	-0.71
			(0.32) ***	(0.40) *
Other			0.57	0.57
			(0.15) ***	(0.14) ***
Austria		1.24		
		(0.60) **		
Belgium		1.52		
		(0.57) ***		
Denmark		1.19		
		(0.49) **		
Finland	0.56	1.41		
	(0.20) ***	(0.53) ***		
France		0.85		
		(0.48) *		
Germany		0.77		
		(0.46) *		
Greece		1.50		
		(0.55) ***		
Luxembourg	1.24	2.35		
	(0.39) ***	(0.70) ***		
Netherlands		1.08		
		(0.48) **		
Unitedkingdom		1.02		
		(0.45) **		
Italy			1.56	
			(0.37) ***	
Spain			0.67	
			(0.11) ***	
Obs.	321	321	343	343

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. $\log(\text{income}_{2006})$)
2. Columns labeled (1) report OLS robust regression estimates; Columns labeled (2) report Huber and Tukey biweights regression estimates
3. Standard Errors in parentheses

OC capital has a strong effect also on profitability; average elasticity is 0.48 for the R&D sample and 0.35 for the non R&D sample. This corresponds to the opposite with respect to what observed for firm performance measured by output, where the effect of OC was higher for non R&D firms. The elasticity of physical capital ranges between 0.26 and 0.31 for the R&D sample and between 0.28 for the non R&D sample; these estimates are slightly higher compared to those obtained with respect to output. Still, physical capital has a lower effect on profitability than OC; interestingly physical appears to have the same effect in both sub-samples. Labour elasticity with respect to profitability is drastically smaller compared to its effect on productivity, which could be expected; it ranges between 0.09 and 0.15 for the non R&D sample and 0.24-0.29 for the non R&D sample. While R&D stock was not significant with respect to productivity, its elasticity is now significant and positive (average: 0.07) with respect to profitability.

Table 4.14 presents results obtained from the translog function using OLS robust procedure and Huber and Tukey biweights. For what concerns the R&D sample, the Wald test rejects the hypothesis of joint non significance of the log-quadratic and interaction terms at the 5% significance level only when controlling for outliers (p= 0.0246); when using the OLS robust procedure the Wald test (p = 0.1371) indicates that the translog goes back to be a simple Cobb-Douglas. For what concerns the non R&D sample, instead, the translog function captures effects not captured by the Cobb-Douglas and it is the model indicated as preferred. Columns A presents the complete translog function, while columns B present the simplified version that only includes significant interaction terms. Elasticities of output are calculated at sample means and are presented in table 4.15; they do not significantly differ from values obtained using median values, as shown in the appendix 1, table A1.7

Table 4.14: Empirical estimates. Translog (levels) - Profitability

	With RD		Withouth RD			
	(2)		(2)		(1)	
Parameter	**(A)**	**(B)**	**(A)**	**(B)**	**(A)**	**(B)**
a	0.84	0.02	0.11	0.18	-0.42	0.25
	(0.86)	0.73	(0.51)	(0.27)	(0.68)	(0.40)
β_k	-0.01	0.26	-0.02	0.01	0.20	0.08
	(0.21)	(0.05) ***	(0.14)	(0.06)	(0.20)	0.09
β_r	0.12	0.08				
	(0.15)	(0.03) ***				
β_l	1.02	0.43	0.06	0.26	-0.09	0.31
	(0.34) ***	(0.17) **	(0.23)	(0.06) ***	(0.27)	(0.08) ***
β_o	-0.51	-0.16	0.69	0.55	0.84	0.52
	(0.45)	(0.28)	(0.21) ***	(0.10) ***	(0.24) ***	(0.13) ***
γ_{kk}	0.04		0.09	0.07	0.07	0.06
	(0.03)		(0.02) ***	(0.01) ***	(0.03) ***	(0.02) ***
γ_{rr}	0.01					
	(0.01)					
γ_{ll}	0.07		-0.05		-0.05	
	(0.05)		(0.04)		(0.05)	
γ_{oo}	0.15	0.08	-0.01		-0.02	
	(0.07) **	(0.03) **	(0.03)		(0.02)	
γ_{kr}	0.02					
	(0.02)					
γ_{kl}	-0.05		-0.01		0.02	
	(0.06)		(0.04)		0.05	
γ_{ko}	-0.02		-0.09	-0.07	-0.12	-0.06
	(0.06)		(0.04) **	(0.02) ***	(0.06) **	(0.03) **
γ_{rl}	-0.02					
	(0.04)					
γ_{ro}	-0.03					
	(0.04)					
γ_{lo}	-0.17	-0.08	0.09		0.11	
	(0.09) *	(0.04) **	(0.06)		(0.06) *	
Control dummies						
Chemicals	-0.54	-0.58				
	(0.22) **	(0.22) ***				
Consumernd	-0.51	-0.56				
	(0.23) **	0.22 ***				
Consumerd					-0.85	-0.83
					(0.32) ***	(0.31) ***
Energy			0.98	1.05		
			(0.35) ***	(0.31) ***		
Busequip			0.42	0.49		
			(0.24) *	(0.24) **		
Healthcare			-1.41	-1.41	-1.57	-1.53
			(0.42) ***	(0.41) ***	(0.29) ***	(0.26) ***
Telecom					0.55	0.50
					(0.22) **	(0.21) **
Wholesale					-0.67	-0.66
					(0.18) ***	(0.18) ***
Austria	1.52	1.51				
	(0.59) **	(0.59) ***				
Belgium	1.64	1.54				
	(0.57) ***	(0.57) ***				
Denmark	1.35	1.25				
	(0.48) ***	(0.49) ***				
Finland	1.64	1.48				
	(0.52) ***	(0.52) ***				
France	1.09	1.01				
	(0.47) **	(0.47) **				
Germany	0.89	0.79				
	(0.46) **	(0.46) *				
Greece	1.58	1.49				
	(0.55) ***	(0.54) ***				
Luxembourg	2.48	2.66				
	(0.71) ***	(0.70) ***				
Netherlands	1.16	1.07			0.68	0.66
	(0.48) **	(0.48) **			(0.35) *	(0.34) *
Unitedkingdom	1.21	1.05				
	(0.45) ***	(0.45) **				
Italy			2.06	2.16	1.86	2.01
			(1.16) *	(1.15) *	(0.36) ***	(0.35) ***
Spain					0.38	0.35
					(0.13) ***	(0.12) ***
Obs.	321	321	343	343	343	343

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. log(income$_{2006}$))
2. Columns labeled (1) report OLS robust regression estimates; Columns labeled (2) reports Huber and Tukey biweight regression estimates
3. Columns labeled (A) report regression estimates for the complete translog function; Columns labeled (B) report regression estimates for the simplified version of the translog function
4. Standard errors in parentheses

Table 4.15: Translog function estimated output elasticities evaluated at the sample mean of the data (levels) - Profitability

	With RD		Without RD			
	(A)	(B)	(A)		(B)	
	(2)	(2)	(1)	(2)	(1)	(2)
Output elasticities						
Physical capital	0.27	0.26	0.28	0.24	0.30	0.26
	(0.05) ***	(0.05) ***	(0.04) ***	(0.04) ***	(0.05) ***	(0.04) ***
R&D stock	0.12	0.08				
	(0.04) ***	(0.03) ***				
Labour	0.11	0.09	0.35	0.32	0.31	0.26
	(0.08)	(0.08)	(0.07) ***	(0.07) ***	(0.08) ***	(0.06) ***
OC	0.47	0.53	0.28	0.29	0.31	0.34
	(0.08) ***	(0.08) ***	(0.07) ***	(0.06) ***	(0.07) ***	(0.06) ***

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. log(income$_{2006}$))
2. Elasticities are evaluated at the sample mean of the data
3. Columns labeled (1) report regression estimates of the complete translog function; Columns labeled (2) report a simplified version of t translog function after selecting only significant log-quadratic and interaction terms through the Wald test
4. Columns labeled (a) report estimates obtained with the OLS robust procedure; columns labeled (b) report estimates obtained with the Huber and Tukey biweights
5. Standard errors in parentheses

Results of the estimates using the translog function are very robust in comparison with elasticities of the Cobb-Douglas production function. Considering the different specifications, we can affirm that average OC elasticity with respect to profitability is 0.49 for R&D firms and 0.32 for non R&D firms. R&D stock elasticity is positive and significant (0.08) even though smaller than the other intangible resource, OC. Also traditional inputs significantly contribute to firm profitability: average physical capital elasticity is 0.27 for both R&D and non R&D firms, while average labour elasticity is 0.11 for R&D firms and 0.29 for non R&D firms. Results seem to indicate a structural difference between R&D and non R&D firms. In non R&D firms, the three inputs, - physical capital, OC and Labour - seem to equally contribute to profitability, which could be a confirmation of the strong interrelated nature of firm resources. In non R&D firms, resources are still interrelated and need one another in order to generate profitability; however, OC seems the most important resource for firm performance, having the highest elasticity. Furthermore, the effect of OC on profitability is significantly higher for R&D firms with respect to non R&D firms.

Even though results are quite robust with respect to the different specifications tested, it has to be reminded that estimates could be biased due to the presence of unobserved firm heterogeneity, as the effect on profitability has been tested only for the model in levels.

Concluding, the main object of this study was to analyze the effect of OC on performance and test the hypothesis that OC is a crucial factor for competitiveness. Results seem to confirm this view; OC elasticity is positive and significant with respect to both measure of performance used.

4.6 Discussion and concluding remarks

The main objective of this chapter was to analyze the effect of OC on performance, using an accounting proxy, preferred to the usual proxies adopted - indexes, qualitative data and survey answers – as able to provide a relatively more objective OC measure. Following the trend that measures intangible stock from income statement proxies, the most recent literature on the subject has proposed the use of two financial proxies for OC: SGA expenses (Lev and Radhakrishnan, 2005) or, alternatively, Administrative expenses (De and Dutta, 2007). These two items represent the majority of firm expenses in OC; as a consequence, OC is defined mainly through its components (organizational practices, information technology reputation enhancement human resources related investments). The two studies (Lev and Radhakrishnan, 2005; De and Dutta, 2007) that measure the effect of OC on performance using income statement proxies have been critically analyzed and compared.

Lev and Radhakrishnan (2005) measure OC as production function residual using SGA expenses; however, the residual is an overall measure of production efficiency that also includes other effects such as measurement errors, aggregation bias and model misspecification. Furthermore, this method implies assuming OC elasticity equal to one. De and Dutta (2007), instead, measure OC through the application of the perpetual inventory method to a percentage of Administrative expenses, similarly to what is done to calculate R&D stock from R&D expenses. Both studies model the production process using a Cobb-Douglas production function; only De and Dutta (2007), however, consider OC as a production input. Even though both studies have the merit to attempt to estimate the effect of OC using financial statement data, De and Dutta's (2007) model has been considered more solid.

Building on these two studies, in the attempt to integrate their strengths and introduce improvements, I have presented a new eclectic model. I have used SGA expenses as OC proxy, being that it is more comprehensive and available than administrative expenses, as in Lev and Radhakrishnan (2005); following De and Dutta (2007), OC has been considered an input of the production function and has been measured through the application of the perpetual inventory method to part of SGA expenses. The effect of OC on firm performance has been tested using a Cobb-Douglas production function, extended to include, besides traditional inputs (labour and physical capital) intangible resources, namely R&D stock and OC. In the attempt to improve the model, I have also used the more flexible translog function, which does not impose restrictions on elasticity of output and elasticity of substitution; results have shown that this last specification is, in fact, better, as it is able to capture effects neglected by the Cobb-Douglas production function. Furthermore, the effect of OC on firm performance has been tested not only on output, but also on profitability (proxied by firm’s income), performance measures less influenced by firm structural factors than output.

Data has been downloaded from Compustat Global, which provides normalized financial templates for global companies and allows meaningful comparisons across a wide variety of global firms using different accounting standards and practices. From this database, I have selected firms belonging to the Euro currency area, extended to also include the United Kingdom and Denmark. As OC is particularly influenced by cultural factors and organizational structures, this geographical selection criterion has minimized possible bias due to differences in business cultures and economic and legal infrastructural systems present in less homogeneous areas. Furthermore, it has increased the novelty of the study as, to our knowledge, the effect of OC, as proxied by an income statement item, has not been tested at the European level.

Firms reporting Selling General and Administrative expenses for the years 2000 - 2006 have been selected. After the cleaning procedure, the final dataset has consisted of 828 firms, 418 with R&D stock and 410 without R&D stock.

Yearly Revenues and yearly incomes have provided the two proxies for performance; the traditional input factors of physical capital and labour have been proxied by yearly Property Plant and Equipment (PPE) and n. of employees. Intangible resources have been represented by innovation related capital – R&D stock, proxied by R&D expenses - and OC, proxied by SGA expenses.

The firms in the sample represent a wide variety of industries; this renders the study particularly original as the empirical literature that investigates the effect of intangible resources on firm performance focuses mainly on R&D capital, and therefore principally addresses sectors where this type of investing activity is conducted. Country distribution reflects the composition of the main financial core of the European Economy.

The dataset analysis indicates that OC appears to be perceived as an important factor by the firms in the sample that invest more heavily in this intangible than in physical capital; OC has registered the highest increase in the period considered, with an average growth rate of 20%. Physical capital, instead, has recorded the lowest percentage increase (5% - R&D sample; 11% - non R&D sample), outlying the importance of intangible resources and the trend towards a dematerialization strategy of the production. Firms appear to be committed to the creation of innovation related capital; the majority of them have, in fact, R&D expenses for at least 5 years and have invested in OC for at least 6 out of the 7 years considered. The investment strategy towards intangibles is therefore similar for both R&D and non R&D firms; the main difference concerns the amount of investments in OC, higher for R&D firms, probably due to the fact that they result to be, on average larger,

The dataset has been divided in two subgroups – R&D and non R&D firms – and the model has been estimated on both sub-samples separately, through the OLS, controlling for heteroskedasticity of errors, endogeneity of inputs and influence of outliers. The two specifications – Cobb-Douglas and Translog production function – have been compared and results have indicated the latter, in its simplified form, as the most appropriate one. The model has been first estimated in levels; to check and eliminate the possible effect of omitted variable bias caused by unobserved firm heterogeneity, I have further estimated the model in first difference and compared results.

Results appear to be quite robust across the different specifications and interesting findings emerge from their analysis.

First of all, OC has a strong effect on output: average OC output elasticity is 0.30 for the R&D sample (ranging between 0.23 and 0.39) and 0.47 for the non R&D sample (ranging between 0.31 and 0.66). This is much higher with respect to physical capital output elasticity and confirms the view that sees intangibles, and in particular OC, idiosyncratic, firm-specific, interrelated and hard to imitate, as a crucial factor for firm performance. Estimates indicate that physical capital is not a key factor for success anymore; the development, globalization and commoditization processes have render it easily available and, therefore, not a factor on which to build up a competitive strategy. Nonetheless - and this leads us to the second interesting finding - physical capital is still important, as shown by its positive and generally significant output elasticities. This outlines the interrelated nature of the intangible OC, and firm resources in general, confirming the RBV postulates; OC, in fact, also needs traditional factors of production, such as labour and physical capital, in order to generate effect on performance. As results show, OC has a significant effect on output, but together with traditional resources: physical capital (average elasticity 0.13 - R&D firms; 0.05 - non R&D firms) and labour (average elasticity 0.55 - R&D firms; 0.42 - non R&D firms).

The third interesting finding concerns the fact that OC elasticity appears to be higher in non R&D firms, even though R&D stock does not show to have a strong effect on firm performance. This is probably due to the fact that firms without R&D stock operate in sectors where R&D stock is not essentially required and therefore OC can “compensate” for the absence of the R&D stock input; another explanation could be the existence of a structural difference between firms that invest and firms that do not invest in R&D.

The last interesting finding concerns the effect of OC on profitability which is also high: average OC elasticity is 0.49 for R&D firms and 0.32 for non R&D firms. Also with respect to profitability, results seem to indicate a structural difference between R&D and non R&D firms. In non R&D firms, the three inputs, - physical capital, OC and Labour - seem to equally contribute to profitability, which could be a confirmation of the strong interrelated nature of firm resources. In non R&D firms, resources are still interrelated and need one another in order to generate profitability; however, OC seems the most important resource for firm performance, having the highest elasticity. Furthermore, the effect of OC on profitability is significantly higher for R&D firms with respect to non R&D firms; the opposite with respect to that observed for firm performance measured as output. Even though estimates are quite robust with respect to the different specifications tested, profitability results have to be read with caution; due to missing income values for the year 2005, the effect of OC on profitability has been tested only in levels and therefore results could be biased due to unobserved firm heterogeneity.

Given the robust, quite stable and reasonable nature of the estimates obtained, the inclusion of the OC measure appears to be justified, not only at the theoretical but also at the empirical level. The model seems to perform well overall, with the exceptions of R&D elasticity estimates, generally very small and not significant. This is the most unexpected result, in contrast with findings of similar studies. Such a result could be caused by the double counting problem – which could be exacerbated in this study by the inclusion of OC among the production inputs; it could also be due to the fact that SGA expenses include, in certain cases, customer or government sponsored R&D expenses, and therefore part of the R&D stock effect could be captured by OC. In this case, the model would provide biased estimates for what concerns R&D stock elasticity and slightly overestimate the effect of OC on output. In search of an explanation for this unusual result, we have tested the same model without considering OC, using a 3 input production function as done by the majority of the studies that analyze the effect of R&D on firm performance. While the elasticities of physical capital and labour do not substantially change, R&D stock elasticity show to be significant and higher: R&D average elasticity is about 0.07 – ranging between 0.03 and 0.11 - which is very close with that found by similar studies (Griliches and Mairesse, 1981, Aiello and Cardamone, 2006). I have concluded that this could suggest that studies that do not include the effect of OC in the production function could be misspecified and overvalue elasticity estimates for R&D stock.

In conclusion, the main objective of this study was to analyze the effect of OC on performance and test the hypothesis that OC is a crucial factor for competitiveness. Results seem to confirm this view; OC elasticity is positive and significant with respect to both measures of performance used. Some objections could however be moved against the methodology used to measure OC.

The main concerns probably arise with respect to the measurement of OC through the perpetual inventory method applied to SGA expenses, even though, as the method has been widely used to measure R&D stock, another intangible, in principle there should be no problems. Due to the novelty of its application to OC, however, the usual worries about proper obsolescence rate, length of the series of expenses and lags to use have not been deeply studied yet. I agree that the percentage of SGA expenses to capitalize and the obsolescence rate are chosen, somehow, in an arbitrary way (as in De and Dutta, 2007), but not *in toto*. I believe that considering only 20% of SGA expenses is appropriate and allows to take into consideration: first, the fact that only part of SGA expenses actually contribute to the creation of OC; and second, that this process takes time. The obsolescence rate of 10% is chosen by comparison with the one commonly adopted for R&D (usually 15%-20%). Even though R&D stock and OC have similar properties that justify the application of a similar methodology to measure them, I believe that OC is more tacit, firm-specific and harder to imitate; for this reason, the lower 10% depreciation rate is considered more appropriate for OC.

Another possible objection to the adopted OC measure is the fact that it assumes that firms with the highest SGA expenses have a higher OC level, which could be false when firms spend more in SGA expenses due to inefficiencies. However, the same consideration could apply the methodology used to measure R&D stock, when firms have higher R&D expenses as a result of inefficient organization of their R&D activities. Finally, it could be objected that this OC measure captures only aspects of the firm that are correlated directly with observed expenditures, while aspects not related to expenditures – for example managerial talent - are disregarded and included in the error; it is however likely that even this unobserved variable requires some sort of monetary investment and, therefore, the effect of these OC aspects should be negligible.

With respect to the validity of the database, two aspects need some consideration: selectivity bias and representative level of the sample. Selectivity bias could affect estimates, as firms that do not report data for SGA expenses have been excluded from the dataset. This is a wide spread and common problem that also characterizes studies that analyze the effect of R&D on performance and can only be overcome by improving the quantity and quality of information released by firms. Regarding the representative level of the sample, the concentration of firms in 6 major European countries does not undermine its validity; the countries represented form the core of the European economy and, besides the six major countries, the dataset also includes other countries with less economic weight and different business cultures, even though on a smaller percentage. Results, however, have to be interpreted on the basis of the sample composition; this study, therefore, mainly reflects the effect of OC on firm performance in those firms belonging to the financial and economic core of Europe.

The study is original with respect to methodology used to measure OC, model used to analyze its effect on firm performance and novelty and composition of the dataset. Even though the model presents some limits, the robustness of the results across the different specifications can be taken as a confirmation of the relative validity of the results, that have produced interesting findings and confirmed the main hypothesis tested: the importance of OC for firm performance.

Appendix 1

Further Estimates: Production function with OC

Table A1.1: Empirical estimates. Cobb-Douglas production function with instruments (levels)

	With RD		Without RD	
	Coefficient		Coefficient	
	(1)	(2)	(1)	(2)
Variables				
Intercept	3.25	3.74	3.01	3.20
	(0.39) ***	(0.21) ***	(0.30) ***	(0.18) ***
$\log(c_t)$	0.17	0.16	0.12	0.10
	(0.04) ***	(0.03) ***	(0.03) ***	(0.03) ***
$\log(r_t)$	-0.01	0.01		
	(0.03)	(0.02)		
$\log(l_t)$	0.41	0.55	0.32	0.37
	(0.10) ***	(0.06) ***	(0.08) ***	(0.05) ***
$\log(OC_t)$	0.47	0.31	0.51	0.47
	(0.14) **	(0.06) ***	(0.09) ***	(0.04) ***
Control dummies				
Energy	0.82	0.77		
	(0.18) ***	(0.19) ***		
Wholesale			0.26	0.25
			(0.11) **	(0.10) **
Telecom			0.46	0.49
			(0.17) ***	(0.16) ***
Other			0.22	0.20
			(0.09) **	(0.09) **
Austria	-0.41	-0.33		
	(0.14) ***	(0.13) ***		
Denmark	-0.45	-0.31		
	(0.20) **	(0.17) *		
France	-0.28	-0.22	0.49	0.50
	(0.14) **	(0.13) *	(0.21) **	(0.20) **
Germany	-0.25	-0.19		
	(0.13) *	(0.12)		
Greece	-0.40	-0.37		
	(0.22) *	(0.20) *		
Ireland	-0.66	-0.56		
	(0.31) **	(0.25) **		
Netherlands	-0.33	-0.27		
	(0.19) *	(0.17)		
UnitedKingdom	-0.33	-0.21		
	(0.14) **	(0.12) *		
Italy			-0.44	-0.46
			(0.10) ***	(0.12) ***
R^2	94.2%	94.5%	84.2%	84.3%
Obs.	375	410	418	418
Hausman		0.66		1.00

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. $\log(\text{revenues}_{2006})$)
2. Columns labeled (1) report regression estimates using instrumented variables. Instruments: $\log(c_{t-1})$; $\log(r_{t-1})$ $\log(l_{t-1})$; sga_{t-1}. Columns labeled (2) report OLS robust regression estimates
3. Robust Standard Errors in parentheses

Table A1.2: Translog function estimated output elasticities evaluated at the sample median of the data (levels)

	With RD							
	(A)				(B)			
	(1)		(2)		(1)		(2)	
Output elasticities								
Physical capital	0.17		0.16		0.16		0.07	
	(0.03)	***	(0.02)	***	(0.03)	***	(0.02)	***
R&D stock	0.04		0.03		0.03		0.02	
	(0.02)		(0.02)	*	(0.02)	***	(0.01)	*
Labour	0.49		0.60		0.54		0.61	
	(0.07)	***	(0.04)	***	(0.05)	***	(0.03)	***
OC	0.36		0.25		0.33		0.25	
	(0.06)	***	(0.04)	***	(0.04)	***	(0.03)	***
	Without RD							
Physical capital	0.06		0.06		0.06		0.06	
	(0.02)	***	(0.02)	***	(0.02)	***	(0.02)	**
Labour	0.47		0.49		0.46		0.47	
	(0.05)	***	(0.04)	***	(0.04)	***	(0.04)	***
OC	0.50		0.48		0.51		0.49	
	(0.04)	***	(0.04)	***	(0.04)	***	(0.03)	***

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Elasticities are evaluated at the sample median of the data
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report simplified version of the translog function after selecting only significant log-quadratic and interaction terms through the Wald test
3. Columns labeled (1) report estimates obtained from the OLS robust procedure; columns labeled (2) report estimates obtained with the Huber and Tukey biweights
4. Standard errors in parentheses

Table A1.3: Empirical Estimates. Cobb-Douglas production function with instruments (first difference)

	With RD				Without RD			
	Coefficient				Coefficient			
	(1)		(2)		(1)		(2)	
Variables								
Intercept	0.05		-0.01		0.02		-0.04	
	(0.07)		(0.02)		(0.06)		(0.02)	**
$\log(c_t/c_{t-1})$	0.04		0.03		0.09		0.07	
	(0.04)		(0.04)		(0.05)		(0.04)	*
$\log(r_t/r_{t-1})$	0.12		0.05					
	(0.09)		(0.04)					
$\log(l_t/l_{t-1})$	0.79		0.66		0.39		0.31	
	(0.15)	***	(0.06)	***	(0.11)	***	(0.08)	***
$\log(OC_t/OC_{t-1})$	-0.01		0.39		0.34		0.66	
	(0.47)		(0.10)	***	(0.31)		(0.09)	***
R^2	57.8%		59.4%		40.1%		43.0%	
Obs.	375		375		453		453	
Hausman			0.74				0.94	

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it}/y_{it-1}(i.e. log(revenues$_{2006}$/revenues$_{2005}$))
2. Columns labeled (1) report regression estimates using instrumented OC. Instruments: sga$_{2004}$, sga$_{2003}$, sga$_{2002}$, sga$_{2001}$,sga$_{2000}$. Columns labeled (2) report OLS regression estimates
3. Standard errors in parentheses

Table A1.4: Translog function estimated output elasticities evaluated at the sample median of the data (first difference)

	With RD			
	(A)		(B)	
	(1)	(2)	(1)	(2)
Output elasticities				
Physical capital	0.12	0.07	0.01	0.10
	(0.09)	(0.02) ***	(0.06) *	(0.02) ***
R&D stock	0.08	0.01	0.06	-0.03
	(0.06)	(0.03)	(0.04)	(0.03)
Labour	0.58	0.60	0.56	0.53
	(0.14) ***	(0.03) ***	(0.12) ***	(0.03) ***
OC	0.34	0.24	0.34	0.22
	(0.14) **	(0.05) ***	(0.15) **	(0.05) ***
	Without RD			
Physical capital	0.08	0.03	0.06	0.03
	(0.04) **	(0.02) *	(0.04) *	(0.02)
Labour	0.37	0.41	0.37	0.41
	(0.07) ***	(0.03) ***	(0.07) ***	(0.03) ***
OC	0.57	0.32	0.58	0.31
	(0.08) ***	(0.04) ***	(0.09) ***	(0.04) ***

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Elasticities are evaluated at the sample median of the data
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report simplified version of the translog function after selecting only significant log-quadratic and interaction terms through the Wald test
3. Columns labeled (1) report estimates obtained from the OLS robust procedure; columns labeled (2) report estimates obtained with the Huber and Tukey biweights
4. Standard errors in parentheses

Table A1.5: Estimated Returns to scale (levels)

	With RD					
	Cobb-Douglas		Translog			
			(A)		(B)	
	(1)	(2)	(1)	(2)	(1)	(2)
Returns to scale	1.04	1.03	1.03	1.02	1.03	0.93
	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
One-tailed test	0.99	0.99	0.95	0.95	0.95	1.00
	Without RD					
Returns to scale	0.95	0.97	1.02	1.01	1.02	1.01
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
One-tailed test	0.98	0.92	0.70	0.73	0.71	0.62

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Columns labeled (A) report estimates of the complete translog function; Columns labeled (B) report estimates for the simplified version of the translog function
2. Columns labeled (1) report estimates obtained with the OLS robust procedure; columns labeled (2) report estimates obtained with the Huber and Tukey biweights
3. Standard errors in parentheses

Table A1.6: Estimated Returns to scale (first difference)

	With RD					
	Cobb-Douglas		Translog			
			(A)		(B)	
	(1)	(2)	(1)	(2)	(1)	(2)
Returns to scale	1.13	0.96	1.09	0.90	1.06	0.80
	(0.06)	(0.03)	(0.10)	(0.04)	(0.09)	(0.04)
One-tailed test	0.98	0.93	0.98	1.00	0.76	1.00
	Without RD					
Returns to scale	1.04	0.84	1.01	0.76	1.02	0.75
	(0.09)	(0.03)	(0.09)	(0.04)	(0.10)	(0.04)
One-tailed test	0.66	1.00	0.54	1.00	0.56	1.00

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Columns labeled (A) report estimates of the complete translog function; Columns labeled (B) report estimates for the simplified version of the translog function
2. Columns labeled (1) report estimates obtained with the OLS robust procedure; columns labeled (2) report estimates obtained with the Huber and Tukey biweights
3. Standard errors in parentheses

Table A1.7: Translog function estimated output elasticities evaluated at the sample median of the data (levels) - Profitability

	With RD		Without RD			
	(A)	(B)	(A)		(B)	
	(2)	(2)	(1)	(2)	(1)	(2)
Output elasticities						
Physical capital	0.26	0.26	0.29	0.25	0.26	0.26
	(0.05) ***	(0.05) ***	(0.04) ***	(0.04) ***	(0.04) ***	(0.04) ***
R&D stock	0.15	0.08				
	(0.05) ***	(0.03) ***				
Labour	0.16	0.14	0.35	0.33	0.26	0.26
	(0.09) *	(0.08) *	(0.08) ***	(0.07) ***	(0.06) ***	(0.06) ***
OC	0.41	0.47	0.28	0.29	0.35	0.34
	(0.09) ***	(0.08) ***	(0.08) ***	(0.06) ***	(0.06) ***	(0.06) ***

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. log($income_{2006}$))
2. Elasticities are evaluated at the sample median of the data
3. Columns labeled (1) report regression estimates of the complete translog function; Columns labeled (2) report a simplified version of the translog function after selecting only significant loq-quadratic and interaction terms through the Wald test
4. Columns labeled (a) report estimates obtained with the OLS robust procedure; columns labeled (b) report estimates obtained with the Huber and Tukey biweights
5. Standard errors in parentheses

Appendix 2

Estimates for the model without OC: 3 input production function

Table A2.1: Empirical estimates. 3 input Cobb-Douglas production function (levels)

	Cobb-Douglas			
	(1)		**(2)**	
Variables				
Intercept	4.47		4.49	
	(0.12)	***	(0.08)	***
$\log(c_t)$	0.21		0.16	
	(0.03)	***	(0.02)	***
$\log(r_t)$	0.06		0.07	
	(0.02)	***	(0.01)	***
$\log(l_t)$	0.73		0.77	
	(0.05)	***	(0.03)	***
Control dummies				
Consumerd	-0.24			
	(0.10)	**		
Energy	0.69		0.74	
	(0.26)	*	(0.17)	***
Wholesale			0.54	
			(0.16)	***
Telecom	0.46		0.61	
	(0.21)	**	(0.21)	***
Healthcare	(0.27)			
	(0.09)	***		
Greece	-0.31			
	(0.16)	**		
Spain	-0.20			
	(0.04)	***		
Obs.	410		410	

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. log(revenues$_{2006}$))
2. Columns labeled (1) report OLS regression estimates; Columns labeled (2) report Huber and Tukey biweights regression estimates
3. Standard Errors in parentheses

Table A2.2: Empirical estimates. 3 input Translog production function (levels)

	Translog			
	(A)		(B)	
	(1)	(2)	(1)	(2)
Parameter				
a	4.56	4.86	4.55	4.76
	(0.22) ***	(0.13) ***	(0.10) ***	(0.08) ***
β_k	0.17	-0.07	0.19	-0.04
	(0.11)	(0.07)	(0.03) ***	(0.03)
β_r	0.00	0.00	0.01	0.03
	(0.04)	(0.03)	(0.02)	(0.02) *
β_l	0.54	0.84	0.49	0.78
	(0.16) ***	(0.10) ***	(0.05) ***	(0.03) **
γ_{kk}	0.00	0.03		0.03
	(0.01)	(0.01) ***		(0.00) ***
γ_{rr}	0.01	0.01	0.01	0.01
	(0.01) ***	(0.00) *	(0.00) ***	(0.00) ***
γ_{ll}	(0.09)	(0.04)	-0.10	-0.05
	(0.03) ***	(0.02) *	(0.01) ***	(0.01) ***
γ_{kr}	0.00	0.01		
	(0.01)	(0.01)		
γ_{kl}	0.07	-0.01	0.08	
	(0.04) *	(0.03)	(0.01) ***	
γ_{rl}	-0.01	-0.01		
	(0.02)	(0.01)		
Control dummies				
Consumerd	-0.27		-0.29	
	(0.08) ***		(0.08) ***	
Consumernd		0.18		0.17
		(0.10) *		(0.10) *
Manuf		0.17		0.17
		(0.06) ***		(0.06) ***
Energy	0.56	0.73	0.56	0.75
	(0.20) ***	(0.16) ***	(0.19) ***	(0.16) ***
Healthcare	-0.29		-0.28	
	(0.10) ***		(0.09) ***	
Telecom		0.44		0.46
		(0.19) **		(0.19) **
Wholesale		0.58		0.57
		(0.15) ***		(0.15) ***
Austria	-0.22		-0.22	
	(0.10) **		(0.09) **	
Greece	-0.40		-0.38	
	(0.17) **		(0.17) **	
Ireland	-0.35		-0.34	
	(0.10) ***		(0.10) ***	
Netherlands		-0.23		-0.22
		(0.09) **		(0.09) **
Obs.	410	410	410	410

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. log(revenues$_{2006}$))
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report a simplified version of the translog function after selecting only significant log quadratic and interaction terms through the Wald test
3. Columns labeled (1) report estimates obtained from the OLS robust procedure; columns labeled (2) report estimates obtained with the Huber and Tukey biweights
4. Standard errors in parentheses

Table A2.3: 3 input Translog function estimated output elasticities (levels)

A2.3.a: output elasticities estimated at the sample mean of the data

	(A)		(B)	
Output elasticities	**(1)**	**(2)**	**(1)**	**(2)**
Physical capital	0.23	0.17	0.23	0.17
	(0.03) ***	(0.02) ***	(0.03) ***	(0.02) ***
R&D stock	0.08	0.08	0.07	0.09
	(0.02) ***	(0.01) ***	(0.02) ***	(0.01) ***
Labour	0.67	0.74	0.68	0.74
	(0.05) ***	(0.03) ***	(0.04) ***	(0.03) ***

A2.3.b: output elasticities estimated at the sample median of the data

	(A)		(B)	
Output elasticities	**(1)**	**(2)**	**(1)**	**(2)**
Physical capital	0.20	0.16	0.20	0.16
	(0.03) ***	(0.02) ***	(0.03) ***	(0.02) ***
R&D stock	0.08	0.08	0.07	0.09
	(0.03) ***	(0.02) ***	(0.02) ***	(0.01) ***
Labour	0.72	0.77	0.73	0.77
	(0.05) ***	(0.03) ***	(0.04) ***	(0.03) ***

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Elasticities are evaluated at the sample median of the data
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report simplified version of the translog function after selecting only significant log-quadratic and interaction terms through the Wald test
3. Columns labeled (1) report estimates obtained from the OLS robust procedure; columns labeled (2) report estimates obtained with the Huber and Tukey biweights
4. Standard errors in parentheses

Table A2.4: Empirical estimates. 3 input Cobb-Douglas production function (first difference)

	Cobb-Douglas	
	(1)	**(2)**
Variables		
Intercept	0.05	0.07
	(0.01) ***	(0.01) ***
$\log(c_t/c_{t-1})$	0.04	0.09
	(0.04) ***	(0.02) ***
$\log(r_t/r_{t-1})$	0.12	0.05
	(0.04) ***	(0.02) ***
$\log(l_t/l_{t-1})$	0.78	0.70
	(0.05) ***	(0.02) ***
Obs.	375	375

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it}/y_{it-1}(i.e. log(revenues$_{2006}$/revenues$_{2005}$))
2. Columns labeled (1) report OLS robust regression estimates; Columns labeled (2) reports Huber and Tukey biweight regression estimates
3. Standard errors in parentheses

Table A2.5: Empirical estimates. 3 input Translog production function (first difference)

	Translog							
	(A)				(B)			
Parameter	**(1)**		**(2)**		**(1)**		**(2)**	
a	0.05		0.07		0.05		0.07	
	(0.01)	***	(0.01)	***	(0.01)	***	(0.01)	***
β_k	0.21		-0.01		0.29		-0.07	
	(0.12)	*	(0.06)		(0.06)	***	(0.02)	***
β_r	0.26		0.08		0.28		0.05	
	(0.06)	***	(0.03)	***	(0.06)	***	(0.02)	***
β_l	0.17		0.73		0.07		0.82	
	(0.18)		(0.09)	***	(0.13)		(0.03)	***
γ_{kk}	0.01		0.02				0.02	
	(0.01)		(0.01)	**			(0.00)	***
γ_{rr}	0.01		0.00					
	(0.01)		(0.00)					
γ_{ll}	-0.18		-0.05		-0.20		-0.03	
	(0.04)	***	(0.02)	***	(0.03)	***	(0.01)	***
γ_{kr}	-0.05		-0.01		-0.05			
	(0.02)	***	(0.01)		(0.01)	***		
γ_{kl}	0.12		0.02		0.14			
	(0.04)	***	(0.02)		(0.02)	***		
γ_{rl}	0.05		-0.03		0.06		-0.04	
	(0.02)	**	(0.01)	***	(0.02)	***	(0.01)	***
Obs.	375		375		375		375	

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Dependent variable is y_{it} (i.e. log(revenues$_{2006}$))
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report simplified version of the translog function after selecting only significant log-quaratic and interaction terms through the Wald test
3. Columns labeled (1) report estimates obtained from the OLS robust procedure; columns labeled (2) report estimates obtained with the Huber and Tukey biweights
4. Standard errors in parentheses

Table A2.6: 3 input translog function estimated output elasticities (first difference)

A2.6.a: output elasticities estimated at the sample mean of the data

	(A)		(B)	
	(1)	**(2)**	**(1)**	**(2)**
Output elasticities				
Physical capital	0.19	0.10	0.19	0.10
	(0.05) ***	(0.02) ***	(0.05) ***	(0.02) ***
R&D stock	0.14	0.05	0.11	0.03
	(0.05) ***	(0.03) *	(0.04) ***	(0.02)
Labour	0.57	0.65	0.58	0.66
	(0.06) ***	(0.03) ***	(0.06) ***	(0.03) ***

A2.6.b: output elasticities estimated at the sample median of the data

	(A)		(B)	
	(1)	**(2)**	**(1)**	**(2)**
Output elasticities				
Physical capital	0.15	0.08	0.15	0.09
	(0.04) ***	(0.02) ***	(0.04) ***	(0.02) ***
R&D stock	0.14	0.06	0.11	0.04
	(0.05) ***	(0.03) **	(0.04) ***	(0.02) **
Labour	0.65	0.67	0.67	0.68
	(0.05) ***	(0.03) ***	(0.05) ***	(0.02) ***

* Significant at the 10% level, **Significant at the 5% level, *** Significant at the 1% level

Notes:

1. Elasticities are evaluated at the sample median of the data
2. Columns labeled (A) report regression estimates of the complete translog function; Columns labeled (B) report simplified version of the translog function after selecting only significant log-quadratic and interaction terms through the Wald test
3. Columns labeled (1) report estimates obtained from the OLS robust procedure; columns labeled (2) report estimates obtained with the Huber and Tukey biweights
4. Standard errors in parentheses

Conclusions

The structural change that has characterised the economic systems in the last few decades, brought about globalization, new emerging powers, international fragmentation, and deregulation privatization, has dramatically augmented market competition, increased the complexity of the innovative process and the market and technological uncertainty. In this new scenario, firms have been forced to reconsider the sources of their competitive advantage; focusing on internal resources and competences is no longer sufficient; understanding which of them more are strategic has become necessary. A vast theoretical and empirical literature has identified intangible resources as the key factors to provide sustained competitive advantage.

This thesis has investigated the scientific foundation of this new "strategic business credo", both from a theoretical and an empirical perspective, starting from a critical examination of the notion of intangibles, the economic nature of the causal link intangibles-performance and the empirical impact that a "special" kind of intangibles – organizational capital (OC) – has on a large number of firms in the European area.

Although the massive literature on the topic apparently seems to make the analysis of the intangible notion a redundant research effort, its relevance and originality become evident as, even though many have written about them, there is still no consensus concerning the real nature of these resources and, consequently, there is no consensus about their definition and classification. The different contributes have generated a real "terminological soup" that needs to be clarified. In this research I have analysed the identification problems, trying to clarify the content of the intangible 'black box'. Among the different terms (capital, asset, resource, investments) adopted to refer to intangibles, I have chosen "resources" as a wider category than assets, able to grasp the variety of these resources and include also the ones that are not taken into consideration by traditional financial reports. Intangibles have not yet been clearly defined. The definitions found in the literature describe them, alternatively, as knowledge-based resources, lacking physical substance, interdependent, firm specific and capable of generating future profits. However, they do not offer clear inclusion or exclusion criteria. The accounting definition of IAS 38 instead, offers precise, but too strict recognition criteria that do not recognize the most valuable intangibles of the firm.

Scholars have tried to improve the framework for the analysis of intangibles by further classifying them in sub-groups. Classifications have been made with the aim of creating a framework for their analysis, but also with measurement or management purposes. I have reorganized the different classifications found in the literature and grouped them according to the number of sub-groups used. The classification based on three sub-groups seems to be the most common, but also classifications in two and four sub-groups seem diffused. The real problem, however, concerns the content of the sub-groups that not only are named differently, but also have different meaning, according to the different authors.

Intangibles form a heterogeneous class of resources with peculiar features that vary across the different types considered. The heterogeneity of intangibles and their peculiar features are surely one of the causes of the lack of a clear definition.
Weak property rights or no property rights cover intangibles. This generates a situation of partial excludability that renders the benefits deriving from intangibles only partially appropriable. Intangibles are non contractible, and do not have a market; furthermore, they are characterised by high risk and uncertainty levels regarding their production and the capacity to the appropriate benefits that they generate.

To the problem of definition one should also add that of their measurement. The peculiar features of intangibles, in fact, generate problems concerning the capacity of the firms to control intangibles and measure the benefits deriving from them. Intangibles are not recorded in financial reports, and markets do not have enough information to value them. Firms and markets are increasingly asking alternative mechanisms for their measurement and valuation. Many alternative measurement methods have been proposed but none have been proven successful; the more diffused seems to be the Balance Scorecard of Kaplan and Norton. Some authors provide management models for intangibles (Sullivan 1999, Kaplan and Norton, 2004), however they are quite abstract and do not seem to provide concrete answers. Firms face also the necessity to communicate the value of their intangibles to the market, that otherwise, left without information and “measures”, does not value intangibles. The consequence is a high cost of capital and resource misallocation. Several authors (Garcia-Ayuso, 2002, Canibano and Sachez, 2003, Lev, 2004) indicate the qualitative and quantitative improvement of information disclosure as a possible solution to these problems, together with the diffusion by public institutions of non-mandatory guidelines in order to improve and facilitate voluntary disclosure (Brennan and Connel, 2000, Vance, 2001, Garcia-Ayuso, 2002).

A second important point of this research has been the search for a theoretical framework for intangibles. The analysis of intangibles is usually not related to a conceptual theory; only a few authors point to the evolutionary theory of the firm and the resource based view (RBV) as possible theoretical frameworks (e.g. Hall, 1992, Clement et al, 1998, Fernandez et al, 2000). The contributions of leading authors in the field of the theory of the firm and RBV have therefore been investigated in the attempt to analyse intangibles and the reasons behind their importance in the context of a "theory".

Economics and has for long neglected this type of resources, due to their peculiar features that make them non-tradable goods. Performing an indirect analysis of intangibles through the theories of the firms, I have shown that the neoclassical theory of the firm relies on assumptions that do not allow the treatment of intangibles and perceives knowledge as fixed, publicly available and equal to information. It is through the critic of these assumptions that intangibles slowly enter into the economic theory of the firm. The recognition of the existence of market failures, imperfect information and bounded rationality of individuals (contractarian approach), the observation that firms, as formed by individuals, are characterised by bounded rationality (behavioralist approach), the introduction of uncertainty and the need to cope with it (Knight, 1921) open the way to the development of a theory of the firm that includes intangibles, mainly in the form of tacit knowledge, skills and competences (Penrose, 1959). On this ground, Nelson and Winter (1982) have developed the evolutionary theory of the firm, which sees those intangibles such as routines, skills and capabilities as the main factors to survive in the market competition. Clement et al. (1998) readapt and apply Nelson and Winter's model to the classification of investments in intangible resources.

The analysis of the theories of the firm shows that those "heterodox" approaches that reject the assumptions of the neoclassical theory, in particular the evolutionary theory of Nelson and Winter (1982) and its strategic analysis development, the RBV, can possibly provide a theoretical framework for the analysis of intangible resources, and hopefully improve their understanding. While the evolutionary theory provides a dynamic framework that well fits the representation of the "flows" (investments) in intangibles, the resource-based view, static approach, offers a possible model for the analysis of the stock of intangible resources.

The resource-based view sees the firm as a bundle of tangible and intangible resources and focuses on the features that the resources must posses in order to confer sustainable competitive advantage. The RBV applied to intangible resources has led to the recognition of the role of knowledge, particularly analyzed by the knowledge-base view (KBV) that has underlined the important role of the organisational culture in its transmission and in the generation process of new knowledge. Three classifications of resources based on the RBV have been presented (Barney, 1991, Hall, 1993, Fernandez et al., 2000), together with the identification criteria that have to be satisfied in order to provide competitive advantage and the protection mechanisms associated with the different types of intangibles. Building on RBV classifications and on the contributions of the literature, mainly managerial, on intangibles, an eclectic classification of intangibles that groups them in human capital, organizational capital (OC), intellectual property and innovation related capital, has been proposed. A RBV model (Barney, 1991), that requires resources to be not only valuable (i.e. controlled and strategically significant) but also heterogeneous and imperfectly immobile in order to be classified as sustainable-advantage resources, has been applied to our proposed classification. This has indicated OC, identified with codified knowledge (norms, guides and databases), tacit knowledge (corporate culture and organizational routines, co-operation agreement) and reputation, for its specific characteristics, as a sustainable-advantage resource, therefore crucial for firm performance, and has provided the first important result of the thesis, although still from a purely theoretical perspective.

Such a theoretical result however needs empirical confirmation. As the theory indicates intangibles, OC in particular, as the most competitive resources of the firm, in search for an empirical confirmation of this theoretical assumption, studies that investigate the effect of intangibles on firm performance have been critically analysed.
The analysis has been conducted with particular attention to the proxy used for the different intangibles, the methods and econometric models utilised to study the

relationship intangibles and performance, the main results reached and the problems and the limits of these studies.

Studies on the impact of intangibles on performance have focused mainly on R&D and innovation related intangibles. More recently, other dimensions of firm's intangibles have been analysed: human capital, IT and advertising. The attention on these types of intangibles is due to the fact that there is relatively no consensus in academia about their definition, even though different proxies are used to measure them. Despite concerns about statistical tools, quality of data and measurement errors, the evidence of a positive relationship between these intangibles and firm performance has been somehow confirmed, even though results are not comparable and strongly vary in magnitude. Efforts of researchers who have attempted to measure the effect of OC on firm performance have instead been "uncoordinated and sporadic" and have not reached conclusive results. Researchers have chosen to proxy OC using data related to its elements: mainly information and communication technologies (ICT), training, Human Resource Systems (HRS) and workplace practice. Even though there is evidence that these single components have an effect on performance, the same conclusion cannot be reached for OC. Given the status of the empirical literature on the relationship OC-performance, the extensive analysis of empirical studies on the relationship between intangibles and firm performance has therefore been important to analyze how the causal relationship mechanisms, measurement and econometric problems have been treated with respect to other types of intangible resources.

As outlined in chapter two, the theory suggests that OC is a very valuable intangible; however its effect on performance has been studied to a smaller extent compared to other intangible resources and theoretical conclusions are not supported by empirical literature. We believe that OC is indeed a source of competitive advantage and that it has positive effect on performance based on theoretical considerations; we also believe that empirical evidence for this relationship, up to date lacking, can be provided with better empirical models and data availability

In the attempt to integrate empirical and theoretical evidence and help filling the gap in the empirical literature on the evidence of the positive effect of OC on performance, I have presented an eclectic model that draws on recent developments in the field (Lev and

Radhakrishnan, 2005, De and Dutta, 2007). In this model the effect of OC on performance is measured using an accounting proxy, preferred to the usual proxies adopted in the literature - indexes, qualitative data and survey answers – as able to provide a relatively more objective OC measure. OC stock has been measured by capitalising an income statement item (Selling, General and Administrative expenses) that includes expenses linked to information technology, business process design, reputation enhancement and employee training. This measure of OC is employed in a cross-sectional estimation of a firm level production function, modeled first, in the Cobb-Douglas form, and then, in the more flexible Translog. This model is used to test the relationship with OC and profitability.

The quantitative data, on which the empirical analysis has been based, is drawn from the Compustat Global database that provides normalised financial data on over 28,500 worldwide publicly traded firms that represent more than 90% of the world's market capitalization. The dataset selected for this analysis includes 1,309 (Euro area, Denmark and UK) reporting Selling, General and Administrative Expenses. Data for each firm in the sample include: industry, country, yearly revenues (2005-2006), yearly SGA (2000-2006), yearly property, plant and equipment (2005-2006), yearly intangible assets (2005-2006), yearly R&D expenses (2000-2006), yearly n. of employees (2005-2006), net income (2005-2006). After the cleaning procedure, the final sample has consisted of 828 firms, 418 with R&D stock and 410 without R&D stock.

The firms in the sample represent a wide variety of industries; this renders the study particularly original as the empirical literature that investigates the effect of intangible resources on firm performance focuses mainly on R&D capital, and therefore principally addresses sectors where this type of investing activity is conducted. Country distribution reflects the composition of the main financial core of the European Economy. The dataset analysis indicates that OC appears to be perceived as an important factor by the firms in the sample that invest more heavily in this intangible than in physical capital outlying the importance of intangible resources and the trend towards a dematerialization strategy of the production. Firms appear to be committed to the creation of innovation related capital; the majority of them have, in fact, R&D expenses for at least 5 years and have invested in OC for at least 6 out of the 7 years considered.

The model is estimated in levels and first difference, through the OLS, controlling for heteroskedasticity of errors, endogeneity of inputs and influence of outliers and provides robust and interesting results.

First of all, OC has a strong effect on output: average OC output elasticity is 0.30 for the R&D sample (ranging between 0.23 and 0.39) and 0.47 for the non R&D sample (ranging between 0.31 and 0.66). This is much higher with respect to physical capital output elasticity and confirms the view that sees intangibles, and in particular OC, idiosyncratic, firm-specific, interrelated and hard to imitate, as a crucial factor for firm performance. Estimates indicate that physical capital is not a key factor for success anymore; the development, globalization and commoditization processes have render it easily available and, therefore, not a factor on which to build up a competitive strategy. Nonetheless - and this leads us to the second interesting finding - physical capital is still important, as shown by its positive and generally significant output elasticities. This outlines the interrelated nature of the intangible OC, and firm resources in general, confirming the RBV postulates; OC, in fact, also needs traditional factors of production, such as labour and physical capital, in order to generate effect on performance. The effect of OC on profitability is also high: average OC elasticity is 0.49 for R&D firms and 0.32 for non R&D firms.

The study is original with respect to methodology used to measure OC, model used to analyze its effect on firm performance and novelty and composition of the dataset. Even though the model presents some limits, the robustness of the results across the different specifications can be taken as a confirmation of the relative validity of the results, that have produced interesting findings and confirmed the main hypothesis tested: the importance of OC for firm performance.

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