THE RELATIONSHIP BETWEEN KNOWLEDGE MANAGEMENT, INFORMATION AND COMMUNICATION TECHNOLOGIES AND PERFORMANCE FROM THE RESOURCE-BASED VIEW IN SMALL AND MEDIUM MANUFACTURING FIRMS

By

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Dedication

A mis padres Jose Mari y Txaro

Acknowledgements

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Abstract

Although much has been written about knowledge management and information systems, there is little empirical evidence of their actual effect on organisational performance and their interrelationship. Aiming at addressing this gap, this thesis investigates the relationships between knowledge management capabilities, information and communication technologies (ICT) capabilities and organizational performance in SMEs. Drawing mainly on the knowledge-based view (KBV) theory, this study suggests that knowledge management capabilities and ICT capabilities are potential sources of competitive advantage and, thus, those firms possessing these capabilities will achieve superior organisational performance. Building upon the KBV and other complementary theories such as the dynamic capabilities and evolutionary theories, a conceptual model is developed, which a range of research questions and hypotheses emerge from. These hypotheses are tested on a sample of 159 manufacturer SMEs within the mechanical engineering sector and located in the UK, using diverse statistical techniques. The results suggest that knowledge management capabilities have a significant and positive impact on innovation, responsiveness and adaptability, while they barely influence on results such as success, market share, growth and profitability. On the other hand, both human and technical capabilities regarding ICT have an impact on all types of performance indicators. Interrelationships between knowledge management and ICT capabilities are found, supporting the idea of capabilities complementarity. The level of turbulence which firms undergo has also been found an important influence on innovation, responsiveness and adaptability. Based on these findings, practitioners and policy makers are given advice about which aspects they should focus on, in order to implement knowledge management practices and manage ICT successfully. This project has uncovered an important gap concerning the lack of research on knowledge management and ICT, separately and in conjunction, within the specific context of SMEs. Also, it has contributed to the KBV theory by providing practical evidence and offering an alternative operationalisation of knowledge management capabilities.

Declaration of Author's Rights

Two conference papers based on this thesis theoretical basis were prepared prior to the thesis completion, including:

Ibáñez de Opacua, A. (2003), "The relationship between Knowledge Management, Information and Communication Technologies and Organizational Performance from a Resource-Based View of the Firm", **British Academy of Management (BAM) Annual Conference,** September 2003, Saint Andrews.

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The author plans to publish the remaining unpublished parts of this thesis in the next year.

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List of Abbreviations

BPR:	Business Process Reengineering
CCA:	Canonical Correlation Analysis
CA:	Competitive Advantage
FA:	Factor Analysis
ICT:	Information and Communication Technologies
IP:	Intellectual Property
IS:	Information Systems
IT:	Information Technologies
KBV:	Knowledge-based View
KM:	Knowledge Management
MBV:	Market-based View
OL:	Organisational Learning
OLS:	Ordinary Least Square
RBV:	Resource-based View
SECI:	Socialisation, externalisation, combination and internalisation
TQM:.	Total Quality Management

Chapter 1: Introduction

The purpose of this chapter is to:

(1) Introduce the reader to the thesis and examine the motives for undertaking this research

(2) Introduce the line of thinking that the present research follows

(3) Provide a brief statement of this research's objectives and expected contributions which include:

- To integrate different organizational capabilities (knowledge management and ICT) into a single model
- To assess and identify which practices in knowledge management should be prioritise in SMEs
- To assess which ICT capabilities are essential for business success
- To understand the impact of knowledge management and ICT in SMEs
- To assess differences across organisational characteristics
- To provide empirical contributions to the KBV theory, based on knowledge-based capabilities.
- To contribute to the RBV operationalisation

(4) Guide the reader in the structure and content of this thesis

1.1. Background: The New Economy

The growing importance of knowledge management in last decade can be explained as a result of the changes in the business environment.

The business arena has gone through many changes in recent years, resulting in a complex and uncertain business environment often called the new economy or network economy (Kelly, 1998). As Teece (1998a) recalls "*advanced industrial economies have entered a new epoch*" (p.55). Harris (2001) describes it as "*the 'third industrial revolution', founded on new technologies rooted in computers and the potential of new information technologies*" (p.22).

The marketplace has become global. The market boundaries and protections are being removed due to the increasing liberalization of the markets, resulting in fiercer competition. As a consequence of the reduced transportation costs and the increased and immediate availability of information, nowadays new products are easily copied by competitors and also quickly substituted by more sophisticated items. Thus, turbulence and instability have become the norm in business (Hitt et al., 1998; Kelly, 1998; Eisenhardt and Martin, 2000; Johnson et al., 2003). D'Aveni (1994) created the term "hypercompetition" to describe this new competitive situation.

One of the factors that have induced this environment of instability is what is commonly called the "information revolution". Large amounts of information are quickly and easily available making it difficult or costly for firms to be able to select the appropriate pieces of information. Therefore, firms need to develop new capabilities in order to cope with information in a manageable way. It is remarkable the influence of the rapid development of information technologies on the information revolution both, in spreading information and in enabling firms to "digest" the great bulks of information available in a way impossible just a decade before.

In the new economy the classical sources of competitive advantage are not distinctive any longer since, due to their tangibility, they are prone to be copied. According to

Drucker (1993), "*increasingly, there is less return on the traditional resources, labour, land and (money) capital. The only – at least the main – producers of wealth are information and knowledge*" (p.183). This is why often the new economy is also named the knowledge economy: "*The term " knowledge-based economy" stems from this fuller recognition of the place of knowledge and technology in modern OECD economies*" (OECD, 1996: 3). Similarly, there are other popular terms such as "information economy" or "weightless economy" (Harris, 2001).

In this environment, the range of available products has expanded since new kinds of products have appeared. Intermediate products are commonly exchanged. Furthermore, instead of raw materials, some firms process information and develop knowledge, producing intangible products such as intellectual property (IP) or services. The importance of IP has augmented due to the strengthening of the law since 1980 (Teece, 1998a). Also, the creation of more sophisticated and complex products integrating great research efforts required a change in the IP regime. In parallel, the nature of work has changed and concepts as "knowledge workers" or "knowledge-intensive industries" have been created.

Another consequence of market globalisation and businesses facing increasing pressure is the emergence of new ways of organizing. The traditional concept of value chain has been undermined (Augier and Teece, 2006; Teece, 1998a) by horizontal and vertical strategic alliances, joint ventures, etc. For example, the use of Internet has promoted the conceptual shift from value chains to value network (Ciborra and Jelassi, 1994; Fjeldstad and Haanes, 2001). Moreover, the pressure to minimise the time-to market is making outsourcing become a usual business practice (Ciborra and Jelassi, 1994; Dess et al., 1995). The boundaries of firms are becoming blurred. The basis of the new structures is networking. Customers, suppliers and even competitors are being integrated in the firms allowing new forms of collaboration.

Indeed, the explosion and convergence of Information Technologies with Communication Technologies (ICT) has contributed to lowering traditional barriers of when and where work is done and value created. In this way firms may take full advantage of specialization, tax benefits and, indeed, a greater range of knowledge bases. The networked organisations might become highly virtual, since real time

communications in spite of their geographical dispersion are possible. The central role of ICT in the knowledge economy is widely recognised (OECD, 1996; Harris, 2001). Therefore, research on the critical issues involved in the best use of the available ICT is both timely and important.

Not only have ICT converged, but classical disciplines are fusing efforts arising new fields of research such as "biomedicine", "mechatronics", "robochemistry", etc. (Teece, 1998a). These new disciplines require further research and the adequate management of the different knowledge bases might be key.

Another feature of the knowledge economy is labour mobility resulting from the obliged deregulation of the labour in the global marketplace (Dingwall, 1999). The accumulation of a greater number of working experiences is highly valued in the career ladder since firms might benefit from these experiences. However, seeing it from the opposite point of view, firms might lose valuable people and, together with them, their knowledge. As a result, the study of the ways in which individual knowledge can be integrated in the organisations has become critical.

Although knowledge and knowledge management have existed at least since the era of the Ancient Greek philosophers, the structural changes in the economy explained above have highlighted the importance of knowledge and its management within the area of business strategy in the last decade.

Nowadays the economy has adopted new characteristics never seen before and, in consequence, the theories hitherto have been applied might not be valid any longer. As Nonaka (1991) points, "*in this environment, the only certainty is uncertainty*" (p.96). The economies are changing at an increasing rate, facing new challenges continuously. In consequence, organisations must be innovative, flexible and adaptive. Proper practices on knowledge management might enable firms to adapt and react with flexibility to uncertain and quick changes in the new economy. However, due to the complex characteristics of knowledge and its management, completely different from those of tangible resources, research on knowledge management is of critical importance in the knowledge economy.

1.2. Introduction

Knowledge management has been explored from multiple disciplines (strategy, computer science, human resources management, etc.). Although all of them have contributed to increase the understanding of knowledge management, there are some debates that still need to be addressed.

First, the *real impact of knowledge management and how to integrate it into the business processes* is still under question. In spite of being widely recognised in the literature, the importance of knowledge for firms' competitiveness might not be readily visible for managers. This can explain the current "disillusionment" (Smith and McKeen, 2004) in relation to the expectations from knowledge management. On the other hand, over fifty percent of knowledge management initiatives fail (Call, 2005). This fact indicates that managers are confused about the way of incorporating knowledge management in their activities (Smith and McKeen, 2004). This confusion has made practitioners sceptical of the benefits of implementing knowledge management, thus there is an urgent need to demonstrate empirically how it can add value to firms and which factors should be taken into account in order to provide generalised guidelines, which will help practitioners to integrate knowledge management into their everyday work.

Second, there is an ongoing debate on knowledge management about the *role of ICT to provide competitive advantage and to enhance knowledge management.* Initially, knowledge management projects concentrated on the development of new information and communication technologies (ICT). However, there is plenty of empirical evidence about failed applications of technologies for knowledge management purposes (Tsoukas and Mylonopoulos, 2004; Damodaran and Olphert, 2000). On the other hand, the usefulness of ICT as a means of supporting the management of knowledge has proved to be important by several researchers (Alavi and Leidner, 2001; Davenport and Prusak, 1998; Ruggles, 1998; Scarbrough et al., 1999). These contrasting views show that the understanding of how to take advantage of the potential of ICT is still vague.

Third, the *lack of research on small and medium enterprises* (SMEs) is striking. SME has received scarce attention in spite of their importance for the European competitiveness. They account for over 95% of the European businesses and they provide two thirds of the European employment (OECD, 2005). More understanding of the needs and problems of SMEs is critical.

Therefore, the aim of this research is to explore the role of knowledge management and ICT in organisations. In order to examine the individual and combined contribution of ICT and knowledge management to organisations, their effect on organisational performance will also be assessed with the aim of providing useful insights on the application and interaction of knowledge management and ICT based on empirical evidence captured by a mailed survey. Finally, these issues will be considered in the context of SMEs and will contribute to the lack of research on this type of firms, essential for the European economy.

The present research lies in the knowledge-based view (KBV) of the firm as theoretical basis. The KBV has emerged as a new stream of the resource-based view (RBV) which considers knowledge as the central resource of organisations and combines principles from other theories such as dynamic capabilities (Teece et al., 1997) and evolutionary theories (Nelson and Winter, 1982).

Having a clear theoretical foundation and conducting a thorough review of the existing literature, the researcher develops constructs which are interrelated and form a conceptual model. This conceptual model will act as a guide for the data gathering, analysis and discussion throughout the entire study.

Following this introduction of the general background of this research and the broad outline of the intention of the present research, this opening chapter discusses the objectives of this research and the research questions in section 1.3. Finally, section 1.4 offers an overview of the structure of the thesis.

1.3. Research Objectives and Expected Contributions

Based on the problems indicated above, this study aims to examine the relationships between knowledge management, ICT and performance in SMEs from a holistic and a balanced perspective.

First, *this research aims to integrate different organisational capabilities (knowledge management, ICT) into a single model, including technical, organisational and human aspects in order to assess how best they contribute to achieving competitive advantage.* Separate investigations on knowledge management and ICT capabilities have been carried out but it is still missing a multidisciplinary integrative approach from the firm perspective within SMEs. Although knowledge management is not new, its study within the area of business strategy is recent and still under researched.

Second, *the present research aims to assess and identify which practices in knowledge management should be prioritised within SMEs*. In spite of the theoretical promises of the value of knowledge management, firms have not experienced the results expected, which has created certain scepticism among firms. The overemphasis on ICT development might have led to this situation, but also the lack of understanding of the critical factors might have contributed. In order to approach knowledge management from a more managerial view, a practice-based view will guide the study of knowledge management.

Third, *this research also aims to clarify which information and communication technologies capabilities are vital for business success* (Sambamurthy and Zmud, 2000a) and to help organisations challenged to harness information and communication technologies in order to create new information and knowledge (Nonaka, 1988). Since these technologies are increasing both in number and in complexity, research to understand the relationship between ICT and knowledge management is increasingly critical.

Fourth, given the lack of research on SMEs, *this research will contribute to our understanding of the value of knowledge management and ICT in SMEs* since they might have different needs in comparison to larger firms due to their specific characteristics. Furthermore, *differences across different contextual characteristics will be examined* in order to identify different patterns regarding knowledge management and ICT practices depending on such characteristics.

As a result of trying to meet the objectives highlighted above, other indirect contributions will be achieved. *The present research will provide empirical contributions to the KBV theory*. The research will also contribute to answering to the criticism that the *RBV has not been sufficiently operationalised* (Hoskisson et al., 1999). The lack of operationalisation within the knowledge management area has also been spotted by Staples et al. (2001) They claim that more *empirical research on knowledge management focused on the knowledge-based capabilities is needed*, since this view may help to develop a new and more managerial approach.

1.4. Structure of the Thesis

The structure of this thesis is presented over 9 chapters, which are organized as shown in Figure 1. This chapter (*Chapter 1*) introduces general background and the rationale of the thesis, objectives and expectations.

Chapter 2 introduces and discusses the theoretical basis underlying the present research, the knowledge-based view (KBV) of the firm. It explains how a more introspective approach such as the resource-based view has become necessary due to the inability to predict the dynamics of the new economy. Given the strategic role of knowledge in the new economy, the RBV has evolved towards the KBV, which starts standing out in the field of strategy. Apart from being a branch of the RBV, here the KBV also includes aspects from other theories such as dynamic capabilities, since it is assumed that resources and capabilities interact and shape each other. This chapter also justifies the adoption of the activity systems theory, as knowledge is created through interactions among all the organisational elements. Thus, the effect of knowledge management and information systems on the organisational performance, but also their interrelationship will be investigated adopting principles of the KBV.

Chapter 3 aims to justify the approach towards knowledge management in the present study and how knowledge management will be researched here. First, an overview of the evolution of knowledge management since it emerged and its current state is commented. Knowledge management is a recent field in management; it just dates back to the early 1990s. A quantitative literature review of the field shows that knowledge management experienced its peak in the mid 1990s but currently is declining. The lack of experiencing the expected results, the over-emphasis on ICT development, the lack of practical approaches in the literature and the failure in researching knowledge management and ICTs from a socio-technical approach, have distorted the impact of knowledge management and the role of ICT in organisations. The conclusion is that a more practical approach is needed. In consequence, the present research adopts a practice-based view to study the knowledge management phenomena from a holistic point of view. This chapter also explains how this research has conceived KM and ICT

capabilities from a balanced and integrative perspective. In concluding, the examination of existing relevant empirical studies concerned with knowledge management and information systems from the capabilities perspective, demonstrates the contributions of this research to the fields.

Chapter 4 discusses the nature of SMEs, their importance, their characteristics and their strengths and weaknesses compared to larger firms. Their most appreciated strength is flexibility, while their main weakness is their lack of resources. In spite of their importance for the European economy, SMEs remain under-researched, especially in the area of knowledge management. Therefore, this research will contribute to filling in this gap. Further discussion regarding knowledge management and information and communication technologies in SMEs takes place. Also, the chapter highlights the importance of the mechanical engineering and machine sector in the UK.

Chapter 5 seeks to make clear the aims and objectives of the present research. Drawing on the existing literature presented in Chapter 3, different themes and ideas converge into specific research questions and hypotheses, reflected in a conceptual model. The valuable contributions of this study to theory and practice are discussed. Afterwards, the measurement of the different constructs involved in the present research is presented.

Chapter 6 presents and discusses the methodological issues behind this study. The methodology design process is fully explained, from the philosophical issues to more practical aspects. After justifying the epistemological position of the researcher, the goals of this research and the process of reasoning are explained. It continues to explain the methodology and methods employed here: among others, issues related to mailed surveys such as the sampling method, the response rate or the questionnaire development, are discussed.

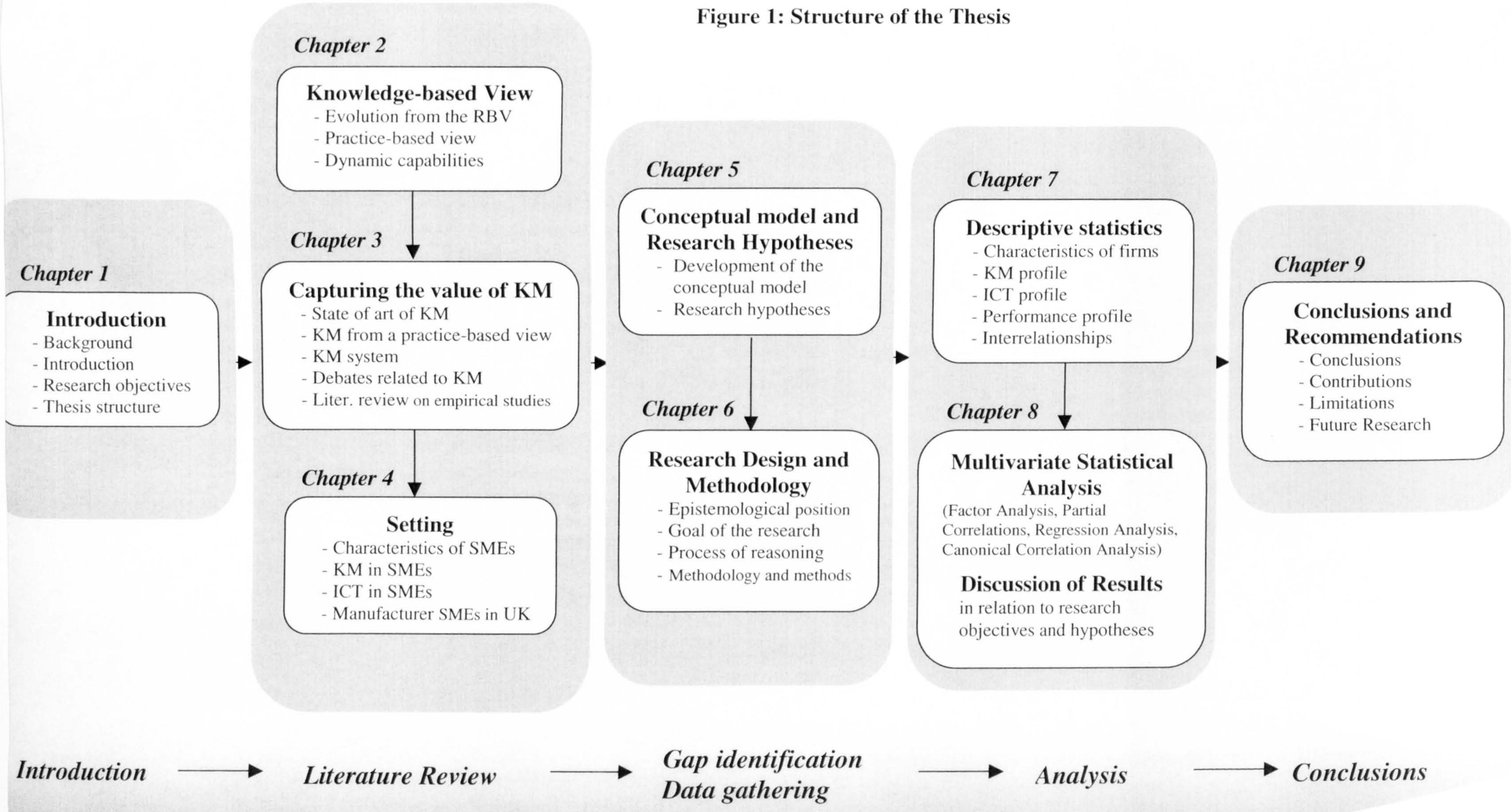
Chapter 7 is the first chapter of results. This chapter deals with descriptive statistics and simple bivariate analysis, that is, analysis limited to two variables. First, the general characteristics of the sample firms are described, followed by a second section about the analysis of the organisational performance indicators. After descriptive statistics on the current state of knowledge management practices and variables regarding ICT, and

their relationship with organisational performance, are commented. The results give us insightful overview of the possible future results regarding KM capabilities.

Chapter 8 presents the statistical results of several multivariate statistical analyses, that is, using more than two variables simultaneously with the aim of analysing the relationship between dependent and independent variables, that is, performance and KM and ICT capabilities respectively. The techniques employed are factor correlation, partial correlations, regression analysis and canonical correlation analysis. As a result, the hypotheses and research objectives presented in Chapter 5 are addressed and discussed in relation to the existing theory and empirical researches reviewed in Chapters 2 and 3.

Chapter 9 ends up this thesis by drawing the conclusions of the present research based on the revision of the objectives defined in Chapter 5. Furthermore, the theoretical and practical contributions of the present research for academics, practitioners and policy makers are discussed. Finally, the chapter goes over the limitations of this research, which points to possible future research directions.

Figure 1: Structure of the Thesis



Chapter 2: Knowledge-Based View Of The Firm

The purpose of this chapter is to:

(1) Present a synthesis of the evolution of strategic theories or approaches with the aim of providing an understanding of the origins of the knowledge-based view

(2) Critically evaluate the strengths and weaknesses of the resource-based view and of the knowledge-based view

(3) Define the position and assumptions of the present research in relation to the theoretical basis

(4) Outline and justify some of the contributions awaited by this thesis as a result of the critical evaluation of the theory

2.1 Introduction

This chapter aims to introduce and discuss the theoretical basis underlying the present research, the knowledge-based view (KBV) of the firm, which combines principles of dynamic capabilities and evolutionary theory. The *KBV* of the firm is central in this research since it assumes that knowledge and capabilities are the source of differential organisational results. The *dynamic capabilities* approach is included given that the present research is based on the assumption that knowledge is not a static concept but its real value should be assessed in practice. The dynamic capabilities approach also claims that organisational capabilities interact between each other, hence, the relationship between knowledge management capabilities and information and communication technologies capabilities will be examined. Furthermore, this research considers that capabilities evolve over time and they are shaped by the organisational history and contextual factors. Therefore, the *evolutionary theory* is also embraced. This section will demonstrate the appropriateness to investigating the effect of knowledge management and information systems on the organisational performance, but also their interrelationship.

The chapter begins by describing the nature of the current economy. The changes happened in the economy in last decades are reviewed since these have promoted the shift from the *traditional strategic* approaches based on the firm positioning within the market, to more *introspective strategic* approaches such as the resource-based view and dynamic capabilities. Furthermore, the new conditions of turbulence and harsh competition have made knowledge turn into a strategic source of competitive advantage. The strategic role of knowledge in the new economy has promoted the development of the KBV as a theory. Such theory originally derives from the resource-based view (RBV), so its evolution over time until today will be presented and critically evaluated with the aim of justifying the adoption of the KBV as the theoretical basis of the present research.

2.2 Towards the Knowledge-Based View of the Firm

Introduction

Strategy is a rather new field within management since it only dates back to the 1950s. Those from the mechanistic perspective argue that strategy is a means of allocating resources to a unique position (Quinn, 1980; Porter, 1985). However, this study supports that the main objective of strategy is to explain the difference in performance among organisations (Caves, 1980; Rumelt et al., 1991), since it is a useful indicator of how well organisations are co-aligned with the environment (Chakravarthy, 1986; Farjoun, 2002).

The field of strategy has evolved along the last 50 years, developing different schools of thinking. According to Mintzberg and Lampel (1999), ten schools of strategy formation can be distinguished (design, planning, positioning, entrepreneurial, cognitive, learning, power, cultural, environmental and configuration). See Mintzberg and Lampel (1999) for a comprehensive discussion. Here it is worth pointing at the main problem in the field of strategy: its fragmentation (Sanchez and Heene, 1997). These different schools derive from different disciplines and, thus, concentrate on different issues and levels of analysis. Mintzberg and Lampel (1999) call for a more integrative approach in strategy formation. The researcher supports that the knowledge-based view (KBV) of the firm might be an attempt to do so. As the focus of this thesis is the KBV, the chapter will commence with a discussion as to how the strategy field evolved through different stages, such as the resource-based view or dynamic capabilities, until the development of the KBV.

Preceding the RBV

In the 70s and 80s strategy literature is mainly based on Industrial Organisation economics (Hoskisson et al., 1999). Porter (1980) with his generic strategies and five forces models is one of the most famous representatives of the Industrial Organisation economics. He develops mechanistic explanatory models which prescribe plans of action for the long term according to the position of the firm within the market. Its focus is on the industry structures rather than on the firm. The firm is addressed as a "black box" which differentiates from other firms depending on their ability to manage

mobility and entry barriers to the market. This is the reason why sometimes this theory is also denominated as the market-based view (MBV). The frameworks developed within the MBV have been very popular (perhaps excessively) and still today Porter's five forces model is taught as one of the basic principles in strategy.

However, this approach assumes that there is equilibrium and that the market works in perfect conditions of competition. It is based on the assumption that the world is stable and predictable (Farjoun, 2002). Given the increasing speed of global competition and technological change of the modern economy, markets are highly uncertain, so the contributions of the MBV seems to have lost its value over the time. Therefore, if markets are unpredictable due to their increasing turbulence, it seems reasonable to shift the focus of attention from the external environment to the internal environment, that is, the firm. As a consequence of the environmental unpredictability or, simply, of the swing of the pendulum in strategy management (Hoskisson et al., 1999), strategy takes up a more introspective focus in the 80s, adopting philosophies which aim at opening up the "black box" and improving the internal functioning of the firms. Even Porter himself with his value chain concept seems to agree with this shift. Strategy shifts the focus of attention to the functional level, adopting popular philosophies such as Total Quality Management (TQM) and Business Process Reengineering (BPR). In fact, an alternative approach to the MBV based on behavioural and organisational perspectives and in tune with the RBV already existed within the strategy literature since the 1950s. However, it had remained unconnected and overlooked by the mainstream of economic strategy, the MBV (Teece, 1998a).

In the 1990s the resource-based view (RBV) becomes increasingly influential as it agrees with the desired introverted approach but at an organisational level. But more importantly, the RBV became more important following economic depression in the early 1990s and a shift in the economy from a proliferation of demand over supply in the 1960s, 1970s and early 1980s to a proliferate of supply over demand in the early 1990s. This meant that firms had to compete harder for customers and for increasingly scarce and costly resources.

Since the resurgence of the RBV, further developments of the theory have appeared in order to cope with its original weaknesses. Next section will address them.

Origin of the RBV

One of the objectives of the present research is to empirically test the effect of the internal composition of firms in terms of knowledge related- and ICT related- resources and capabilities on the organisational performance. This objective comes out of the following line of thinking. Although there are some precursors such as Selznick (1957) with his idea of "distinctive competences", it was Penrose (1958) who established the foundations of the resource-based view as a theory, conceiving firms as bundles of productive resources. In her book "The theory of the firm" Penrose claims that the basis to compete resides in the heterogeneity of the internal composition of the firm, unique for each firm due to the unique starting conditions and evolutionary paths of each firm. However, in spite of the innovativeness of this theory at that time, until recently it has not received sufficient attention. In fact, several authors (Wernerfelt, 1984; Rumelt et al., 1991; Barney, 1991) have supported the idea that internal analysis of the firms accounted for more variance in performance than the industry effects in the last decades.

"*Resources*" is the keyword of Penrose's definition of firm. However, the RBV lacks commonly agreed terminology and definitions of resources. In this study we support the definition given by Wernerfelt (1984):

> *"Those attributes of a firm's physical, human and organisational capital that do enable a firm to conceive of and implement strategies that improve its effectiveness and effectiveness"* (p.171)

Physical capital includes tangible resources such as financial resources, technology, machinery, etc. On the contrary, human capital and organisation capital are intangible resources. *Human capital* deals with expertise, skills, relationships, etc. while *organisational capital* with issues such as structure, processes, culture, reputation, etc. In some cases, different types of resources are interrelated among each other. For example, physical technology, a tangible resource, is intrinsically linked to intangible resources such as social relations, culture, etc.

Many types of resources have been distinguished within the literature (Sanchez and Heene, 1997; Collis and Montgomery, 1995; Grant, 1991; Teece et al., 1997). The

framework suggested by Maier (2004) is presented here (Figure 3), given its comprehensiveness and its linkages to competitive advantage.

However, not the simple possession of resources might provide with competitive advantage. Given the current harsh competition, resources might be copied and/or transferred by competitors almost immediately. Therefore, resources should aim to facilitate sustained competitive advantage. With this aim, different taxonomies of the criteria that resources should meet are provided in the literature (Hamel and Prahalad, 1994; Barney, 1991; Grant, 1991; Peteraf, 1993). The most commonly addressed within the literature are shown in Figure 2.

Barney (1991)
Value
Rareness
Imperfect inimitability
• History dependent
• Causal ambiguity
• Social complexity
Imperfect substitutability

Peteraf (1993)
Heterogeneity
Ex ante limits to competition
Imperfect mobility
Ex post limits to competition

Figure 2: Resource features to achieve sustainable competitive advantage

The main idea underlying the above criteria can be summarized as "*sustained valuable uniqueness*". *Uniqueness* refers to the fact that if a resource is widely available cannot differentiate firms among each other. Unique resources must be rare and heterogeneous and can derive from ex ante limits to competition (e.g. economies of scales, unique location). But this rareness must be preserved from being copied or transferred by competitors and, thus, lose its uniqueness feature. In consequence, rare resources must also be non-substitutable and imperfectly mobile, that is, difficult to be replaced or transferred in order to be *sustainable* over the time. Sustainability might depend on ex post limits to competition such history dependence (e.g. brands, technological know-know), causal ambiguity or social complexity (e.g. organisational culture). Williamson (1975) refers to asset specificity in order to assess the lack of transferability of assets intended for specific use in a given transaction to other uses. He claims that asset specificity can be in three forms: site specificity, physical specificity and human asset specificity. These three aspects are equivalent to imperfect inimitability and imperfect substitutability due to location, specific uses and human skills related to the assets.

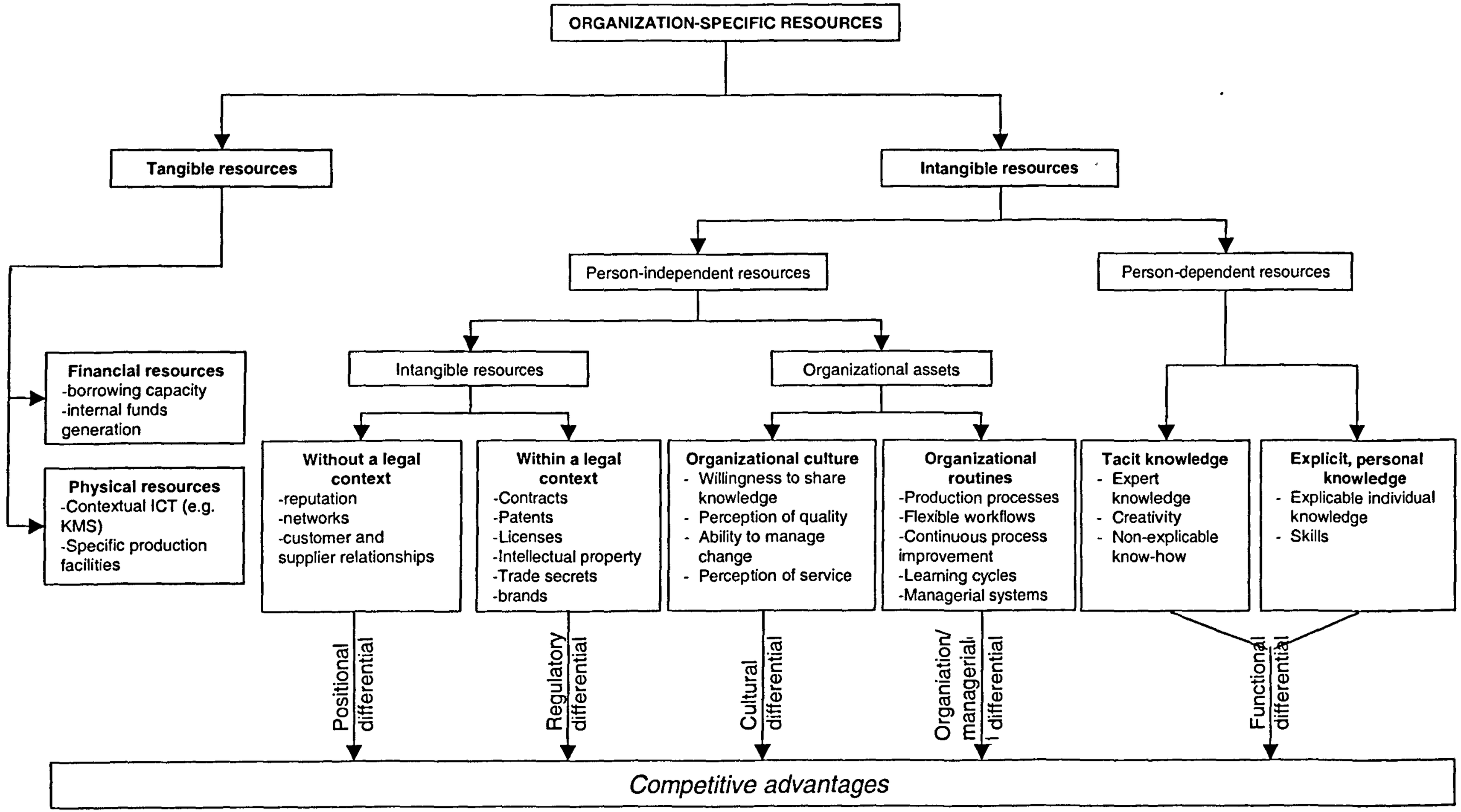
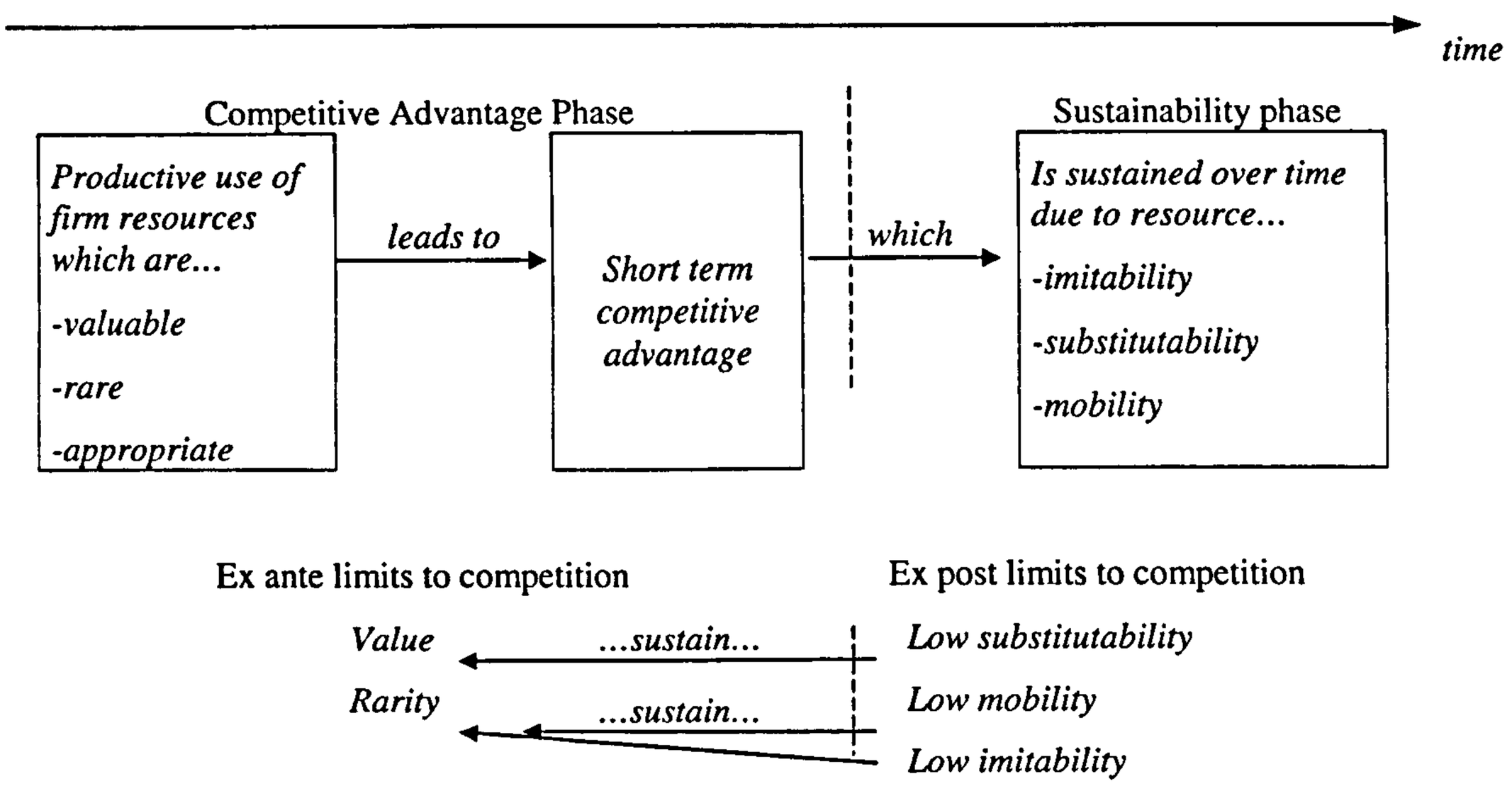


Figure 3: Classification of organisational resources (Source: Maier, 2004)

Finally, a resource might be sustainably unique but not provide any value with respect to the competitors. Therefore, a resource must be also valuable. However, it must be noticed that the assessment of the competitive superiority of resource must be carried out according to the market conditions and that the resource value might be eroded by time and hard competition (Rumelt, 1984). This situation has been named as time diseconomies by Dierickx and Cool (1989).

Wade and Hulland (2004) integrate the two classifications of criteria explained above within the following framework (Figure 4):



(Source: Wade and Hulland (2004))

Figure 4: Getting sustainable competitive advantage from resources

In general, intangible resources are keener to meet the previous requirements, since they are more likely to provide competitive advantage. In contrast, the possession of tangible resources might be a matter of availability of financial resources. According to Itami and Roehl (1987), "invisible" resources are more likely to be the only real source of competitive advantage that can be sustained over time. These resources are unattainable with money alone and consume time to be developed. Furthermore, their history dependence, causal ambiguity and social complexity make them difficult to be imitated or transferred.

The increasing significance of intangible resources has stimulated the recent convergence of RBV and knowledge management, emerging as a sub-stream of the RBV, the ***Knowledge-based View (KBV)*** (Kogut and Zander, 1992; Grant, 1996; Spender, 1996; Hoskisson et al., 1999; Eisenhardt and Martin, 2000; Eisenhardt and Santos, 2002; McGee and Thomas, 2004), which focuses on a specific resource inside the firm: knowledge.

Nevertheless, in spite of its useful insights, the RBV has been often criticised because of *overlooking the market conditions* (Priem and Butler, 2001). *This research takes into account this critique and limits its focus to SME manufacturers within a unique sector, the mechanical engineering and machine sector*. While the environmental models focus on the external consistency of the firm with the market conditions in excess, the RBV also narrowly concentrates on the internal consistency between strategy and the organisational elements (Farjoun, 2002). However, resources interplay with the market forces, thus the RBV should not be a pendulum swing to the opposite direction of the MBV but an integration of the environmental and the internal focus (Collis and Montgomery, 1995). In order to diminish this downside of the RBV, Barney (2001) suggests that any good research must begin by analysing the market since it will establish whether different resources are valuable or not.

Interestingly, another weakness of the RBV is its *assumption of economic equilibrium* (Priem and Butler, 2001), so criticised within the MBV, but with an inward focus. *The topic of knowledge management itself overcomes this weakness since knowledge management should be assumed as an ongoing and dynamic process which constantly matches the markets' needs.* However, the original assumption of the RBV was the opposite. Penrose (1958) supports the idea of disequilibrium, flexibility, organisational learning, among others. As Foss (1999) points out, there have been misleading interpretations of the masterpiece of Penrose's theory of the firm. In reality, her approach was towards a more dynamic view of the firm, in constant adaptation, in order to cope with the changes of the uncertain world. Within this line, Nelson and Winter (1982) describe competition as a dynamic process which involves uncertainty and disequilibrium.

Developing the RBV: the notion of Capabilities

In the present research a comprehensive view of capabilities associated to knowledge management and ICT is adopted. Technology is usually studied as a technical and tangible resource, however the present study evaluates ICT capabilities from a holistic view, including the human skills and capacities associated to ICT. In this way, it will be possible to estimate the real value of information systems as a capability.

The stance taken in this thesis is that capabilities are embedded in organisational routines and process. Thus, this research aims to contribute to filling in the existing gap in the literature, by paying attention to the organisational processes and practices within the firms in relation to knowledge management and ICT. However, not only the content of these processes will be studied, but also the format in which these practices take place (e.g. formal vs. informal means). The theoretical justification for adopting this stance derives from the evolutionary theory. As seen in the previous section, an initial development on the RBV adopts a *non-appropriate static view* of the resources (Priem and Butler, 2001). Indeed, the possession of particular assets does not imply that full use of them is made, or what is more, that they are used in the same way in all the cases. Using Penrose's terminology, the uniqueness of resources comes from their service.

For example, the fact that two firms possess the same information technology does not imply that this will add value to firm to the same extent. Individuals' skills to use them, managerial skills, organisational issues such as structure, and previous experience in dealing with information technology would determine the impact of such technology on the organisations. However, information technologies are usually considered from the technological point of view, forgetting all the intangible and tacit aspects involved (see Figure 4 (Maier, 2004)), where technology appears as a tangible resource). Information systems capabilities should be addressed by taking into account all the tangible and intangible resources involved. For example, such information systems resources are comprehensively classified by Powell and Dent-Micallef (1997) as human resources, business resources and technology resources. The RBV has indeed uncovered the strategic value of information systems resources by opening the view of information

system within firms (Wade and Hulland, 2004), including not only technical issues but also organisational and behavioural aspects which are determinant in the impact of information systems in organisations.

The need for adopting more comprehensive view of resources is consistent with the idea of *capabilities* defended by Amit and Schoemaker (1993), who argue that the value of resources does not reside in the resources themselves but in their utilization, in the way they are deployed. Therefore, capabilities can also be seen themselves as intangible resources. In fact, although resources and capabilities are conceptually different, both terms are usually used interchangeably. This has contributed to the terminological confusion in the RBV, where abundant terms have been created (resources (Barney, 1991); assets (Williamson, 1975; Teece and Pisano, 1994); firm attributes (Wernerfelt, 1984); (core) capabilities (Grant, 1996; Amit and Schoemaker, 1993), dynamic capabilities (Teece and Pisano, 1994; Eisenhardt and Martin, 2000), core competences (Hamel and Prahalad, 1994), search routines (Nelson and Winter, 1982), distinctive competences (Selznick, 1957))

Capabilities are unique in themselves since they are highly path-dependent. That is, past experiences, the events through which the firm has undergone shape the way in which a firm behaves and, as a result, its capabilities. According to Helfat and Raubitschek (2000), capabilities have a life cycle (founding, development and maturity) determined by selection of events. The unique history of every firm makes capabilities difficult to be copied and, in consequence, a potential source of sustainable competitive advantage.

This research will investigate the organisational processes and differing practices regarding knowledge management within the firms and relate this to organisational performance, since this is an issue where the literature shows a lack of other published research. The importance to do so is that capabilities are intimately related to the evolutionary theory of economic change proposed by Nelson and Winter (1982). They believe that organisations slowly adapt to the changes in the environment according to the organisational routines, which are socially constructed knowledge accumulated by experience. The experiential learning provides firms with search and renewal

capabilities which will be the key to adapt to future changes. Thus, unlike resources, capabilities are embedded in the organisation and its processes (Makadok, 2001) or routines (Eisenhardt and Martin, 2000). As a consequence of the attempt to understand the renewal phenomena, strategy is shifting the focus to the micro-dynamics of organisational processes (Johnson and Bowman, 1999). In fact, some scholars have even proposed a new stream of the RBV, the "practice-based view". Antonacopoulou et al. (2005) criticise that, although operational practices enact the organisational renewal, they are not receiving due attention. Indeed, sometimes they are ironically addressed from a static perspective (e.g. Majumdar, 2000).

In a similar vein, Chandler (1990) states that organisational capabilities are also embedded in the organisational structures, since the coordination of resources often affects the hierarchy and the management of the firm. Therefore, *the present study will also investigate whether the organisational structure and structural aspects such as internal turbulence, control and centralization have a differentiating effect on the results*.

Dynamic Capabilities

Given their intrinsic interrelationship, the achievement of sustainable competitive advantage might come from the synergistic interaction among capabilities and resources (Andreu and Ciborra, 1996). Resources and capabilities might complement among each other, creating co-specialized assets (Teece, 1982). This interaction phenomena might be the source of firm heterogeneity (Dierickx and Cool, 1989). Indeed, the fit between key resources might be the determinant of differences in organisational performance (Whittington et al., 1999).

Teece et al. (1997) introduce the concept of *dynamic capabilities* which they define as "*the ability of firms to integrate, build, and reconfigure their resources and competencies over time*" (p.516). This ability developed over time is part of the organisational renewal process and might be the source of sustainable competitive advantage in the current dynamic and complex environment (Teece, 1998a).

Teece et al. (1997) stress that competences should not be replicable and imitable. For example, tacitness, firm-specific history, observability of the technology or the organisation, and regional forces are some of the factors that make replication and imitation of dynamic capabilities difficult. Nevertheless, revisiting the criteria proposed by Barney (1991) (valuable, rare, inimitable, and non-substitutable), Eisenhardt and Martin, (2000) state that competitive advantage derives from valuable, somewhat somewhat rare, equifinal, substitutable, and fungible dynamic capabilities, since "*Although dynamic capabilities are idiosyncratic in their details and path dependent in their emergence, they have significant commonalities across firms (popularly termed 'best practice')*" (p.1105).

One of the contributions of the dynamic capabilities is the fact that resources are treated as part of *bundles of resources*, rather than the approach of the RBV of considering them as singular distinct factors (Black and Boal, 1994). Firms should be conceived as systems where resources and capabilities are interactively interrelated with the aim of carrying out the firm objectives (Sanchez and Heene, 1997). Therefore, resources and capabilities should be considered jointly due to their interactions. In fact, firms achieve their objectives by organizing the use of their own resources together with the resources acquired from outside (Penrose, 1958).

The aim of the present research is to empirically research the interrelationship and complementarity between knowledge-based capabilities and ICT capabilities by adopting the dynamic capabilities approach. In this way, this research will also contribute by offering some empirical grounding of the RBV (Priem and Butler, 2001); (Eisenhardt and Martin, 2000). Within this line of reasoning, the study of how different capabilities can complement and interact synergistically might give very useful insights. For example, the combination of technical and human capabilities is supported by Hamel and Prahalad (1994) who argue that organisational capabilities are "*bundles of skills and technologies rather than a single discrete skill or technology*" (p.223). Regarding knowledge management, it seems reasonable to adopt a socio-technical systemic approach and study in detail its interrelationship with information and communication technologies, since they can support knowledge management processes. Although usually information systems do not directly contribute to gaining sustained competitive advantage, it might exert strategic influence in supporting and

complementing other resources, such as knowledge. In spite of this, the interdependent role of information systems resources with other resources remains largely unknown (Wade and Hulland, 2004). In order to empirically research the interaction between knowledge management and ICT capabilities. The dynamic capabilities approach based on observed best practices is adopted in the present research. According to Eisenhardt and Martin (2000), dynamic capabilities are identifiable and specific routines, thus they cannot be accused of being "*tautological, vague and endlessly recursive*" as Priem and Butler (2001) state.

As said before, *the present research will study firms within a unique sector, the mechanical engineering and machine sector. The search for commonalities in practices across firms within the same sector is appropriate since the external environment is controlled to a certain extent.* Regarding the external environment, Eisenhardt and Martin (2000) state that the nature of dynamic capabilities varies according to the dynamics of the market. While moderately dynamic markets require dynamic capabilities traditionally conceived as routines, high dynamic markets demand more experiential and unstable processes based on learning.

The theory of dynamic capabilities overcomes another criticism to the RBV: *its focus on the factors which allow the protection of resources within the organisations instead of on how to facilitate the development of new capabilities.* Dynamic capabilities are the main source of learning and innovation, thus, of organisational renewal. According to Kogut and Zander (1992), combinative capabilities are the source of continuous innovation. Firms must engage themselves in constant transformation and retransformation (Teece, 1998b). In fact, dynamic capabilities emerge as the result of the RBV embracing the organisational learning theory (Antonacopoulou et al., 2005).

Bowman and Ambrosini (2003) go further in the analysis of how new capabilities are developed and propose six modes of resource creation: reconfiguration of support activities, reconfiguration of core processes, leverage of existing resources, encouraging learning, provoking learning and creative integration. Most of these activities are key issues in knowledge management and organisational learning, so they are covered by the knowledge-based view of the firm (KBV), which can be seen as an extension of the dynamic capabilities theory.

To summarize, the aim of the RBV and, in consequence, of the KBV is "*to attempt to explain and predict why some firms are able to establish positions of sustainable competitive advantage and, in so, earn superior returns*" (Grant, 1996: 110). Given the interaction among resources and capabilities, the dynamic capabilities approach is required in the investigation of their relationships and their effect on organisational results. However, although theoretically widely accepted, empirical foundations (Priem and Butler, 2001; Eisenhardt and Martin, 2000) are still needed in order to corroborate the theory. As seen before, there are some critiques to the RBV that need to be more developed. *This research will contribute to the empirical grounding of the KBV theory.*

The knowledge-based view (KBV) of the firm

Although the origin of the KBV as a theory in itself is commonly attributed to Grant (1996) and Spender (1996), Penrose was the precursor of such theory and that, in fact, it might be the approach that the RBV should have adopted initially. She highlights the need for, apart from accumulating productive knowledge, creating and managing it in order to get the flexibility needed to cope with the world uncertainty and enable the firm growth. However, her claim for organisational learning as an evolutionary discovery process has been overlooked by the RBV (Spender, 1996; Foss, 1999). Although Penrose's (1958) primarily propose a theory of the growth of the firm, *this study will test the influence of knowledge management capabilities and ICT capabilities on a broad range of performance indicators, including growth, profitability, success, market share, innovativeness, responsiveness and adaptability.* The justification of this assumption lies in the idea that strategy aims to explain difference in firm performance. Therefore, a comprehensive measure of performance is required in order to assess in what aspects of performance knowledge management and ICT are more influential.

Also, Nelson and Winter (1982) advance the foundations of the KBV conceiving firms as repositories of knowledge which are memorized in organisational routines embedded in techno-administrative systems.

The KBV has emerged as the result of accepting knowledge as the main strategic resource of the reviewed RBV, which adopts a more dynamic and systemic perspective.

Grant (1996) defines firms as social communities whose essence is their organisational capabilities to integrate multiple knowledge bases and creates the term the knowledge-based view in order to emphasise the central role of knowledge in the RBV theory. The KBV suggests that capabilities and knowledge form the basis for differential firm performance since they transform individual and social expertise into economically valuable products (Hoskisson et al., 1999).

However, knowledge possesses different features compared to the traditional strategic resources. Knowledge is a complex and ambiguous concept which abundant definitions in the literature have tried to describe (Nonaka and Takeuchi, 1995; Davenport and Prusak, 1998; Tsoukas and Vladimirou, 2001, etc.). These definitions range from more philosophical to more pragmatic perspectives. However, there are two groups of knowledge dimensions universally agreed. First, we address the distinction of tacit and explicit knowledge, drawn by Polanyi (1966). This regards to the fact that a dimension of knowledge, named *tacit knowledge*, is highly personal, to the point that the person is unaware of it. As a consequence, tacit knowledge is difficult to be formalized and shared, in contrast to explicit knowledge, which can be articulated. Despite being simple to be understood, this epistemological distinction is extremely important when managing knowledge. *Explicit knowledge* may be articulated, and therefore, copied or transferred easily. Therefore, explicit knowledge might result a required but not distinctive resource in organisations. On the contrary, due to the unconsciousness characteristic of tacit knowledge, this kind of knowledge is difficult to be captured or imitated, so it might be a potential strategic source of competitive advantage. However, this fact also impedes the measurement of tacit knowledge. Hence, *this study opts for operationalising tacit knowledge indirectly by assessing the objects and processes where it resides or is created.*

The second set of dimensions is based on the place where knowledge resides. Knowledge can be individual or collective. *Individual knowledge* is the knowledge possessed by individuals and refers to cognitive issues (e.g. individuals expertise and skills). On the other hand, *organisational knowledge* refers to the knowledge commonly shared within the organisation, that is, a collective understanding. Organisational knowledge is shaped by the organisational routines, symbols, behavioural norms and values, etc., that is, the organisational culture, which has been developed over time and,

thus, is distinctive of the firm. It is remarkable that organisational knowledge is highly path-dependent since it accumulates the experiences and knowledge gained along the organisation history, which is embedded in the organisational routines (Nelson and Winter, 1982). As a result of the increased organisational knowledge through experience, the absorptive capacity of the firm grows (Cohen and Levinthal, 1990), being absorptive capacity defined as "*the ability of a firm to recognize the value of new, external information, assimilate it and apply it to commercial ends*" (p.128). Given the abundance of information and the need for quick responses to the market, absorptive capacity has become an strategy issue, for example in technology transference (Teece, 1998a). Organisational routines embedding organisational knowledge might be explicit in written procedures and norms, or implicit in the organisation's culture (Nelson and Winter, 1982). In Barney's (1986) terms, organisational culture is a valuable, rare and imperfectly imitable. Furthermore, the strategic importance of organisational knowledge has aroused in the current economy, due to the mobility of individuals, together with their experiences. Therefore, *the analysis of the factors influencing the development of organisational knowledge is of critical importance to firms and the present study aims to contribute to our understanding of these factors*.

Logically, there is a dual interaction between the levels of knowledge, individual and organisational knowledge. For example, the cognitive process of decision making which managers and entrepreneurs exert, is highly shaped by social processes. The success of decision making depends on how the organisation understand the environment. Also, managers might be the key to break the learning rigidities of the firm. From the point of view of the firm, several levels of interactions between different knowledge bases can be identified (interactions of individuals and groups within the firm, between firms and suppliers, between firms and customers, and between firms and competitors/co-operators (Sanchez and Heene, 1997)). The interaction between the different levels of the firm is also supported by Dosi et al. (2000). They argue that individual behaviour has consequences at the organisational level. Hence it seems reasonable to analyse all the levels of the firm, despite the fact that the firm is the target of research.

When reviewing the different taxonomies for knowledge developed in the literature, Spender (1996) highlights the controversy of such the concept. He claims for a clearer epistemology in order to have the appropriate foundations for the new theory. Having this objective in mind, he proposes a framework to explain the different types of organisational knowledge (see Table 1) which combines the two sets of dimensions explained above. In consequence, different knowledge-based theories for each type of organisational knowledge might be necessary.

	Individual	Social
Explicit	*Conscious*	*Objectified*
Implicit	*Automatic*	*Collective*

Table 1: Types of organisational knowledge
(Source: Spender (1996))

The approach adopted in the present research concentrates on examining all types of organisational knowledge, with special emphasis on collective knowledge. According the terminology of Nelson and Winter (1982), automatic knowledge corresponds to skills, while collective knowledge to routines and, as said before, this study will investigate the practices and routines carried out within firms, in relation to knowledge management. Indeed, collective knowledge, which is socially constructed, is embedded in the organisation routines and culture and forms the basis for communication within organisations since they provide the grounds for a common understanding (Nonaka and Takeuchi, 1995). While for other knowledge types, agency theory or institutional theory would be more suitable, the most appropriate theory to study collective knowledge should mainly focus on the processes of knowledge creation (Spender, 1996).

Within this line of thinking, Nonaka and Takeuchi (1995) propose a theory for knowledge creation based on four modes of dynamic interplay between the different types of knowledge: socialization, externalisation, combination and internalisation (SECI). They suggest that the establishment of a "*ba*" is essential for knowledge creation. "*Ba*" is defined as a common place or space for creating knowledge. Four

types of "ba" corresponding to the four modes of knowledge creation are identified: originating "ba", interacting "ba", cyber "ba", exercising "ba". *Socialization* takes place in the *originating "ba"* and involves transforming objectified knowledge into collective by sharing experiences among individuals and thus, developing a shared culture. In the *interacting "ba"*, the concern is about making the implicit knowledge of individuals conscious by articulating it through dialogue and collaboration. This process is named *externalisation*. *Combination* refers to the development of explicit organisational knowledge from explicit knowledge of individuals. Due to the great importance of information systems in enabling the combination process, the place in which takes place is called *cyber "ba"*. Finally, *internalisation* involves the assimilation of social explicit knowledge by individuals in the *exercising "ba"* through practicing and experimenting.

These processes are interrelated in a dynamic and iterative way, creating what is called the spiral of organisational knowledge creation (see Figure 5).

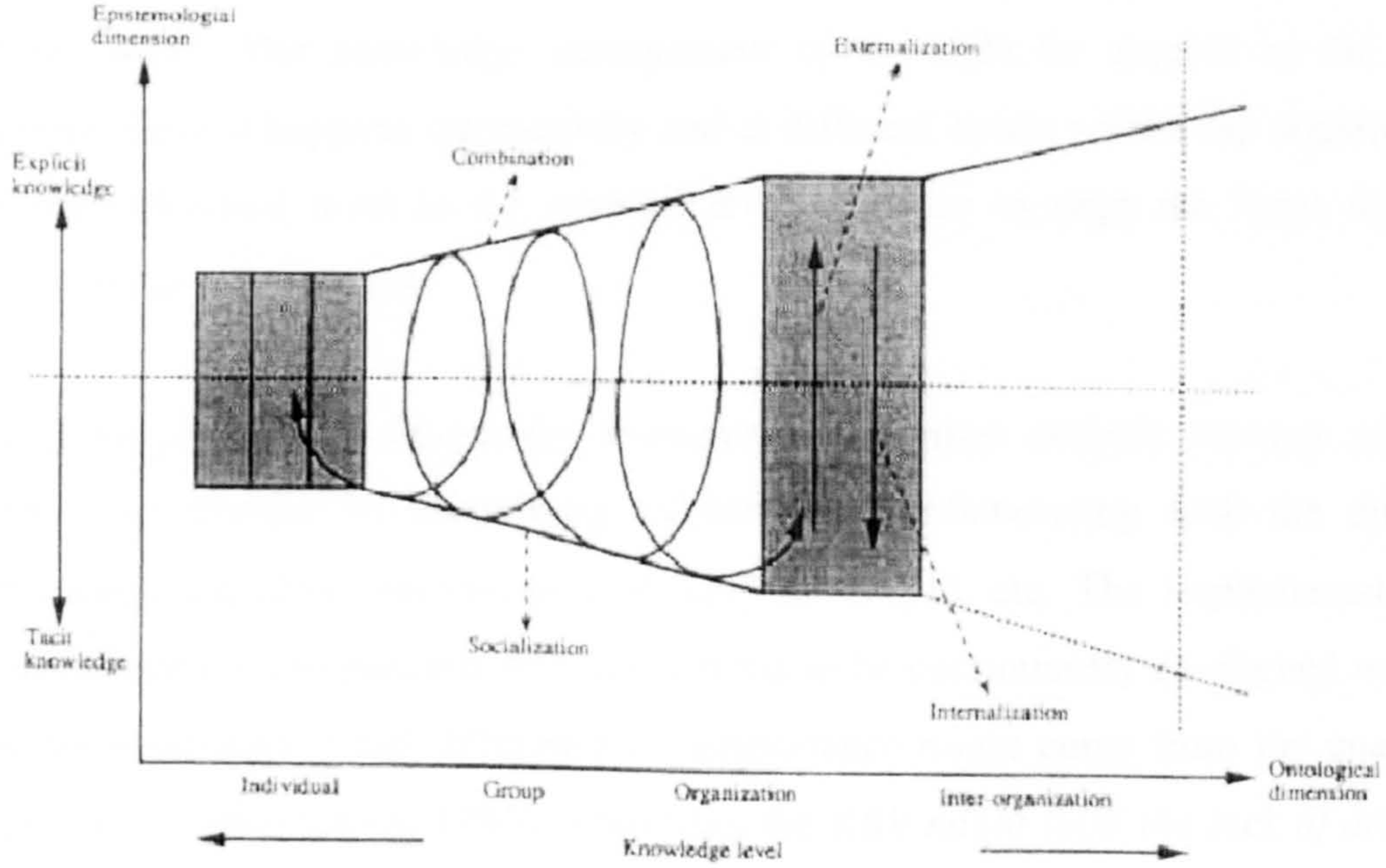


Figure 5: The spiral of organisational knowledge creation (Source: Nonaka (1994))

This framework reflects the organisational renewal process of the firms in alignment with the changes of the external environment. The whole organisation should be continuously moving following the pattern of the knowledge spiral through the different organisational levels with the aim of adapting to the changes. When studying knowledge management practices, *the present study will adopt the taxonomy defined by* March (1991), *who determines that knowledge management involves knowledge exploration and knowledge exploitation, taking into account the different organisational levels*. The adoption of this perspective is very interesting since, apart from assessing which knowledge management processes are more significant, it will allow identifying what levels in the organisations are more or less influential. Although a number of taxonomies of processes involved in creating knowledge have been developed, the dynamic nature of knowledge management is commonly agreed. In consequence, the operationalisation of knowledge management should attend the activities or processes performed within organisations, which will allow the capture of the existing tacit knowledge. Another common classification of knowledge processes is based on the knowledge management life cycle: knowledge creation, knowledge storage and retrieval, knowledge transfer and knowledge application (Alavi and Leidner, 2001). The knowledge management cycle might be applied to the spiral metaphor, since it happens interactively and at different levels within the organisation, from the individual level to the external level, in order to align the firms with the changes in the environment.

Thus, *firms engaged in knowledge management activities actively interact with the external environment* by monitoring its dynamics, collaborating with the different stakeholders, adopting innovations externally developed, etc. The implementation of adaptive feedback mechanisms will allow firms to be continuously co-aligned with the uncertain environment and difference in performance might come from the quality of this process (Chakravarthy, 1986). Therefore, the *KBV might fulfil the lack of attention to the environment attributed to the RBV* (Priem and Butler, 2001). The knowledge bases existing within the firm should include the market knowledge (knowledge of customers needs, supplier capabilities and competitors capabilities and dynamics) (Tippins and Sohi, 2003).

This research aims to capture organisational knowledge and the different bases of knowledge in the firms, by assessing their practices in relation to knowledge management. Given its characteristics, knowledge seems to be an adequate resource for the RBV. Its stickiness, its embeddedness in organisational practices, culture and structure, its tacitness and its path-dependence make it a valuable, rare, imperfectly inimitable and substitutable. However, the KBV tends to treat knowledge from a static point of view, while knowledge is a transformational cumulative process which increases the absorptive capacity of the firm (Cohen and Levinthal, 1990) to adapt to new situations. For example, the acquisition of external knowledge might trigger resource reconfiguration to accomplish the necessary organisational transformation with the aim of co-aligning with the external environment. Thus, the ability to reconfigure the firm's asset structure continuously enhances the organisational renewal (Antonacopoulou et al., 2005; Dougherty, 1992), which has become key to organisational survival given the uncertainty of market changes. To understand the way in which the knowledge base of a firm leads to a set of capabilities is a great challenge since the knowledge of a firm rests in the organizing of human resources (Kogut and Zander, 1992), but the practice-based approach seems the most appropriate to explain it in its course of action.

To sum up, given that there is not sufficient consensus regarding its tenets, the KBV is not yet a theory of strategy (Eisenhardt and Santos, 2002). However, it can be considered a stream of the RBV which focus on knowledge with enormously useful theoretical insights. Therefore, the KBV can be seen as a reconstruction of the RBV in which the key elements are (1) the individuals' cognitive skills, (2) the coordination and recombination of the different resources and bases of knowledge, inside and outside the firm, and (3) learning as process of organisational adaptation and renewal through social processes, all this with the aim of achieving the organisational objectives.

2.3 Summary of the Chapter

In this chapter the evolution of strategy as a filed has been reviewed and critically discussed justifying, as a result, the suitability of the KBV as a theoretical framework for the present research.

The main issues identified in the literature can be summarised as follows:

1. Due to the unpredictability of the environment, strategy pays more attention to the internal development of the firm (e.g. RBV) in order to promote flexibility, adaptability and innovativeness
2. Despite its contributions to strategy, the RBV has been criticised for being static and ignoring the external environment. The RBV should not be seen as a pendulum swing to the opposite direction from the MBV.
3. The KBV is a reconstruction of the RBV, which considers firms as dynamic systems which integrate both internal and external knowledge bases and continuously adapt to the environment.
4. There are different organisational knowledge types which mutually interact, contributing to the creation of new organisational knowledge.
5. Collective knowledge is the most strategic organisational knowledge since it is "invisible", rooted in the organisational culture, norms and routines and this makes it difficult to be imitated, transferred or substituted. However, since all types of organisational knowledge interact among each other, the rest of the organisational types will also be considered.
6. Due to its embeddedness in the organisational routines, organisational knowledge must be studied adopting an approach based on organisational practices.
7. Therefore, internal organisational practices driven by an organisational culture which values learning and knowledge as assets might, lead to differences in organisational performance and competitiveness (Von Krogh et al., 2001)
8. Capabilities and resources do not act alone but in a systemic way. Thus, complementarity of capabilities such as knowledge management and ICT might be source of competitive advantage

9. ICT should be studied from a holistic point of view, including tangible and intangible aspects.
10. There is lack of empirical studies from the RBV perspective (Priem and Butler, 2001; Eisenhardt and Martin, 2000).

Regarding the assumptions or decisions made in relation to the literature discussed in this chapter, the present research will:

- be based on the KBV, stream emerging from the RBV
- be limited to a unique sector (mechanical engineering) and firms segment (SMEs).
- address knowledge management from the practice-based view, as it is assumed to be a dynamic phenomenon
- concentrate on examining collective knowledge assuming that there is an interplay between the different levels of knowledge in the firms
- opt for operationalising tacit knowledge indirectly by assessing the objects and processes where it resides or is created
- assume that capabilities are embedded in organisational routines and processes
- also assume that internal contextual factors such organisational structure might have a differentiating effect
- conceive knowledge management and, especially, ICT capabilities from a comprehensive perspective
- adopt the taxonomy defined by March (1991): knowledge exploration and exploitation

In conclusion, the KBV seems to be an appropriate theoretical basis to investigate the interrelationship between knowledge-based capabilities, centre of the firm strategy, and information and communication technologies capabilities, with a leveraging potential, and their effect on organisational performance. To do so, practices on knowledge management will be analysed, as well as the practices regarding information and communication technologies capabilities. In the next chapter, we will discuss the main issues knowledge management and its practices will be discussed in more detail.

Chapter 3: Capturing Value From Knowledge Management

The purpose of this chapter is to:

(1) Identify gaps in the literature by examining the evolution of the area of knowledge management based on bibliometric literature reviews

(2) Give an overview of the main concepts within knowledge management

(3) Clarify some commonly confused issues and introduce the common debates that emerge from them

(4) Determine the position and assumptions of this research regarding knowledge management

(5) Justify the contributions of this study based on the revision of the existing empirical publications

3.1 Introduction

As introduced before, the aim of the present research is to analyse the relationship between knowledge management capabilities, ICT capabilities and organisational performance, adopting an integrative approach. With the aim of justifying the contribution of this piece of research, this chapter will discuss the existing literature on knowledge management, directing the discussion from more general issues to detailed empirical studies.

Thus, first there will be an overview of the evolution of knowledge management since it emerged till its current state. Knowledge management is a recent field in management, which substantially grew up since the mid 1990s. However, some authors have questioned its significance and its evolution as a management fashion (Scarbrough and Swan, 2001). Similarly, others from a more practitioner-oriented approach claim that there are evidences to conclude that knowledge management is fading out. In order to investigate the real state of knowledge management, a quantified literature review is carried out, showing some interesting differences in the evolution of the literature between scholar- and practitioner-oriented publications. While scholar publications are steadily increasing, practitioners seem to have lost their faith on knowledge management, maybe because knowledge management has not met their desired expectations. The conclusion is that a more practical approach is needed. In consequence, the present research adopts a practice-based view to study the knowledge management phenomena. Thus, the second section of this chapter discusses the theories of practice and clarifies what is understood by practice in this study.

Having justified the theoretical bases in which the research lies in, the main practices and the key mediating or supporting factors involved in knowledge management processes are presented. Given that the literature on knowledge management is extensive and diverse, it must be highlighted that some issues within the knowledge management literature occupied an extensive place within the literature on knowledge management (5986 hits result from searching "knowledge management" in title/abstracts according to ABI/Inform database (accessed on 16/03/2006)). However, here they will be introduced in a broad way, since the objective in this chapter is not to give a detailed review on every specialized area of knowledge management, but to demonstrate the link between

the literature and the knowledge management practices which will be included as part of the assessment of knowledge management capabilities.

Following this, the different perspectives adopted in common debates within knowledge management will be posed. First, the debate on the role of ICT in knowledge management between behaviouralists and "technophiles" will be discussed, and as a result, the differences and commonalities between knowledge management and organisational learning will be also clarified. The final debate focuses on the main assumption of the knowledge-based view, that is, that capabilities and knowledge are the basis for differentiating firm performance. *The present research aims to contribute in these debates, by providing empirical evidence from a balanced and integrated perspective, based on empirical evidence from organisational practices*.

In order to demonstrate the contributions of this research to the field, a review of the existing empirical studies is presented and discussed.

3.2 Knowledge Management: The State of the Art

In order to identify the gaps within the literature in knowledge management, a systematic review of the publications on knowledge management has been performed. To do so, two databases have been chosen: ABI/Inform databases and EBSCO Business Source Premier database. The reason for this selection is that both databases have been used by other literature reviews on knowledge management (Gordon and Grant, 2004; Raub and Clemens-Ruling, 2001; Scarbrough and Swan, 2001), hence results here can be compared with previous reviews.

The arising of knowledge management within the business arena is recent. As Figure 6 shows, researchers started speaking about knowledge management as a field in itself in the mid 1990s, although there are other theories that precede knowledge management such as organisational learning. From this starting point, as Raub and Clemens-Ruling (2001) demonstrate by using EBSCO database, the number of publications regarding knowledge management exploded with the new millennium (see Figure 6). The initial "boom", mainly after 1995 illustrates that knowledge management was embraced with high expectations and optimism. Like with any innovative idea, immediately it became very popular not only within the business arena, but in other disciplines (sociology, information systems, psychology, etc.). Resulting from this explosion, diverse and specialised debates flourished, which resulted in extensive multidisciplinary but fragmented literature on knowledge management (Easterby-Smith and Lyles, 2003). As Davenport and Prusak (1998) predicted, knowledge management was still in its infancy only in 1998. A similar pattern is observed in Figure 8, which illustrates the evolution of the literature on knowledge management using a different database (ABI/Inform).

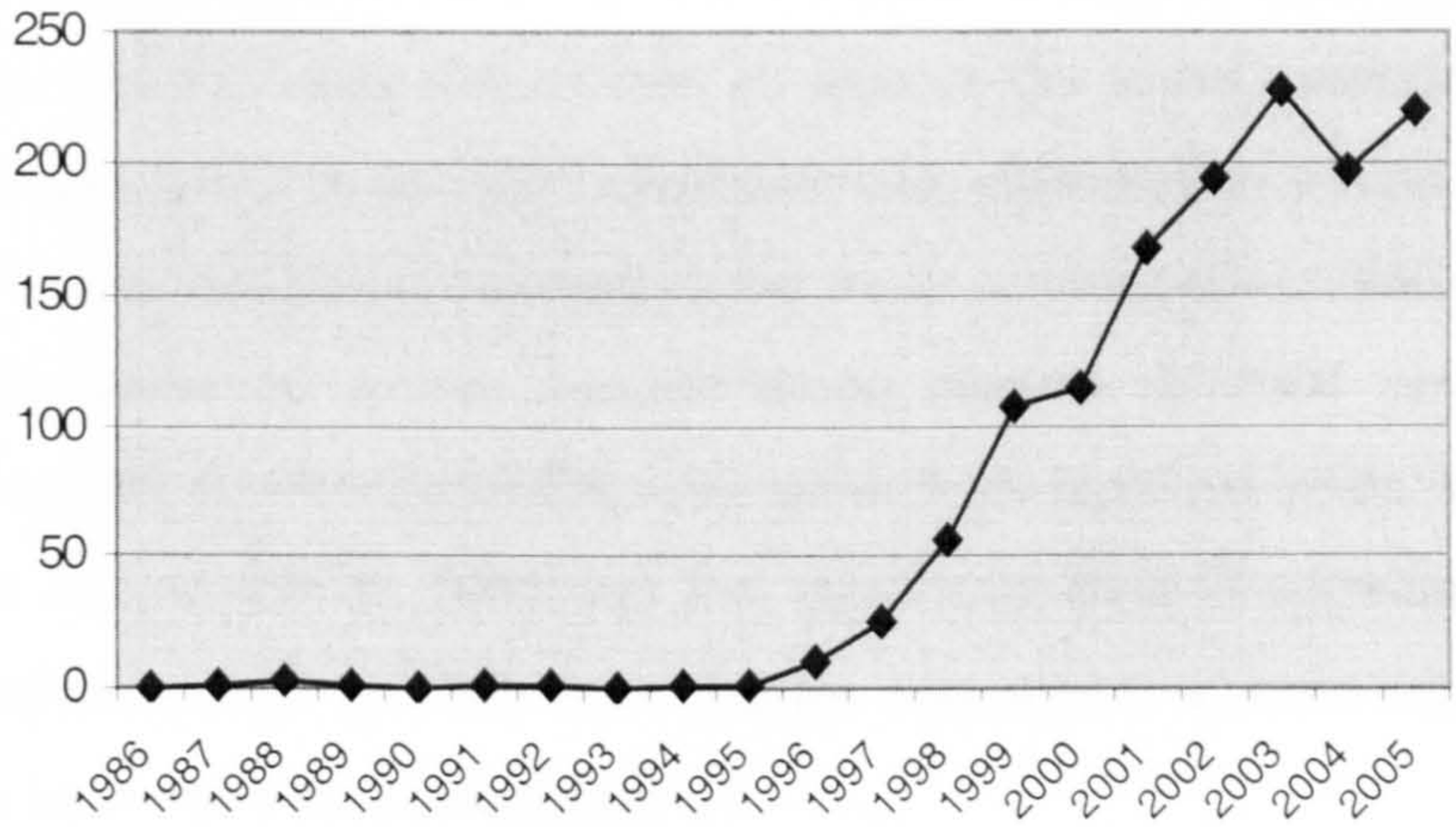


Figure 6: Number of publications with the keyword "knowledge management" in their abstracts or title according to the EBSCO Business Source Premier database
(accessed on 16/03/2006)

In 2001 Scarbrough and Swan (2001) carry out a longitudinal quantitative study regarding the publications on knowledge management until 1998 using ABI/Inform database. They predict that knowledge management might follow the bell-shaped path of other management areas such as Learning Organisation, BPR or CIM (see Figure 7), which some describe as management fashions or fads (Abrahamson, 1996; Castorina and Wood, 1988). Contrary to ephemeral disappearance of aesthetic fashions, the critical point for the management fashions either to extinguish or to find their own place within the management theory is their contribution to improve the real or perceived effectiveness gaps (Scarbrough and Swan, 2001).

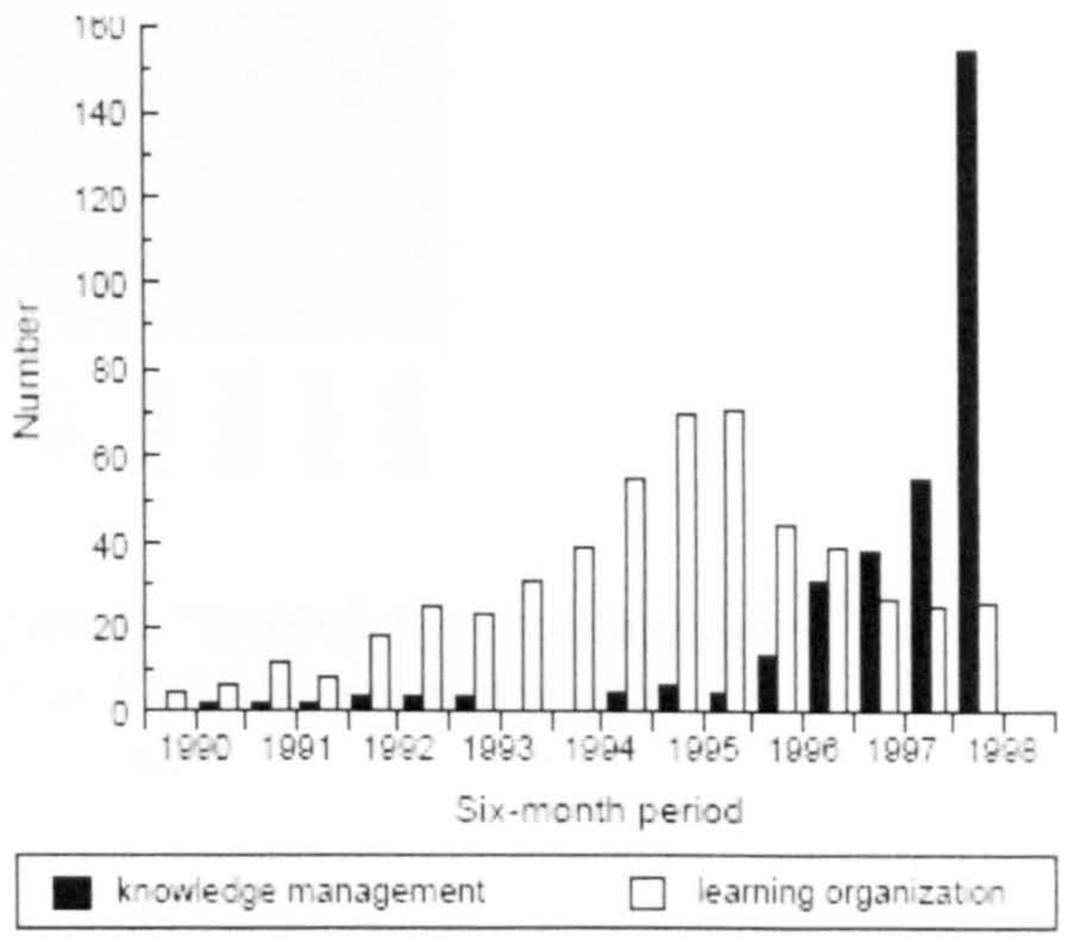


Figure 7: ProQuest references to "knowledg management" and "learning organisation"
(Source: Scarbrough and Swan (2001))

Similarly, when analysing the evolution of the literature, Gordon and Grant (2004) claim that the decline in the number of publications regarding knowledge management occurred

in 2003 and 2004 might be due to two possible scenarios are: either knowledge management is starting fading out, or that, in spite of the lower quantities, literature on knowledge management has become significant and grounded as a field. The limitation of their study is that, the period covered by the study is from 01/01/1986 till 31/07/2004, therefore, the amount of articles for the seven months of 2004 resulted from the ABI/Inform database is not comparable with those from previous years. In fact, Figure 8 shows that the real decline in 2004 was less significant than Gordon and Grant (2004) stated and temporary since in 2005 more articles with regard to knowledge management than ever have been published (see Figure 8).

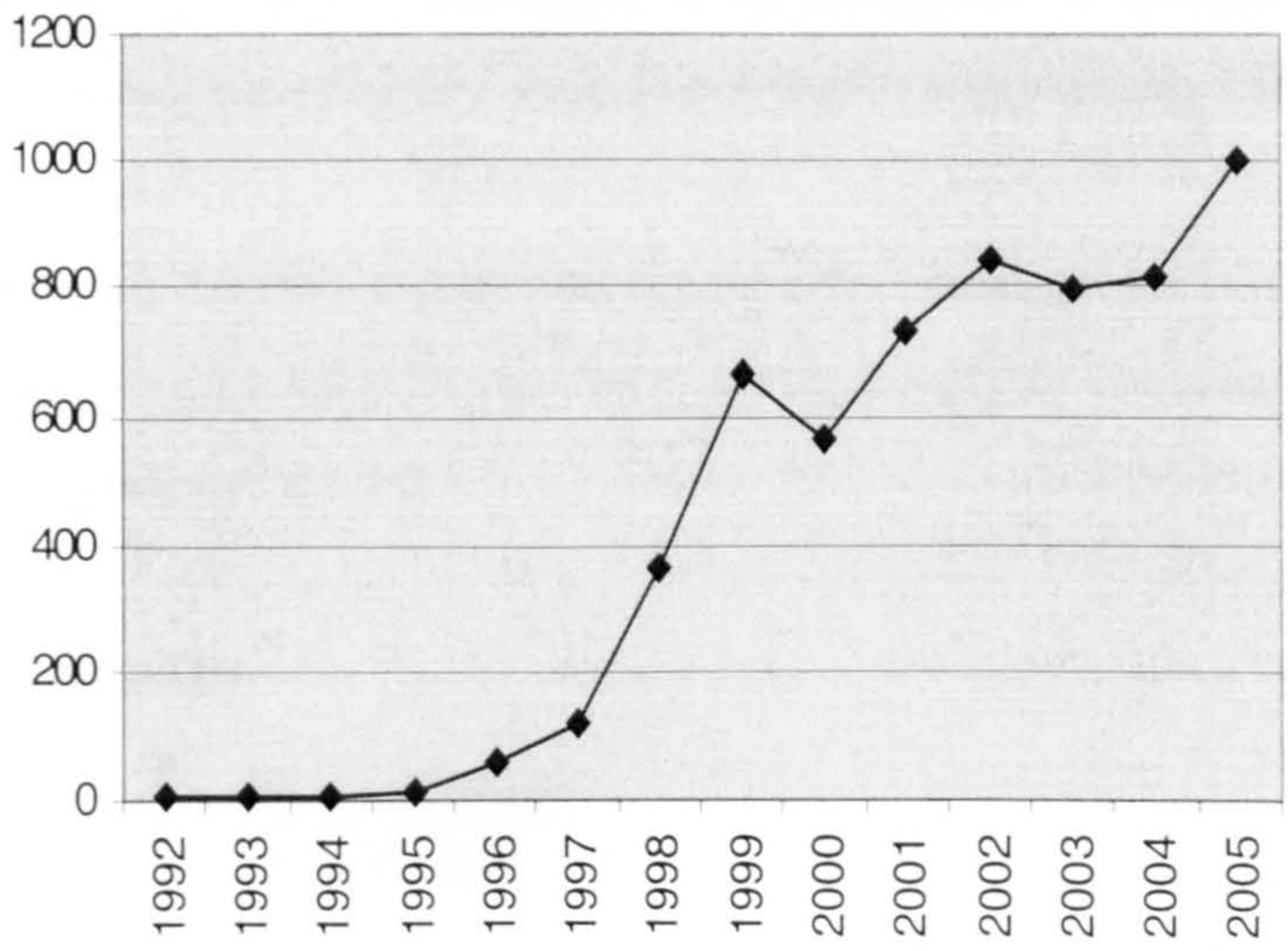


Figure 8: Number of publications with the keyword "knowledge management" in their abstracts or title according to the ABI/Inform database
(accessed on 16/03/2006)

Therefore, so far it seems that the case of knowledge management should not be considered just a management fashion, but a new field in development. This certifies the recognition of knowledge management as beneficial for organisations in the new economy (Roos and Von Krogh, 1996; Ruggles, 1998; Amidon, 1998).

On the other hand, at the practical level Pollard (2003) spots real evidences that show the decline of knowledge management:

- "*Budgets for knowledge management have been slashed everywhere, and whole knowledge management departments eliminated*

- *many companies are now trying to outsource knowledge management, no longer viewing it as a core competency*
- *where at one time six of the top 10 best sellers at Books for Business were about knowledge management, now very few knowledge management titles even crack the list*
- *writers are starting to predict 'the death of knowledge management', lament 'where did knowledge management go wrong' and even decry 'the autism of knowledge management'*
- *there are now fewer Chief Knowledge Officers in Fortune 500 companies than there were five years ago*
- *half of the knowledge management conferences scheduled in the past year in Toronto were cancelled for lack of interest*" (accessed on 15/10/2005)

Smith and McKeen (2004) argue that knowledge management is going to the typical stages of the hype cycle (see Figure 9) and "*currently is somewhere on the downward slope of disillusionment*" (p. 27).

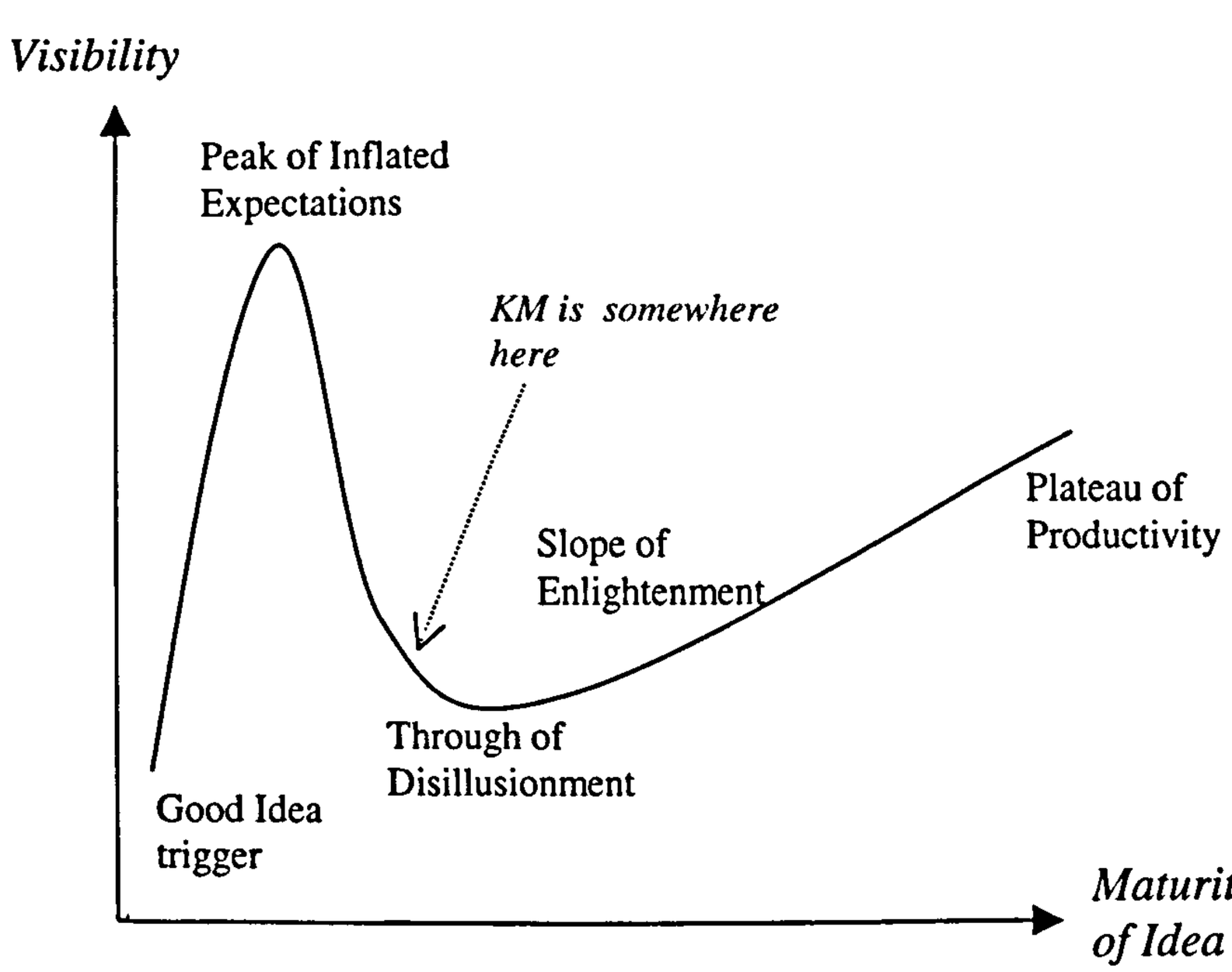


Figure 9: A Typical Hype Cycle

(Source: Gartner_Group (2004) adopted by Smith and McKeen (2004))

Given the common agreement on the fundamental role of knowledge management in organisational success, the decreasing interest on knowledge management by practitioners is surprising, in comparison to the increasing number of publications on knowledge management. Therefore, with the aim of clarifying the position of knowledge management within the literature, the researcher believes it is essential to distinguish academic or scholarly reviewed publications and those more practitioner-oriented, such as magazines, trade publications, etc. Following this line of thinking, Barley et al. (1988) discuss the influence between academics and practitioners regarding organisational culture. One of their proposed views is that the two communities exist independently and "*the direction and degree of influence might vary from issue to issue*" (p.25). Here in the issue of knowledge management is analysed.

Figure 10 shows different patterns of volume of literature with respect to knowledge management depending on the type of publications. While scholar publications have steadily augmented in number since 1995 till reaching their peak in 2005, trade publications experienced their highest point in 1999, following a shape similar to the management fashions. In a similar way to trade publications, reference / reports follow a bell-shaped curve with their top in 1999.

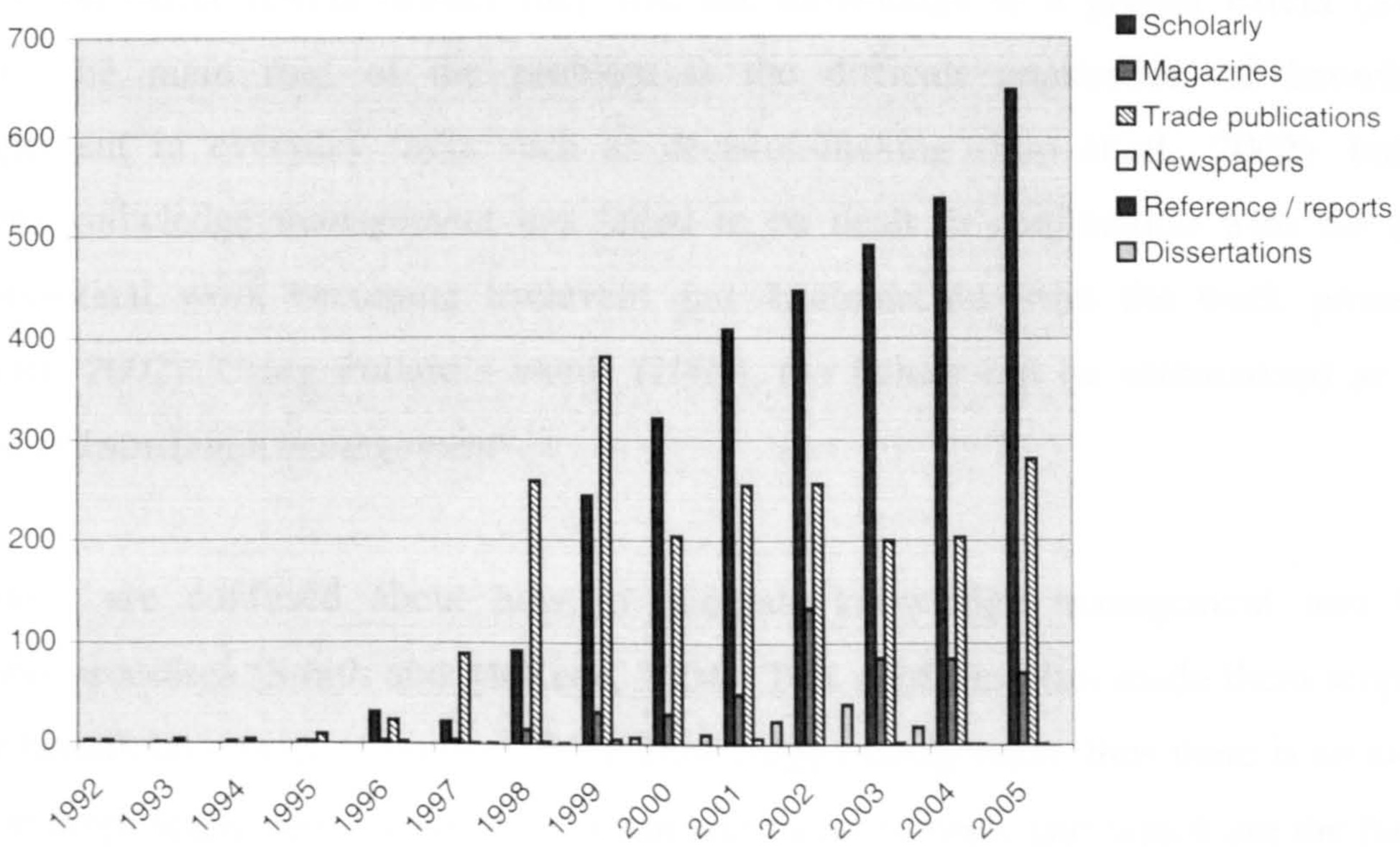


Figure 10: Number of publications according to type of publications, with the keyword "knowledge management" in their abstracts or title according to the ABI/Inform database

The conclusion emerged from this observation makes reference to the difference between academic and practitioner-oriented research. The increasing amount of literature among scholars might be interpreted as the result of the demand from practitioners or, simply, because of the establishment and recognition of knowledge management as an academic field.

The main reason for the decline in practitioner-oriented publications might be that, in spite of the initial enthusiasm, the awaited benefits from knowledge management have not been reached (Tsui, 2002; Davenport and Glaser, 2002), vanishing all "faith" put on this new idea. Indeed, few organisations have experiment the benefits of implementing knowledge management initiatives (Smith and McKeen, 2004; Call, 2005). This might be due to the gap between theory and practice, between knowledge management and action (Pfeffer and Sutton, 2000; Baird and Henderson, 2001; Smith and McKeen, 2004). Despite the widely recognized importance of knowledge management, there is little understanding of how it is generated within the firms (Eisenhardt and Santos, 2002).

Even if nowadays the acquisition, storage and distribution of great amounts of knowledge and information seems more feasible than before, this does not imply that organisations will obtain better results neither they will use knowledge to a greater extent (Swan, 2003). The main root of the problem is the difficult application of knowledge management in everyday tasks such as decision-making (Soo et al., 2002). Indeed, hitherto knowledge management has failed to be dealt in conjunction with the daily organisational work becoming irrelevant and disconnected from the work processes (Stewart, 2002). Using Pollard's words (2003), the failure can be summarized as "*the autism of knowledge management*".

Managers are confused about how to integrate knowledge management into their business processes (Smith and McKeen, 2004). This confusion has made them sceptical of the beneficial results of implementing knowledge management, thus there is an urgent need to empirically demonstrate how it can add value to firms and which are the factors to be taken into account in order to provide generalised guidelines, which will help practitioners to integrate knowledge management in their everyday work.

In fact, as mentioned earlier, Figure 10 shows that academic research is proliferating in the last years, while practitioners have already lost their interest. However, the rebound spotted in 2005 in the latter might indicate that knowledge management is advancing in the "slope of enlightenment" (see Figure 9), maybe in consequence of more academic evidence or advances.

In order to coordinate both academic and practitioner efforts to understand knowledge management and see its real application and benefits in firms a practice-based approach seems to be the most appropriate way to do future research. Thus, the extent to which knowledge management processes and specific practices take place in firms is measured through a questionnaire in order to provide with generalised guidelines on how to implement knowledge management programmes and to provide with empirical evidence for further academic research. Even if firms might differ in the way of dealing with knowledge management, the different approaches towards knowledge management will have some key common themes. Therefore, *this research aims to contribute by investigating the practical application of knowledge management to the business processes, based on empirical data on current practices from business*. Adopting a more managerial perspective is the critical point in order to advance in the slope of enlightenment towards the "plateau of productivity" (see Figure 9).

Given the focus on practices and processes of this thesis, next section will introduce the view of organisations as activity-systems, in which organisational elements inter-influence each other through organisational practices. Thus, the following section theoretically justifies the use of practice-based approach and goes into detail about the processes and practices involved in knowledge management.

3.3 Theories of Practice

The need for paying attention to the daily activity of organisations has also been spotted within the strategy field. In fact, recently there has been a shift of focus within strategy from a macro level to a micro level. Strategy has become more concerned about the detailed processes and activities that are carried out within the organisations, since these micro-activities are the ones which directly provide value to the organisations. In consequence, a new view of *strategy as practice* has arisen, as in other fields of management, with the aim of bridging the gap between theory and practice.

Theories of practice lie in the notion of practice. *Practices* are the unit of analysis and can be defined as the way in which actors perform everyday activities in interaction with the organisational context (Jarzabkowski, 2003). Therefore, organisations can be conceived as collective social structures in which actors perform activities (Blacker, 1993). It is important to understand the distinction between activities and practices. Although they are intrinsically interrelated, practices are the ways of performing activities. Thus, actors do activities by applying different practices.

However, there is also a social interaction between actors and the activity system in which they carried out the practices. The activity system comprises social and physical elements. For example, social interactions with other actors within the system or the incorporation of physical tools (e.g. information technologies) might transform practices themselves, since they dynamically change as conditions change. Reciprocally, the development of some practices might affect the structure of the activity system over time. In consequence, the collective organisational structure of an organisation embeds its organisational history and culture.

Jarzabkowski (2003) illustrates the four key elements of activity theory: actors, context, activities and practices in the framework shown in Figure 11. This framework also represents the interplay between the different elements, how practices mediate between the three constituents of an organisation (actors, collective social structures and practical activities).

Figure 11: Activity system in which strategy as practice occurs
(arrows indicate the mediating properties of strategic practices) (Source: Jarzabkowski (2003))

Knowledge as Action

The adoption of theories of practice in order to study knowledge and its management is appropriate since knowledge should be considered as action.

Within the literature on knowledge management, there are two contrasting epistemological approaches: content or possession and relational perspective (Cook and Brown, 1999; Scarbrough and Burrell, 1996; Tsoukas, 1996). The *epistemology of content* treats knowledge as content, as a static asset. However, knowledge is not an asset, an object which can be possessed and kept in the individual's mind but is implicitly embedded in the practices the individual is engaged in (Tsoukas, 1996). Knowledge results from the process of knowing, so it is inextricably linked to action and interaction (Cook and Brown, 1999). The *relational perspective* assumes this view. The knowledge creation theory proposed by Nonaka and Takeuchi (1995) reflects the dynamic dimension of the process of knowing, which bridges together the two epistemologies (Cook and Brown, 1999; Spender, 1996). Therefore, knowledge should be observed in practice. The concept of communities of practice (Brown and Duguid, 2001) arises from the view that sharing knowledge within a community is reflected in common practices, they are "networks of practice".

As the activity theory postulates, there are continuous interactions between knowledge and the collective social structures in which knowledge is developed, hence "*organisational knowledge is inherently indeterminate and continually emerging*" (Tsoukas, 1996: 22). Thus, organisational knowledge is an ongoing and dynamic socially constructive process in which individuals, groups and organisations interactively shape each other.

Since these changes are reflected in the organisational practices, as they act as mediators among the components of the knowledge activity system, the measurement of organisational practices seems to be the appropriate way of measuring knowledge management capabilities indirectly (Godfrey and Hill, 1995; Un and Cuervo-Cazurra, 2004). Thus, *the present research will analyse quantitatively knowledge management practices, in order to indirectly measure organisational capabilities. In this way, their impact on the organisational performance will also be tested. Furthermore, the key elements of the activity system, that is, the organisation will be included in the study due to their interplay with the practices. As a result, this study will contribute to reducing the lack of empirical studies, given that research has mainly focused on theoretical or conceptual studies and on case studies-based empirical tests, which generally address the process of knowledge sharing* (Un and Cuervo-Cazurra, 2004).

To conclude, *this research assumes that although knowledge relates to people, it does not reside in their minds, but is expressed in the course of their actions.* Knowledge is something dynamic and resulted from the process of knowing; hence it is essentially linked to action. Thus, the study of knowledge management in terms of practices seems reasonable and promising (Easterby-Smith et al., 2000). In order to clarify what is understood by *knowledge management practices* the definition given by Coombs and Hull (1998) is borrowed: "*observable routines involved directly in the development and application of knowledge*" (p.7).

The next section will analyse the practices and main issues involved in the knowledge management processes.

3.4 Knowledge Management Practices

The main objective of the present section is to provide a general understanding of the essential issues in knowledge management, since many aspects constitute vast and in-depth literatures by themselves. First, comments on the different practices involved in knowledge management will be made. Second, a review of the key elements which enable the success of such practices in firms will be discussed. These elements include the strategic alignment and the technical, structural and cultural infrastructure within organisations. The comments will be made in relation to the existing literature; however, it must be taken into account that due to its extensiveness, the topics will be addressed in a broad way.

As Shin et al (2001) review, there exist different classifications of the processes involved in knowledge management (e.g. Nonaka and Takeuchi, 1996; Teece, 1998a; Alavi and Leidner, 2001; Bhatt, 2000). However, here knowledge management practices will be grouped according to two main processes within knowledge management originating from the work of March (1991) on organisational learning: knowledge exploration and knowledge exploitation. *Knowledge exploration* refers to the process of actively seeking for new knowledge or for existing knowledge held from others, that is, it involves knowledge creation and knowledge acquisition. Practices such as search, variation, experimentation and discovery are some of the practices included. On the other hand, *knowledge exploitation* refers to the process of making use of existing knowledge, by transferring and/or integrating it within the organisation. It includes practices such as refinement, choice, and implementation. In fact, these two processes could correspond to the three components identified by Almeida et al. (2003): knowledge search, transfer and integration, which form the scanning, sourcing and combinative capabilities of the firm.

Despite the distinction between the two processes, they act simultaneously and interrelated. The relationship between knowledge exploration and exploitation has been recognised (March, 1991; Lyles and Easterby-Smith, 2003). Ideally organisations should engage themselves in both processes in a balanced way. Zack (1999) poses that exploration without exploitation cannot engender sustained

competitive advantage. The phenomena can be represented by the metaphor of detecting fuel and extracting and using it, one process has not sense without the other one.

Next the different practices which organisations can carry out in order to explore and exploit knowledge will be outlined.

Knowledge exploration

One of the most recognized processes of knowledge acquisition is **learning.** Learning occurs at the different levels of the organisations (individual, group, organisational and inter-organisational levels) (Nonaka and Takeuchi, 1995; Kogut and Zander , 1992). However, some scholars from the cognitivist perspective argue that learning only takes place in human brain (Simon, 1991).

At the individual level, humans can learn cognitively, reflecting and anticipating experiences, or through their body, by doing and experimenting (Vera and Crossan, 2003). The characteristics of the different ways of learning should be taken into account when designing training with the aim of developing the skills of individuals. For example, the skills required to use a new technology can be learnt by providing the user guide and following the instructions (*declarative knowledge*). But also, it can be learnt by shadowing experts in the new technology (*procedural knowledge*). Although both ways target the same objective, the latter one allows to learn the tacit elements of the job which are difficultly reflected in the declarative knowledge, and to integrate this knowledge in the course of action. Thus, the process of actively seeking for new knowledge, namely research, is highly interrelated to the process of learning-by-doing; through experimentation and simulations.

Moving to the group level, individuals within the group might lack the required knowledge in order to perform a task, but this knowledge might exist within or outside the firm. Therefore, the formal and informal mechanisms existing within the firm with the aim of locating and accessing existing knowledge bases will determine the firm's capability for **scanning internal knowledge.** Although internal knowledge can be identified by direct personal contact, some firms have developed knowledge

directories (also called "yellow pages"), which informs about the skills possessed by each person within the firm (Davenport and Prusak, 1998). These directories are usually recorded in paper form or stored in the internal information system of the firm. Although the initial idea of the knowledge directories seems adequate and efficient, firms should be cautious to use common language and keep them updated, since the internal scanning would rely heavily on this initiative, reducing face-to-face enquiries or searches.

Another way of acquiring knowledge within the group is by learning from past and/or current experiences. Other organisation might have gone through similar experiences, hence potential mistakes or problems might be avoided through investigating the "lessons learned". There are different mechanisms to access to the **organisational memory** (Walsh and Ungson, 1991). Similar to the individual learning-by-mind, *declarative memory* contains knowledge about facts and events. Past experiences might be recorded in reports or other kind of documentations, stored in paper or computer form. But another more direct way of getting information about past experience is through speaking to staff involved in previous projects. In this way, there is opportunity to discuss and fully understand the context of past experiences. On the other hand, it must be noticed that organisational learning is implicitly assimilated in the organisational routines and culture over time. Thus, the study of organisational memory should include the organisational routines and culture. This kind of organisational memory is named *procedural memory*. The development of such organisational memory is of great importance since it prevents firms from losing the knowledge acquired over time, independently from the staff turnover or leadership changes (Hedberg, 1981).

Since **managers** are key players in making strategic decisions on the entrepreneurial activities of the firm, they should keep up-dated about the developments within the firm. To do so, managers might hold regular communication with departmental managers. Furthermore, some might also complement this information by walking around in the firm and, thus, drawing their own conclusions. Information systems can also inform of the state of the different processes within the firm. The more integrated the information system is, the more valuable and sensible information can provide.

Regarding **external knowledge**, firms can engage themselves in market research activities or access to external sources of knowledge (e.g. conferences, fairs, etc.). But more frequently and importantly firms may develop **social capital** as a strategy to acquire knowledge. Organisational relationships including customers, suppliers, competitors, and so on, create opportunities for knowledge acquisition and also, exploitation (Yli-Renko et al., 2001; Dyer and Singh, 1998). For example, information provided by customers and suppliers about the market might be a source of new knowledge which can drive changes within the firm. The relationship with the actors in the network is a key factor in learning among them, thus organisations' social capital is highly dependent on the level of social interaction (Nahapiet and Ghoshal, 1998). Within the literature there has been found a positive relationship between social interaction and knowledge acquisition (Liebeskind, 1996; Yli-Renko et al., 2001). Similarly, Van Wijk et al. (2003) review the literature on networking and state that most of the studies have found a positive relationship between networking and performance. Networking happens around a common problem or issue (Baker, 1992) and can take place not only at the inter-organisational level but also at the intra-organisational. Therefore, internal and external network opportunities are important sources of information and know-how (Soo et al., 2002).

However, the location of external and internal knowledge might be local or distant, concentrated or dispersed. As Tsoukas (1996) states, organisational knowledge systems are not homogeneous but dispersed, so organisations should deploy mechanisms to access, coordinate and integrate them. Networking aims at linking the different knowledge bases which, supported by advanced information and communication technologies, can overcome the constraints of distance and time at an ever-seen speed. Another option for firms is to search for geographically localized knowledge having in mind the exploitation of linkages between firms in the region (Saxenian, 1990) in the form of **clusters**. Further comments on networking will be expanded as part of knowledge exploitation.

As said before, learning and search for knowledge are "path-dependent" (Nelson and Winter, 1982) and become embedded in the organisational routines, culture and structures. The abilities of learning and scanning for new knowledge are developed over the time, thus they become strategic capabilities difficult to be copied. However,

firms paradoxically restrict their search for new knowledge depending to their existing knowledge and experience (Cohen and Levinthal, 1990). To an extreme, organisations might suffer from the "competence trap" which impedes learning due to the rigid mental models (Leonard-Barton, 1992; Levitt, 1989). However, this can be avoided by continuous engagement in knowledge exploration and exploitation.

Knowledge exploitation

One of the most important processes within knowledge exploitation is ***knowledge sharing*** across the different levels of the organisation. Given the dispersed distribution of knowledge systems (Tsoukas, 1996), organisations are responsible to facilitate the interaction among the individuals located in different parts of the organisation.

However, differently from physical objects, knowledge can only be transmitted though social interaction (Dewey, 1916). Internal communication plays a key role in the internal transfer of knowledge within organisations. The level of **internal communication** can vary both in the frequency and in the nature, ranging from sporadic and informative contacts to frequent and strong collaborations. Internal communications can take place in different formats: through formal and informal channels (Maltz and Kohli, 1996; Slater and Narver, 1995) and based on direct contact, text or images. Although sometimes informal channels of communication are overlooked (Edmondson et al., 2001), they are of high importance in networking.

Continuous and intense communication and interaction around a common interest induce the creation of communities in which knowledge is socially embedded and thus, intrinsically linked to practice. Brown and Duguid (1991) name them as "communities of practice". In this interacting "ba" (Nonaka et al., 2000), communities build up a common understanding, a shared sense of identity over the time (Von Krogh et al., 1998; Schultze and Boland Jr., 2000). This consensus influences on the interpretation and acquisition of future knowledge (Slater and Narver, 1995), allowing the community to seize knowledge opportunities timely by deeply improving knowledge sharing (Von Krogh, 2003).

However, in order to enable internal collaborations and communities of practice, the provision of sufficient **resources** and time is required (Brown and Duguid, 1991). Paradoxically, the cultivation of social networks is often an indirect source of resources (Bower (1970); Kanter (1983) cited by Floyd and Wooldridge (1999)).

In addition, **organisational structures** should enhance social interaction. Thus, the way in which work is organized plays an important role in the internal interactions. For example, if firms promote individual work, it is less likely to have intense internal communications. On the contrary, team working encourages internal contact and depending on the composition of the team (functional, cross-functional or multidisciplinary) the communication can flow across the different boundaries of the firm. Within this line of thinking, the type of organisational structure might be an indicator of the level of internal communication and collaboration, since more hierarchical structures are more prone to hamper internal flows while teams-based organisations supports collaborations. Similarly, the incentive system should be in tune with the organisation structure and promote knowledge sharing, solving interest conflicts.

But maybe more importantly, the organisational culture will condition the nature of the internal flows of communications. According to Davenport and Prusak (1998), organisational **culture** is decisive in knowledge sharing. A climate of trust, active empathy, help offer and lenience should form a social norm of care, which enables human relationships (Von Krogh et al., 1998). A firm where communication is open and regular, where employees feel it as trustworthy and transparent, is more likely to have effective knowledge sharing. Thus, the ability to communicate knowledge throughout organisations depends on having a widely spread shared language and culture (Zenger and Lawrence, 1989). Furthermore, cultures based on goodwill trustworthiness increase the influence of social capital (Nahapiet and Ghoshal, 1998; Tsai and Ghoshal, 1998).

Shortly, Zack (1999) summarizes the requirements for knowledge transfer capabilities as "*culture, reward systems, and communication networks that support the flow of knowledge and a well functioning organisational memory (both embedded in humans and in technology) to transcend the time delays between developing and applying*

knowledge as well as between applying and developing the next round of knowledge" (p.137). In his opinion, a well-developed internal knowledge transfer capability is key for balancing knowledge exploration and exploitation.

It must be noticed that knowledge is shared and integrated through interactions among individuals and between individuals and their environments. Individuals interpret information based on their social, cultural and historical contexts (Nonaka et al., 2000). But, simultaneously, socialization processes also influence on the organisation and its learning which is reflected in its procedural memory (routines, culture, values). There is a mutual learning over time (March, 1991), which illustrates the interactions between the different components in an activity system.

Regarding external knowledge, firms must develop linkages to enable the knowledge transfer in order to take advantage of the new knowledge provided by external sources (Almeida et al., 2003; Dyer and Nobeoka, 2000; Gulati and Nohria, 2000). For example, **clusters** enable collaborations within regional social networks (Rogers and Larsen, 1984). Also, interacting and communicating with stakeholders can enhance knowledge sharing. The level of **external communication** can differ on intensity and format. For example, firms can have regular exchanges of data with the stakeholders through electronic channels or develop close relationships in the form of informal collaborations involving personal contact. Reciprocally, the possession of valuable internal knowledge attracts and facilitates the access to external knowledge. In some cases in order to ensure this knowledge transfer, firms formalize their inter-firms relationships by forming alliances, mergers or other kinds of strategic relationships (von Hippel, 1988). However, several studies (Liebeskind, 1996; Yli-Renko et al., 2001; Soo et al., 2002) have demonstrated that in knowledge exchange informal networking are more effective than formal networking. All in all, social **networking** is widely recognized as means of knowledge transferred at the different levels of the organisation (Nahapiet and Ghoshal, 1998; Henderson and Cockburn, 1994; Davenport and Prusak, 1998).

However, although firms might have formal or informal networks which can become important sources of external knowledge, the real impact on the organisation will depend on the firm's **absorptive capacity,** that is, on the firm's ability to absorb and

learn from it (Szulanski, 1996). Cohen and Levinthal (1990) define absorptive capacity as "*the ability of a firm to recognize the value of new, external information, assimilate it and apply it to commercial ends*" (p.128). Absorptive capacity is built up over time through "*active information and knowledge sharing, recording and sharing, and knowledge accumulation behaviours (such as participating in conferences, updating skills through training and self-learning, and keeping abreast of the latest technology)*" (Soo et al., 2002: 133). Thus, it is a path-dependent capability, determined by prior related knowledge (Cohen and Levinthal, 1990)). However, other scholars (Gupta and Govindarajan, 1991; Szulanski, 1996) argue that organisational factors such as the structure of communication and distribution of knowledge are more influential on firm's absorptive capacity.

In order to clarify the influence of the critical factors in knowledge sharing (e.g. formal versus informal networking, structure of communication, etc.), *the present research will empirically analyse the relationship between the different practices on knowledge sharing and organisational performance with the aim of identifying patterns among firms, which can result in generalisable recommendations*.

To conclude, contrary to cognitivists (Simon, 1991) who claim that knowledge resides essentially in individuals' brains, social constructivists (Brown and Duguid, 1991) argue that social processes are not only means of enabling knowledge transfer but also a source of creating new knowledge. Indeed, some argue that innovation derives from **interaction between individuals** (Argyris and Schon, 1996; Arrow, 1963) or even more, that networking is essentially knowledge. Furthermore, apart from facilitating knowledge acquisition, social interaction also enhances the absorptive capacity of the firm, since it increases the ability to recognize and evaluate new knowledge. As an old proverb says, the value of knowledge multiplies when it is shared. Although usually firms should promote knowledge sharing, issues such as confidentiality should be taken into consideration. There might be necessary to restrict the access to strategic knowledge or **protect** it by intellectual property rights.

Together with knowledge sharing, knowledge integration is a fundamental part in knowledge exploitation. ***Knowledge integration*** is the process through which different knowledge bases are assimilated by individuals and organisations (Grant,

1996; Iansiti and Clark, 1994). This process is of great importance since it results in new innovation enhancing capabilities, that is, in value creation.

At the individual level, integration requires much self-observation and reflection. However, reflection should not only entail mental processes but action. In terms of Nonaka et al. (2000), this process is named internalisation and takes place in the exercising "ba". Knowledge integration allows the accumulation of tacit knowledge through experience. **Experimentation** has been commented as a source of new knowledge since it involves trying new ideas, however, the drive to experiment is the application and internalisation of knowledge acquired by individuals or transferred through social interaction. For example, information about the needs of the market might trigger experimentation or application of new ideas, or the benchmarking of competitors' products might trigger imitation or prototyping. This phenomenon is essential, since the organisational learning should continuously adjust and respond to the feedback from the environment (Cyert and March, 1963). Nevertheless, experimentation requires spare time and resources. Indeed, the availability of resources to work both individually and in group allows experimentation and can lead to innovation (Chakravarthy et al., 2003), thus it conditions the process of learning from experience. As Penrose (1958) predicted, the existence of "resources in excess" might be a key determinant of competitive differentiation.

At the group level, **open discussions** are required in order to develop common views. Despite the fact that different internal views might enrich the organisation perspective, groups should agree a common direction of working. Indirectly, at the organisational level, integration is reflected in the **alignment** of the functional strategies with the general strategy of the firm and coordination among the different sub-units and individuals towards the same vision. In consequence, integration might mediate in knowledge-based results, such as innovations, flexibility, adaptability and, in consequence, in the organisational financial results.

Furthermore, **reflection** is another way of integrating knowledge within firms. Reflection on the organisational initiatives might provide very insightful knowledge for future activities. Although organisations might find it difficult to discuss about failures, they should consider them as one of the richest sources of organisational

learning. As a result of knowledge integration, the new knowledge should be incorporated in the organisational knowledge in the form of new rules and routines or new documentation, which implies that **outdated** knowledge should be replaced systematically.

Almeida et al. (2003) state that the linkage among different sub-units within organisations through intra-organisational mechanisms, processes and systems facilitates the knowledge integration process, thus, it is intrinsically linked to the knowledge sharing mechanisms. However, the integration process involves **sense making** of the different knowledge bases shared (Weick, 1995), the achievement of agreed interpretations.

Summarizing, there are different practices regarding knowledge exploration and exploitation, which form the knowledge management capabilities. However, as the activity systems theory claims, practices reciprocally interplay with the organisational context or activity system (Jarzabkowski, 2003). Therefore, the following section will review what are the main elements that form the knowledge management system.

3.5 Knowledge Management System

As seen in the previous section, a combination of technological and behavioural elements mediates in the effectiveness of knowledge management practices (Alavi and Tiwana, 2003). At the same time, individual and group learning becomes institutionalised, embedded in the organisational repositories such as routines, systems, structures, culture and strategy (Nelson and Winter, 1982; Walsh and Ungson, 1991; Vera and Crossan, 2003). This illustrates the interaction between the elements of the activity theory.

This section reviews the main organisational elements which influences on the effect of knowledge management practices which in the present research have been classified as: strategic alignment, culture, structure and information and communication technologies. The latter is discussed to a greater extent since it is central in the present study.

Strategic Alignment

Regardless the extent to which knowledge management practices are carried out, their impact on the organisational performance depends on the suitability to support the organisational strategy (Bierly and Chakrabarti, 1996). As Levitt (1989) states, "*learning does not always lead to intelligent behaviour*" (p.335).

Organisations need a vision to synchronize the entire organisation by giving a meaningful purpose of the everyday activities (Leonard-Barton, 1992). Furthermore, it determines the direction in which knowledge may evolve over the long term (Nonaka et al., 2000). Therefore, a main factor for effective knowledge management is the clarity on organisational goals. Indeed, in the previous section strategic alignment was referred as an indicator of the firm's ability to integrate knowledge. However, the organisational objectives might differ from the individuals' objectives, resulting in internal conflicts. Issues such as the rewarding systems and other motivational factors should be considered in order to promote commitment to the

organisational mission (Nonaka et al., 2000). Thus, right incentives for sharing should be carefully chosen in order to cope with diverse and distributed interest.

On the other hand, firms must effectively communicate their visions throughout the organisation in order to involve individuals in the organisational future and, in consequence, achieve their commitment to the organisational goals.

Culture for knowledge

Organisations are social entities, where culture acts as the invisible glue that unites individuals into social structures (Smircich, 1983). Many scholars agree in the essential role of culture for effective knowledge management (Davenport and Prusak, 1998; Leonard-Barton, 1992; Nonaka et al., 2000). A culture of love, care, trust and openness is a necessary condition to enabling effective interaction and dialogue between individuals and groups (Von Krogh et al., 1998).

According to Williamson (1991), currently trust is the coordination mechanisms between different intermediate institutions such as networks, while traditionally price and authority ruled the coordination process.

Moreover, as commented previously, culture holds part of the collective knowledge, the organisational and tacit knowledge, and shapes the routines and ways of acting within organisations. Thus, organisational knowledge is shaped and embedded in the organisational culture, which is developed over time and, thus, is distinctive of the firm. As Barney (1986) states, organisational culture is of strategic importance due to its value, rarity and imperfectly imitability.

Organisational structure

Knowledge management activities should be aligned with the organisational structure. The promotion of team working or internal collaboration might be hindered by hierarchical and bureaucratic structures. Similarly, the level of centralization, autonomy (Nonaka et al., 2000), technological turbulence and control might be key factors in enabling knowledge management practices.

Another important issue regarding the organisational structure is the availability of resources. Sufficient time and physical resources are necessary in order to carry out practices such as experimentation, simulation or social interactions. According to Nonaka and Takeuchi (1995), managers should nurture a "good" ba by providing physical space (e.g. meeting rooms), mental goals (related to the organisational alignment) and virtual space (e.g. computer networks). In relation to this last point, next the role of information and communication technologies as enablers of knowledge management practices will be discussed below.

Information and Communication Technologies

There has been a great emphasis on communication and information technologies in knowledge work. According to Easterby-Smith et al. (2000) around 70% of publications on knowledge management focus on information technologies. This demonstrates that knowledge management initiatives are commonly associated to the development of information and communication technologies (Zuboff, 1988; Hayes and Walsham, 2003).

When analysing the role of information and communication technologies, it is important to understand the distinction between data, information and knowledge, since processing data does not directly imply creating knowledge. In short, data is raw numbers and facts, information is processed data, and knowledge is meaningful information (Dretske (1981); Machlup (1983); Vance (1997) cited by Alavi and Leidner (2001)).

There is a recursive and hierarchical relationship between data, information and knowledge (Bhatt, 2000; Alavi and Leidner, 2001; Earl, 2001), which depends on the degree of the 'organisation' and 'interpretation' (see Figure 12). Therefore, the distinction between information and knowledge depends on users' perspectives (Bhatt, 2000). Nonaka and Takeuchi (1995) agree, arguing that knowledge is the flow of information "*anchored in the beliefs and commitment of its holder*" (p.58). Thus, if knowledge is "*information added value*" (Davenport, 1997), people who use this

information are the responsible element for incorporating the value of knowledge. As a result, although information has the potential of converting into knowledge, there are no direct means to readily determining when information has become knowledge. Thus, the role of information and communication technologies in enabling knowledge management practices focus on exposing individuals to potentially useful information and facilitating the assimilation of information. But their effect on knowledge management will depend on the users.

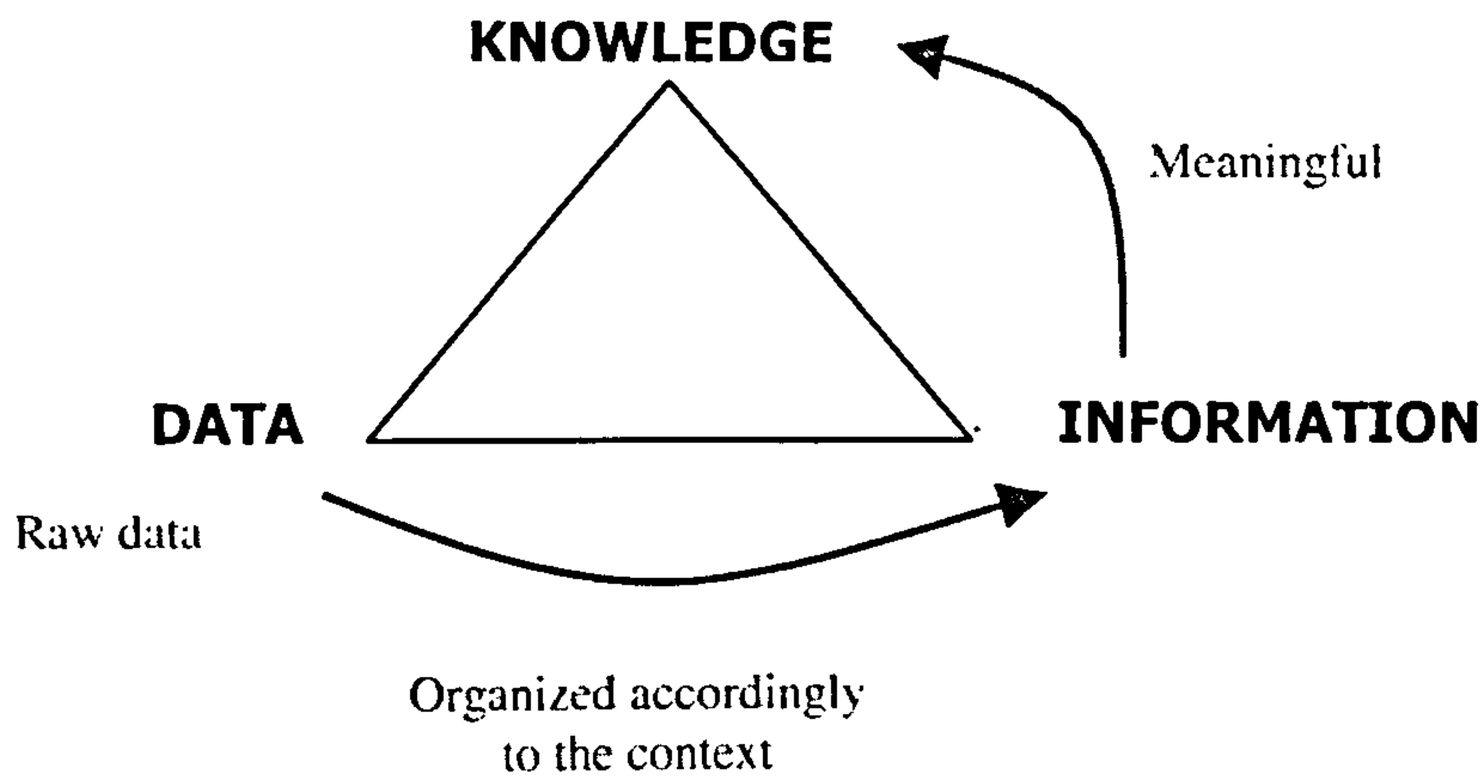


Figure 12: The recursive relations between data, information and knowledge
(Adapted from Bhatt (2000))

Alavi and Leidner (2001) elaborate an excellent review on knowledge management and knowledge management systems. They show how information and communication technologies can enhance the knowledge creation, storage and retrieval, transfer and application. Figure 13 illustrates their conclusions.

On the other hand, information and communication technologies can also be classified as integrative (store and retrieve information) and interactive applications (Zack, 1999).

Knowledge Management Processes and the Potential Role of IT				
Knowledge Management Processes	Knowledge Creation	Knowledge Storage/Retrieval	Knowledge Transfer	Knowledge Application
Supporting Information Technologies	Data mining Learning tools	Electronic bulletin boards Knowledge repositories Databases	Electronic bulletin boards Discussion forums Knowledge directories	Expert systems Workflow systems
IT Enables	Combining new sources of knowledge Just in time learning	Support of individual and organizational memory Inter-group knowledge access	More extensive internal network More communication channels available Faster access to knowledge sources	Knowledge can be applied in many locations More rapid application of new knowledge through workflow automation
Platform Technologies	Groupware and communication technologies			
	INTRANETS			

Figure 13: Knowledge management processes and potential role of IT

(Source: Alavi and Leidner (2001))

Integrative technologies may enhance organisational declarative memory. For example, electronic databases, which include structured information; expert systems, which include codified human knowledge; and document management technology, which allows the storage and retrieval of knowledge on past experiences and current information. Based on these technologies, organisations may develop vast repositories of knowledge about customers, projects, competition and the industries in which they play (Alavi, 1997).

Furthermore, systems such as ERP integrate all the relevant information about the internal performance of the organisation in a unique application, avoiding duplications, mistakes and thus, making the internal sharing of information more efficient and effective. In consequence, the process of decision-making should improve.

On the other hand, integrative technologies such as data warehousing and data mining, document management systems and agents may be great value by processing or getting information at a rate never-seen before. It is undeniable their powerful potential, mainly for those industries where getting the right information timely might provide competitive advantages (e.g. insurance companies).

In general, the storage and retrieval of organisational knowledge through easily accessed and unique channels allows organisations to apply it on solving problems, avoiding re-inventing the wheel. This results in reduced organisational transaction costs (Walsh and Dewar, 1987).

A limitation which integrative ICTs present is that they are only helpful if the user knows what he is looking for (Powell and Dent-Micallef, 1997). Indeed, a heavy reliance on ICTs might discourage individuals, and specially newcomers, to learn from others with more expertise (Ruhleder, 1994; Orlikowski, 1996). It must be taken into account that the tacit elements of knowledge cannot be articulated due to its contexts-specific dependency. Thus, the potential of ICTs to store knowledge is limited to explicit knowledge.

In addition, since this type of technologies promote declarative memory, they enhance 'encased' learning, resulting in a "learning trap" (Levitt, 1989). This hinders creativity, innovation, and flexibility (Zack, 1999). Denison and Mishra (1995) remark that the excessive use of organisational memory can lead to stable organisational cultures that resist changing.

Interactive technologies aim to support collaboration, social interaction and communication processes which are the basis of knowledge transfer and integration. The availability of new channels of communication and collaboration such as e-mail, intranet-extranet, groupware, forums and bulletin boards allow formal and informal contacts among individuals, without any time or space limitations. Therefore, they nurture the interacting "ba".

Internet, search engines, web crawlers have proven to speed up the access to external knowledge and the organisational memory without any intermediary. Also, multimedia technologies such as videoconferencing provide sophisticated access to stored information, enabling the capture of some contextual characteristics. Furthermore, ICTs can enhance the capture, store and manipulation of explicit knowledge in a number of forms, such as numbers, text, video and graphs.

The exercising "ba" also can be enhanced by ICTs, as individual learning can be supported with different tools such as computer simulation. Also, tools such as CAD-CAM, CATIA, PDM and simulation software enable designers to create new products in more effective ways. Thus, ICTs can be enabler of learning and creativity, and of easy access to stored knowledge about past experiences.

ICTs are widely seen as useful aid in collaboration, since they work across spatial, temporal and functional boundaries (Walsham, 1998; Schultze, 2000). However, the reliance on ICTs for knowledge transfer might not be adequate due to the nature of organisational knowledge, socially embedded in their practices (Brown, 1998; McDermott, 1999; Hayes and Walsham, 2003). They might hinder the build-up of a shared understanding (Brown, 1998; McDermott, 1999; Schultze, 2000; Hayes and Walsham, 2003), requirement for an effective knowledge sharing.

In short, the huge amount of available information and communication technologies provides a wide range of possible support for knowledge management, from automation to creativity, from purely mechanistic functions to more human functions. Due to the characteristics of knowledge, socially constructed by interaction, interactive applications might be more suitable than integrative applications (Zack , 1999; Olivera, 2000; Ruhleder, 1994). However, ICT are not a "panacea" (Constant et al., 1996; Dewett and Jones, 2001). Often, a strong focus on ICT is at the expense of the development of a suitable organisational culture (Liebowitz and Chen, 2001). This fact has engendered a debate on the role of ICT in supporting knowledge management processes between technophiles and HR supporters. This debate will be dealt in more detail in the next section.

3.6 Common Debates Within Knowledge Management

The role of ICT within Knowledge Management

The usefulness of ICT as means of supporting the management of knowledge has proved to be important by several researchers (Alavi and Leidner, 2001; Scarbrough et al., 1999; Ruggles, 1998; Davenport and Prusak, 1998; Zack, 1999; Alavi and Tiwana , 2003). However, despite the fact that much research on knowledge management exists, the role of ICT in knowledge management continues to be obscured and this has lead to a continuous debate which tends to either overemphasize or underestimate the role of ICT (Sørensen and Kakihara, 2002). On the one hand, the 'hard party' consists of practitioners and IS specialists focusing on the technology, mainly on developing tools and systems. On the other hand, the 'soft party' concentrates more on accumulating intellectual capital through the development of skills and competences (Scarbrough and Swan, 2001). Accordingly to Earl (2001), the technical approach is the longest established within the knowledge management research literature. As seen in Figure 14, initially the literature on knowledge management was driven by the technical issues such as information management or IT/IS. However, in the last years, knowledge management has been addressed from a more balanced proportion of different views. The decline in ICT focus might be due to the decreased interest on knowledge management from practitioners. Figure 15 gives evidence that for practitioners knowledge management is equivalent to managing information and ICT.

In fact, organisations already guess that technologies might not be the only main issue in knowledge management but other issues are also significant (see Edwards et al., (2003)). This might be an indicator of how difficult organisations find to implement knowledge management.

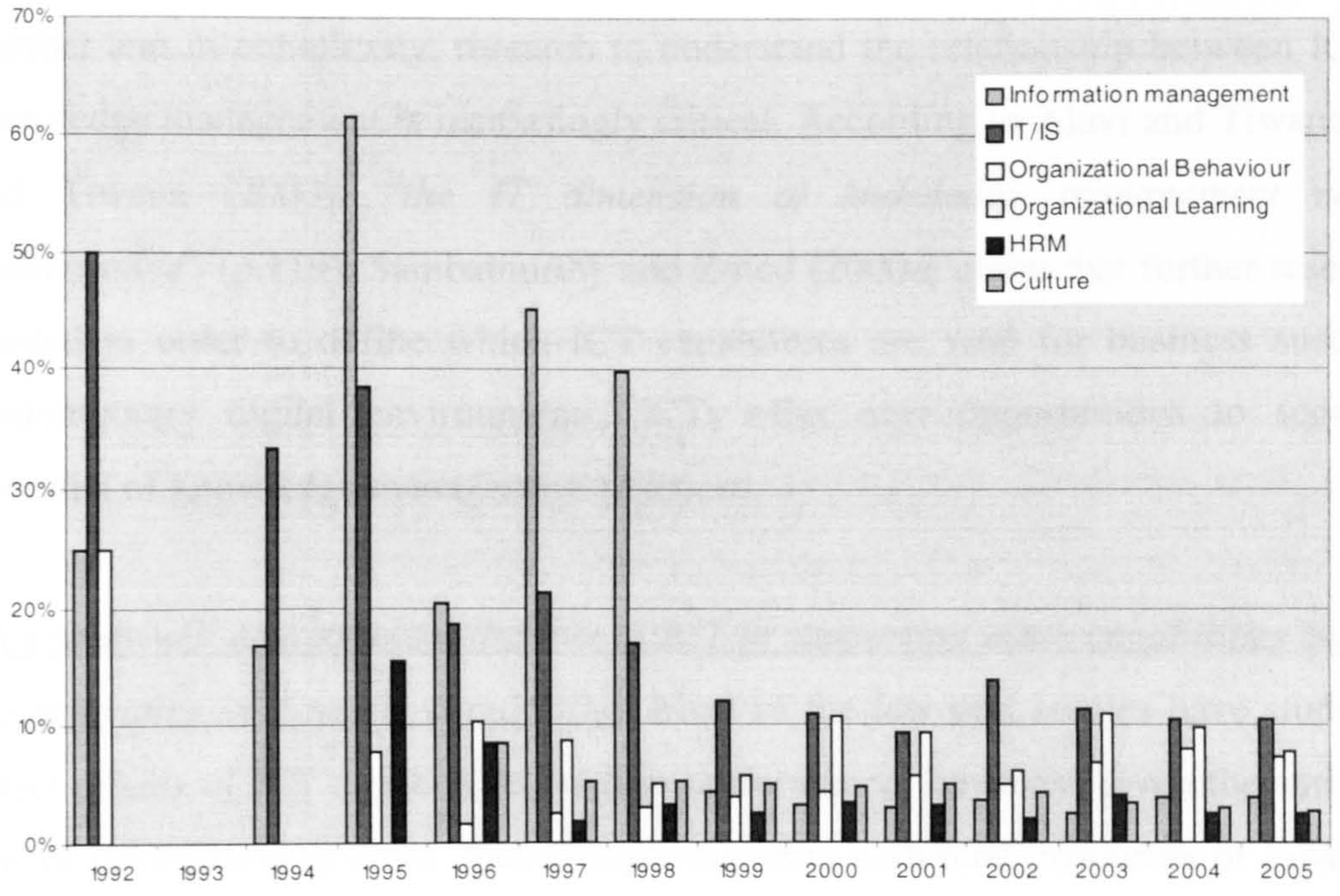


Figure 14: Evolution of themes in the literature on knowledge management (ABI/Inform database)

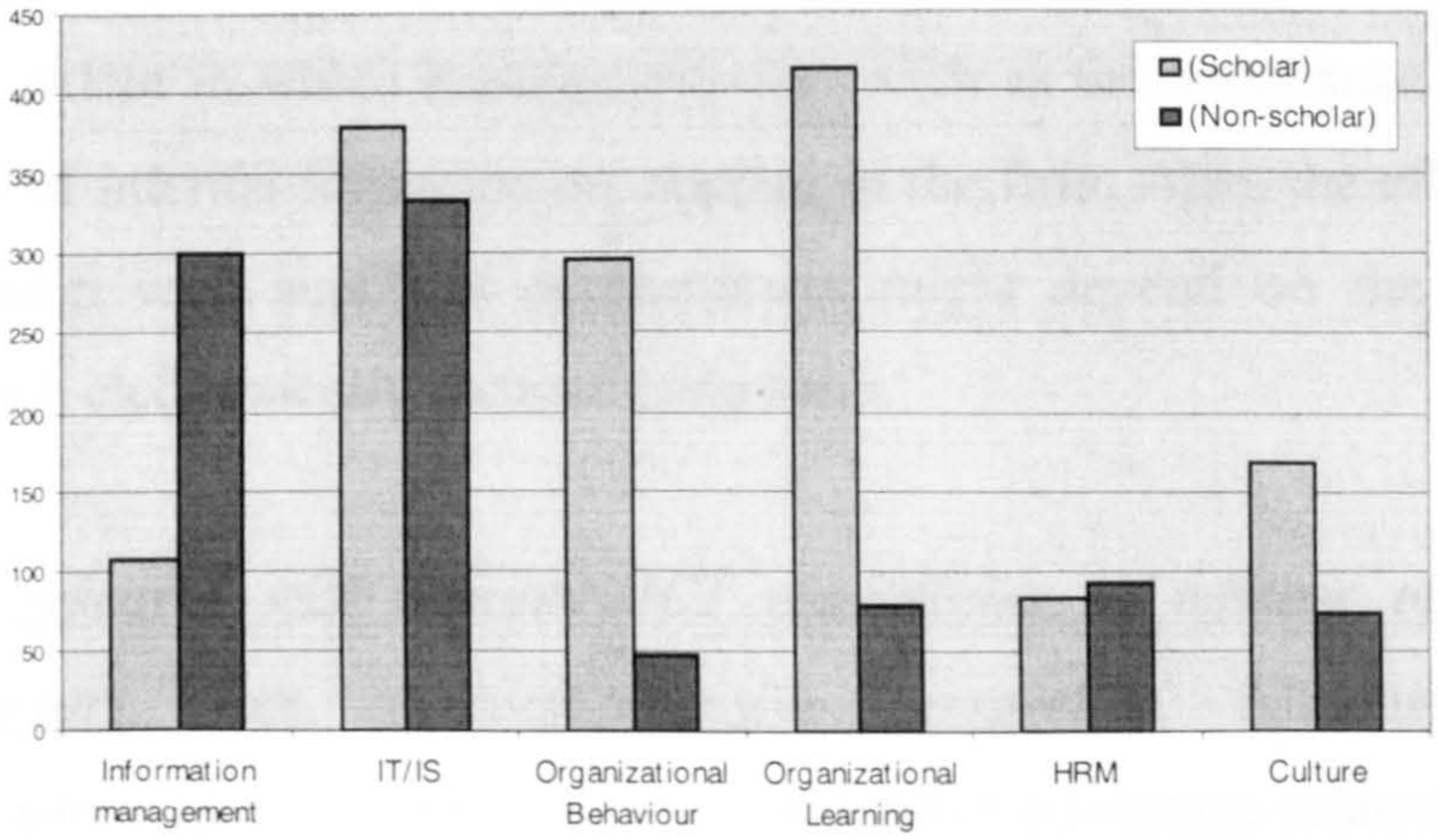


Figure 15: Themes within knowledge management for scholar and non-scholar publications (ABI/Inform database)

This research will examine the effect of ICT capabilities on organisational performance, given that there is plenty empirical evidence about the failed applications of ICT for knowledge management purposes (Tsoukas and Mylonopoulos, 2004). Organisations are challenged to harness ICT in order to create

new information and knowledge (Nonaka, 1988) and, since ICT are increasing both in number and in complexity, research to understand the relationship between ICT and knowledge management is increasingly critical. According to Alavi and Tiwana Alavi and Tiwana (2003), "*the IT dimension of knowledge management remains understudied*" (p.119). Sambamurthy and Zmud (2000a) claim that further research is needed in order to define which ICT capabilities are vital for business success in contemporary digital environments. ICTs offer new opportunities to scoop the potential of knowledge management practices.

This study will also examine the role of ICT in supporting other capabilities based on the principles of dynamic capabilities. Most of the few past studies have studied the direct effects of ICT capabilities on firm performance, however, given the supportive role of information systems, their complementarity with other resources or capabilities should be researched (Clemons, 1986; Ravichandran and Lertwongsatien, 2005; Tanriverdi, 2005). Similarly, *this research will analyse the influence of knowledge management capabilities on ICT capabilities.* According to Eisenhardt and Martin (2000), dynamic capabilities are shaped by learning mechanisms. For example, the skills existing in firm to use information and communication technologies might be related to the extent in which learning activities such as the attendance to courses or the frequency of internal formation are applied in the firm. Also, the effectiveness of the collaboration with suppliers or customers might depend on the existence of platforms which electronically communicate them.

The present research will conceive ICT capabilities as mixture of human and technical factors from a comprehensive perspective. Although nowadays organisations can acquire similar ICT, the competitive advantage related to the use of ICT will only come from idiosyncratic characteristics of the firm. Sambamurthy and Zmud (2000) suggest that new thinking focused on the core ICT capabilities will provide a better understanding of ICT management. As within the knowledge management literature, a number of cultural, organisational, strategic, human and technical factors have been identified as determinant in the use of ICTs for supporting knowledge management processes. Therefore, ICTs should be considered in conjunction with these elements. Some IS researchers have adopted this approach when studying the effect of information systems in organisational performance

(Powell and Dent-Micallef, 1997; Feeny and Willcocks, 1998; Bharadwaj, 2000; Byrd and Turner, 2000; Van Der Heijden, 2001; Dehning and Stratopoulos, 2003). These studies will be discussed later.

In spite of the different conceptualisations of ICT capabilities, all studies agree in the need for including human-based resources in order to be precise when researching the impact of ICT on the organisation (Melville et al., 2004). While there is abundant empirical evidence that supports the economic value of IT resources (Kohli and Devaraj, 2003), their contribution to provide competitive advantage is less conclusive (Melville et al., 2004). According to Mata and Fuerst (1995), it is increasingly agreed that human IT resources are more likely to confer competitive advantage. However, there are few studies that have examined it and it is still unclear what human skills (technical or managerial) are more strategic.

Therefore, *the present study will investigate the relationship between knowledge management practices and ICT capabilities with the aim of empirically analyse the complementary effect from a holistic view*.

In relation to this point, another debate has arisen regarding the nature of Knowledge Management in comparison with Organisational Learning. Next section will explains the main points in this debate in order to clarify the distinctions and commonalities.

Organisational Learning versus Knowledge Management

As shown in Table 2, the IT and HR communities refer to different discourses, Knowledge Management and Learning Organisation respectively (Scarbrough, 2003). Both discourses have similarities and differences which will be discussed here.

Organisational learning focuses on studying the learning processes, while knowledge management aims to prescribe how to augment organisational knowledge. While the former is mainly theoretical and "people" oriented, the latter is concerned about technical aspects such as the development and implementation of information technologies. Consequently, while organisational learning is descriptive, knowledge management is prescriptive, being learning organisation and organisational knowledge their prescriptive and descriptive related views respectively (see Table 2)

Table 2: Differences between Organisational Learning and Knowledge Management

Criteria	Organisational Learning	Knowledge Management
Approach	Philosophical, academic	Technical
Objective	To understand and criticise the learning processes of and within organisations	To create ways of disseminating and leveraging knowledge effectively
Basic assumptions	Organisations harness the learning capability of the firm and individuals within it through people development, empowerment, leadership and culture change (Scarbrough and Swan, 2003)	The development of better tools and methods will facilitate the capture, codification, use and exploitation of the knowledge and experience of employees
Focus	Learning as a process of change Human resources, social capital, training, education, leadership, change management	Knowledge as a resource that provides competitive advantage and its management is studied. Information technology and systems, intellectual capital
View	Descriptive	Prescriptive
Related view	Learning Organisation (prescriptive)	Organisational Knowledge (descriptive)
Defenders	HR community	IT community

(Source: Author mainly based on Vera and Crossan (2003) and Easterby-Smith and Lyles (2003))

In spite of these differences, both discourses are intimately related. Learning implies the bi-directional flow of knowledge across the different organisational levels. Learning is a process of change which enables the accumulation of organisational knowledge, which differentiates organisations from each other. In fact, this coincides with the idea of knowledge supported in this study, similar to the theory of knowledge creation of Nonaka and Takeuchi (1995) that knowledge is dynamic and created throughout all the organisation. The confusion comes from those who adopt the view of knowledge as object, as something that can be stored like physical objects. Therefore, organisational learning is more similar to the knowledge epistemology of practice and capability to act. The view of knowledge as content corresponds to the knowledge epistemology of possession. However, this research agrees with Cook and Brown (1999) and defends that both epistemologies, of possession and of practice, should be bridged since they are indispensable components of knowledge management. Doing so, although theoretical insights might be the basis, organisations need to understand their implementation and integration in their work processes, thus research need to adopt more prescriptive approaches based on practices. Almost 23% of the literature on knowledge management refers to organisational learning; however, it remains underestimated by practitioners who tend to conceive knowledge as an object, as explicit knowledge (see Figures 14 and 15)

On the other hand, it is undeniable that modern ICTs can support knowledge management and learning processes, but at the same time the wrong assumption that information technologies are the immediate solution for knowledge management should be forgotten, since the development of technologies do not provide advantage on its own due to the decisive role of organisational and human aspects in their success. Thus, the alignment of the different elements of the organisation (strategy, structure, culture, routines, technologies) should be achieved. Finally, it must be pointed out that the theoretical foundations of organisational learning and organisational knowledge cannot be forgotten. For example, the fact that knowledge is socially created at the different levels of the organisation is something that ICTs cannot replace, but, on the contrary, can enhance or complement. For this reason, this study is based on a comprehensive view of what the researcher believes knowledge management should stand for, a balance between human and technical aspects, focusing on organisational practices

(Figure 16). In her opinion, the adoption of an integrated approach based on practices will provide insightful contributions to the existing debates.

Therefore, *this study assumes that organisational knowledge is accumulated through organisation's practices and has an effect on the organisational performance*. This is the basis of the knowledge-based view of the firm, which claims that firms' abilities to manage their knowledge determine performance differences. However, this point is also under debate, so it will be discussed in the next section.

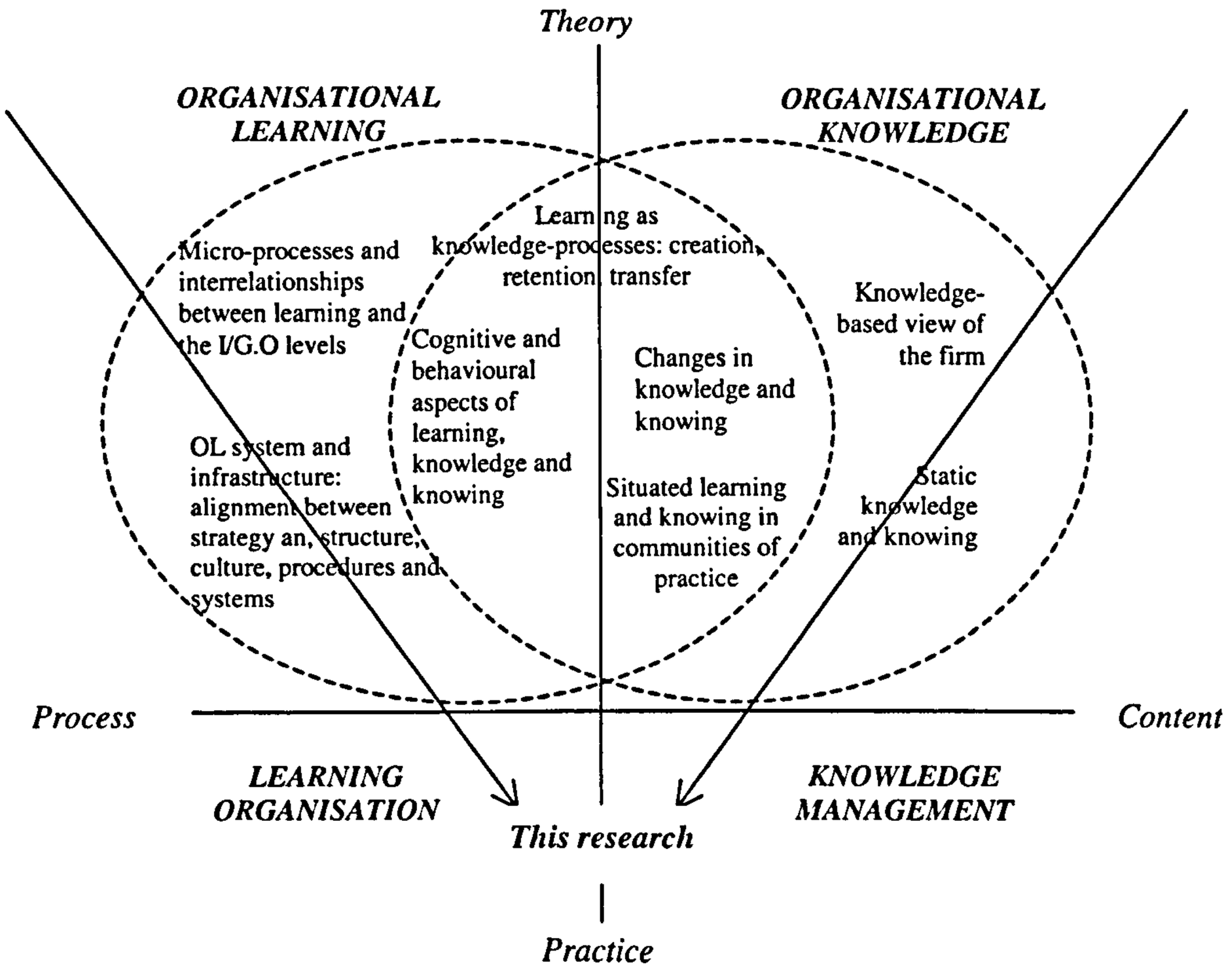


Figure 16: This research: integrative and practice-oriented approach of LO and KM
(Adapted from Vera and Crossan (2003) and Easterby-Smith and Lyles (2003))

Performance

The debate on the impact the impact of learning and knowledge on firms' performance is held between two opposite extremes (Lyles and Easterby-Smith, 2003). On the one side, there are researchers that claim that there is a positive relationship (Cangelosi and Dill, 1965; Fiol and Lyles, 1985; Appleyard, 1996; Bontis et al., 2002; DeCarolis and Deeds, 1999; Hitt et al., 2001; Lee and Choi, 2003). On the other side, there are researchers who oppose this view (Argyris and Schon, 1996; March and Olsen, 1975), arising issues such as core rigidities (Leonard-Barton, 1992).

However, the measurement of organisational performance might be critical in the debate (Droge et al., 2003). Knowledge management might not directly provide financial benefits, but its effect on the organisational capabilities such as innovation, flexibility and adaptability might be the source of competitive advantage in the long term. Having in mind the volatility of the new economy, long-term advantages might be more reliable. Thus, "*knowledge makes performance more reliable*" (March, 1991: 83), although in the short-term learning may negatively impact performance (Crossan et al., 1999).

This study assumes that as a result of the knowledge exploitation or application, organisations should be able to improve the quality of the decision making process, increasing their comprehensiveness, their creativity, the level of consensus achieved and their innovativeness (Soo et al., 2003). Although an increased level of know-how within organisation might not imply better financial results, the specific application of this new knowledge will have an effect on other organisational outcomes such as the development of organisational capabilities (e.g. innovativeness, flexibility and adaptability). In order to clarify this debate, *this research will employ different indicators in order to measure organisational performance and its variability according to knowledge management practices and information and communication technologies capabilities.*

Next section will focus on the review of the existing literature regarding knowledge management and ICT from the RBV. This revision will allow identifying the gaps in the literature and corroborating the important contributions of the present research.

3.7 Literature Review on Empirical Studies

In spite of the explosion of scholar publications regarding knowledge management in the last decade, Staples et al. (2001) claim that more empirical research on KM focused on the knowledge-based capabilities is needed, since this view may help to develop a new and more managerial approach. Existing research has mainly focused on theoretical or conceptual studies and on case studies-based empirical tests (Un and Cuervo-Cazurra, 2004).

Therefore, this section starts with the revision of the existing few empirical studies regarding knowledge management capabilities which use questionnaires or surveys for data gathering. Table 3 summarises the characteristics of such studies and finalises by highlighting the differential contributions of the present research in comparison with the existing ones. There are three main contributions with regard to: (1) the scope of the research, (2) the inclusion of contextual variables, (3) the relationship with organisational performance. In order to examine the relationship between knowledge management and ICT capabilities, first the existing empirical studies on ICT capabilities are summarized in Table 4. As before, the differences among those studies are discussed: first, (a) the scope of research, (b) the inclusion of contextual variables and (c) the relationship with organisational performance. Finally, the relationship between knowledge management and ICT capabilities will be discussed.

Quantitative Studies on Knowledge Management Capabilities

(1) Scope of Research

As said in before in this chapter, *this research will conceive knowledge management capabilities as two components: knowledge management processes and knowledge management system.*

Table 3: Quantitative studies on knowledge management

	Location	Target	Industry / Sector	Focus	Structure	Link to ICT	Contextual Variables	Link to performance	Findings
Nonaka et al (1994)	Tokyo	large (?)	_	SECI process	KW CREATION (SECI) **A.** Socialisation **B.** Externalisation **C.** Combination **D.** Internalisation	Technologies for the Combination mode	NO	NO	The four knowledge creation conversion modes are important. Contemporary org focus mainly on C, but the other three play an important role as they involve tacit knowledge
El Sawy, et al (2001)	Finland	project teams	High technology (knowledge intensive environment)	shared knowledge creation (NPD)	**1.** Organisational factors **2.** NPD process **3.** Role of IT **4.** Interaction => NPD process	Frequency of use, value of the use of IT, evaluation of the technical level of the IT infrastructure	1.NPD cycle time 2.focus 3.phase 4.site	NO	List of findings (17) and implications (7)
Gold et al (2001)	USA	all (mainly large 89%)	All (financial & manufacturing = 58%)	KM - effectiveness	**1.** KW INFRASTRUCTURE (technical, structural, cultural) **2.** PROCESS CAPABILITIES (acquisition, conversion, application, protection processes)	Technological KM infrastructure (use of ICT for...)	As part of Knowledge infrastructure	YES (effectiveness)	Infrastructure and process capabilities are additive phenomena and contribute uniquely to the achievement of organisational effectiveness
Lee and Choi (2003)	Korea	All but mainly major companies	3 sectors (Industrial, Service, Financial)	Relationships between variables	KM ENABLERS (Culture, Structure, People, IT) KM PROCESSES (SECI)	IT support for work activities	As part of KM enablers	YES (creativity, org. performance)	Impact of trust on knowledge creation. IT support has a +impact on knowledge combination only. Org creativity is critical for improving performance. Neglecting ideas can undermine a business
Tippins and Sohi (2003)	USA	large (?)	Manufacturing (SIC codes: 35, 36, 37, 38)	Organisational Learning - IT Focus on Market knowledge	ORGANISATIONAL. LEARNING (info acquisition, info dissemination, shared interpretation, declarative memory)	YES (IT Competency) (IT knowledge, IT operations, IT objects)	Market power measured with (1) Size (2) Market share	YES (org. performance)	OL plays a significant role in mediating the effects of IT competency on firm performance
Droge et al (2003)	USA	all (?) Average: 4573, ranging from 15 to 122.000	Manufacturers (different sectors) - Focus ==> Supply Chain	Mediation of Knowledge on the effect of Context on Performance	KNOWLEDGE: - knowledge creation - knowledge application	NO (only technological turbulence)	(1) Size (2) Production Techno Routineness (3) Tech Turbulence (4) Demand unpredictability	YES (financial performance)	No direct context-performance relationships were found (I.e. all effects were indirect): knowledge, in particular applied knowledge, completely mediated the impact of context on performance

Table 3: Quantitative studies on knowledge management (KM) (continued)

	Location	Target	Industry / Sector	Focus	Structure	Link to ICT	Contextual Variables	Link to performance	Findings
Sabherwal and Becerra-Fernandez (2003)	USA	one large	Space Center	How do KM processes influence perceived KM effectiveness?	KM PROCESSES A. Socialisation (S) B. Externalisation (E) C. Combination (C) D. Internalisation (I)	Mainly technologies for the Combination mode	respondent's (1) experience in the current group (2) experience in other groups (3) seniority level And Dummies for eight groups	NO (but link to KM EFFECTIVENESS at individual-level, group-level and organisational-level)	I & E influence perceived effectiveness of individual-level KM. S & C influence perceived effectiveness of KM at group and organisational levels, respectively. Upward impact in perceived effectiveness of KM is supported
Soo et al (2004)	Australian	Mixed (more than 20 employees)	17 sectors (Industrial & Service)	The role of knowledge quality in firm performance	ACQUISITION OF USEFUL AND INNOVATIVE KNOWLEDGE Influenced by: (1) formal networking (2) informal networking (3) absorptive capacity	NO	(1) Firm size (2) Industry	YES (innovative performance, financial performance)	Both informal NW and absorptive capacity contribute to knowledge quality, but not formal NW. There is a mediating effect of innovation between knowledge and financial performance
Tanrivardi (2005)	USA	Large Multibusiness firms	All	(1) IT relatedness of the firm's business units enhance cross-unit KM capability (2) KM capability, in turn, leads to superior firm performance	KM CAPABILITY Creation, transfer, integration and leverage in (1) Product KM capability (2) Customer KM capability (3) Managerial KM capability	YES (IT relatedness => (1) IT infrastructure (2) IT strategy making process (3) IT HRM process (4) IT Vendor mgt process)	(1) Industry performance (2) Related diversification (3) Size (4) Structure (5) Risk Level	YES (ROA, Tobin's q)	Both hypotheses are supported. Synergies between IT and KM capabilities reflected in increased performance. KM capability also mediates in the effect of IT relatedness on performance
Ruiz-Mercader et al (2006)	Murcia (region in Spain)	Small (less than 10 employees)	IT sector	Relationship between IT and learning in small business, as well as their impact on performance	ORGANISATIONAL LEARNING - Individual - Collective	individual and collaborative IT	(1) Age, (2) Size, (3) subsector	YES (cash flow, market share, quality, introduction of new technology, level of objectives achievement)	(1) Individual learning along with Individual and Collaborative IT have a + impact on performance (2) unlike Individual and Collaborative IT, Individual and Organisational learning have a + impact on performance
Present Research	UK	SMEs	Manufacturers - Mechanical Engineering and Machine	Organisational performance, relationship between KM-ICT, influence of contextual factors	KM CAPABILITIES (1) *KM processes* (knowledge exploration and exploitation) (2) *KM system* (culture for knowledge and strategic alignment)	YES (ICT capabilities (technical and human skills))	(1) Org Structure, (2) Turbulence (3) Control (4) Centralization (5) Product (6) Process (7) Location (8) Age among others	YES (success, market share, profitability, growth, innovativeness, responsiveness, adaptability)	Chapter 9

The scope of the existing researches within the literature on knowledge management varies. Nonaka et al. (1994) focus on the conversion processes between tacit and explicit, and individual and organisational knowledge, based on the knowledge creation theory, while El Sawy et al. (2001) has a more narrowed focus on the knowledge sharing process. Others concentrate on organisational learning processes (Ruiz-Mercader et al., 2006) or knowledge management processes depending on the content of knowledge such as customers (Tanriverdi, 2005). However, this research supports the conceptualisation of knowledge management capabilities adopted by Gold et al. (2001) and Lee and Choi (2003) since, in the researcher's opinion, they capture the philosophy of the KBV more adequately.

(2) Contextual Factors

The present model will contribute to analysing KM and ICT capabilities in the context of SMEs. Similarly, the focus of analysis differs. Most of the studies (Tanriverdi, 2005; Tippins and Sohi, 2003; Gold et al., 2001) take organisations as units of analysis, especially large firms Context is a key issue when dealing with organisational knowledge (Tsoukas and Vladimirou, 2001). Knowledge management activities might vary depending on the stability of the environment, the technological turbulence, etc. For example, Lee and Choi (2003) state that their results are valid for large and profitable firms located in Korea and, therefore, they might differ in other contexts.

Regarding the type of firms targeted, El Sawy et al. (2001) concentrate on the dynamics of project teams. What is striking is that no study till 2006 has focused on small and medium firms (SMEs) and most of the studies have been carried out beyond Europe. Only Ruiz-Mercader et al. (2006) do so by addressing IT small firms located in the Spanish region of Murcia.

The fact that all the firms targeted by this research are SMEs belonging to the same sector, carry out manufacturing activities and are located within the UK gives a certain control of the external environment. In this way, the critique to RBV for overlooking contextual factors such as the market conditions (Priem and Butler, 2001) is addressed. According to Barney (2001), the analysis of the market will determine whether different resources are valuable or

not. Nevertheless, issues such as the technological turbulence are also studied as internal contextual factors.

Thus, drawing upon the contingency theory, *the present research will test whether certain internal contextual variables mediate in the linkages between knowledge management capabilities and ICT capabilities and performance.* The contextual variables included in this study and commented later in the development of the constructs measures include organisational hierarchy, process routineness, product type, control level, etc.

Some studies (Nonaka et al., 1994; Soo et al., 2003) exclude from their analysis any reference to internal organisational characteristics. On the other extreme, some studies (Gold et al., , 2001; Lee and Choi, 2003; Sabherwal and Becerra-Fernandez, 2003) take into account internal contextual factors when operationalising KM. However, they fail to control variables concerning the external environment such the size and sector to which firms belongs.

(3) Knowledge Management - Performance

Thirdly, *this research will analyse the relationship between KM, ICT and performance in order to test their effect on providing competitive advantage. Moreover, the impact of specific practices regarding knowledge management will be assessed in relation to organisational performance, which will provide manager with empirical evidence on how successful knowledge management initiatives take place.*

As seen in Table 3 studies have analysed the relationship between knowledge management capabilities and other constructs (effectiveness (Gold et al., 2001); performance (e.g. Lee and Choi, 2003; Tippins and Sohi, 2003; Tanriverdi, 2005),); knowledge management effectiveness (Sabherwal and Becerra-Fernandez, 2003).The main argument of the KBV is that the ability of firms to manage knowledge leads to differential results compared to their competitors. Thus, it seems reasonable to state that knowledge management will improve the organisational effectiveness over time. However, only in the last years, the relationship between knowledge management and performance is receiving attention (Figure 17).

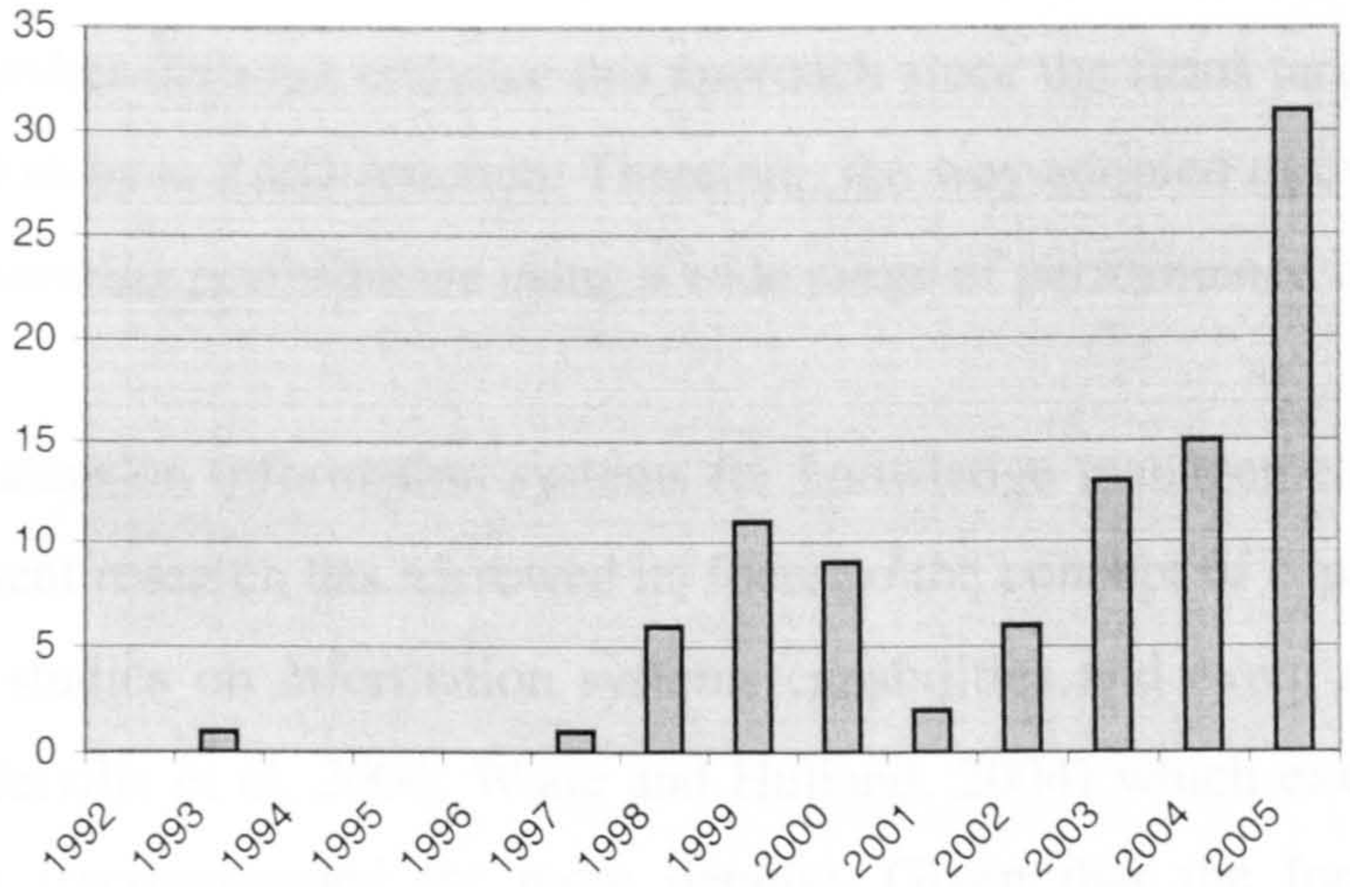


Figure 17: Number of empirical publications dealing with performance (keyword: "knowledge management", subject area: "performance" and "empirical studies") (EBSCO Business Source Premier database)

Although some researches assume a positive relationship between knowledge management and organisational performance (Lee and Choi, 2003; Tanriverdi, 2005), this assumption has not always been supported by empirical research. Droge et al. (2003) argue that the existence of such relationship may depend on what measures of knowledge management and performance are considered. For example, the studies of Tippins and Sohi (2003) and Lee and Choi (2003) capture the contribution of knowledge management in organisational performance. However, the former study measures organisational performance by using four market-oriented indicators (customer retention, sales growth, profitability and return on investment (ROI), while the latter one measures it in a more comprehensive way (the degree of superiority in success, market share, growth, profitability and innovativeness in comparison with the firm's competitors). In the study of Tanriverdi (2005), performance is solely measured with financial indicators such as ROA and Tobin's q.

Thus, *this research will test the impact of knowledge management and ICT capabilities on a comprehensive set of different financial and non-financial indicators over the last three years are included*, since a snapshot might not reflect the real performance results of a firm and given that these capabilities might have an effect on non-immediate and tangible results. Likewise, Ray et al. (2004) claim that using the overall performance of the firm in order to assess the relationship with other resources can lead to equivocal conclusions. Agreeing with

this view, the study of Lee and Choi (2003) include creativity as an intermediate result. Here, however, the researcher does not embrace this approach since the firms targeted include firms which do not need to have R&D function. Therefore, the way adopted to overcome the above weakness is by measuring performance using a wide range of performance indicators.

Although the literature on information systems for knowledge management purposes is very extensive, the present research has narrowed its focus to the concept of capabilities. There are diverse empirical studies on information systems capabilities and even, a couple of strong review articles (Melville et al, 2004; Wade and Hulland, 2004) which examine and criticise the existing work (recommended for more details). Given that the focus of the present research was primarily knowledge management and that there is already a well established range of empirical work dealing with ICT capabilities, the researcher decided to rely on the existing literature on ICT capabilities to inform the construction of my model and constructs.

Therefore, the next section reviews the existing empirical studies regarding the impact of ICT on organisational performance, which appear summarized in Table 4. As in the previous section, the contribution of the present research will be justified in relation to the scope of research, the relationship with performance and the inclusion of contextual factors. Finally, a discussion on how ICT have been addressed within the literature on knowledge management will lead to the conceptual framework of the present research.

(1) Scope of Research

This research aims to empirically investigate the relationship between ICT capabilities and organisational performance. The scope of the existing researches within the literature on ICT capabilities is twofold: on the one hand, some studies (Byrd and Turner, 2000; Van Der Heijden, 2001) concentrate on the development of appropriate construct; on the other hand, some (Powell and Dent-Micallef, 1997; Bharadwaj, 2000; Dehning and Stratopoulos, 2003; Ravichandran and Lertwongsatien, 2005) examine their impact on performance. This study is in line with the latter, since the real value of ICT for businesses is still an unsolved question (Tanriverdi, 2005).

(2) Information and Communication Technologies - Performance

In doing so, the *relationship between ICT and performance will be analysed adopting a broader concept of organisational performance*, such as the one proposed above for knowledge management capabilities.

Indeed, when reviewing extensive literature on ICT from the RBV, Melville et al. (2004) conclude that most empirical studies support a positive association between ICT and organisational performance (Bharadwaj, 2000; Lehr and Lichtenberg, 1999; Lichtenberg, 1995; Siegel, 1997), although fewer studies find this association inconclusive (Cron and Sobol, 1983; Stiroh, 2001). Also, they detect that most of the studies analyse the effect on organisational performance by using financial metrics. Only Powell and Dent-Micallef (1997) use qualitative indicators to capture the firm's self-assessment. However, information and communication technologies might have an indirect effect on organisational effectiveness, which might not be translated into financial improvements. Thus, previous researches do not adequately address the real impact of ICT on organisational performance.

Table 4 : Quantitative studies on ICT capabilities

Author & Year	*Purpose / Research Question*	*Operationalisation of ICT/IT*	*Setting*	*Link to Performance*	*Conclusions*
Powell and Dent-Michallef (1997)	To study the linkages between IT and firm performance	1. HUMAN RESOURCES 2. BUSINESS RESOURCES 3. TECHNOLOGY RESOURCES	Retail Industry, USA, large	YES (IT performance, overall performance)	IT alone does not produce sustainable performance advantages but advantages can be gained by using IT to leverage intangible, complementary human and business resources.
Byrd and Turner (2000)	To better define the IT infrastructure flexibility	1. TECHNICAL IT INFRASTRUCT. 2. HUMAN IT INFRASTRUCTURE	USA, one large	NO	3 out of 8 factors influence IT infrastructure flexibility (Integration, Modularity, IT personnel flexibility)
Bharadwaj (2000)	To empirically examine the association between IT capability and firm performance	1. IT INFRASTRUCTURE 2. HUMAN IT RESOURCES ▪ technical IT skills, ▪ managerial IT skills 3. IT-ENABLED INTANGIBLES	USA, longitudinal, large? (DB)	YES (financial ratios)	Firms with high IT capability tend to outperform a control sample of firms on a variety of profit and cost-based performance measures
Van Der Heijden (2001)	Theoretical development and empirical validation of a measurement instrument for three IT core competence	1. IS/IT GOVERNANCE 2. BUSINESS SYSTEMS THINKING 3. RELATIONSHIP BUILDING	The Netherlands, online communities	NO	Two capabilities (BS thinking and Relationship building) are reliable and valid measures IS/IT governance is the aggregation of two other capabilities (B IT Strategic thinking and IT mgt)
Denhing and Stratopoulos (2003)	To examine and empirically test the factors that are believed to lead to a sustainable competitive advantage (CA) due to an IT-enabled strategy	1. MANAGERIAL IT SKILLS 2. TECHNICAL IT SKILLS 3. IT INFRASTRUCTURE	USA, longitudinal, large? (DB)	NO? (CA = peer rating)	Managerial IT skills are positively related to sustainability. Competitor's knowledge of CA is negatively related to sustainability. There is no support for technical IT skills or IT infrastructure as source of sustainable CA
Ravichandran and Lertwongsatien (2005)	IS capability ==> IT Support for Core Competence ==> Firm Performance	1. IS HUMAN CAPITAL 2. IS PARTNERSHIP QUALITY 3. IT INFRASTRUCTURE FLEXIBILITY	USA, large?	YES (financial ratios)	General support to the resource complementarity arguments put forth in the IS literature Requirements ==> more than investing, more cooperating with business leaders to play an active role in IT deployment decisions Strong IS functional capabilities enable organisations to effectively leverage IT in pursuit of firm strategies Resource endowments affect capability development
The present research	ICT capability ==> (KM capabilities) ==> Firm Performance	*1. IT INFRASTRUCTURE* *2. TECHNICAL IT SKILLS* ***3.** MANAGERIAL IT SKILLS*	UK, SMEs, manufacturers, mechanical engineering sector	YES (various)	Chapter 10

(3) Contextual factors

As all previous studies, this study takes organisations as a unit of research. Concretely, this research will undertake the research of ICT capabilities on SMEs located in the UK, as it is significant that all except of one, which researches Dutch online communities, focus on large firms located in the USA. No study has studied before the role of ICT capabilities in SMEs.

Furthermore, *this study will include several contextual factors and investigate their influence on ICT capabilities.* The firm's characteristics might determine the use of information and communication technologies. For example, a company of 15 employees located in a unique site might not need an information system to support its internal communication. Also, according to Melville et al. (2004), the competitive environment and the macro environment of the firm might influence on information and communication technologies strategies. Only Ravichandran and Lertwongsatien (2005) include some control variables such as size, age and information intensity. As Droge et al. (2003) claim, the key issue is to identify which of the many elements of context are significant.

Knowledge Management - Information and Communication Technologies

This study will simultaneous analyse the three constructs (KM, ICT and performance) which will allow to test whether ICT have an indirect effect by leveraging knowledge management capabilities and/or a direct effect on performance. Consequently, this analysis will contribute to the empirical research of the dynamic capabilities theory.

Supporting the idea of indirect effects of ICT on organisations, Powell and Dent-Micallef (1997) find that "*ITs alone have not produced sustainable performance advantages in the retail industry, but that some firms have gained advantages by using ITs to leverage intangible, complementary human and business resources*" (p.375). Therefore, information and communication technologies capabilities might mediate on the effect of the knowledge management capabilities.

So far, those few studies which analyse the relationship between knowledge management and organisational performance (see Table 3) fail to study ICT comprehensively, simply considering technology as part of the organisational infrastructure (see Figure 18 as an example).

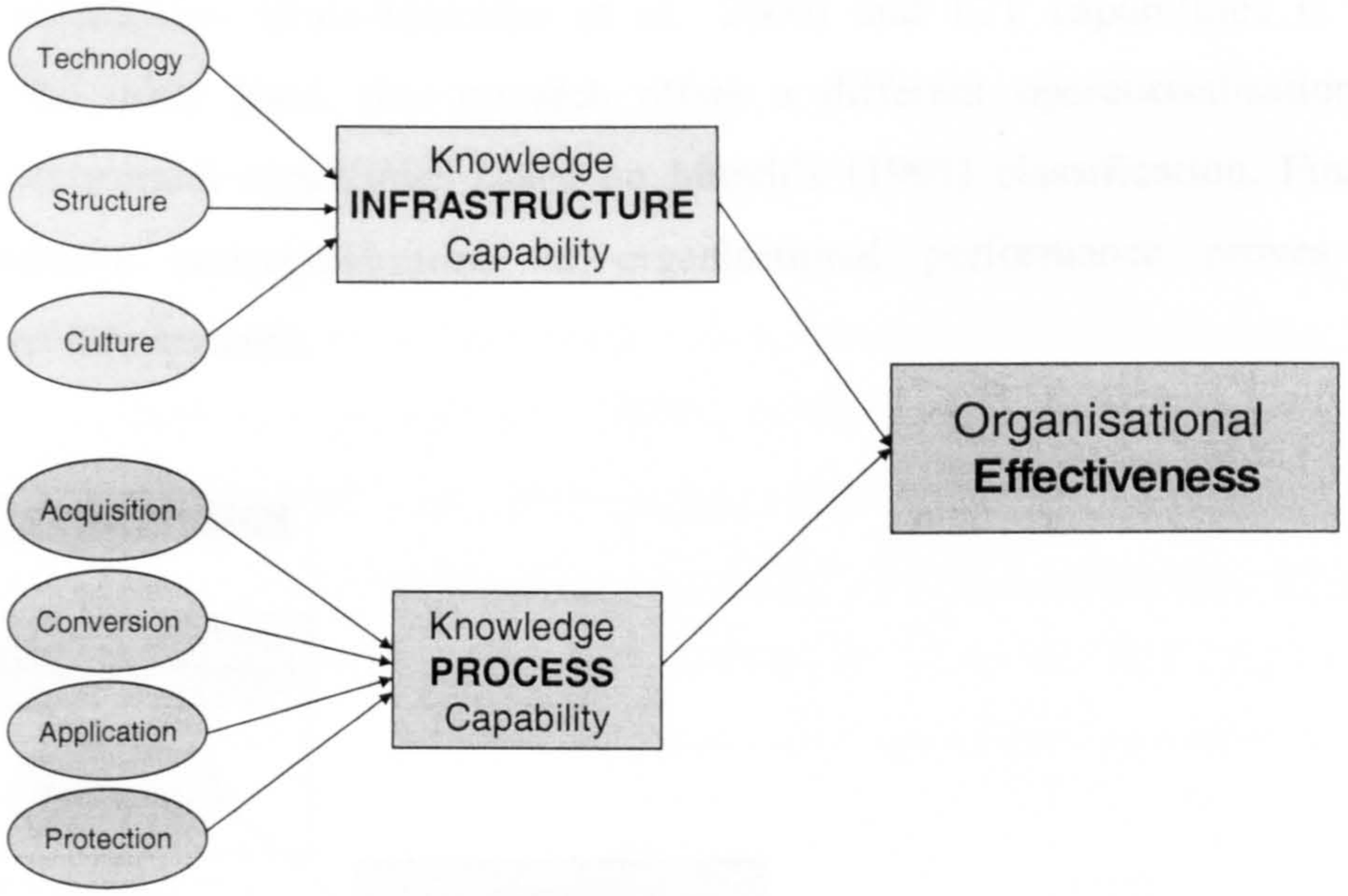


Figure 18: Conceptual model of Gold et al. (2001)

In such studies, technology is included as a resource, from the technological point of view. However, the simple acquisition of technology does not guarantee the expected outcomes. In fact, there are plenty of failed applications of technologies for knowledge management purposes (Tsoukas and Mylonopoulos, 2004), since, as seen in Chapter 4, the impact of ICT on the firms' results depends on the ability of the organisation to implement them and adjust their processes to it. Therefore, technology should be considered as a capability involving human and organisational skills to use it, that is, as an organisational capability. Thus, *the present research aims to integrate the view of ICT capabilities in the study of knowledge management effect on organisations*. The conceptual model hence derives into the one shown in Figure 19. To the best of the researcher's knowledge, only two studies (Tippins and Sohi, 2003; Tanriverdi, 2005) have envisaged ICT from a holistic perspective when analysing whether organisational learning plays a significant role in determining the outcomes of IT. The recent publication of these studies show the interest and lack of research on the gap this research spotted in the literature. However, the study of Tippins and Sohi (2003) is narrowed to only market knowledge, while Tanriverdi (2005) focuses on multibusiness large companies assessed according to financial indicators. This study will concentrate on SMEs, where either separately or from a holistic approach, research on knowledge

management capabilities (Ruiz-Mercader et al., 2006) and ICT capabilities is still missing. On the other hand, this research offers a different operationalisation of knowledge management capabilities based on March's (1991) classification. Finally, the comprehensive conceptualisation of organisational performance proves the contributions of this research.

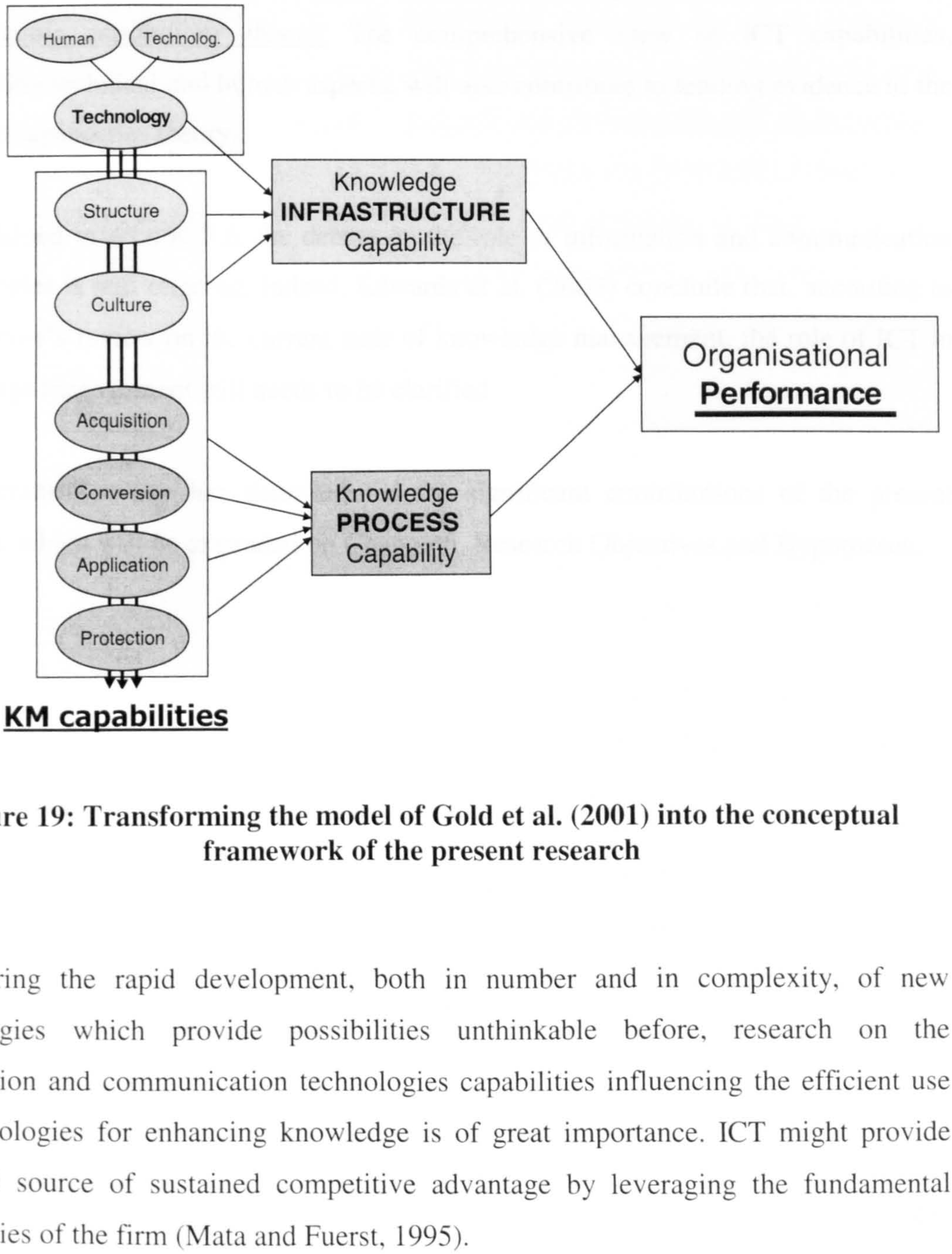


Figure 19: Transforming the model of Gold et al. (2001) into the conceptual framework of the present research

Considering the rapid development, both in number and in complexity, of new technologies which provide possibilities unthinkable before, research on the information and communication technologies capabilities influencing the efficient use of technologies for enhancing knowledge is of great importance. ICT might provide potential source of sustained competitive advantage by leveraging the fundamental capabilities of the firm (Mata and Fuerst, 1995).

Thus, *the present research aims to develop a new integrative focus drawing on the resource-based perspective, including KM and ICT capabilities along with contextual variables, with the aim of explaining differences in organisational performance*. Different fields such as strategy and information systems might provide important insights into specific aspects of knowledge management but standing alone, none provides an integrating framework (Teece, 1998b). At the same time, *this research aims to undertake the challenge of empirically examining the interaction and complementarity of knowledge management capabilities and ICT capabilities based on the dynamic capabilities theory.* The comprehensive view of ICT capabilities, considering technical and human aspects, will also contribute to lending evidence to the dynamic capabilities theory.

As explained in section 3.6, the debate on the role of information and communication technologies is still ongoing. Indeed, Edwards et al. (2003) conclude that, according to their survey's review on the current state of knowledge management, the role of ICT in knowledge management still needs to be clarified.

This literature review has demonstrated the significant contributions of the present research, which will be expanded on Chapter 5. Research Objectives and Hypotheses.

3.8 Summary

Along this chapter the researcher has defined and justified the approach to knowledge management adopted in the present study and its contributions in comparison with the existing literature. The main issues identified in the discussion can be summarized as follows:

1. *The present study will analyse the practices within knowledge management quantitatively in order to provide generalised guidelines based on empirical results. In this way, organisations will find it easy to implement knowledge management within their activities and will see the contribution of knowledge management.* The reason to do so is that most studies on knowledge management have concentrated on conceptual issues and empirical studies in the form of case studies. In spite of their useful insights, organisations have become sceptical since they have not experienced the expected results. The main reason for this disillusionment is the lack of integration of knowledge management into the work practices, which results in confusion when implementing knowledge management initiatives.

2. *In this study knowledge is considered something dynamic*, which takes place in the course of action. Therefore, the *practice-based approach seems appropriate*.

3. Multiple and different *knowledge practices will be grouped according to knowledge exploration and knowledge exploitation*, being these processes intrinsically linked and essential in knowledge management.

4. Embracing principles of the Activity Systems Theory, *this research assumes that practices on knowledge management interact with organisational elements such as organisational alignment, culture, structure and information and communication technologies*. Thus, diverse contextual factors are taken into consideration in the present study.

5. Moreover, *a comprehensive range of indicators will be included in the organisational performance construct*. Knowledge management and ICT might not have direct or immediate effects on the organisational results, so other indicators such as flexibility, innovativeness and adaptability will be considered.

In the long term, knowledge management and ICT can constitute organisational capabilities which will enable knowledge and organisational renewal.

6. *This research aims to adopt a comprehensive view of ICT* since research on the relationship between knowledge management and ICT has usually considered ICT as simple objects, while they involve human and organisational aspects which will determine their effectiveness in organisations. Therefore, information and communication technologies constitute an organisational capability by themselves and should be considered in a comprehensive way.

7. *In this way, the present research will contribute to clarifying the role of ICT in knowledge management from a holistic perspective*. Edwards et al. (2003) detect this need in their survey-review among practitioners. In order to investigate this relationship, sound theory on knowledge management and learning is needed, since ICT can be supportive but not central. As a result, the debate between knowledge management and organisational learning will be balanced.

8. Simultaneously, *it will examine whether KM capabilities can intercede in ICT capabilities*, which will test the complementarity between KM and ICT capabilities. Learning processes can shape other capabilities (Eisenhardt and Martin, 2000)

9. The literature review on existing empirical studies has demonstrated the valuable contributions of the present research to the field.

In conclusion, *this study will research knowledge management and its impact on the organisational performance from a practice-based approach which will provide practitioner with evidence on a best-practice basis. A holistic view of the activity system will be adopted, with special focus on the relationship between knowledge management and ICT, being the latter considered as a capability in itself.*

The next chapter will introduce the setting in which this research will focus on, that is, small and medium firms.

Chapter 4: Setting

The purpose of this chapter is to:

(1) Explain the definition of SMEs and comment their important role in the European economy

(2) Describe the specific characteristics of SMEs, in contrast to larger firms

(3) Discuss the characteristics and nature of knowledge management and ICT in SMEs

(4) Introduce the Mechanical Engineering sector and comment their importance in the European economy and the challenge it faces

4.1 Introduction

The present study will research the UK firms' behaviour regarding knowledge management and information and communication technologies of firms in a particular context: small and medium enterprises (SMEs), within the mechanical engineering sector with manufacturing facilities.

Research on SMEs has been underdeveloped in spite of their importance in amount and in employment generation. The purpose of the present study is to contribute to filling up the lack of research on SMEs. However, the specific circumstances of such firms should be understood first.

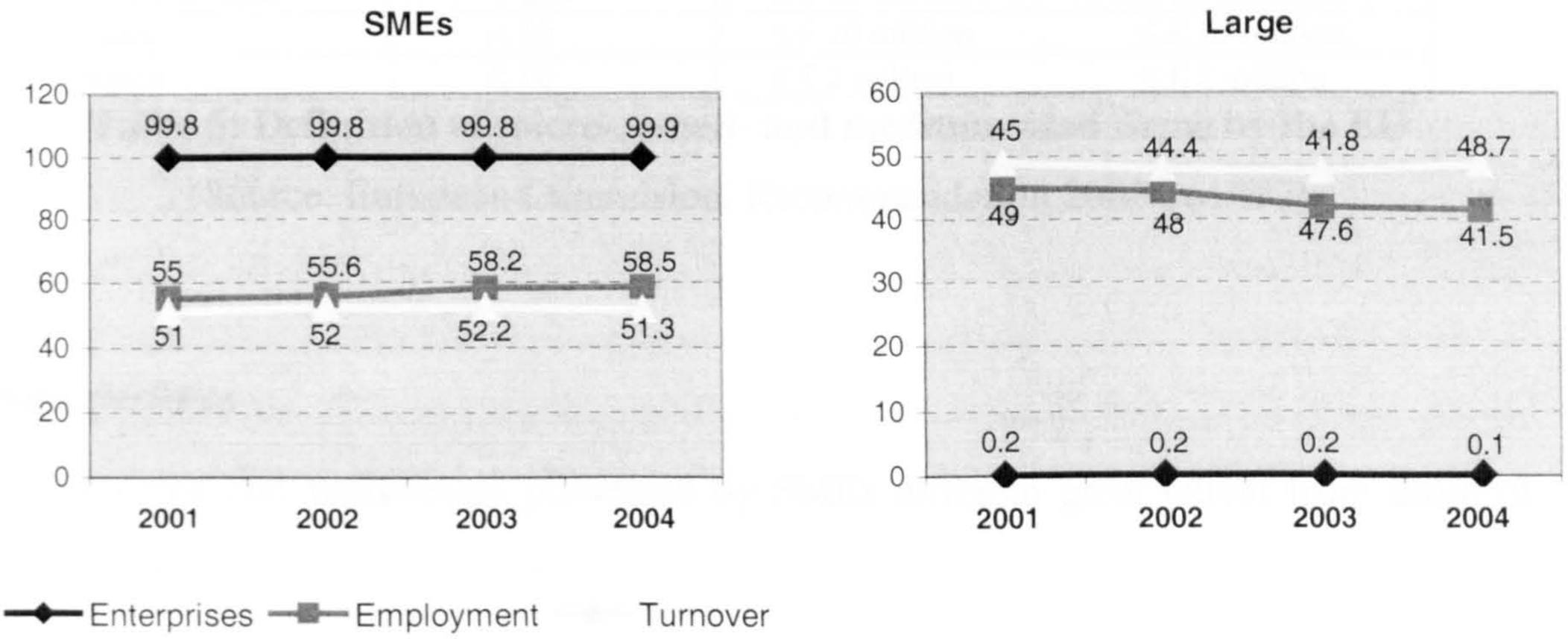
Thus, the purpose of this chapter is to give an overview of the main characteristics of SMEs. First, general characteristics of SMEs will be described, passing to specify the main issues of this type of firms in relation to knowledge management and information systems. Second, a short description of the mechanical engineering sector will be shown, emphasising its importance in the European economy and the specific challenges firms in this sector face.

4.2 Small and Medium Firms

Importance

SMEs account for 95% of the European businesses (OECD, 2005). Furthermore, they provide around 65 million jobs, what represents 66% of the total employment, and produce 65% of the business turnover (OECD, 2005). Furthermore, they are also widely recognized as key contributors in entrepreneurship. Indeed, all SMEs have the potential of growing and becoming a large firm.

In 2004 in the UK alone there were 3.75 million SMEs distributed by size as seen in Figure 20. They were responsible for two thirds of total employment (74.5 million people) and produce 40% of the GDP. Even more, studies have forecasted that the number of SMEs is predicted to increase by another million in this decade. Indeed, Figure 20 shows a slight increase in the number of SMEs and in the amount of employment they generate. However, their turnover tends to decrease in comparison to larger firms. Hence, given their vital role in the UK economy, research aiming at improving their competitive advantage is required.



Figures 20: Evolution of % firms, employment and turnover according to firm size
(Source: DTI National Statistics)

Despite recognizing the need to investigate in detail the specific behaviour of SMEs due to their social and economic importance, they still remain under-researched.

The next sections will define what is a SME and will describe the definition of SMEs and their main characteristics.

Definitions

There are several definitions of small and medium companies (SMEs). According to (Bolton_Committee, 1971), the definition depends on the sector studied and it can make reference to the turnover or the number of employees, depending on the type of sector. Regarding the manufacturing sector, firms are considered SMEs when they have more than 200 employees.

Nevertheless, the present study adopts the definition developed by the European Union. Firms must have less than 250 employees and an annual turnover of more than €40 million or a total balance of €27 million (European_Commission, 1995). Table 5 gives a more disaggregated definition of the definition of medium-, small- and micro-sized companies, according to the European Union.

ENTERPRISE CATEGORY	HEADCOUNT	TURNOVER	OR	BALANCE SHEET TOTAL
medium-sized	< 250	≤ € 50 million		≤ € 43 million
small	< 50	≤ € 10 million		≤ € 10 million
micro	< 10	≤ € 2 million		≤ € 2 million

Table 5: Definition of micro-, small- and medium-sized firms by the EU

(Source: European Commision, Recommendation 2003/361/EC)

Characteristics

The strengths and weaknesses possessed by SMEs differ to great extent from those of larger firms.

SMEs have been widely recognised for their resource limitation. The lack of finance is frequently pointed as a main constraint for SMEs growth and performance. Because of such a constraint, SMEs are focused on dealing with daily activities which can prove their value immediately. This also explains the fact that SMEs do not carry out much long-term planning, which usually remains implicit to the managers. However, the narrow attention to operational issues might ironically cause underperformance.

According to the report of the (European_Commission, 1995), SMEs constantly underperform (Nelder and Skandalakis, 1999)

The lack of resources and the inability to face highly risky initiatives make SMEs more likely to fall in capabilities traps related to their familiarity, their maturity and their proximity (Liao et al., 2003). These traps hinder their responsiveness to the environment. Thus, the tight financial situation makes SMEs very vulnerable, so they find it difficult to make an impact on their environment (DuPont, 1986). Research indicates that not all SMEs have growth potential. In fact, 70% SMEs close down within the first three years of activity. Nevertheless, SMEs are very diverse and the differences in performance between leaders and losers are huge. This difference might corroborate the idea of heterogeneity among SMEs that some authors (Lelic, 2002; Sparrow, 2005) have described.

The present study might provide governments insightful evidence for developing their policies aiming at enhancing knowledge management within SMEs, based on the empirical data gathered from existing businesses. Given their importance for the economy, governments understand their role in backing SMEs competitiveness by developing policies which grant benefits and support for their activities. However, governments should carefully develop effective policies, since the impact of governmental policies has been criticised. Thus, policies should be based on empirical evidence of the key issues involved in the phenomena.

On the other hand, a widely recognised and essential strength of SMEs over larger companies is their flexibility to react to the environment given the nature of the current economy. They are able to adapt and respond quickly to the changes in the environment. An important factor which enables SMEs' flexibility is their organisational structures. Generally, they are flatter, more organic-like and less bureaucratic and hierarchical compared to larger firms. Similarly, internal communications are more fluent and working life is controlled in easier ways, which allows quicker decision-making and response. Due to their need for survival, their entrepreneurial orientation and their agile response, SMEs are thought to be more innovative than larger firms. SMEs' flexibility and quick response allows them to work on their main concern, customer service.

Reciprocally, SMEs usually have a base of very loyal customers (Julien et al., 1988), also maybe due to the proximity of SMEs to their markets.

However, this flexibility might be limited by their lack of information on market opportunities and, in general, of scanning capabilities (Hartley and Hutton, 1998). Their resource constraint make SMEs prioritise immediate production problems rather than focusing on strategic activities (Hagmann and McCahon, 1993). Vos et al. (1998) warn that SMEs tend to fall in a vicious circle: being too busy solving daily problems, they cannot pay attention to strategic issues, hence they remained stuck "fire-fighting" their operational problems.

Another difference in comparison with larger companies is the lack of in-house specialists (Duhan et al., 2001). SMEs have lower technical expertise, together with poor managerial skills (Caldeira and Ward, 2002). Often a single individual such as the owner or a small team are the responsible for the management of the whole SME, being in charge of all kind of activities, from solving operational problems to recruiting new staff. However, given the turbulent conditions of the current environment, nowadays SMEs need greater managerial skills (Duhan et al., 2001). For example, such managerial expertise might be key in developing strategic alliances with other firms or in expanding their market share.

Thus, *the present study aims to contribute to filling a gap in knowledge management and ICT research focused on SMEs that has been detected in the literature review (see Tables 3 and 4)*. To analyse this particular group of firms is of great importance, since, as said before, they constitute the majority of all the EU firms. The challenges and strengths of SMEs differentiate them to a great extent from large companies. Hence research focusing on this specific set of companies is needed. This line of thinking can also be applied to knowledge management and the information systems. Due to the specific characteristics of SMEs, the benefits from knowledge management and information technologies might not be the same as for larger companies. Moreover, the key success factors or issues resulting from previous studies might not be applicable to SMEs.

The following sections will be discussed the main issues in such areas in the context of SMEs.

4.3 Knowledge Management in SMEs

The present research will empirically study knowledge management on SMEs within a single sector, mechanical engineering. The lack of research of SMEs is also noticed within the literature on knowledge management, since, although few exemptions, the empirical literature on knowledge management has mainly focused on large enterprises (Armbrecht et al., 2001; Levy et al., 2001; Liao et al., 2003). The conclusions derived from the studies on knowledge management concerning larger firms have been argued not to differ from smaller firms (Beijerse, 2000; Lelic, 2002; Sparrow, 2005). However, its barriers and development seems to operate differently in the context of SMEs (Sparrow, 2005). Indeed, knowledge cannot be managed in the same ways across sectors and company sizes (Sørensen and Kakihara, 2002; Tsoukas and Vladimorou).

Lelic (2002) argues that the unique barriers in SMEs for knowledge management include the lack of knowledge management vision due to their over-emphasis for tangible results. Thus, they are usually not engaged in the processes of knowledge acquisition, sharing and integration, although they have greater potential to diffuse and internalise information throughout the firm (Pelham, 2000). In general, SMEs are poor at knowledge management (Duhan et al., 2001; Loebbecke et al., 1999)

The present study will analyse the influence of regional institutions by studying the differences among the diverse areas within the UK. The reason to do so is that, as commented before, the over-emphasis on operational activities deviates the attention of SMEs from strategic knowledge management activities such as benchmarking (Nelder and Skandalakis, 1999), which opens access to broad range of knowledge bases. In consequence, they might lose the opportunities such as establishing linkages with other firms, which can help them to lower costs or enable strategic collaborations. In general, SMEs find it difficult to formulate and acquire new knowledge and skills (Vos et al., 1998). Martin et al. (2002) claim that SMEs should feel urged to renew their knowledge bases. The development of regional cluster might be crucial in supporting SMEs in this kind of activities through institutionalised resources. Their participation in clusters is a potential and powerful way of accessing knowledge and collaborating, although they should not fall in proximity trap.

On the other hand, *the present research aims to analyse the correlation between the different practices between knowledge management and organisational outcomes, in order to discover patterns and assess the practices' impact and, as a result, to get a better understanding. Furthermore, the inclusion of contextual factors will allow detecting differences across firms depending on such characteristics.* The lack of internal expertise might be overcome by finding right external knowledge sources, by collaborating with other firms or simply by providing training activities. The report from CBI (2001) reminds firms that in their interaction with the external environment they might come across with "*venture capitalists and business angels are actively seeking companies that are 'investment ready'*" (p.13), which could alleviate the financial difficulties faced by SMEs. On the other hand, the study of Oyeleran-Oyeyinka (2004) on learning through training in SMEs show that they usually opt for in-house training, contrary to larger firms which tend to acquire knowledge externally. Furthermore, they found correlation between the amount of resources invested in training and organisational performance. This research will follow the same line. As Clarke and Turner (2004) state, the focus on SMEs will contribute to developing the current KBV of the firm. But, in order to do so, a holistic approach of the firm should be adopted when researching SMEs (Sparrow, 2005). Thus, the present study includes the analysis of organisational variables such as size, age, turnover, customers' dispersion, etc. with the aim of identifying key differences. These variables will help to analyse heterogeneities among SMEs regarding knowledge management.

As a result of the analysis of knowledge management in SMEs, *similarities and differences between SMEs and large enterprises studied by previous studies will be discussed*.

The understanding of these issues is of critical importance, since SMEs should be aware of the need for competing, not only on a low-cost basis, but on a knowledge and innovation basis due to the fact that the globalisation of the markets have made industrialized countries such the UK high-cost environment (Vos et al., 1998).

As seen in the literature review, one of the key factors might be the use of ICT. This point within the context of SMEs will be extended in the next section.

4.4 Information and Communication Technologies in SMEs

A detailed examination of the ICT used by SMEs together with the analysis of their ICT capabilities will be carried out in the present study. In this way, it will contribute to understanding what makes SMEs use ICT more effectively or with a greater impact on organisational performance. Also, the comparison of results with those studies focused on large firms will give useful insights on the idiosyncratic characteristics of SMEs and their use of ICT.

According to several researchers (Kautz and Thaysen, 2001; McAdam and Reid, 2001), the lack of investments in information systems is one of the major constraints in knowledge management within SMEs. However, it must be noticed that the format of practices within firms seems to be in accordance to the size; as the size increases, procedures tend to be more formalized. SMEs find it easy to have face-to-face interaction throughout their organisations (Lee and Bennett, 2000). Therefore, the need of information systems within SMEs might not be as important as in larger firms.

However, on the other hand, the lack of use and investment in information systems might not be a matter of their little impact, but of the particular conditions of SMEs (e.g.. limitation of human, material and financial resources, operation focus, nature of their planning and decision processes, rapid development (Raymond et al., 1998; Blili and Raymond, 1993; Levy and Powell, 2000). In fact, the drivers for adopting information technology are usually SMEs' clients, especially large ones (Sparrow, 2005). Once the firms have experienced the value of information systems, they are more likely to adopt further technology. Thus, due to their specific conditions, SMEs often lack of an overall information system strategy (Duhan et al, 2001). They usually acquire technology as they need it, since the high cost of customized information systems impedes their justification (Hashmi and Cuddy, 1990; Levy and Powell, 2000; Sparrow, 2005). They do not perceive ICT as a strategic opportunity but as waste of money (Levy et al., 2001). However, Blili and Raymond (1993) identify the usefulness and need for strategic planning, and claims that it should be integral to the business

strategy in order to improve the firm competitiveness, not just its effectiveness and effectiveness.

All in all, the use of information and communication technology by SMEs is relatively recent (Caldeira and Ward, 2002), which justifies the limited research in this area. However, ICT might be the key to survive in the current environment. Thus, SMEs should not overlook the new opportunities offered by the advancement in telecommunications. New technologies might enable SMEs to operate at reduced costs or, what is more, to grow without any sacrifice of effectiveness or innovativeness (Dewett and Jones, 2001). For example, ICT might enhance the customer-oriented approach of SMEs, by enabling collaboration with customers and suppliers.

Agarwal (1998) finds that investments in information systems contribute in the SMEs survival, which support the argument that ICT are vital to SMEs. According to Blili and Raymond (1993), the importance of information systems depends on the centrality of technology in the products and processes of SMEs. Nevertheless, when studying the impact of information and communication technologies a holistic view of the elements involved must be taken. For example, Walsham (1993) claims that the organisational culture might mediate on the strategic use of ICT. Also, Levy and Powell (2000) state that usually the reason for ICT adoption failure is the lack of reorganisation of the organisation structures. Corroborating this line of thinking, one of the few empirical studies on information systems with the context of SMEs carried out by Caldeira and Ward (2002) conclude that management attitudes and perspectives and attitudes towards ICT and the internal competences in ICT are the most significant factors affecting the implementation of ICT within SMEs. Indeed, this view supports the idea of considering ICT from a holistic perspective, including human and organisational aspects, apart from technical characteristics.

4.5 Mechanical Engineering Sector in the United Kingdom

"We are quite clear that UK prosperity now depends on a successful and dynamic manufacturing sector. We are committed to making sure that it continues to be at the heart of the British economy in the future" (Nigel Griffiths MP, 2002) (presentation of the Institution of Mechanical Engineers Manufacturing Excellence Awards 2002)

The above statement reflects the significance of studying firms within this sector should be highlighted. According to the DTI, the manufacturing sector is key for British economy:

As already commented, *this study will focus on SMEs located in the UK, specifically within the mechanical manufacturing sector.* According to the EU, mechanical engineering refers to the economic activities classified under Division 29, groups 1-5 of the NACE Revision nomenclature and it comprises the manufacture of all kind of machinery and mechanical equipment.

The focus on particular sectors and activities is proved to be appropriate by several researchers. In their literature review of the existing studies on innovation and SMEs, Hoffman et al. (1998) posit interesting conclusions which could be applied to the present research. They argue that among most of the empirical studies include service and industrial SMEs together, in spite of their different characteristics. The present research however, concentrates on industrial SMEs, with manufacturing activities in their premises. Furthermore, previous researches usually focus on specific geographical locations, which reduces the generalisability of the results. This study includes firms from all over the UK, so a more comprehensive view of the current state of SMEs in the UK will be achieved. Also, past studies tend to over-concentrate on high-technology sectors, including large proportion of non-manufacturing firms. But this study will only focus on manufacturing firms.

A EU report (European_Commission, 1995) states that UK constitutes the fourth most important country within the mechanical manufacturing sector within the EU, accounting for 9% of the European production. Moreover, it must be noticed that the mechanical engineering sector within the EU is strategic. The EU is the largest producer and exporter of mechanical equipment in the world (see Figure 21). The sector plays a key role in the European economy, as supplier of capital goods to other strategic sectors such as agriculture, fisheries, etc. Their products are usually highly specialized and provided on a just-in-time basis, which requires flexibility and good relationships with customers and suppliers. On the other hand, the European mechanical engineering sector excels in its export performance. This indicates that even SMEs should become global players to compete effectively.

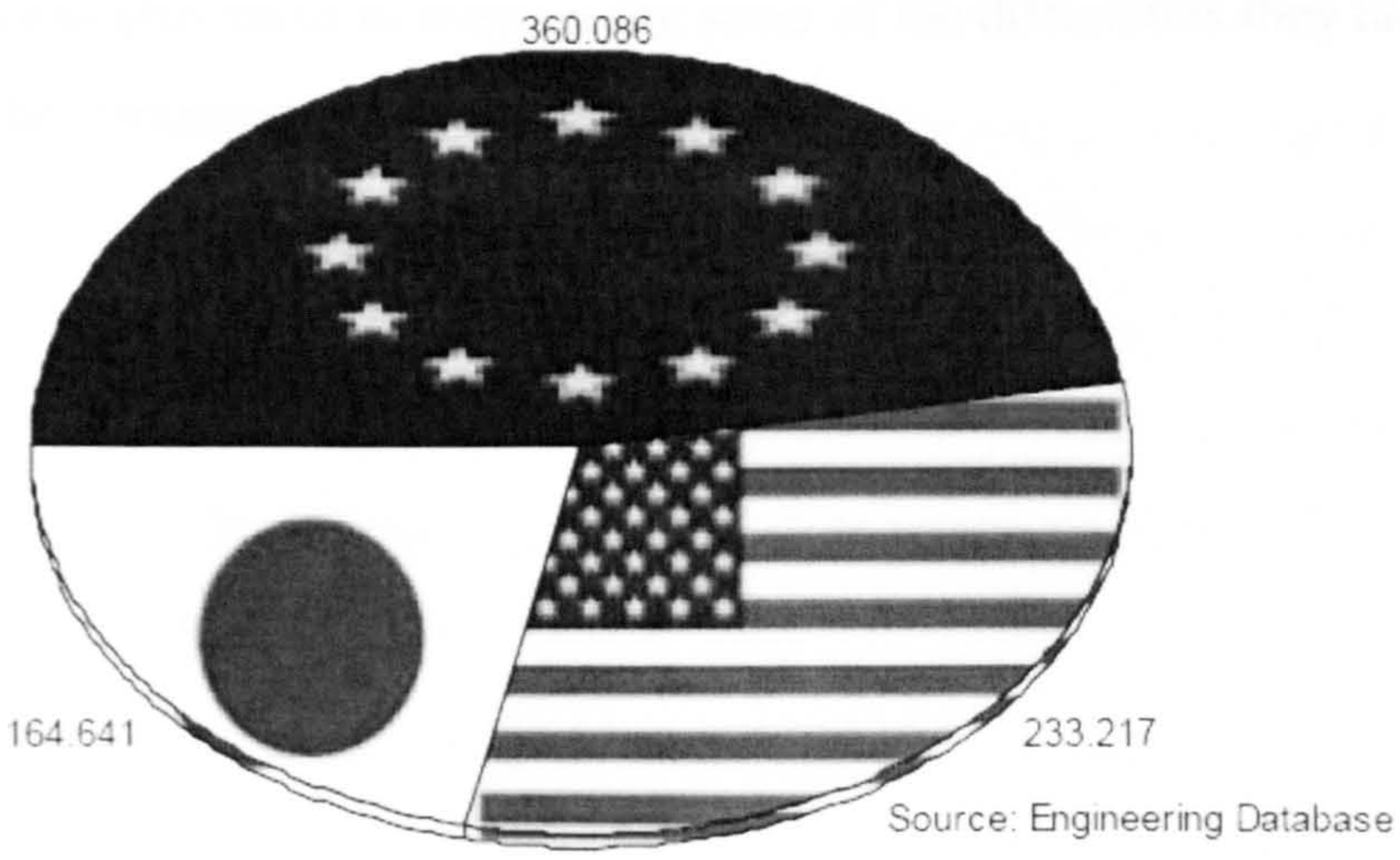


Figure 21: Distribution of mechanical engineering output 2003 (in current million €)

However, the sector is facing difficulties due to the fierce competition. According to the report commissioned by the EU (European_Commission, 1995), the current difficulties are caused by several factors: the decreasing investment in the essential capital goods for business, the financing difficulties, the high labour costs in Europe, the labour productivity gap with its main competitor (USA), the lack of engineers and technicians and the increasing importance of service aspects.

As seen earlier, manufacturing SMEs can benefit from effective knowledge management in different ways. The development of constant surveillance of the market dynamics and opportunities might enhance this export-oriented industry or diminish their financing problems. Moreover, the scarce availability of expertise might require the development of internal skills based on external sources of knowledge. Given the global market in which they play, SMEs should take advantage of the wide range of possibilities offered by modern information and communication technologies, which overcome any time and space constraint essential in the global economy. Also, effective knowledge management practices have proved to accelerate innovation (McAdam, 2000).

So, it seems that SMEs within the mechanical engineering sector can benefit from knowledge management by enhancing their strengths such as flexibility and renewal capabilities and can also assist in overcoming some of the difficulties they face. These facts reinforce the importance of the present study.

4.6 Summary of the Chapter

The main conclusions of this chapter can be summarized as follows:

1. SMEs are strategically important for the economy due to several reasons such as their large extension or the important source of employment.
2. SMEs have different characteristics than larger firms. Flexibility is one of the most appreciated strengths from SMEs over large companies. However, they face particular difficulties such as the lack of resources.
3. Despite the recognized importance, SMEs have remained under-researched, even to a greater extent in the areas of knowledge management and information systems.
4. Research on knowledge management and information and communication technologies can be very fruitful in order to facilitate the survival of SMEs by overcoming their weaknesses (focus on operational issues, lack of attention to the environment and external sources of knowledge, lack of resources, etc.) and enhancing their flexibility (quicker acquisition of knowledge about the market needs and opportunities)
5. The selection of manufacturers located in the UK within the mechanical engineering sector is very appropriate in order to distinguish the heterogeneity within SMES (industrial versus service) and to have generalisable results. Furthermore, the mechanical engineering sector plays a key role in the UK and European economy.

Having defined the setting of the research, the next section will specify the research questions to which this study aims to contribute.

Chapter 5: Conceptual Model and Research Hypotheses

The purpose of this chapter is to:

(1) State clearly the research objectives and aims of this research

(2) Outline specific questions that aims to be addressed by this research

(3) Define the hypotheses which this thesis attempts to test

(4) Develop a conceptual model

(5) Discuss the contributions of the present research

(6) Present how the constructs used are formed and how they emerged from relevant literature

(7) Discuss the nature of the scales employed and the assumptions made in relation to them

5.1 Introduction

The purpose of this chapter is to make clear the aims and objectives of the present research. Drawing on the existing literature presented in previous chapter, different themes and ideas will converge into specific research questions and hypotheses. As a result, the conceptual model will be developed.

Therefore, this chapter will start with outlining the research questions this research aims to contribute to. Thus, based on the review of the empirical literature discussed in Chapter 3, the research hypotheses will be defined next. In this way the conceptual model will be outlined and the contributions expected from addressing the research objectives and hypotheses will be discussed. Once the conceptual model is defined, how the different constructs employed in the present research are formed will be explained and will be related to the relevant literature. Finally, the chapter will end up with a summary of the main points covered in this chapter.

5.2 Research Objectives and Hypotheses

The main research question that this research attempts to answer is the following:

Are knowledge-based capabilities and/or ICT capabilities related to organisational performance in SMEs?

This question can be broken down into the following sub-questions:

- What benefits are obtained by firms engaged in knowledge management practices? What is the nature of such benefits?
- What are the benefits obtained by firms with greater ICT capabilities?
- What are the key factors in KM and ICT capabilities that influence in these benefits?
- What are the vital ICT capabilities that enable a strategic use of knowledge? Do particular ICT capabilities enable specific knowledge-based capabilities?
- Do knowledge-based capabilities influence on ICT capabilities?
- Are some specific knowledge management practices more influential on performance than others?
- Are there specific ICT which are more frequently associated to better performance?
- What similarities and differences are there between SMEs and large enterprises in relation to these issues?
- What are the implications or advices for managers and policy makers in order to promote the effective implementation of KM capabilities and enhancement of ICT capabilities?

Based on the above questions and the gaps spotted within the literature of empirical studies (see Section 3.7), the hypotheses that the present research aims to test are outlined below.

The main argument of the KBV is that the ability of firms to manage knowledge leads to differential results compared to their competitors (Hoskisson et al., 1999). Thus, it seems reasonable to state that knowledge management will improve the organisational effectiveness over time. Thus, it is hypothesized:

Hypothesis 1: *there is a positive relationship between knowledge management capabilities and organisational performance.*

Although still unresolved, since most empirical studies support a positive association between ICT and organisational performance (Melville et al., 2004), this study proposes:

> ***Hypothesis 2:*** *there is a positive relationship between ICT capabilities and organisational performance*

Based on the principles of dynamic capabilities theory, the complementarity between knowledge management capabilities and ICT capabilities will be analysed by the following hypotheses:

> ***Hypothesis 3a:*** *knowledge management capabilities are mediated by ICT capabilities*
>
> ***Hypothesis 3b:*** *ICT capabilities are mediated by knowledge management capabilities*

Taking into account the principles of the contingency approaches and the activity-systems theory commented in Chapter 2 and 3, the next hypotheses are formulated:

> ***Hypothesis 4a:*** *the impact of knowledge management capabilities on performance is mediated by the organisational context*
>
> ***Hypothesis 4b:*** *the impact of ICT capabilities on performance is mediated by the organisational context*
>
> ***Hypothesis 4c:*** *the impact of KM and ICT capabilities on performance is mediated by the organisational context*

The above hypotheses can be summarized in the conceptual model shown in Figure 22. Such model reflects the interrelationship of the different constructs: knowledge management capabilities, ICT capabilities, organisational context and organisational performance that this study will investigate. Each of the constructs is captured by different variables which will be explained in the next section and which will enable testing the conceptual model.

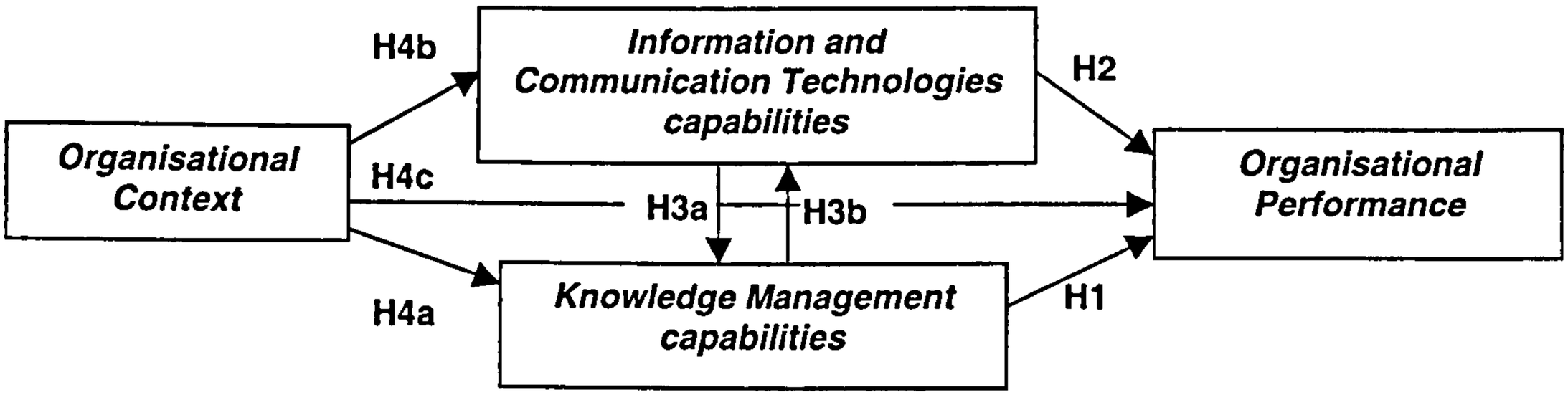


Figure 22: Conceptual model for the thesis

Furthermore, apart from testing hypotheses, the present research aims to identify the key factors regarding knowledge management and ICT that promote better organisational results. In addition, practices on knowledge management from different approaches are examined in relation to organisational performance, in order to help managers to implement knowledge management based on empirical evidence. Similarly, the key contextual factors influencing on the effect of knowledge management and ICT capabilities will be identified with the objective of testing differences among firms depending on their characteristics.

5.3 Contributions

The outlined research objectives and hypotheses *contribute to increasing the empirical research on the RBV and KBV, and its operationalisation*, which has been subject to criticisms (Hoskisson et al., 1999).

Despite the fact that much research on knowledge management exists, research on knowledge management has focused on theoretical or conceptual studies and on case studies-based empirical tests (Un and Cuervo-Cazurra, 2004). Within this line of thinking, Staples et al. (2001) claim that, in order to *develop a new more managerial approach, more empirical research on knowledge management focused on the knowledge-based capabilities* is needed. Here the researcher has proposed an *operationalisation of the knowledge management phenomena from a systemic approach*, including further constructs such as ICT and organisational performance and controlled by different contextual factors such as size, sector, technological turbulence, etc.

The governmental support for SMEs has been proved to be critical, so the operationalisation and test of the model might be of critical importance. Since, it will benefit managers and policy makers since it will help them to have a *better understanding of the key factors in the whole picture based on observed "best practices"*. Thus, it will enable them to make the right decisions about policies for enhancing knowledge management and ICT, with the aim of improving their organisational performance.

Regarding information systems strategy, Duhan et al. (2001) state that further research should address the operationalisation of the competence perspective and the leverage of capabilities in order to build new ones. Therefore, ICT can have complementarities and synergistic interactions with other resources, such as, in this case, knowledge management and vice versa. Furthermore, this model will contribute *to clarifying the role of ICT*, which are still one object of polemic debate that leads to polarized opinions.

Few studies have addressed the operationalisation of knowledge management and only two has envisaged ICT as an organisational capability with a supportive role. At the same time, researchers have investigated ICT' impact on organisational performance. However, this research, *will analyse the value of knowledge management capabilities and ICT*

capabilities, separately and simultaneously, for the first time to date within the context of SMEs. The adoption of a comprehensive range of organisational performance indicators will make the assessment of knowledge management and ICT capabilities more reliable.

Furthermore, given that most of the studies focus on US firms, this is the first time UK firms are object of research in these areas. The macro-environmental and cultural differences could lead to different conclusions. Finally, it must be highlighted that these *firms belong to a single industry and all have manufacturing facilities, hence, the comparability of the data is ensured*. Nevertheless, *differences across micro-environmental aspects, that is, those regarding the organisational context, will be examined* with the aim of identifying different patterns in relation to knowledge management and ICT.

The proposed model has important implications for theory. Drawing on the dynamic capabilities theory (Teece, 1998b), knowledge management can integrate important work in different fields such as strategy, human resources management and information systems. The results might *help to discover specific aspects of knowledge management such as ICT, difficult or even impossible to be achieved when studied individually*.

5.4 Definition and Measurement of the Research Constructs

Knowledge Management capabilities

Based on the discussion in Chapter 3, knowledge management capabilities are captured by the following constructs: knowledge exploration, knowledge exploitation, strategic alignment and organisational culture (Figure 23). Each of these constructs is measured by the items shown in Table 7, which derive from the literature (the specific literature related to the items is indicated between brackets). In order to recall these concepts from previous chapters, Table 6 summarizes the definition of the main aspects.

Table 6: Definitions of main concepts

KM capabilities	organisation's ability to assemble, integrate, and deploy valued knowledge resources, usually, in combination or copresence *(*)*
ICT capabilities	organisation's ability to assemble, integrate, and deploy valued ICT resources, usually, in combination or copresence (*)
Knowledge exploration	process of actively seeking for new knowledge or for existing knowledge held from others
Knowledge exploitation	process of making use of existing knowledge, by transferring and/or integrating it within the organisation
KM practices	"*observable routines involved directly in the development and application of knowledge*" (Coombs and Hull, 1998: 7)

(*) based on definition of capabilities given by Amit and Schoemaker (1993)

Given that SMEs have different structural characteristics than larger firms (size, centralization, formalization), the present research has opted to control such differences. However, some structure-based items have been included within the knowledge management processes, in case of being intrinsically interrelated to certain knowledge management process (e.g. *(ex8) The firm's organisational structure supports collaboration*).

Table 7: Operationalisation of Knowledge Management Capabilities

Knowledge exploration	Items (Five-point scale anchored by "strongly disagree" and "strongly agree")
(er1)	The firm knows the skills and capabilities of each of their staff (2) (6) (10) (11)
(er2)	Staff are valued for their individual expertise (2) (4) (6) (9)
(er3)	The firm provides all their staff with training (1) (2) (4) (5) (6) (9) (10) (11)
(er4)	Staff know who to ask when they need knowledge which already exists in the firm (4) (5) (6)
(er5)	Staff are encouraged to ask for assistance when is needed (4) (5) (6)
(er6)	Groups get knowledge from existing data about past and/or current experiences (2) (3) (4) (8) (9) (10) (11)
(er7)	The firm values research activities (2) (4) (7) (9)
(er8)	Managers keep themselves updated about what happens within the firm (1) (4) (5)
(er9)	The firm learns a lot from its customers (1) (2) (3) (4) (5) (7) (8) (11)
(er10)	The firm learns a lot from its suppliers (1) (2) (3) (4) (5) (8) (11)
(er11)	The firm learns a lot from its competitors (1) (2) (4) (5) (8) (11)
(er12)	The firm acquires knowledge from other external sources (1) (2) (4) (5) (8) (11)

Knowledge exploitation	Items (Five-point scale anchored by "strongly disagree" and "strongly agree")
(ex1)	Nature of internal communication (*) (1) (2) (3) (4) (5) (10) (11)
(ex2)	Staff are encouraged to interact with other groups (1) (3) (4) (5) (6) (9)
(ex3)	Staff are encouraged to discuss their work with people in their own workgroup (3) (4) (5) (7) (8) (11)
(ex4)	The incentive system promotes group work and activities (2) (4) (10) (11)
(ex5)	Knowledge and/or information are distributed throughout the firm (1) (4) (5) (7) (8)
(ex6)	Knowledge and/or information is exchanged with business partners (2) (4) (7)
(ex7)	The firm looks for possible collaboration opportunities with other firms (1) (3) (8)
(ex8)	The firm's organisational structure supports collaboration (1) (2) (4) (5) (10) (11)
(ex9)	Staff have adequate resources to work individually (2) (3) (6) (11)
(ex10)	Staff have adequate resources to work in groups (2) (3) (6) (11)
(ex11)	The firm attempts to protect its strategic knowledge (1) (2) (4)
(ex12)	Staff are encouraged to practice what they have learnt (1) (4) (5) (6) (11)
(ex13)	Staff are encouraged to try out new ideas at work (1) (4) (5) (6) (11)
(ex14)	Disagreements between staff are allowed (3) (4) (5) (7) (8) (11)
(ex15)	Outdated knowledge and/or information is replaced systematically (4) (6)
(ex16)	Open discussions happen in order to arrive at a common view (3) (4) (5) (7) (8) (11)
(ex17)	After every successful project, the group reflects on the "lessons learned" (2) (4) (7) (8) (9) (11)
(ex18)	After every unsuccessful project, the group reflects on the "lessons learned" (2) (4) (6) (7) (8) (9) (11)

(*) Average of the nature of internal communication of each department/function

(1)	(2)	(3)	4)	(5)
Sporadic and informative contacts	Passing information when required	Frequent Communications	Regular communications and sporadic collaboration	Frequent and strong collaborations

Alignment	Items (Five-point scale anchored by "strongly disagree" and "strongly agree")
(a1)	The mission, vision and objectives of the firm are clearly explained to new staff (2) (6)
(a2)	New staff are briefed on the technical specifications and their job/role (2) (6)
(a3)	The values and philosophy of the firm are clearly explained to new staff (2) (6)
(a4)	Commitment to the firm's mission is promoted by the firm (4) (5) (6) (11)
(a5)	All the staff are working towards the same vision (1) (9) (10) (11)
(a6)	Functional strategies are aligned with the general strategy of the firm (1) (9) (10)

Culture for Knowledge	Items (Five-point scale anchored by "strongly disagree" .
(c1)	Communication within the firm is open (1) (4) (5) (6) (11)
(c2)	Communication within the firm happens regularly (1) (4) (5) (6)
(c3)	Trust is promoted by the firm (1) (4) (5) (6) (11)
(c4)	Transparency is promoted by the firm in communication (4) (5) (6)

NOTE: being:

(1) (Nonaka, 1994)
(2) (Coombs and Hull, 1998)
(3) (El Sawy et al., 2001)
(4) (Gold et al., 2001)
(5) (Lee and Choi, 2003)
(6) (van den Hooff et al., 2003)
(7) (Tippins and Sohi, 2003)
(8) (Kraaijenbrink et al., 2002)
(9) (Grant, 2002)
(10) (Liebowitz and Wilcox, 1997)
(11) (Von Krogh et al., 1998)

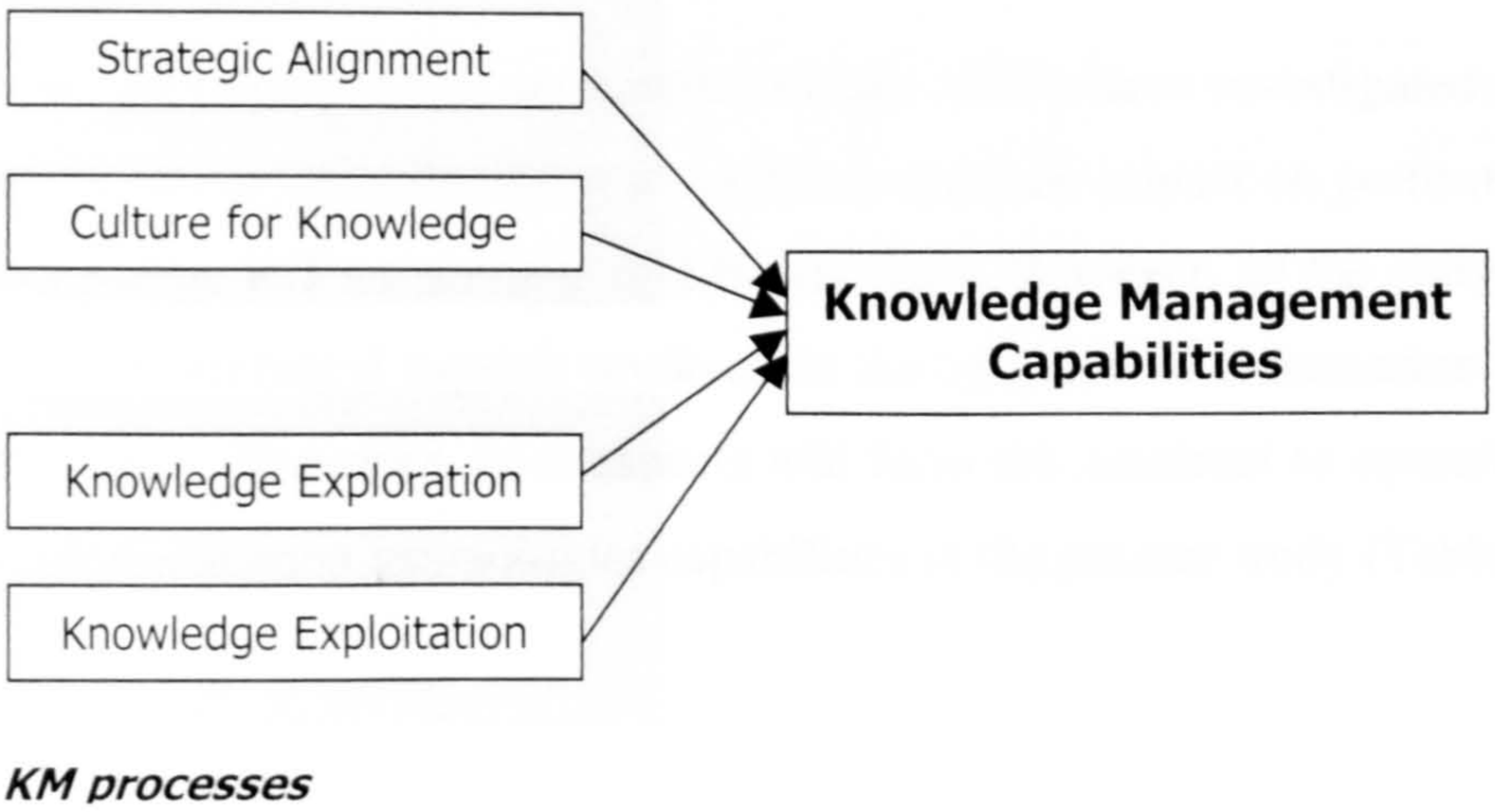


Figure 23: Operationalisation of KM capabilities

Knowledge management practices

Furthermore, practices included within the model in order to operationalise knowledge management capabilities, will be studied in more detail. For example, taking into consideration the following practice: *(er3) The firm provides all their staff with training.* Doing so, firms can employ numerous diverse techniques (e.g. on-the-job training, apprenticeship / shadowing with experienced staff, rotation, attendance at external centres, fairs, conference or other events, consultancy, implementation of continuous training plans, courses provided through the Internet, paper-based documentation (books, articles, brochures, handbooks, etc.). Hence, the description and analysis of the relationship between the format of knowledge management practices and their impact on the organisational performance, is crucial since it will help managers to implement and integrate knowledge management in their work processes. As discussed in Chapter 3, around fifty percent of knowledge management initiatives fail. This indicates that practitioners find difficult to understand such a complex concept and, what is more important, to implement it successfully.

Information and Communication Technologies Capabilities

As seen previously, there are parallel studies which have investigated the information and communication technologies as a capability and their impact on performance. These studies operationalise ICT capabilities in different ways. However, all the constructs agree with the human and technical aspects involved in the adoption of information and communication technologies. Therefore, both aspects will form the construct to operationalise information and communication technologies capabilities in the present study (Table 8 and Figure 24)

Table 8: Operationalisation of ICT Capabilities

IT infrastructure	Items (Five-point scale anchored by "strongly disagree" and "strongly agree")
(inf1)	Few problems of compatibility arise when adding new IT to the existing one (13) (17) (18)
(inf2)	The firm has addressed the issue of data security (13)
(inf3)	New IT aims to enable better communication (12) (13)
(inf4)	The firm is consistently able to provide the necessary capital for IT investments (13) (19)
(inf5)	The firm creates customized software applications when necessary (13) (14)
(inf6)	The firm prevents its IT infrastructure from being imitated (13) (14)
(inf7)	The firm possesses an appropriate IT infrastructure to support the business (13) (17) (18)

Human IT skills	Items (Five-point scale anchored by "strongly disagree" and "strongly agree")
Staff responsible for the implementation of IT...	
(hit8)	... possess a high level of technical expertise (13) (14) (17) (18)
(hit9)	... are encouraged to learn about new technologies (13)
(ht10)	... closely follows emerging trends in IT (12) (14)
(hit11)	... take part in the formulation of organisational strategy (12) (13) (14) (17)
(hit12)	... know well all of the firm's processes (12) (13) (14) (17)
(hit13)	... are actively engaged in the redesign of the business processes (12) (13) (14) (18)
(hit14)	... aim to support communication across the firm (13) (14) (17)
(hit15)	... collaborate with customers & suppliers to ease communications (12) (13) (14) (17) (18)
(hit16)	... write clear and useful documentation regarding IT (13) (17)
(hit17)	... work together with other departments in teams (12) (13) (14)
(hit18)	... are self-directed and proactive (13)
(hit19)	... manage contracts effectively with IT suppliers (12) (13) (14) (17) (18)
(hit20)	... actively research the best IT practices of other companies (12) (13) (14)
Staff, in general, ...	
(hit21)	... are well trained in the use of new IT (12) (16)
(hit22)	... make full use of the current IT infrastructure (13)
(hit23)	... accept new IT with few problems (12) (14)
(hit24)	... are involved early in the process of IT adoption (14)
(hit25)	*managers* are clearly committed to IT (12) (13) (17)

NOTE: being:
(12) (Powell and Dent-Micallef, 1997)
(13) (Byrd and Turner, 2000)
(14) (Bharadwaj, 2000)
(15) (Van Der Heijden, 2001)
(16) (Dehning and Stratopoulos, 2003)
(17) (Ravichandran and Lertwongsatien, 2005)
(18) (Melville et al., 2004)
(19) (Dehning and Richardson, 2002)

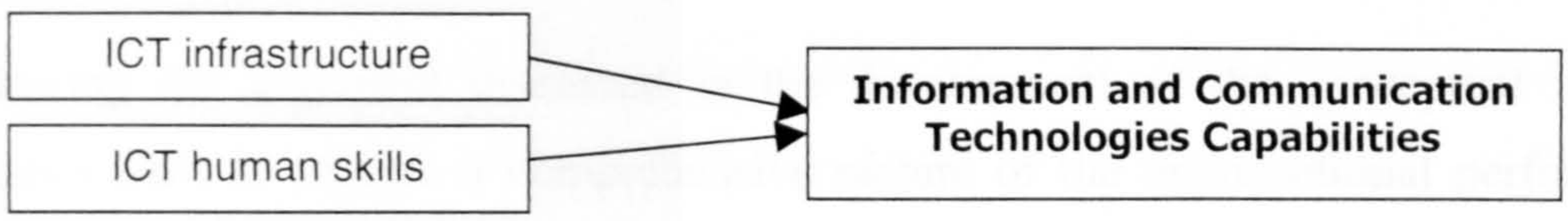


Figure 24: Operationalisation of ICT capabilities

List of Information and Communication Technologies

Moreover, firms are asked to state whether they possess specific information and communication technologies (see Table 9) and evaluate their importance for the firm operation (from 1 to 5, from less to more important, respectively). In this way, the analysis of the relationship between ICT and other aspects in the model, such as specific knowledge management practices and organisational performance might provide insightful conclusions.

Table 9: List of available ICT

- Data mining / text retrieval software
- Expert or decision support software
- Automatic e-mail alerts
- Search engine or Web crawler
- Intelligent agent or artificial intelligence
- Mind / knowledge mapping software
- Computer based training / e-learning.
- Design SW (CAD, CAM, PDM)
- Simulation software
- Phone
- E-mail or chatting software
- Groupware (e.g. bulletin board)
- Project management software
- Extranet
- Integrated software (MRP, ERP)
- Content / document management software
- Intranet or enterprise information portal
- Knowledge repository or digital archive
- Workflow / process management software

(Source: adapted from Kraaijenbrink et al. (2002))

Organisational Performance

Following the argument discussed in the development of the conceptual model, this research aims to capture a comprehensive picture of the organisational performance, by including qualitative and quantitative indicators, covering financial and non-financial aspects (see Table 10 and Figure 25).

Table 10: Operationalisation of Organisational Performance

Qualitative indicators	Items (Seven-point scale anchored by "strongly disagree" and "strongly agree")
	Compared with your main competitors, over the last 3 years your firm…:
(pql1)	… has been more successful (5) (12)
(pql2)	… has had a greater market share (5) (11)
(pql3)	… has grown faster (5) (7) (12)
(pql4)	… has been more profitable (5) (7) (1) (12)
(pql5)	… has been more innovative (4) (7) (11)
(pql6)	… has responded quicker to changes in the market (4) (5)
(pql7)	… has been more adaptable and flexible, adjusting your objectives to changes in the market (4)
Quantitative indicators	**(percentage change over the last 3 years (2001, 2002, 2003))**
(pt1)	Sales growth
(pt2)	Market share growth
(pt3)	Profit growth
(pt4)	ROA (return on assets)

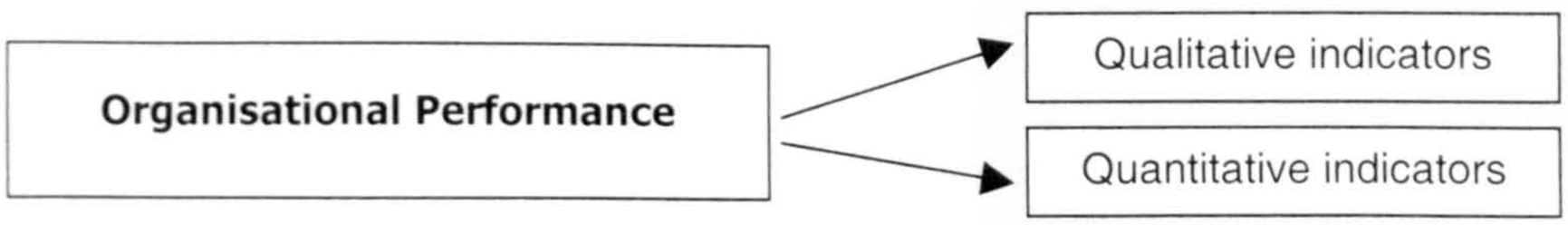


Figure 25: Operationalisation of Organisational Performance

Control variables

At the same time, a set of contextual variables (see Table 11) will be controlled for the different constructs in order to test the differences between firms with dissimilar characteristics.

Table 11: List of control variables employed

Contextual variables	
Products	(one question)
Production process	(one question) (18)
Size (18) - five years ago	(one question each)
Age	(one question)
Formal education level	(weighted average)
Technological turbulence	(construct adopted from Lin et al (2003)) (10) (11) (18)
Formal control	(construct adopted from Lin et al (2003)) (5) (6) (19)
Decentralization	(construct adopted from Lin et al (2003)) (5) (6) (19)
Dependence	(one question)
Dispersion	(weighted average)
Percentage of turnover in 2003 invested in Information Systems	(one question)
Estimated total sales in 2003	(question)

NOTE: being
(18) (Miller and Droge, 1986)
(19) (Dewett and Jones, 2001)

5.5 Nature of the Scales

Likert scales are used for most of the variables. However, much debate and literature has arisen regarding the nature of such data. Theoretically Likert scales are ordinal scales, since they measure a characteristic using few intervals, which are not equal. Thus, statisticians among other researchers claim that they should be analysed by applying non-parametric tests (Cliff, 1983).

However, contrary to the opinion of "purists", most social researchers adopt the "pragmatic" view of categorical data as interval (Diamantopoulos and Schlegelmich , 1997; Kline, 2000; Nunnally, 1978), so they analyse them by using parametric tests. There are three main reasons supporting this argument. First, if the underlying characteristic to be measured is continuous, that measures can be considered interval in spite of the scale. Second, if categorical data approximate normal distribution, they can be treated as interval (Jaccard and Wan, 1996). Anyway, although parametric tests such as factor analysis and regression analysis are based on the assumption of normality, the individual normality of each variable included in the analysis is not necessary given the central limit theorem. The central limit theorem states that the mean of repeated random samples follow a normal distribution, even when the distribution from which the mean is computed is non-normal. Thus, the assumptions will be tested for the multivariate. Third, the use of this kind of scales assumed as continuous has been widely used in social sciences, having successful results (Joreskog and Sorbom, 1993). Furthermore, due to their robustness, statistical techniques provide non-distorted results when using categorical variables with enough categories (Rust and Golombok, 2000).

After having discussed the main arguments of the debate, the present research adopts the view of Likert scales treated as continuous given their pragmatism, the compliance of the data to approximate normality distribution and the successful application of parametric techniques when this assumption is made. However, the downside of doing so is that a measurement error is introduced (Jaccard and Wan, 1996). This is one of the limitations of the research and will be revisited in the concluding chapter (Chapter 9).

5.6 Summary of the Chapter

To sum up, this chapter has defined the research objectives and hypotheses that the present study aims to address with the aim of investigating the interrelationship of the different constructs: knowledge management capabilities, ICT capabilities, organisational context and organisational performance. Furthermore, it has defined how the constructs are formed and measured.

The hypotheses are summarized in Table 12 and Figure 26 includes them within the conceptual model resulted from relating the involved constructs.

Table 12: Summary of Hypotheses

Hypothesis 1: there is a positive relationship between knowledge management capabilities and performance
Hypothesis 2a: there is a positive relationship between ICT capabilities and organisational performance.
Hypothesis 3a: knowledge management capabilities are mediated by ICT capabilities
Hypothesis 3b: ICT capabilities are mediated by knowledge management capabilities
Hypothesis 4a: the impact of knowledge management capabilities on performance is mediated by the organisational context
Hypothesis 4b: the impact of ICT capabilities on performance is mediated by the organisational context
Hypothesis 4c: the impact of knowledge management capabilities and ICT capabilities are mediated by the organisational context

As a result, the present study will contribute to:

(1) The operationalisation of the RBV / KBV

(2) The integration of different fields (KM, ICT) into a single model

(3) Give empirical evidence to the dynamic capabilities theory

(4) For the first time, carry out a quantitative study of KM and ICT from the RBV focused on SMEs, from the UK, within the mechanical engineering sector, and manufacturers

(5) Clarify the debate about the role of ICTs from a balanced and holistic view

(6) Advice policy-makers and managers on the needs of SMEs

The operationalisation of the different constructs has been indicated in relation to the literature. Regarding the nature of the scales, the view of categorical data as interval has been justified.

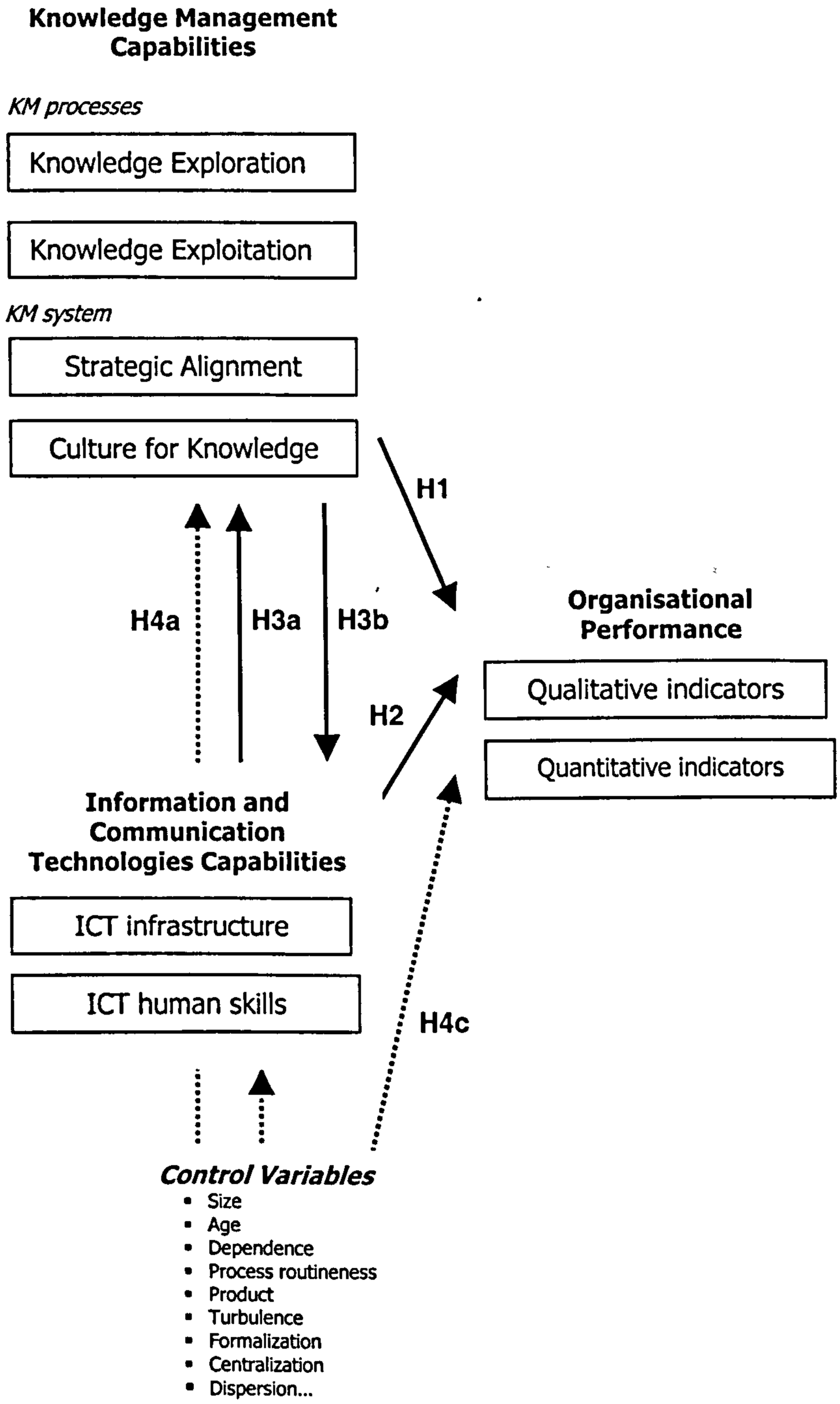


Figure 26: Comprehensive conceptual model

Chapter 6: Research Design and Methodology

The purpose of this chapter is to:

(1) Discuss the basic aspects that any research should consider when planning the research design

(2) Assess the available alternative choices and justify the decisions made in this study when constructing the research design

(3) Describe the process of designing the research instrument and of implementing the mailed survey

(4) Discuss the appropriateness of the results based on their representativeness of the population

(5) Assess the non-response and ensure that the data gathered is non-biased

(6) Evaluate the survey response rate

6.1 Introduction

This chapter aims to explain the reasoning behind the research design of the present study. The research design of any study is affected by different factors (see Figure 27). First, the *ontological assumptions* of the researcher and, thus, his/her epistemological stand intervene in the research design, since they shape the way of seeing reality and, therefore, the way of trying to extract knowledge about it. Second, whether the *goal of the research* is to explore a new issue, to describe it or to investigate the causality of a known phenomenon, will determine what research technique suits better in the research. Finally, the *researcher's personal approach to reasoning* will forge the research design. All these issues will be discussed in the present chapter and the choices made in this research will be discussed.

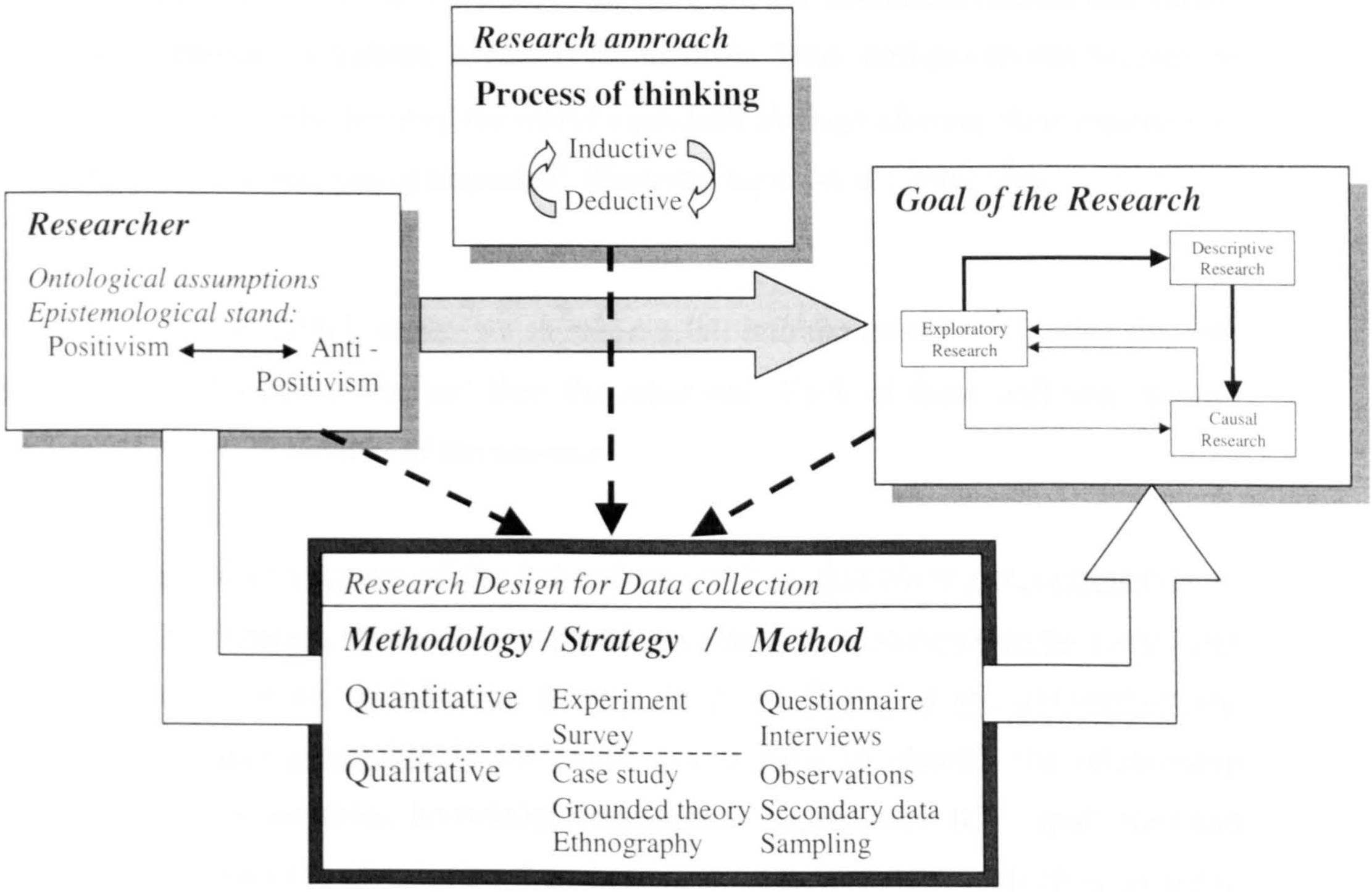


Figure 27: Factors influencing any Research Design
(Source: Author)

6.2 Epistemological position

The epistemological stance of a research refers to the way the researcher knows about the reality. Therefore, it is intrinsically linked to the ontological assumptions adopted by the research, that is, to the assumptions that are made about the nature of reality.

The epistemological position of a research may lie in the continuum between two bi-polar extremes: positivism and anti-positivism (Johnson and Scholes, 2000). *Positivism* reflects the philosophical stand typically adopted within the natural science. Positivism is based on realism, idealism or representationalism, which are philosophical views which believe that the world we see is an exact reality replica of the real world itself. Furthermore, one of the main principles of positivism is that the world works according to certain laws and, therefore, they can be discovered through scientific methods. On the other hand, *anti-positivism* assumes that there are not universals outside our minds. This idea, opposite to realism, is named nominalism. Thus, anti-positivism focuses on "*the ways people make sense of the world especially through sharing their experiences with others via the medium of language*" (Easterby-Smith et al., 2002: 29).

As Saunders et al. (2003) argue, we should not fall into the mistake of stating that one philosophical domain is "better" than the other one. Each of them will suit "better" depending on the objectives of the research.

The ontological assumption of the present research is that there are organisational practices regarding knowledge management and information systems within companies and that the researcher will be able to map these out. Based on this assumption, the research embraces positivism in the sense that it aims to identify the relationship between different variables, knowledge management capabilities, ICT capabilities and performance, under the assumption that there is an objective reality which is aimed to be discovered. However, this philosophical position should not be confused with the view of knowledge management adopted in this research, which include principles of the social constructivist perspective. Knowledge management is addressed as a dynamic phenomenon socially constructed.

The approach adopted here in relation to knowledge management and ICTs could be arguable by some (e.g. the existence of a unique culture or of a true and unbiased organisational memory). However, the assumptions about knowledge management in which the present research lies in depend on the epistemological approach adopted.

Schultze and Leidner (2002) review the different epistemological approaches or discourses in the study of knowledge and knowledge management based on Deetz's classification of discourses. There are not right or wrong but different approaches to study the same phenomena depending on the goals, methods and hopes of the research. While the dialogic discourse assumes that "*a single reality remains elusive*" (p.217), the normative discourse "*reflects modernity with its assumptions of progressive enlightenment as well as increasing rationalization, management and control (also Havey, 1989)*" (p.216). The latter is the usual discourse used when "*seeking to establish general laws and causal relationships through hypothesis testing*" (p.217). Schultze and Leidner (2002) also classify the existing literature on knowledge management research in IS and the results show that most studies rely on the normative discourse. Therefore, the assumptions or approaches adopted by the present study seem completely acceptable.

In spite of the fact that one could see that the rational approach adopted here is unrealistic, the findings of this research will be a strong base to understand in more depth the issues identified here, by using qualitative research. Harrigan (1983) discusses the restrictions and advantages of quantitative and qualitative researches, named as "fine-grained" and "coarse-grained".

"*In much existing research, insights gained using "fine-grained"(Hambrick, 1981) methodologies (such as case studies) lack generalizability and statistical rigor, but "coarse-grained" methodologies, such as the profit impact of market strategies (PIMS) studies, loses the nuances and insights concerning the individual firms' strategies*" (Harrigan, 1983: 398)

The advantages and disadvantages of the different types of research will be discussed later in detail.

6.3 Goal of the research

According to several authors (Churchill, 1987; Ghauri and Gronhaug, 2002), research can pursue three main goals: exploration, description or explanation. *Exploratory* studies aim to examine in detail the phenomenon, since little is known about it. Once the problem is structured and some possible explanations are found, descriptive and explanatory research can take place. While *descriptive* studies attempt to describe the phenomenon, *explanatory* studies intent to explain the reasons for such (Cooper and Emory, 1995).

However, these research goals are intrinsically related and not necessarily exclusive. As shown in Figure 28, each type can lead to the others, as research should be like a "wheel" which passes through different stages.

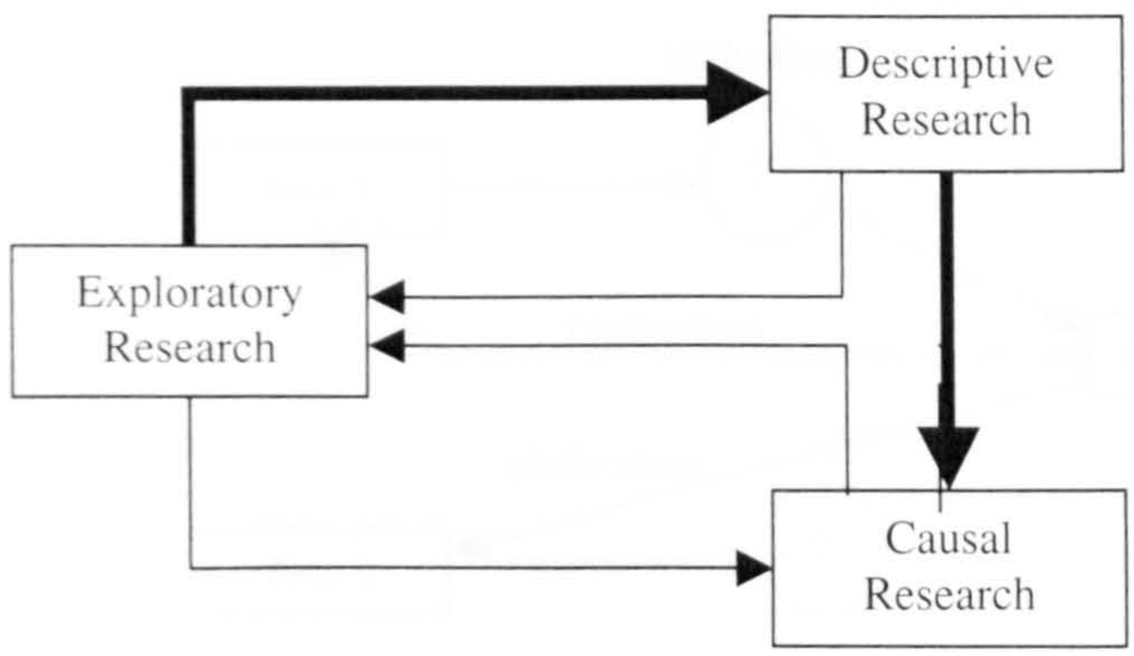


Figure 28: Relationship between different research objectives
(Source: Churchill, 1987)

As said in Chapter 5, *the present research aims to explain the relationship between different constructs, although a section for descriptive research will also be included*. This decision is based on the fact that exploratory studies abound within the literature on knowledge management, while generalised conclusions based on large-scale surveys are still missing. However, *given that the objective of this research has never been research within the context of SMEs, the study is slightly exploratory*.

6.4 Process of reasoning

The approach to reasoning is also underlying in the research design. There exist two main approaches to thinking: induction and deduction. *Induction* entails proposing general theories or hypotheses from detailed evidence acquired through observation. On the other hand, *deduction* involves testing theories; hence, it pursues achieving conclusive results. These two approaches should be sequential in research. As Cooper and Emory (1995) state, they represent what Dewey calls the double movement of reflective thought. Figure 29 illustrates the circular relationship between induction and deduction. However, the question of what comes first, data or theory, arises. It is the purpose of the research what will dictate which of the two approaches is more convenient.

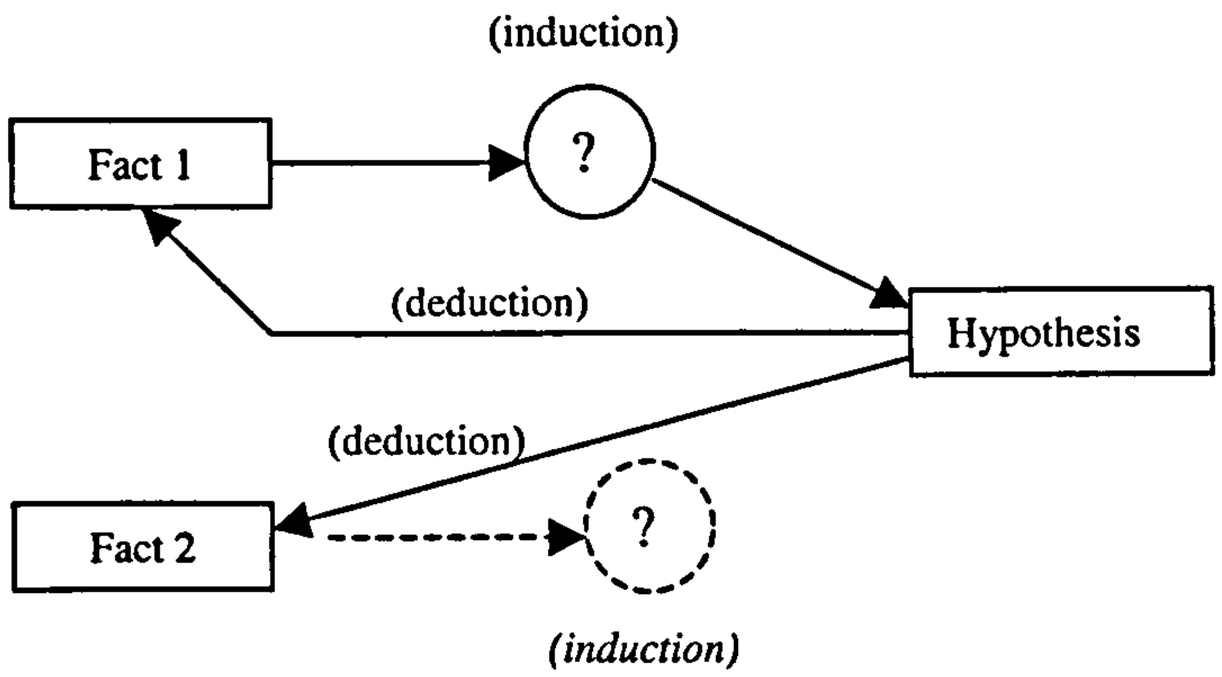


Figure 29: Dualism between induction and deduction
(Source: adapted from Cooper and Emory (1995))

Given that theoretical hypotheses have already been drawn from inductive studies, *the present research embraces a more deductive approach and several hypotheses, shown in Chapter 5, will be tested. Nevertheless, the descriptive section will provide some inductive conclusions.*

6.5 Methodology and methods

Taking into account the previous issues, the quantitative methodology strategy is chosen. Although not necessarily, the usual decisions in relation to the research design derive from more general aspects. Saunders et al. (2003) use the metaphor research process "onion", being the outer layers referring to the philosophical stand and the core part, to the research method. Table 13 indicates the bi-polar extremes in each continuum of these layers. The definition of the limits between the different extremes has created strong debates. In relation to the research strategy, Davidsson (2004) argues "*what entrepreneurship research does not need is the often confused and confusing debate about qualitative versus quantitative research that goes on in business studies; perhaps in Europe in particular*" (p. 57). His reflection on the debate on qualitative versus quantitative methodologies is well worthy to have a look at. Nevertheless, here the most common approach to discuss qualitative versus quantitative research is presented.

Table 13: Layers of the research process "onion"

Research Ontology	Realism ⟷ Nominalism
Research Epistemology	Positivism ⟷ Anti- Positivism
Research Goal	Exploratory — Descriptive ⟷ Explanatory
Research Approach	Deduction ⟷ Induction
Research Strategy	*Quantitative* ⟷ *Qualitative* Survey, experiment — Case study, grounded theory, ethnography, action research
Research Method	Questionnaire, secondary data ⟷ Interviews, observation, secondary data

The main difference between qualitative and quantitative methodologies is the type of data collected. *Qualitative research* aims to collect rich and in-depth data in the form of words. The objective sought is "*to describe, decode, translate and otherwise come to terms with the meaning, not the frequency, of certain more or less naturally occurring phenomena in the social world*" (Van Maanen, 1983: 9). The techniques associated with qualitative research are interviews, observation and secondary data. Due to the richness of the data, qualitative methods target a small number of respondents or cases. The main advantage of such methods is their flexibility in generating data. The questions are open-ended; hence they can provide new insights about the phenomenon.

Thus, the validity of qualitative methods is very strong, although it is at the expense of their reliability and generabilisability. Given the small-scale of qualitative methods, the results cannot be generalised, but only extrapolated in order to propose new theories or hypotheses, based on the better understanding of the problem.

On the other hand, *quantitative research* seeks to collect data in the form of numbers through experiments and surveys with the aim of enabling statistical analysis which will allow the verification or falsification of the pre-stated hypotheses. Since the problem is usually already structured, the questions of quantitative methods tend to be quite rigid and seek broad information regarding the "macro" aspects of the situation. In order to be statistically representative, this kind of methods target large-scale of respondents. Therefore, they are characterized by their high reliability and generabilisability, despite its validity is not as strong as when applying qualitative methods.

As a result of their different approach, qualitative and quantitative methodologies have different characteristics, shown in Table 14.

Table 14: Differences between qualitative and quantitative methodologies

	Qualitative	**Quantitative**
Objective	Unfolding the real-world situations	Measurement and quantification
Data	In-depth, words	Broad, numerical data
Scope	Small-scale	Large-scale
Focus	"Micro" aspects of everyday life and social interactions	"Macro" aspects of social relations – social, economic and political structures
Flexibility	Open-ended questions, emerging methods	Rigid, predetermined, close-ended questions
Validity	Strong (rich and detailed information)	Weak (broad data)
Reliability	Lack of consistency / repeatability	Strong
Generabilisability	Not statistically representative, speculations based on extrapolation	Strong (statistically representative)
Data analysis	Sense-making	Verification / falsification
Outcome	Understanding	Causality

The above discussion can be summarized as follows: qualitative methods generate data while quantitative methods collect data. It must be noticed the interrelationship between the two research strategies, drawn from the natural cycle of research. However, their delimitations are not completely defined. Thus, some studies use both strategies within the same research in order to get more consistent results. The adequacy of mixing

methods will be determined by, apart from the availability of resources, the existence of previous researches. *The present research will only rely on quantitative techniques*. The literature is plenty of qualitative researches; therefore, it has been considered more insightful to test the causal relationships between knowledge management, information and communication technologies and organisational performance by the application of statistical techniques. In this way, the hypotheses or theories emerged from exploratory studies will be verified or falsified. However, it must be noticed that, although the subject has been largely explored, a slightly exploratory statistical technique (factor analysis) (Davidsson, 2004) is used in order to define the patterns of behaviours in SMEs, never addressed before in a quantitative way. Therefore, the goals the research indicates that quantitative methods are more appropriate.

Having narrowed down the research technique employed in the present research, the next sections will focus on the implications of using surveys, since the purpose here is not to explain the characteristics of each of the research techniques or methods, but to justify the reasoning behind the decision of adopting survey as the main research strategy.

Survey approach

Surveys aim to question people regarding their attitudes, opinions or descriptions in order to record their answers for analysis (Cooper and Emory, 1995).

Surveying can be carried out by interviewing, face to face or over the phone, or by mailing a self-administered questionnaire. Each survey method has different advantages and disadvantages, which are summarized in Table 15. A compromise between positive and negative aspects has to be made when deciding which method is the most suitable for a research.

Given that this research aims to cover firms located all over the UK, personal interviews are discarded. Mail survey is adopted in spite of its low response rate due to the high costs involved in telephone interviews and its limitation in the amount of questions.

Table 15: Comparison of survey methods

	Personal interviews	Telephone interviews	Mail Survey
Advantages	- good cooperation from respondents - interviewer can answer questions about the survey, prove for answers, use follow-up questions, and gather information by observation - special visual aids and scoring devices can be reached - interviewer can pre-screen respondent to ensure he/she fits the population profile - CAPI-Computer-assisted personal interviewing: responses can be entered into a portable microcomputer to reduce error and cost	- lower costs than personal interview - expanded geographic coverage without dramatic increase in costs - uses fewer, more highly skilled interviewers - reduced interviewer bias - fastest completion time - better access to hard-to-reach respondents through repeated call-backs - can use computerized random digit-dialling - CATI-computer-assisted telephone interviewing: responses can be entered directly into a computer file to reduce error and cost	- often lowest cost option - expanded geographic coverage without increase in cost - requires minimal staff - perceived as more anonymous - allows respondents time to think about questions - allows contact with otherwise inaccessible respondents (i.e. CEOs)
Disadvantages	- High costs - Need for highly trained interviewers - Longer period needed in the field collecting data - May be wide geographic dispersion - Follow-up is labour intensive - Not all respondents are available or accessible - Some respondents are unwilling to talk to strangers in their homes - Some neighbourhoods are difficult to visit - Questions may be altered or respondent coached by interviewers	- response rate is lower than for personal interview - higher costs if interviewing geographically dispersed sample - interview length must be limited - many phone numbers are unlisted or not working, making directory listing unreliable - some target groups are not available by phone - illustrations cannot be used - responses may be less complete	- low response rate - no interviewer intervention available (for probing or explanation) - cannot be long/complex - accurate mailing lists needed - often respondents returning survey represent extremes of the population (skewed responses)

(Source: Cooper and Emory (1995))

In order to overcome the predicted low response rate, some techniques are used aiming at motivating the participation of the respondents (Ghauri and Gronhaug, 2002; Diamantopoulos and Souchon, 1996):

(1) *Pre-contact* ➔ firms were contacted by phone in advance with the aim of checking that the address given by the Europages database was correct and the aim of asking for the name of the managing director or CEO

(2) *Sponsor* ➔ the name of University of Glasgow appeared in the mailed questionnaire, since it inspires feelings of reliability and respect.

(3) *Appeal* ➔ a brief explanation of the goals of the research and the important role of the respondent in enabling its realisation is included.

(4) *Stimulus* ➔ a detailed report assessing their firm in comparison with the rest of the participants was offered to the respondents as a reward and gratitude for their collaboration

(5) *Format* → a trade-off was made with respect to the length of the questionnaire, since it is long (twelve pages) and it could discourage the respondents from answering. However, the pilot study allowed confirming its appropriateness. On the other hand, the layout of the questionnaire is quite friendly and clear, hence it should positively influence on the decision of participating.

(6) *Covering letter* → a covering letter was included in order to explain the objectives of the research, the reward offered for their participation and also to highlight the interest on aggregated results and the confidentiality of the data provided. As Ghauri and Gronhaug (2002) comment, the tone and stance of the covering letter is highly influential (see Appendix II),

(7) *Stamped and self-addressed envelope* → a stamped and self-addressed envelope was included together with the questionnaire, for the respondent to have all the facilities to send the answers back, since any effort or cost should be avoided.

(8) *Reminders* → after a period, reminders including a new questionnaire and new stamped and self-addressed envelope were sent. It has been proved to be an effective technique to increase the response rate, although cost constraints should always be taken into account.

Before passing to comment the research instrument and the respondents, the sampling methods will be addressed in the next section.

6.6 Sampling

The underlying implication of carrying out quantitative analysis is that inference will be made from data representing the total population. Therefore, it is important to make sure that the sample is adequate to draw conclusions about the population.

The *population* of a research is defined as the units belonging to the category of interest. In this case the population of interest is SMEs, located all over the UK and with manufacturing facilities. In order to exactly identify the elements of the total

population, a list named *sampling frame* is developed. Then, the *sample* used for the survey is extracted from the sampling frame.

Since the initial aim was to make a comparative study between the UK and Spain, databases including firms located in both countries were sought. The first idea that came up was to check whether the European Union provides any informative service about the businesses running within the European Union. The online database EuroPages was discovered. This database provides information about firms in all the countries of the EU and allows searches according to different criteria: name, sector, size, specific location, type of activity... These options were very valuable, as it allowed to extract the listing of companies according to the *criteria* pursued by this research (commented in Chapter 4):

- *SMEs* → the size ranges in EuroPages pass from less than 200 to less than 500 employees, hence, the listing frame of the present research include those companies with less than 200 employees. Although the turnover is also a determinant of SMEs, this information is not always provided by EuroPages neither is given as a search option. Therefore, only size determined the list of SMEs, though the turnover of the respondents was checked to see their appropriateness.
- *Sector* → all the mechanical engineering and machine sub sectors were included.
- *Location* → UK as a whole.
- *Manufacturers* option was also selected.

Other databases such as KellySearch, Applegate or Yell among others and the websites of the companies were consulted when there was the need of checking some data. The researcher was aware of other private databases such as Dunn and Bradstreet or Kompass which hold an important amount of information about firms, however, this information must be purchased. Thus, due to the financial constraints the free online database Europages was employed.

Having selected the required criteria, a more manageable database of the sampling frame was built in the format of spreadsheet. The characteristics of the population are broken down as Table 16 describes:

Table 16: Characteristics of the Population of the present research

Workforce	Frequency	Percentage
1-10	284	10.29%
11-50	1926	69.78%
51-100	375	13.59%
1001-200	175	6.34%
Total	2760	100.00%
Turnover		
blank	1188	43.04%
0-1	317	11.49%
1-2.5	563	20.40%
2.5-5	330	11.96%
5-10	176	6.38%
11-50	117	4.24%
>50	69	2.50%
Total	2760	100.00%
Location		
Birmingham / Midlands	607	21.99%
Manchester / North West	506	18.33%
Newcastle-upon-Tyne / North East	346	12.54%
Norwich / East	295	10.69%
Reading / South Central	224	8.12%
Exeter, Bristol / South West	199	7.21%
Edinburgh / Scotland	151	5.47%
Brighton / South East	137	4.96%
London and area	111	4.02%
Cardiff / Wales	102	3.70%
Belfast / Northern Ireland	68	2.46%
Other regions	14	0.51%
Total UK	2760	100.00%

Once the population was clearly defined, the researcher decided the sampling method.

There are several *sampling techniques* that can be grouped into two main categories: probability and non-probability sampling. As their names indicate, the main difference resides in the usage of probability methods in the selection of the sample. The definition of the various sampling methods is shown in Table 17.

Table 17: Sampling methods

Probability Sampling (each member of the population has a known non-zero probability of being selected)	
Random sampling	Each member of the population has an equal and known chance of being selected.
Systematic sampling	Also called an Nth name selection technique. After the required sample size has been calculated, every Nth record is selected from a list of population members.
Stratified sampling	Random sampling used to select a *sufficient* number of subjects from each stratum, that is, each subset of the population that share at least one common characteristic.
Non-Probability Sampling (members are selected from the population in some non random manner)	
Convenience sampling	As the name implies, the sample is selected because they are convenient.
Judgement sampling	The researcher selects the sample based on judgment (usually an extension of convenience sampling)
Quota sampling	Like stratified sampling, the researcher first identifies the stratums and their proportions as they are represented in the population. Then convenience or judgment sampling is used to select the required number of subjects from each stratum.
Snowball sampling	Snowball sampling relies on referrals from initial subjects to generate additional subjects.

(Source: adapted from StatPac website (accessed on 5/11/05))

The purest sampling method is probability sampling. However, non-probability sampling usually provides superior response rates at the expense of introducing a sort of bias. The advantage of using *probability sampling* methods is that sampling error, that is, the degree of potential difference between population and sample, can be calculated, while in *non-probability sampling* this error remains unknown (StatPac website, accessed on 5/11/05). Thus, probability sampling was selected and, concretely, the systematic sampling due to practical reasons.

Regarding the sample size, there are different theoretical and practical considerations which should be taken into account. Practical considerations include cost, time and labour issues. However, the most important factor when determining the sample size is the population variance, since the greater the variance of the population is, the larger sample is needed (Cooper and Emory, 1995). In relation to the present study, this information is unknown; hence a sample size of 1500 firms (54.34% of the entire population) was considered adequate.

An underlying assumption of this study is the assumption of sample homogeneity. In spite of having limited the study to those manufacturing firms within the mechanical engineering sector in order to account for the variability across different industries or sectors, there are still a variety of sub-sectors that are distinguishable among each other to some extent. However, this study has assumed that the sample is homogenous and, therefore, comparable. Though not entirely true, a trade-off had to be done in order to be able to employ quantitative methods. Such methods require large number of cases, which would not have been achieved if focusing on a single sub-sector due to their small population. Thus, the assumption about the homogeneity of the sample is a limitation of the present research. Nevertheless, given that the sample has been narrowed down to those firms which are manufacturers (whose situation is completely different from those which provide services), and which are within the mechanical engineering sector, I believe this limitation is of lesser importance in comparison to other limitations such as being a cross-sectional study.

6.7 Key Informants

The questionnaires were addressed to the CEO or managing director of the companies. Table 18 shows that the majority of the non-anonymous answers were indeed completed by the managing director.

Table 18: Demographics of Respondents

	Frequency	Percentage
M.D.	100	62.89%
IT manager	2	1.26%
Other departmental manager	13	8.18%
Others	4	2.52%
Total	119	74.84%
Anonymous	40	25.16%
Total	*159*	*100%*

Although the use of single respondents is a common practice within positivistic organisational research (like most studies shown in Tables 3 and 4, which focus on

large companies), one could argue that a single-respondent is biased or does not provide an objective response. This would result in what is called common-method bias.

However, SMEs are simpler organisations compared to larger ones, so the senior managers usually have a comprehensive knowledge of the organisational processes and issues (Caldeira and Ward, 2002). Other authors also corroborates the suitability of CEOs in SMEs in order to inform about the activities of the firm, in contrast to large firms:

"*in large firms CEOs might be separated from "how a firm operates" by layers of middle-managers". This is less likely a problem for small and medium sized businesses*" (Wiklund and Shepherd, 2003: 1310).

Similarly, the use of single respondents does not allow to evaluate different opinions about the organisation, as for example, regarding the organisational culture. However, the assumption of a single culture may be applied to SMEs since the formation of sub-cultures is less significant than in larger firms:

"... the organisational learning has been developed on the assumption that executives can assess accurately the levels of organisational learning and the extent to which this learning is focused in their organisation. This assumption may apply ... small firms but the assumption does become challenged with the complexity of organisational learning and the formation of sub-cultures of learning in larger firms" Jashapara (2003: 45)

Therefore, this study's assumption of being managing directors or CEOs the most appropriate respondents to inform about the current practices in the firm seems to be supported since the firm is the unit of analysis of the present research. Nevertheless, it must be highlighted that data are based on manager's perceptions, rather that organisational attributes (Sabherwal et al, 2003). When discussing this type of limitation, Birkinshaw et al (2002) state that "*the measures of knowledge, interestingly, can probably not be collected in any other way because in such things perception is reality*" (p. 286)

6.8 Data collection instrument

Questionnaire development

The questionnaire was developed as a result of the extensive review of existing literature. It consists of twelve pages, divided into four main sections. The first section includes questions regarding the characteristics of the firm (e.g. type of products, size, type of structure, etc.). The second section deals with questions on knowledge management practices. Within this section there are two parts: while it starts with an assessment of what practices do the firms perform, the following part concentrates on the way these practices are carried out. The third section is concerned about information and communication technologies capabilities. It begins with a list of possible technologies used by the firm in order to be ticked and evaluated according to their importance. It continues with a list of questions on practices with regard to information systems characteristics and skills. The fourth and final section includes questions about performance. In spite of following a logical order, some of the questions were misplaced on purpose aiming at improving the appearance of the questionnaire. The content of the questionnaire is fully explained in Chapter 5.

Discussion with Experts

The first draft of the questionnaire was repeatedly reviewed by the supervisors of the researcher. Furthermore, the questionnaire was administered to several academics and members of the researcher's department who have long experience on questionnaire development. In order to get their feedback after scrutinising the questionnaire, personal meetings were held.

The main mistakes found were double questions, ambiguous terms, difficult wording and loaded questions.

Also, it was suggested to rearrange the layout of the questionnaire, by transforming the grouping of the questions. As a result of these discussions, the questionnaire was

modified following the advices given by the experts and a much more appealing questionnaire was obtained. The final questionnaire is shown in Appendix I.

Another alternative could have been to develop the questionnaire by organizing focus groups with practitioners. However, apart from having to make a trade-off of time and effort, the topic is rather complex since it is highly based on intangible or invisible aspects. Therefore, the researcher decided to base it on the extensive literature existing.

Questionnaire Pre-test

In spite of testing the questionnaire with experts, the researcher believed that a dry-run of the survey with a small number of firms would be convenient in order to examine the real impact of the questionnaire in a survey and assess the response rate.

Thus, the questionnaire was mailed to 50 companies selected systematically from the sampling frame, together with a covering letter and a freepost self-addressed envelope and a covering letter. Previously, an email informing about the survey was sent to those firms that had email address. After three weeks, seven filled up questionnaires and other seven negative answers were received. Then, a reminder was sent, including a new questionnaire and a freepost self-envelope, which resulted in two more filled-up questionnaires and five new negatives to participate.

The final outcome was 9 filled-up answers, which means a response rate of 18%. This level of response rate is acceptable and even a response rate of 14% would have been acceptable since, although it seems low, this level is expected when dealing with small business managers due to their aversion for anything bureaucratic and that consumes time needlessly (Karimadaby and Brunn (1991) cited by Raymond et al. (2001)).
The reasons for non-participation stated by the firms were:

a) *Not enough time, being very busy*. SMEs are usually criticised for being too focused on the daily operations. So, this cause seems to be justified.

b) *Policy of the company*. Due to the huge amount of questionnaires that firms receive everyday, many companies have adopted the policy of not answering any questionnaire.

c) One company returned the questionnaire *without stating any reason* and without identification

d) Another firm argued that the questionnaire did *not meet the requirements* of the survey population, since it was part of a MNC of 25,000 employees. This answer was very useful because it highlighted the existence of dependent and independent SMEs, so it was decided to include a new question to control the dependency of the firms.

e) Also, an email communicating the researcher about the *liquidation* of a firm arrived. This was another significant issue to be considered in the final survey: how to identify those firms that had closed down, since 70% of SMEs shut down during the first 3 years of existence. This is very important from the point of view of the response rate, since it made the researcher aware of the fact that some of the firms surveyed could not exist anymore and that this could affect the response rate of the survey unnecessarily. Therefore, the researcher decided to modify the procedure in the final survey and make a preliminary contact by phone in order to check whether firms were still existing, whether the contact details were correct and finally, to ask for the name of the managing director or CEO to give a more personalized touch to the envelope. In this way, the response rate of the survey would be enhanced.

Finally, it must be remarked that all the completed questionnaires showed well understanding of the questions and contained very few missing values. The only question that was not answered in any of the usable questionnaires was the question enquiring about the SIC code, which gives information regarding the industrial sector to which the firm belongs. Since the database already selected the sample frame by sector, the researcher considered that such question could be removed from the questionnaire.

In conclusion, the pilot study was positive and very useful for the final survey. The questionnaire seemed to be an adequate and robust tool and the response rate was acceptable. However, in order to enhance the response rate, several strategies commented before were applied: phoning the firms in advance to filter the sample, check the contact details and manager's name, and control the non-existent firms.

Implementation of data collection

After re-designing this small detail in the questionnaire, the final survey was carried out in two waves, one targeting at 1000 firms, and the second one at 500 firms. The reason to do so was to allow an intermediate control and, if necessary, to introduce required measures.

In the first wave, as commented before, firms were contacted by phone in advance to inform them about the survey and to check their contact details and to ask for the managing director's name. Already at this stage, 140 firms out of 1000 were excluded from the survey. Fifty of them seemed not to exist any more. The remaining ones denied their participation due to different causes (no time, policy, etc.)

After updating the database with the correct contact details and the names of the manager directors, the questionnaire together with a freepost self-addressed envelope and a covering letter, was mailed to the manager directors of 860 firms. After three weeks a reminder, including a new questionnaire, was sent to those firms which had not replied yet. The results of this first wave can be seen in Table 19.

The results of this first wave were slightly different from the pilot study. The pilot study went better than the first wave of the final survey. This might be due to being in a busy period (end of the year), which was highlighted by seven firms as a reason for not answering. The pattern of behaviour in answering was also different: in the pilot study the reminders did not make a great impact on the response rate, while in the survey they considerably improved it.

Either by phone or from the mailed answers, it was found out that 73 firms were not valid since the firms were not existing any longer or since they did not meet the criteria of the research (mainly not being SMEs or manufacturers). This information made the researcher aware of the inaccuracy of the used database. The non-respondent firms were tracked with the aim of "cleaning up" the sampling frame. As a result, the number of estimated valid questionnaires sent was 748.

Considering the unreliability of the database, in the second wave a more restricting preliminary phone contact was undertaken, asking more details regarding the size and the production activities. In this way, invalid firms were filtered in advance. The effect of such initiative was very positive, as it reduced the number of useless questionnaires delivered and unusable filled-up questionnaires. In consequence, no respondents (except of one, who belonged to the farming sector) wasted their time in collaborating in this research and the wasted expenditure in mailing to invalid firms was avoided. Furthermore, it must be remarked the greater response answer in the second wave (see Table 19), although two respondents also stated the fact of being immerse in a high workload period. This can illustrate the high pressure under which SMEs constantly perform. On the whole, the average response rate of the survey was 15.17%, which can be considered acceptable. Chaston et al. (2001) warn: "*over the last two years, the authors and other researchers have been experiencing a significant decline (from 30 percent to less than 10 percent in some cases) in response rates to surveys mailed to UK SME sector firms*" (p.144). Therefore, the response rate achieved can be considered rather positive. See Table 19 for full details regarding the response rate.

Table 19: Responses to the survey

	First wave		*Second wave*		*Total*
	First mailing	*Reminder*	*First mailing*	*Reminder*	
Initial sample	1000		500		1500
	Pre-contact by phone - Contact details - Manager director's name		- Contact details - Manager director's name - Size - Production facilities		
Questionnaires sent	860	624	301	257	1161
Valid questionnaires sent	(748)	(543)	(300)		(1048)
Not return	725	578	259	212	672
Return	135	147	44	50	376
Total Response rate	**37.70%**		**31.33%**		
Rejections	62	102	20	21	205
Filled up	73	45	24	29	171
Positive Response rate	**13.72%**		**17.61%**		**14.73%**
Unusable answers	9	1	1	1	
Usable answers	64	44	23	28	
Valid Response rate	**14.43%**		**17%**		**15.17%**

The non-response bias was assessed using two alternative methods: the justification of non-response and differences between early and late respondents.

The examination of the reasons given for not participating shows no concern about the results since they are expected given the characteristics of the population targeted, survey method, and the questionnaire. The main reasons are summarized in Table 20. The most frequent reasons were the lack of time or being too small. Small firms did not feel valuable or relevant for the research. Some of them expressed their concern of distorting the final results. Also, it was striking that, while in the pilot study none of the firms claimed that the questionnaire was too long or complex, there were 13 firms in the final survey that found it too comprehensive.

Table 20: Analysis of non-responses

Reasons	First wave		Second wave		Total
	First mailing	Reminder	First mailing	Reminder	
No reason - unable	20	31	9	5	65
No time - too busy - no resources	13	14	4	5	36
Too small - no relevant - distortion	8	17		3	28
Too long, questions, too theoretical	3	5	1	4	13
Policy	2	8	1	1	12
Confidentiality	2	3	1		6
Illness - retiring – new in the position	1	3		1	5
Away on Business	2	1		1	4
No information available - Send to HQ	2	2			4
Re-structuration	1	2			3
Others	2				2

The non-response bias was assessed by analysing the differences between early and late respondents with respect to the means of the key variables (Amstrong and Overton, 1977). The respondents are divided into early respondents if they responded before issuing the reminder, and into late respondents if they answered after receiving the reminder. Results show that the differences in the means are insignificant (Table 21).

Table 21: Comparison of early and late responses

	Early Responses		Late Responses	
	N	Mean	N	Mean
Organisational culture	83	4.28	73	4.13
Strategic Alignment	83	3.85	74	3.67
Collective learning	84	4.11	75	4.03
Individuals knowledge identification	84	4.39	75	4.37
Research valuation	82	3.75	74	3.59
External sources	83	3.66	75	3.32
Encouragement to participate	84	4.19	74	4.02
Organisational Integration	84	3.53	75	3.47
Resource availability	84	4.02	75	4.04
Support for collaboration	83	3.40	74	3.20
Incentive for knowledge sharing	81	3.07	73	3.12
Internal distribution of knowledge	84	3.73	75	3.67
Knowledge exchange with partners	84	3.29	72	3.29
IT technical intercommunication	83	3.60	71	3.54
IT special characteristics	82	2.70	71	2.70
Technical compatibility	84	2.81	72	2.82
IT skills by non-technical people	79	3.47	71	3.31
Individual expertise	84	3.26	72	3.36
Business support by IS	82	3.44	72	3.51
IT managerial skills	82	3.28	72	3.24
Effectiveness	81	4.44	72	4.53
Flexibility	83	4.84	73	4.81

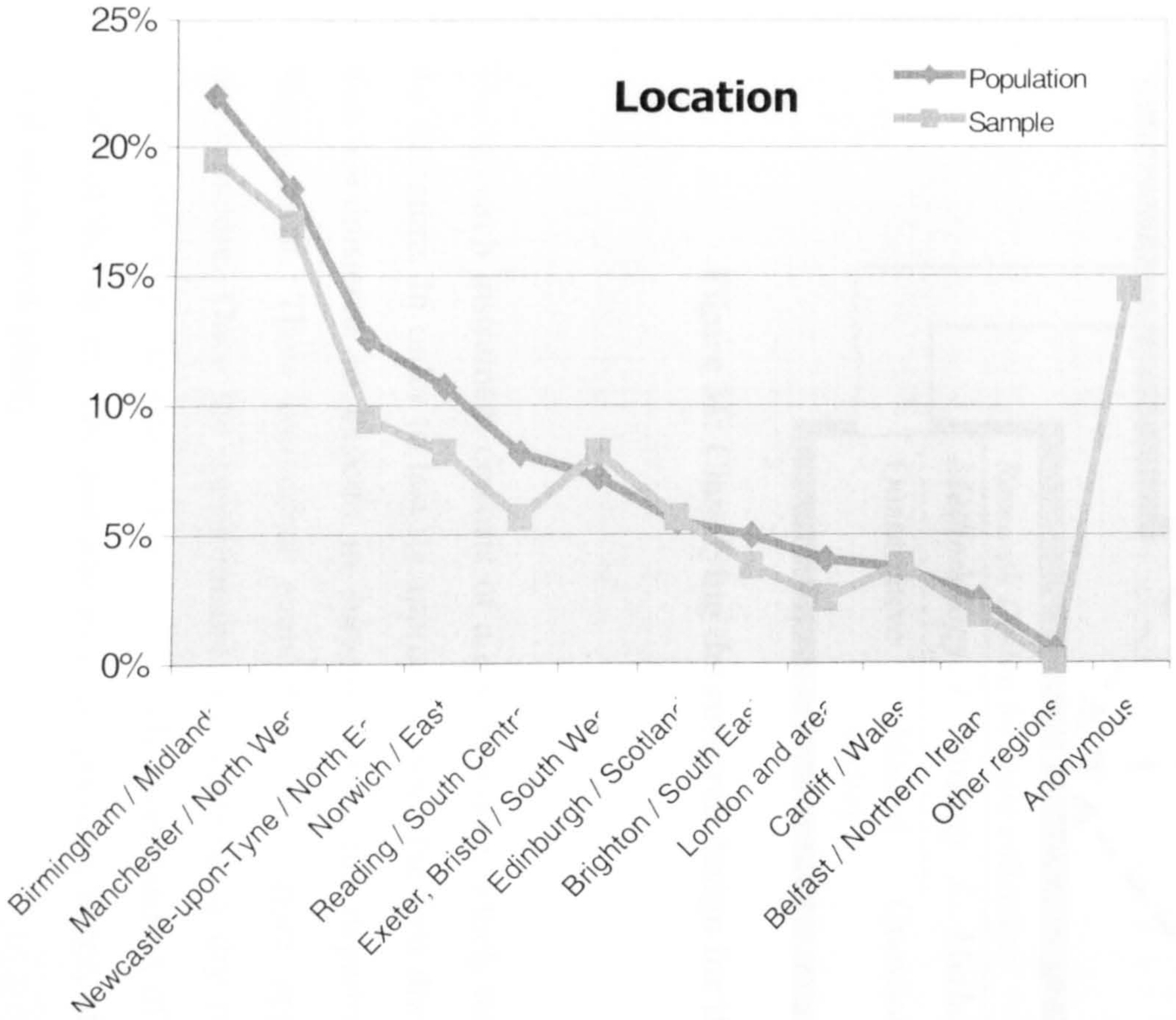
All in all, the sample obtained should represent the entire population. The characteristics of the sample are compared to the entire population in relation to the information given by the database, that is, size, turnover and location. In general, it shows a good representativeness of the population by the sample (see Table 22 and Figures 30).

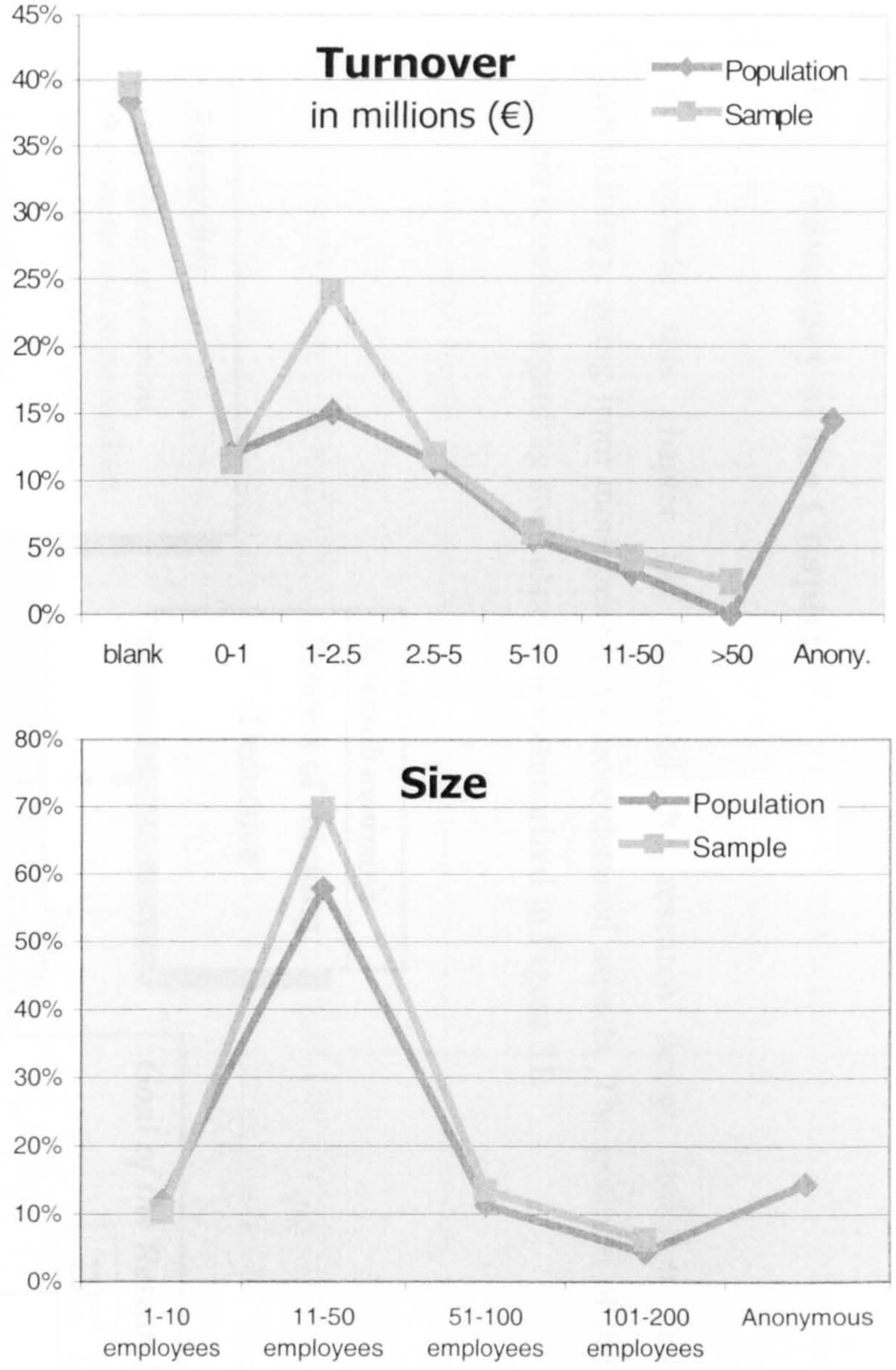
Table 22: Characteristics of the sample obtained

Workforce	Frequency	Percentage
1-10	19	11.95%
11-50	92	57.86%
51-100	18	11.32%
1001-200	7	4.40%
Anonymous	23	14.47%
Total	159	100%

Turnover		
blank	61	38.36%
0-1	19	11.95%
1-2.5	24	15.09%
2.5-5	18	11.32%
5-10	9	5.66%
11-50	5	3.14%
>50	0	0.00%
Anonymous	23	14.47%
Total	159	100%

Location		
Birmingham / Midlands	31	19.50%
Manchester / North West	31	19.50%
Newcastle-upon-Tyne / North East	17	10.69%
Norwich / East	14	8.81%
Reading / South Central	11	6.92%
Exeter, Bristol / South West	14	8.81%
Edinburgh / Scotland	8	5.03%
Brighton / South East	7	4.40%
London and area	4	2.52%
Cardiff / Wales	7	4.40%
Belfast / Northern Ireland	3	1.89%
Other regions	0	0.00%
Anonymous	15	9.43%
Total UK	159	100%





Figures 30: Comparison of the characteristics of the population and the sample of firms obtained

6.9 Summary of the Chapter

To conclude, this chapter has described the research design research and methodology, going from more general to more detailed aspects. The position of the present research regarding such aspects is summarized in Figure 31:

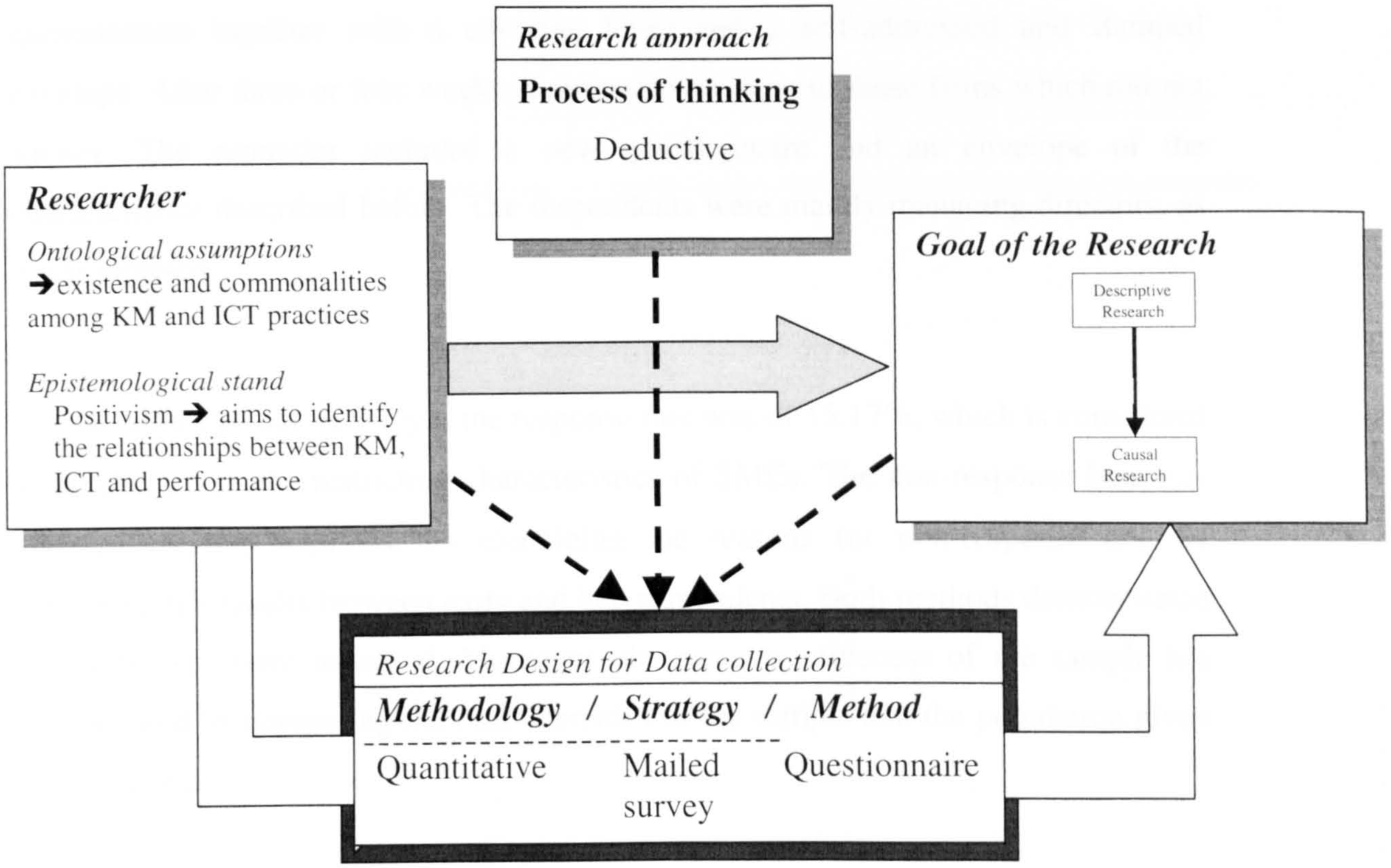


Figure 31: Classifying the research design for the thesis

The research instrument consists of a questionnaire, which was developed based on the literature. In order to test its appropriateness, the first draft of the questionnaire was administered to experts in surveys within the department of Business and Management. Their comments enabled a much more appealing and effective questionnaire. Once the questionnaire was updated, a dry run of the survey was carried out with the aim of testing the well understanding of the questions and the results of the survey. The outcome was very positive, hence, after minor changes, the final survey took place.

When designing this research, some decisions and compromises in relation to the time, cost and accessibility limitations had to be done. Finally, the survey was implemented by mail in two stages, which allowed the introduction of intermediate initiatives in order to increase the response rate. For example, the unreliability of the database used was found out. Thus, a pre-screening of the sampling frame was necessary. The general procedure was to pre-contact the firms by phone in order to filter the valid firms in advance and after send to their manager directors a questionnaire together with a covering letter and a self-addressed and stamped envelope. After three or four weeks, a reminder was sent to those firms which did not answer. The reminder included a new questionnaire and an envelope of the characteristics described before. The respondents were mainly managing directors, as it was targeted.

In total, although not very high, the response rate was of 15.17%, which is considered acceptable given the restricting characteristics of SMEs. The non-response bias was assessed by two methods: by examining the reasons for non-response and by comparing the results between early and late respondents. Both methods demonstrated that responses were unbiased. Moreover, the representativeness of the sample has been assured by comparing the characteristics of the sample and the population given by the database.

Since the sample seems adequate, the analyses of the answers will take place in the next chapters.

Chapter 7: Descriptive Statistics

The purpose of this chapter is to:

(1) Describe the nature of the firms that filled up the questionnaire in regard to the organisational characteristics

(2) Discuss the state of knowledge management practices in these firms according to how frequently they take place and their importance for the organisations

(3) Describe some characteristics related to ICTs and discuss the use of specific ICTs according to how frequently they are adopted and their importance for the organisations

(4) Discuss in relation to the results the following questions (also outlined in Chapter 5) in relation with the literature:

- Are there specific knowledge management practices more influential on performance than others?
- Are there specific ICT that are more frequently associated to better performance?

(5) Present a preliminary analysis of the existing relationships among variables based on bivariate analysis

7.1 Introduction

The results gathered through the mailed survey were statistically analysed and the results are presented in Chapter 7 and 8. Chapter 7 focuses on more simple analysis, describing the variables themselves and analysing some bivariate relationships. Undertaking a more complex analysis, Chapter 8 deals with multivariate statistical techniques, with the aim of summarizing the data and analysing the relationships between dependent and independent variables.

The descriptive analysis is divided in four main parts. First, the general characteristics of the sample firms are described, followed by a second section about the analysis of the organisational performance indicators. In order to analyse the relationship between organisational performance and contextual factors, correlation analysis is performed. Third, the current state of knowledge management practices is studied individually and in relation with organisational performance. In the same way, ICT and different variables related are examined in the fourth section. The chapter ends by summarizing the most significant results.

When studying the *bivariate relationship* among variables, there are several measures of association that can be used depending on the nature of the data (Cramer's V for nominal data, Spearman's Rho for ordinal data, and Pearson's correlation for continuous data). Given the assumption of viewing Likert scales as interval data, Pearson's correlation is performed in most of the cases. However, this correlation coefficient is based on the premise that the variables subject to analysis are linearly interrelated. The most common method to test linearity is by plotting the variables and check for linear relationships. Plots were examined and no signs of non-linearity were found. In consequence, Pearson's correlation is used to analyse the strength and direction of such relationships. In the few cases where one of the variables are categorical or nominal, Spearman's Rho and Cramer's V are used.

Another point to be commented is that *missing data* were not replaced by any value, since they were not many in amount and the action could mislead the results. The option of excluding the missing variables given by SPSS has been chosen.

7.2 Firm General Characteristics

As Tsoukas and Vladimirou (2001) claim, organisational knowledge is highly shaped by the organisational context. Thus, the differentiation according to organisational characteristics such as size or internal turbulence might give useful insights on the analysis of the state of knowledge management. In fact, to the best of my knowledge, this study will address, for the first time, the study of knowledge management in manufacturing SMEs in relation with organisational performance using quantitative methods. Similarly, the characteristics of the firm might determine the use of ICT (Ravichandran and Lertwongsatien, 2005; Droge et al., 2003). Thus, it has been considered appropriate to analyse in detail the characteristics of the sample firms.

- *Main products*

As expected within the mechanical engineering and machine sector, the main product of most of the firms (55%) is machinery, followed by materials (28,5%), consumer products (5.7%) and others (10.8%).

- *Production process*

Given that firms produce in small batches (48%) or specialized products (24%), it can be stated that firms have low production routineness, defined by Lin and Germain (2003) as "*the level of repetitiveness in transforming inputs into outputs*" (p.1134).

Table 23: Descriptive statistics of contextual variables

Characteristics	Frequency	Percent
Main products	(N=158)	
machinery	87	55.1
materials	45	28.5
consumer products	9	5.7
others	17	10.8
Production process	(N=152)	
single	37	24.3
small	73	48
large	18	11.8
mass	19	12.5
don't know	5	3.3

- *Size*

The sample is constituted by small (14%) but mainly by medium (86%) firms, which remains almost in the same proportion as five years ago (13% and 87% respectively). Furthermore, equal proportions of firms have undergone downsizing (32%) and have increased their size (32%). However, the downsizing tends to be more dramatic (up to 140 employees less, compared to the 40 employees extra incorporated in the larger firms). These facts might be an indicator of the volatility of SMEs as consequence of their instability.

Table 23. Descriptive statistics of contextual variables (continued)

Characteristics	Frequency	Percent
Number of employees		(N=157)
<5	5	3.2
6-10	17	10.8
11-25	57	36.3
26-50	40	25.5
51-100	28	17.8
100-200	10	6.4
N.employees (5 years ago)		(N=146)
<5	7	4.8
6-10	12	8.2
11-25	57	39.0
26-50	40	27.4
51-100	15	10.3
100-200	15	10.3

In the literature, size is usually transformed into logarithm in order to correct its skewness. Here size is also skewed, hence the logarithmic transformation has been performed (Tabachnik and Fidell, 2001).

- *Proportion of employees involved in R&D*

Regarding the number of employees involved in R&D, the amount of firms without any R&D activity remains the same as five years ago (around 33%). Furthermore, it is observed that 63% of the firms have not changed the proportion of staff dedicated to R&D tasks while the remaining firms have tended to slightly increase it. While 11.2 % of the firms have decreased the proportion of R&D staff, almost 26% of the firms have augmented it. These percentages include the cases of firms

Table 23. Descriptive statistics of contextual variables (continued)

Characteristics	Frequency	Percent
% employees in R&D		(N=151)
None	51	33.8
0%-20%	92	60.9
>20%	8	5.3
% employees in R&D (5 years ago)		(N=145)
None	48	33.1
0%-20%	91	62.8
>20%	6	4.1
R&D outsourcing		(N=156)
no	128	82.1
yes	28	17.9
R&D outsourcing (5 years ago)		(N=150)
no	130	86.7
yes	20	13.3

that have decided not to outsource anymore their R&D function (1.3%) and those which have opted for outsourcing (6%). Thus, a trend to outsource the R&D function (12.6% outsourced five years ago, while currently 17.6%) has been detected. It seems that more firms decide to specialize on manufacturing and outsource their R&D activity. This fact is rather surprising, given the extreme competition from low-cost labour countries, firms should be aware that the engagement in R&D might be one of the most crucial sources of competitive advantage.

- *Proportion of employees involved in IS*

Similarly, the evolution of employees involved in information systems has been examined. Five years ago, 30% of the firms did not have any person dedicated to information systems and the proportion of firms with more than 20% of their staff in IS was of 4.9%. Nowadays, however, the amount of firms without any IS staff has been reduced to 22.4% and those with more than 20% of their staff involved in IS has reached 10.9%. This supports the argument of Caldeira and Ward (2002), SMEs have recently embraced ICT. Thus, 55.3% of the firms continue with the same proportion of staff specialized in IS, while the remaining firms tend to increase this proportion (37.6% compared to the 7.1% which have reduced the staff in IS). This fact indicates that IS are taking a more important role in SMEs activities and re-affirms the importance of the research being conducted here. These data also agree with the weak tendency not to outsource any more the IS function (17.6% outsourced five years ago, while currently 15%). The decision of keeping the IS related activities in-house might show the increased awareness of firms regarding the strategic potential of information systems.

Table 23. Descriptive statistics of contextual variables (continued)

Characteristics	Frequency	Percent
% employees in IS (N=147)		
None	33	22.4
0%-20%	98	66.7
>20%	16	10.9
% employees in IS (5 years ago) (N=142)		
None	43	30.3
0%-20%	92	64.8
>20%	7	4.9
IS outsourcing (N=153)		
no	130	85.0
yes	23	15.0
IS outsourcing (5 years ago) (N=148)		
no	122	82.4
yes	26	17.6

- *Structure*

The main type of structure reported is hierarchical (64%), followed by flat structures (25.6%). This contrasts the argument exposed in Chapter 4, where it is stated that SMEs as less hierarchical and flatter than larger firms. Nevertheless, due to their small size, hierarchical structures in SMEs are quite flatter as they usually formed by few layers.

Paying attention to the organisational structure is important, since flatter structures allow better communication within firms due to the lesser bureaucracy. Also, this kind of firms is able to restructure their organisation more easily and, therefore, be more flexible and agile to cope with unexpected situations. Hence, difference in performance depending on the organisational structure will be tested.

Table 23. Descriptive statistics of contextual variables (continued)

Characteristics	Frequency	Percent
Structure	(N=123)	
hierarchical	100	64.1
flat	40	25.6
matrix	8	5.1
flexible	7	4.5
others	1	0.6
Dependence	(N=159)	
autonomous	128	80.5
subsidiary	31	19.5

- *Dependence*

The majority of the sample firms are autonomous (80.5%) while the remaining ones (19.5%) are subsidiaries of other firms. One might intuit that the latter ones are more likely to outsource their R&D and IS activities than the former ones. However, statistical tests do not show any correlation between the two facts.

On the contrary, there has been found a relationship between size and autonomy of the firm. Generally, autonomous firms tend to be smaller than subsidiaries. Due to the lack of backup by other firms, autonomous firms might need to remain small in order to cope better with the uncertainties of the market, discarding the risk of following strategies of economies of scale.

- *Age*

Most of the firms are reasonably well established with some operating for more than 100 years. Only 3.3% of the firms indicate being less than five years old. This demonstrates that the mechanical engineering sector is traditional and reasonable stable in the UK economy. However, the lack of young businesses may be due to fact that they have not been registered in databases yet or, maybe more probably, due to the uncertain situation of the sector facing aggressive competition from Asian and East European markets.

On the other hand, age might be an indicator of the accumulated experience and knowledge along their existence, which have shaped the current practices. Hence, it will be tested as a control variable.

- *Total sales in 2003*

As commented in Chapter 5, sample firms have to be checked in relation to their turnover, since the database used does not provide enough information about it. The result is that all the firms meet the criteria of SMEs defined by the EU, that is, producing a turnover of less than €50 million. The difference in turnover between firms is quite significant, from less than £0.5 million to up to £36 million.

Table 23. Descriptive statistics of contextual variables (continued)

Characteristics	Frequency	Percent
Age	(N=153)	
<5	5	3.3
6-10	10	6.5
11-15	10	6.5
16-20	18	11.8
21-30	34	22.2
31-40	39	25.5
41-60	19	12.4
61-100	8	5.2
>100	10	6.5
Total sales (in 2003, £m)	(N=123)	
<0.5	6	3.8
0.51 - 1	22	13.8
1.01 - 2.5	49	30.8
2.51 - 5	22	13.8
5.01 – 10	13	8.2
10.01 - 40	11	6.9

There has been found a positive relationship between turnover and dependence of the firm and, following the relation between dependence and size, between turnover and size. This suggests that subsidiaries and larger firms are related to greater turnover than autonomous and small firms. The most obvious explanation of such relationship is the fact that larger and subsidiary firms can apply economies of scale and have

more resources available to deal with the market constraints, while the advantages of smaller and autonomous firms might not appear reflected in their turnover, but in their flexibility. On the contrary, there has not been found any statistical relationship between turnover and age, location, process or product types, hence, no association can be pointed regarding these characteristics. These results, however, should be cautiously considered since they are based on a snapshot (2003) and fail to capture the investments along the years.

- *Formal education*

Traditional SMEs have been known for their lack of formal expertise. The results confirm the low education level, being the average of school leavers of 75.85% and of postgraduates, of 1.47%. It can be expected that activities regarding R&D and IS might require higher levels of expertise. Following this line of reasoning, this assumption has been statistically corroborated, showing a relationship between the proportion of postgraduates and the proportion of staff employed in R&D and IS.

Table 23. Descriptive statistics of contextual variables (continued)

Characteristics		Mean	S.D.
Formal education			
% School leavers	(N=152)	75.85	23.87
% College graduates	(N=152)	15.63	19.19
% University graduates	(N=152)	6.15	8.19
% Postgraduates	(N=150)	1.47	4.19

- *Nature of Internal communication*

The frequency and nature of internal communication within firms is an important factor to be considered when analysing knowledge transfer. Firms whose departments are highly engaged in communicating among each other are more likely to take advantage of the benefits of acquiring and applying knowledge. Thus, a summated scale of the ratings allocated to each department is used to measure the level of internal communication. Differences in the descriptive statistics regarding the departmental communicative activities have been found. Departments dealing with primary activities and cost related activities (production, sales, purchasing and finance) are rated higher than supportive departments such as HRM, IS and R&D. This could indicate that firms are not making full use of the advantages provided by these departments.

- *Dispersion*

Regarding firms' dispersion, it must be said that firms tend to be concentrated on the same site. A third of the firms have reported having sites in other locations. However, it is remarkable that most of them are located abroad, within and beyond the EU. This fact corresponds with the current situation, in which traditional manufacturing firms are moving their facilities or opening new ones in countries where the labour cost is significantly cheaper. Indeed, those firms which are dependent are highly related to the dispersion within and beyond EU. Also there has been found relationship between dispersion and turnover.

Table 23. Descriptive statistics of contextual variables (continued)

Characteristics	Frequency	Percent
Dispersion (yes / no) (N=148)		
No other sites	95	64.2
Other sites	53	35.8

Characteristics		Mean	S.D.
Dispersion (location)	(N=148)		
locally	(N=147)	.24	0.80
within the country	(N=149)	.16	0.58
within the EU	(N=148)	.46	1.66
beyond the EU	(N=148)	.51	1.68

Since information and communication technologies offer the great potential of overcoming time and space constraints, the relationship between ICT and those firms with more than one site will be analysed later.

- *Technological turbulence*

In order to analyse the level of change to which SMEs are subject, a scale has been borrowed from the literature (Lin and Germain, 2003). This scale measures the dynamism in products and processes in relation to their logistic processes, their product life cycle, their core production processes and the introduction of new products. The reliability of such scale has proved to be adequate (Cronbach alpha=0.88).

Table 23. Descriptive statistics of contextual variables (continued)

Characteristics	Frequency	Percent
Turbulence (N=146)		
1	8	5.48
2	17	11.64
3	42	28.77
4	58	39.73
5	21	14.38

NOTE: 1: no change within the last 5 years
3: small changes in the last 3 years
5: significant changes within the last year

Generally, firms have reported high level of changes within their firms. In particular, the introduction of new products creates greater changes within companies. The investigation of the level of turbulence which firms undergo seems to be crucial within the knowledge management area, since the level of change appears to be intrinsically related to aspects such as flexibility and continuous adaptability and learning.

Correlations show that turbulence is significantly related to flexibility (see Appendix IV). Mintzberg (1971) states that those firms experiencing higher uncertainty usually tend to have organic structures which enhance flexibility and adaptability (Lin and Germain, 2003). In this case, the relationship between non-hierarchical structures and greater turbulence has not been found. This might indicate that Mintzberg's argument is valid for larger firms, since SMEs are quite flexible due to their small size.

- *Control*

The level of control exerted within firms has also been measured according to a scale developed by Khandwalla (1974) and used by Lin and Germain (2003), which has proved to be reliable (Cronbach alpha=0.73) although for unidimensionality reasons, an item has been removed. This construct includes items regarding the frequency of comprehensive management and IS control, frequency of centres for cost control, frequency of quality control operations and frequency of formal appraisal of personnel. In general, the level of control over the processes of the firms is quite high, especially the control applied for quality purposes.

Table 23. Descriptive statistics of contextual variables (continued)

Characteristics	Frequency	Percent
Control (N=149)		
1 (never)	18	12.08
2 (once)	22	14.77
3 (every 6 months)	36	24.16
4 (monthly)	37	24.83
5 (weekly)	36	24.16
NOTE: In the last year		
Empowerment (N=146)		
1	48	32.88
2	63	43.15
3	28	19.18
4	4	2.74
5	3	2.05
NOTE: 1: decisions made at general manager level 5: decisions made at the shop level		

Control is considered an important factor to be included in this research, given their influence on aspects such the organisational culture and on the feedback and reflection processes. Firms will be able to improve their performance by gathering enough information of their current activity and reflecting on their adequacy.

However, an excessive control on the organisational processes might have negative consequences on the organisational culture, since employees might feel under continuous surveillance or pressure. In order to investigate the real impact of control on these organisational aspects, control is included in the analysis of the multivariate relationships.

- *Empowerment*

Aiming at analysing the impact of the empowerment level, an existing scale (Miller and Droge, 1986; Lin and Germain, 2003) has been adopted. Such scale measures the level at which decisions on factory/warehouse location planning, new process design/research budgeting, IS and inventory planning are made. The reliability of this measure has resulted in a Cronbach alpha=0.79, after removing an indicator due to not meeting unidimensionality criteria. The results show that decisions are quite centrally made, that is, that the manager director is usually the one who makes decisions. Only decisions on the inventory planning appear to be more decentralized. In fact, techniques such as just-in-time production or the implementation of ERP involves high empowerment of employees over inventory decisions. In some cases firms even delegate communications with suppliers and clients to those employees directly involved in managing products/materials.

Empowerment might mediate in the level of innovativeness of firms, since empowered employees are more likely to feel free to try new ideas and to experiment without the need of permissions or approvals. However, it is dubious the significant influence of empowerment in SMEs due to their lower and flatter structures. The present research will include this scale as a control variable in order to assess its importance.

It must be remarked that turbulence, control and empowerment appear to be positively related to autonomy. This implies that subsidiary firms suffer more changes, exert more control and empower their employees to a greater extent than autonomous firms.

- *Stakeholders*

Analysing the characteristics of the stakeholders can give some useful insights for assessing the knowledge management practices and the use of the different information and communication technologies.

Regarding location, in general firms tend to act within the country. Customers and specially suppliers, appear to be physically closer to firms than the competitors, which could be argued to be reasonable in the past given the nature of the products and the need to reduce logistic costs. However, as indicated in Chapter 2, in the knowledge economy barriers of time and location have been lowered as a result of the explosion of advanced ICT such as the Internet. The globalisation of the markets is a reality but it seems that manufacturing SMEs have not entered in the new dynamics of the marketplace. It should also be recalled from Chapter 4 that the European mechanical engineering sector excels in its export performance. Therefore, in order to maintain this strategic position, SMEs should start playing globally, supported by the appropriate ICT and making full use of them.

In relation to size, most of the customers, suppliers and competitors are also SMEs. Nevertheless, the proportion of large firms is higher within the customers and less within the competitors, which have the largest proportion of small firms. The smaller size of their competitors might illustrate the value of being flexible in this competitive environment.

7.3 Performance Profile

Organisational performance has been assessed according to different indicators (see Table 24). In general, the sample firms evaluate their results higher than the performance of their competitors. The highest scores are allocated to their capability of being more adaptable and flexible, and of being quicker in responding to the changes in the market.

Table 24. Descriptive statistics of performance indicators

Characteristics		Mean	S.D.
Qualitative Performance Indicators			
more successful	(N=156)	4.80	1.36
greater market share	(N=154)	4.52	1.54
grown faster	(N=155)	4.28	1.42
more profitable	(N=154)	4.32	1.57
more innovative	(N=156)	4.67	1.54
quicker response	(N=156)	4.84	1.43
more adaptable and flexible	(N=156)	4.97	1.57

Being aware of the limitations of using self-assessed evaluations, other more objective informations was requested. In spite of asking for relative measures of organisational performance to avoid sensitive data, few firms responded to the questions. Some of them indicated their ignorance about them. In consequence, the results obtained were not included in bivariate or multivariate analysis, since they would cause high variability and non-normality. Although the comparison of results for qualitative and quantitative performance indicators could have generated additional interesting information, the comprehensive range of qualitative measures still allows addressing the research questions and hypotheses outlined in Chapter 5. In fact, some studies have also used only qualitative measures (Powell and Dent-Micallef, 1997; Gold et al., 2001; Ruiz-Mercader et al., 2006)

Firm Characteristics – Performance Profile

The relationships between different contextual factors and qualitative indicators on performance have been statistically tested by using different correlation measures depending on the nature of the variables. On the one hand, Spearson's Rho has been used to analyse correlations between variables which, at least one, are categorical, that is, process, and Cramer's V for nominal data (product, area, autonomy and hierarchy).

On the contrary, Pearson correlation has been examined in order to assess the relationship between continuous or assumed as continuous variables, such as age, turnover in 2003, turbulence, control, empowerment and size in terms of number of employees. Table 25 shows the results.

Table 25: Correlation analysis between firms' characteristics and performance

	successful	market share	grown faster	profitable	innovative	quicker	adaptable and flexible
Process	**0.20***	**0.22****	**0.27****	0.15	**0.20***	**0.25****	**0.22***
Product	0.18	0.20	0.18	0.21	0.15	0.17	0.20
Area	0.26	0.26	0.27	0.31	0.27	0.26	0.24
Autonomy	0.15	0.15	0.22	0.17	0.21	0.24	0.21
Structure	0.22	0.17	0.20	0.18	0.19	**0.25***	0.21
Age	-0.14	0.00	-0.12	0.03	-0.07	-0.05	-0.16
Turbulence	0.11	0.14	**0.23****	0.13	**0.33****	**0.39****	**0.27****
Control	0.04	0.04	0.16	0.03	**0.23****	**0.21****	**0.21***
Empowerment	0.04	-0.31	-0.01	-0.05	0.07	0.07	0.09
Turnover 2003	**0.19***	0.17	**0.24****	**0.22***	**0.19***	0.11	0.18
N_employees (ln)	**0.23****	**0.18***	**0.16***	0.09	0.15	**0.19***	0.14

Significance level: ** p<0.01 * p<0.05

The correlation analysis shows that some firm characteristics are associated to different dimensions of organisational performance. However, although significant, the relations do not appear strong.

Size (in regard with turnover and number of employees) statistically relates to many performance indicators, especially success and growth. This implies that bigger firms are more likely to have better results. It is interesting to see, by contrast, that generally size does not relate to innovativeness, flexibility and adaptability.

The type of organisational structure seems to be also related to quicker response. Cramer's V does not allow to interpret the direction of the relationships, but it permits to assess their strength. Flatter structures theoretically promote quicker reactions to the market changes, although in the case of SMEs structure could be of less importance due to their small size. Cross-tabulation analysis showed that, in fact, non-hierarchical structures are more related to quicker response. Almost 60% of flexible

structures report the maximum score in this indicator. On the other hand, whether firms are autonomous is not associated to the performance indicators and neither age differentiates the organisational results. Therefore, accumulated experience over the years does not indicate more chances of getting superior results. Firms' location is also unconnected to organisational performance.

Similarly, the type of products is not linked to differential organisational performance. However, in spite of its relationship with product type, the routineness of the production processes seems to be a characteristic connected to the firm's performance. The more routine the production technology is the more likely seems to have better organisational performance.

Finally, turbulence and control positively relate to indicators regarding innovation, quick response and flexibility. Thus, those firms suffering higher levels of turbulence and exerting greater control over their processes are more likely to be more innovative, quicker and more adaptable. On the other hand, empowerment does not statistically relate to any indicator, which implies that, given their size, empowerment might not be a critical factor for differential results. Furthermore, this fact corroborates the high dependence of SMEs on their CEO.

7.4 Knowledge Management Profile

This section aims to give an overview of the current state of knowledge management reflected by the practices performed within firms. The section will start with a brief comment of the general knowledge management practices and will continue to examine more detailed knowledge management practices.

General KM practices

Appendix IV includes the descriptive statistics of those variables assessing the general knowledge management practices. The results indicate that knowledge management practices are highly rated since, on a 5-point Likert scale, the means range from 3 to 4.5. These variables will be assessed in more depth in the next chapter, by applying multivariate methods such as factor analysis and regression analysis.

Specific KM practices

Specific knowledge management practices have been analysed, first, to see whether they are adopted, and second, to assess their importance for firms.

Tables 26 to 29 show the assessment of the knowledge management practices done by the firms. In order to summarize their opinion, practices have been grouped according to the upper 15 and lower 15, both in relation to their importance and their frequency. Thus, the first two tables indicate what practices have been selected as the upper 15, while the latter two tables display the lower 15 practices.

In general, descriptive statistics of the upper 15 practices are the same both, with regard to their importance and to their frequency. The results show the importance of firms' relationship with their customers. They specially value formal and informal personal contacts with their customers and closer relationships, in the form of collaboration. This can explain why, as stated in Chapter 4, SMEs usually have loyal

customers. Also, they consider that the provision of training to their employees is of great importance. This indicates the awareness of SMEs about the need for constantly updating themselves with the aim of coping with the competitive environment. The involvement of the CEO or manager director in the firm's activity is also highly evaluated. The role of managers in SMEs is critically important, since organisational decisions are usually made by them, individually to a large extent. Regarding the way of working, firms remark the importance of individual and functional team work, emphasizing the need for formal team meetings. This information raises the debate on formal versus informal encounters. While formal meetings are more structured and, therefore, inspire more internal recognition, informal meetings have the advantage of allowing quicker adaptability or problem solution. SMEs are known for their less bureaucratic and less formal ways of working within the firm (illustrated in Table 26 about frequent practices). However, it seems that they recognize the need for more formal internal meetings. Finally, the protection of information and knowledge in any form, database or paper, appears to be of critical importance. This information might be a sign of the awareness of the strategic importance of knowledge in the firms' survival.

Table 26: UPPER 15 KM practices by FREQUENCY

KM practices		Yes	No
visits by customers to our firm	(N=159)	148	11
visits to customers	(N=159)	148	11
data stored in computer databases form	(N=159)	148	11
training on the site of job	(N=159)	147	12
CEO wanders around the firm	(N=159)	147	12
collaboration with customers on specific projects	(N=159)	146	13
visits by suppliers to our firm	(N=159)	144	15
formal f2f meetings with customers	(N=159)	143	16
informal f2f meetings with team members	(N=159)	142	17
informal f2f meetings with customers	(N=159)	142	17
individual work	(N=159)	141	18
data stored in paper form	(N=159)	141	18
CEO communicates regularly with departmental managers	(N=159)	140	19
records stored in paper form	(N=159)	139	20
informal f2f meetings with suppliers	(N=159)	137	22

Table 27: UPPER 15 KM practices by IMPORTANCE

KM practices		Mean	S.D.
formal f2f meetings with customers	(N=142)	4.45	0.80
training on the site of job	(N=148)	4.44	0.68
visits to customers	(N=147)	4.39	0.88
informal f2f meetings with customers	(N=140)	4.35	0.85
CEO communicates regularly with departmental managers	(N=142)	4.34	0.87
CEO wanders around the firm	(N=147)	4.33	0.87
collaboration with customers on specific projects	(N=146)	4.26	0.87
data stored in computer databases form	(N=148)	4.22	0.82
individual work	(N=141)	4.22	0.85
controlled access to confidential information stored in DB	(N=128)	4.21	0.97
formal f2f meetings with team members	(N=134)	4.13	0.90
visits by customers to our firm	(N=147)	4.12	1.05
protection by intellectual property rights	(N=88)	4.11	1.04
work in functional teams	(N=122)	4.10	0.89
controlled access to confidential information stored in paper form	(N=121)	4.09	1.00

Regarding the lower 15 practices, there are commonalities with reference to their importance and frequency. Basically, they consider less important to develop relationships with competitors, to make acquisitions and to seize the opportunities offered by e-learning systems. Furthermore, those practices which enhance the creation of a friendly atmosphere in the workplace have been reported less critical and frequently adopted. It is also interesting to see that firms do not highly evaluate the acquisition of external knowledge through consultancy services or the attendance to external events.

When comparing the results of both tables, there should cautiously be considered that practices related to strategic ways of collaboration (mergers, R&D contracted-in or Licensed-in, acquisitions and joint-ventures) cannot happen as frequently as the rest of the practices due to their nature. Joint-ventures seem to be preferred over the remaining types of strategic collaboration.

Table 28: LOWER 15 KM practices by FREQUENCY

KM practices		Yes	No
organisation of social activities outside the firm	(N=159)	73	86
statement of values	(N=159)	65	94
joint-ventures or strategic alliances	(N=159)	58	101
incentives for team results	(N=159)	50	109
simulation by computer software	(N=159)	49	110
periodic internal publications	(N=159)	43	116
use of metaphors, examples, visual communication	(N=159)	41	118
R&D contracted-in or Licensed-in	(N=159)	33	126
incentives for helping others	(N=159)	28	131
collaboration with competitors on specific projects	(N=159)	28	131
acquisitions	(N=159)	28	131
e-learning	(N=159)	24	135
regular exchanges of basic data with competitors	(N=159)	21	138
incentives for participation in social activities	(N=159)	17	142
mergers	(N=159)	5	154

Table 29: LOWER 15 KM practices by IMPORTANCE

KM practices		Mean	S.D.
acquisitions	(N=28)	3.50	1.14
spare time for problem solving, research, etc.	(N=107)	3.49	0.89
use of metaphors, examples, visual communication	(N=41)	3.44	1.07
attendance at external centres, fairs...	(N=118)	3.41	0.98
paper-based documentation (books, articles, brochures...)	(N=116)	3.34	1.07
periodic internal publications	(N=43)	3.33	1.08
use of memos, suggestion schemes, etc.	(N=41)	3.32	1.06
reliance on memory	(N=97)	3.32	1.20
incentives for participation in social activities	(N=17)	3.29	1.05
organisation of social activities outside the firm	(N=73)	3.19	0.95
consultancy services	(N=98)	3.16	1.10
incentives for helping others	(N=28)	3.14	1.27
e-learning	(N=24)	2.88	1.08
collaboration with competitors on specific projects	(N=28)	2.79	1.42
regular exchanges of basic data with competitors	(N=21)	2.52	1.50

Following, relationships between knowledge management practices and performance will be examined. Statistics show significant correlations between the number of practices adopted and most indicators of organisational performance, with more strength in the indicators regarding flexibility, adaptability and quicker response (see Table 30).

Table 30: Relationship Performance indicators– Number of KM practices

Performance indicators	Number of practices statistically related
market share	10
successful	15
grown faster	20
profitable	21
innovative	29
quicker	37
adaptable and flexible	39

Table 31 shows the relationship between knowledge management practices and the two factors resulting from performing factor analysis on the organisational performance indicators, which will be fully explained in the next chapter. *Effectiveness* is formed by the market share, success, growth and profitability while *Flexibility* includes innovativeness, responsiveness and adaptability.

Given the greater mobility of employees in the new economy, the issue of training and assimilation of individual skills in the organisation is of critical importance. Therefore, regarding the relationship between ***training*** and performance, there are three specific ways which appear to be more related to better results. On-the-site training, continuous plans and rotation are the ways of training that firms with superior performance are using. On the contrary, computer-based learning, consultancy, apprenticeship and documentation-based training do not show any relationship with performance. It is significant the similarity between the practices not correlated and those poorly assessed in terms of frequency and importance, and vice versa. This might indicate that firms understand which type of training is more fruitful.

It must be pointed out that the most correlated practices are those referring to *procedural knowledge* (explained in Chapter 3), that is, knowledge that is learnt and assimilated in the course of action, allowing learning the tacit elements of the job.

Table 31: Correlation between KM practices and Organisational Performance

KM Practices	Effectiveness	Flexibility
Training		
training on the site of job	**0.21*****	**0.27*****
continuous plans of training for each employee	**0.26*****	**0.29*****
apprenticeship	-0.01	0.10
employee rotation	0.10	**0.26*****
consultancy services	0.12	0.11
e-learning	0.00	0.06
paper-based documentation (books, articles, brochures...)	-0.06	0.08
Communication types		
formal f2f meetings with team members	0.07	**0.17****
formal f2f meetings with other departments	**0.23*****	**0.24*****
formal f2f meetings with CEO	**0.18****	**0.26*****
formal f2f meetings with suppliers	0.06	0.12
formal f2f meetings with customers	0.12	**0.16****
informal f2f meetings with team members	0.01	**0.22*****
informal f2f meetings with other departments	0.13	**0.23*****
informal f2f meetings with CEO	**0.21*****	**0.37*****
informal f2f meetings with suppliers	0.02	**0.16****
informal f2f meetings with customers	0.03	**0.16****
use of memos, suggestion schemes, etc.	**0.14***	**0.20*****
periodic internal publications	**0.16****	**0.18****
use of metaphors, examples, visual communication	0.01	**0.13***
visits by customers to our firm	0.00	**0.20*****
visits to customers	**0.18****	**0.18****
visits by suppliers to our firm	0.12	**0.19****
visits to suppliers	**0.15***	**0.21*****
Intensity of relationships with stakeholders		
regular exchanges of basic data with customers	0.12	**0.14***
regular exchanges of basic data with suppliers	**0.14***	**0.20*****
regular exchanges of basic data with competitors	0.00	0.08
collaboration with customers on specific projects	0.06	**0.15***
collaboration with suppliers on specific projects	0.12	**0.18****
collaboration with competitors on specific projects	-0.13	-0.08
CEO's organisational knowledge acquisition		
CEO communicates regularly with departmental managers	**0.20*****	**0.39*****
CEO use data provided by the IS	0.09	0.13
CEO wanders around the firm	0.13	**0.23*****
Values promotion		
incentives for team results	**0.14***	**0.23*****
incentives for helping others	0.10	**0.16****
incentives for participation in social activities	0.02	0.12
organisation of social activities outside the firm	**0.23*****	0.12
example given by senior staff	-0.02	0.06
statement of values	**0.20*****	**0.34*****

Individuals' knowledge integration		
provision of resources to experiment	**0.19****	**0.44*****
simulations/experiments in pilot areas	0.13	**0.33*****
simulation by computer software	0.13	**0.22*****
provision of meeting rooms	**0.16****	**0.28*****
spare time for problem solving, research, etc.	**0.14***	**0.26*****
ergonomic and comfortable work places	**0.29*****	**0.30*****
Work characteristics		
individual work	-0.05	-0.05
work in functional teams	**0.17****	**0.26*****
work in cross-functional teams	**0.23*****	**0.24*****
work in multidisciplinary groups	**0.14***	**0.29*****
Acquisition of external knowledge		
attendance at external centres, fairs...	**0.18****	**0.17****
benchmarking	0.13	**0.27*****
market research	**0.22*****	**0.20****
monitoring market continuously	**0.18****	**0.35*****
mergers	**0.15***	0.08
acquisitions	0.05	0.08
joint-ventures or strategic alliances	-0.01	-0.03
R&D contracted-in or Licensed-in	0.11	**0.19****
Individuals' knowledge identification		
documentation showing the skills of every person in the firm	**0.21*****	**0.15***
knowledge of people's skills based through direct contact or informal means	0.02	0.08
records stored in paper form	-0.03	0.01
records stored in computer form	-0.05	0.03
speak to staff involved in previous projects	**0.15***	**0.39*****
Organisational knowledge storage		
data stored in paper form	-0.07	-0.08
data stored in computer databases form	0.09	0.11
reliance on memory	0.04	0.04
generation of meeting report after meetings	**0.15***	**0.18****
collection of records such as written notes, e-mail, etc.	0.07	0.00
protection by intellectual property rights	0.09	**0.20*****
controlled access to confidential information stored in paper form	**0.20****	**0.23*****
controlled access to confidential information stored in DB	**0.14***	**0.26*****

Significance level: *** p<0.01 ** p<0.05 * p<0.10

Taking into account the environmental uncertainty in the new economy, it is important to ensure that individuals develop their skills and are equipped with an extensive range of abilities that could be used when required. Rotation, for example, promotes individuals' flexibility to perform different activities and, as results show, organisational flexibility. Especially in SMEs, where usually there is not excess of staff, rotation can be of crucial importance to survive. It is surprising that apprenticeship has not come up significant since it also encourages procedural knowledge and is similar to on-the-job training. However, the difference might lie in the connoted inexperience of the former. Another point to remark is that all this practices mainly focus on in-house training, which ensures the transference of skills among employees and the integration of individual knowledge into the organisation since it can result in different work processes. This re-affirms the preference of SMEs for in-house training (commented in Chapter 4) in contrast to larger firms, which usually opt for external training.

On the other hand, the remaining training practices not associated to performance are based on *declarative knowledge*, that is, on explicit knowledge based on instructions and transmitted through paper or computer-based means (through documentation or e-learning) or face to face (through consultancy services). Contrary to those practices based on procedural knowledge, these practices fail to capture the tacit dimension of knowledge. To summarize, results support that the promotion of tacit knowledge originated from internal knowledge might be the source of competitive advantage reflected in better performance results.

Practices regarding the ***ways of communicating*** within and with external parties have been grouped under the name of communication. As seen in Table 31, communicative practices are related to performance indicators, more significantly to flexibility. When firms are highly engaged in communicating, they can act in a coordinated and effective way. The format of the interaction ways has arisen much debate. While formal meetings might imply more bureaucracy, this might vary when dealing with SMEs, since SMEs rely more often on informal face-to-face interactions by its own nature. Studies (Liebeskind, 1996; Soo et al., 2003) have demonstrated that knowledge exchange through informal networking is more effective than formal networking. However, according to the obtained data, in the context of SMEs it is

suggested that all kinds of communication are important, although indeed informal meetings relate with performance to greater extent than formal meetings. On the other hand, the use of periodic internal publications relates to higher effectiveness and flexibility. Internal publications serve as a means to communicate everybody about the activities and events related to the firm. In this way, organisations promote transparency and allow the development of a sense of identity. The inclusion of personal occasions (e.g. new paternities or maternities) contributes to create a more caring and closer atmosphere. However, according to the results, the use of this type of communications is not frequent.

The commented results can infer that in general in SMEs all communication practices promote firm's absorptive capacity, since they significantly correlate to flexibility. As commented in Chapter 3, some scholars (Gupta and Govindarajan, 1991; Szulanski, 1996) argue that organisational aspects such the structure of communication influences on firm's absorptive capacity. On the other hand, Liao et al. (2003) find a positive relationship between absorptive capacity and SMEs responsiveness, which is included in the concept of flexibility employed here. Therefore, the above conclusions can be drawn.

Similarly, the ***intensity of relationships with stakeholders*** varies from simple exchange of data to close collaborations. Results show that all types of relationships with suppliers and customers are intrinsically associated to flexibility, while regular exchange of data with suppliers is the only one that relates to effectiveness, though rather weakly. When comparing the results with more formal ways of collaboration such as mergers, acquisitions etc., it seems that less formalized collaborations are more related to better flexibility.

The ***CEO*** plays a crucial role in SMEs, hence the ways in which CEOs are kept informed is analysed here with respect to organisational results. Surprisingly, the use of information systems does not appear significantly related to any of the performance indicators. CEOs opt for getting information about the internal functioning through direct contact with the departments or by wandering around. Indeed, meetings with the CEO appear significantly correlated to organisational performance factors, especially more strongly to informal meetings.

Practices which generate appropriate working atmosphere by encouraging the right ***values promotion*** have been studied. The promotion of team working and helping others seems to be the most important relevant cultural issue in terms of performance, especially in flexibility. Furthermore, the explicit statement of the organisational values is strongly related to effectiveness and flexibility and the organisation of social activities is highly associated to effectiveness. Indeed, it is commonly recognized that social networking is an important means of knowledge transferred at all the levels of the organisation (Nahapiet and Ghoshal, 1998; Henderson and Cockburn, 1994). However, it is surprising that flexibility is not correlated to this practice.

On the other hand, the characteristics of ***how work is organized*** gives implicit information of the values encouraged and how individuals interact. The organisation of all kinds of teams (functional, cross-functional and multidisciplinary teams) and the adoption of an incentive system aligned with teamwork is linked to both effectiveness and flexibility. As high levels of communication, team working allows firms to act in a unified and efficient way. It must be noticed that individual work was not associated to any of the performance indicators.

The lack of ***resources*** is a crucial issue when speaking about SMEs, due to their constraints of finance and time. Data show that the availability of resources to experiment together with simulation software or pilot areas is highly associated to flexibility, which includes innovativeness, quick response and adaptability. Moreover, the availability of resources to experiment is also linked to higher effectiveness. Likewise, the remaining practices show significant association with both performance indicators, especially stronger with flexibility. These practices are: the provision ergonomic and comfortable work places and the availability of time and other resources to work in groups. The provision or such resources contributes to the creation of the suitable context to work and collaborate.

Linking to the theory outlined Chapter 3, results lends evidence to the argument of Penrose (1958), who claims that competitive advantage is highly determined by the existence of "resources in excess".

According to the correlation analysis, the ***acquisition of external knowledge*** about the market by means of benchmarking, market research or continuous monitoring is more probable in firms with higher levels of effectiveness and flexibility. The acquisition of other external knowledge through attendance to external events, also relates to better organisational results, in terms of effectiveness and flexibility. In the case of strategic collaborations, few modes appear related to better performance. Only R&D contracted-in or Licensed-in seems correlated to flexibility while mergers is linked to effectiveness. Therefore, formal strategic collaborations do not imply the excellence in organisational performance in comparison to their competitors.

Once knowledge has been identified or created through interaction, the ways of ***accessing to this individuals' knowledge*** might vary from more personal contact to more documented knowledge. While speaking to staff participating in previous experiences is related to most of the performance indicators, documented conclusions do not appear to be associated to superior results. Once again, *procedural knowledge* seems to be more related to performance indicators than *declarative knowledge*. However, the acknowledgement of staff skills based on paper seems to be a common practice of those firms with better performance.

In regard to the ***storage of organisational knowledge***, none of the practices (data stored in paper form, in electronic form, on memory, in informal written form) seems to be correlated to any of the performance indicators, with the exception of the meeting reports generated after meetings which is linked to both, effectiveness and flexibility. These results indicate that the reliance on explicit knowledge is not especially associated to firms with better results. However, the reason why generation of meeting reports result significant might be based on the fact that these meeting reports are the proof of the collective common agreements on interpreting acquired knowledge and on defining future actions. Therefore, they can ensure the alignment of objectives within the organisation and the integration of knowledge at the organisational level.

Finally, some comments on those practices which aim at ***protecting*** organisational knowledge. More innovative and flexible firms are more likely to protect their knowledge by restricting its access via computer and by applying intellectual property

rights. On the other hand, the protection of knowledge stored in paper is related to most of the organisational results.

All in all, communication in all kinds of formats, the availability of resources and cultural factors appear to be the most correlated practices to performance indicator, with special emphasis on flexibility. Another important conclusion is that those practices implying procedural knowledge are more associated to higher performance than those based on declarative knowledge. Therefore, the strategic value of tacit knowledge can be glimpsed.

Although the examination of correlations gives useful insights on the existing relationships between knowledge management practices and performance, it must be remarked that correlations do not imply causality.

Knowledge Management Profile – Firm Characteristics

In similar manner, relationships between knowledge management practices and firms' characteristics have been examined following the same process. Nevertheless, the full results will not be included here due to their length and to confidentiality issues. Even so, the significant relationships will be commented below.

The first conclusion drawn from the outcomes of the correlation analysis is that greater amount of practices correlates to control, size and turbulence. Firms which exert high levels of control seem to be more related to knowledge management practices, mainly to those regarding communication and the promotion of a collaborative culture. It seems that control over processes requires from firms to be highly engaged in transparent and collaborative communications within firms and with their customers and suppliers. It must be noticed that contacts through visits and formal face to face meetings predominate. This pattern is also identified in larger firms. Furthermore, size is positively related to most of the training practices, which indicates that larger firms are more probable to provide training than smaller firms. Regarding turbulence, the most correlated practices are those with respect to the availability of resources and the acquisition of external knowledge. This seems reasonable since firms undergoing greater turbulence need to invest more and pay more attention to what happens in the marketplace. Results also indicate that greater turbulence is linked to more resources and spare time for experimentation, and appropriate work places for individual and group work. At the same time, external knowledge is also highly associated to control and size. Indeed, control should cover not only the internal matters but also the external ones and, to do so, bigger firms might have more resources available.

There are several significant correlations that are negative. Turbulence is negatively associated to practices referring to data stored in paper-form. This implies the need for more easily accessible data (maybe, in computer-based form) in turbulent contexts. On the other hand, empowerment and size have negative correlation with reliance on memory. When empowering employees, it seems logical that records are needed in order to have control over the internal processes to some extent. Such formalized records are also more needed in bigger firms, since they are more difficult to control

due to their size. Another negative relationship has been found between process and accessing to knowledge gained in previous projects by speaking to staff. The more routine the process is the less contact with experienced employees is taken place, probably due to the fewer changes required in more routine processes. The final negative correlation has been found between age and employee rotation, in spite of its positive and significant relationship with flexibility. Employee rotation is a relatively new technique within organisations. Given its innovativeness and challenge to traditional methods of work, it seems logical that older firms are more reluctant to try new ways of working. In Chapter 4 the mechanical engineering sector in the UK was characterized as traditional and well established. There are firms within the sample running for more than 100 years. These older firms should recognise the importance of changing their mindset with regard to the ways of working. The new economy has new rules of play based on issues such as innovation or renewal capabilities.

7.5 Information Systems Profile

- *Number of ICT used*

The number of information and communication technologies used ranges from 1 to 18 (see Table 32) and is distributed normally. The average number of technologies is 8.10 and the standard deviation of 3.55. Contrary to the amount of knowledge management practices performed by firms, the total number of ICT does not correlate with any of the performance indicators. This supports the idea supported by this study, in the sense that the adoption of ICT is not always required, unless they enhance the organisational objectives and strategy.

Table 32: Descriptive statistics of variables related to ICT

Characteristics	Frequency	Percent
Number of ICT		(N=157)
1-2	7	4.5
3-5	33	21.0
6-8	53	33.8
9-11	34	21.6
12-14	24	15.3
15-17	6	3.9

- *ICT tools*

Tables 33 and 34 show the ratings allocated to each information and communication technology, according to their importance and frequency. In general, firms do not employ many technologies (average of less than 8 technologies). There are five ICT which are more widely used: phone, email, search engine, automatic email alerts and design software. On the other hand, the least used technologies are artificial intelligence, mind mapping software and extranet.

Regarding their importance, except from phone, email and design software, the rest of the tools considered of greater importance are not frequently used. Such tools aim to enable a better coordination of the internal processes of the firm (decision making, design, purchase, planning, etc.). On the contrary, those technologies designed to enable electronic communication or contact such extranet and groupware are rated as less important compared to other tools.

Table 33: ICT use by FREQUENCY

ICT		YES	NO
phone	(N=157)	148	9
email or chatting software	(N=155)	143	12
search engine or web crawler	(N=157)	126	29
automatic email alerts	(N=156)	119	37
Design software (CAD, CAM, PDM...)	(N=156)	111	45
Content/doc management software	(N=155)	73	82
data mining / text retrieval software	(N=154)	63	91
integrated software (MRP, ERP)	(N=154)	60	94
project management software	(N=155)	59	96
workflow / process management software	(N=155)	52	103
knowledge repository or digital archive	(N=154)	50	104
computer based training / e-learning	(N=155)	48	107
intranet or enterprise information portal	(N=156)	44	112
simulation software	(N=152)	43	109
expert or decision support software	(N=152)	40	112
groupware (e.g. bulletin board)	(N=155)	40	115
extranet	(N=155)	22	133
mind/knowledge mapping software	(N=153)	11	142
intelligent agent or artificial intelligence	(N=153)	10	143

Table 34: ICT use by IMPORTANCE

ICT		Mean	S.D.
phone	(N=137)	4.68	0.65
Design software (CAD, CAM, PDM...)	(N=106)	4.61	0.64
email or chatting software	(N=133)	4.50	0.76
integrated software (MRP, ERP)	(N=50)	4.09	1.00
workflow / process management software	(N=37)	3.98	1.10
expert or decision support software	(N=42)	3.95	1.05
simulation software	(N=46)	3.90	1.10
knowledge repository or digital archive	(N=115)	3.89	1.08
search engine or web crawler	(N=68)	3.84	0.92
Content/doc management software	(N=56)	3.78	1.16
project management software	(N=38)	3.77	1.10
intranet or enterprise information portal	(N=10)	3.74	1.25
intelligent agent or artificial intelligence	(N=43)	3.70	0.95
computer based training / e-learning	(N=61)	3.70	1.06
data mining / text retrieval software	(N=110)	3.66	1.06
automatic email alerts	(N=21)	3.65	1.10
extranet	(N=11)	3.43	1.33
mind/knowledge mapping software	(N=33)	3.36	1.12
groupware (e.g. bulletin board)	(N=140)	3.24	1.39

- *IS investment in 2003*

In 2003 the sample firms invested an average of 3.39% of their turnover in information system in 2003, varying from 0% to 12.5% of the total turnover. Although the amount of ICT do not correlate to any performance indicator, the expenditure in IS is statistically related to adaptability and quicker response. This could indicate that sophisticated or customized information systems to the existent needs can support more effectively the new directions taken by firms, given their potential of automating operations, minimising the time and effort required. On the other hand, no relationship between IS investment and turnover, age, autonomy, process, product and location has been found.

Table 31: Descriptive statistics of variables related to ICT (continued)

Characteristics	Frequency	Percent
% turnover invested in IS	(N=135)	
<0.10	13	9.6
0.10 - 0.5	19	14.1
0.51 - 1	39	28.9
1.01 - 4	38	28.1
4.01 - 7	19	14.1
>7	7	5.2
IS responsible position	(N=156)	
Finance	40	25.5
Directorial	87	55.4
Design	11	7.0
IT	8	5.1
Sales & Marketing	3	1.9
Manufacturing	2	1.3
others	5	3.2
None	1	.6

It is important to remark that the available information on IS investments is limited to the year 2003. Thus, it has to be considered with caution.

- *Position of the person responsible for IS*

Generally, the person in charge of information systems belongs to the directorial level. The finance department appears to be the second most common responsible for IS, followed by the design function. This reflects the different views firms have regarding information systems: while some see information systems as tools for strategic issues which involve the whole firm, others conceive them as tools for administrative and financial issues or for product design issues. In spite of the different roles, no relationship has been found between the position of the person responsible for IS and any performance indicator.

- *ICT capabilities*

Appendix IV summarizes the descriptive statistics regarding ICT capabilities. In general, ICT capabilities are not so generously rated as knowledge management practices. Means range from 2.58 to 3.85, while standard deviations vary between 0.94 and 1.5. As in the case of general knowledge management practices, ICT capabilities will be profoundly studied in the next chapter.

Information Systems Profile – Performance Profile

In order to investigate the relationship between specific information and communication technologies and the organisational performance, correlation analysis using Pearson correlation has been performed due to nature of the data. The outcome of such analysis is summarized in Table 35.

Few information and communication technologies relate to performance and they do it in a positive but weak way. In fact, the number of technologies employed is not statistically linked to better performance.

Data mining or text retrieval software and *artificial intelligence* technologies, which allow levels of automation impossible for human brains, are associated to effectiveness and flexibility, and to flexibility respectively. However, *artificial intelligence* is the least often used technology among the sampled firms.

On the other hand, *simulation software* and *process management software* are linked to more innovative and responsive firms. *Simulation software* allows virtual experimentation without the inconvenience of real experiments, such as waste of resources. *Workflow or process management software* deals with the automation of collaboration among different parts of the organisations.

Finally, *phone* is surprisingly related to effectiveness. Although, *email* might be thought as a substitute of phone, there are features that email does not usually offer. For example, listening to a voice can give a more personal approach to

communications and also avoid misinterpretations. Furthermore, the invasion of emails such as spam emails might have put users off from making full use of it for business purposes.

Table 35: Correlation between ICT and Organisational Performance

ICT	Effectiveness	Flexibility
data mining / text retrieval software	**0.20*** **	**0.14***
expert or decision support software	0.10	0.13
automatic email alerts	0.00	0.13
search engine or web crawler	0.01	0.11
intelligent agent or artificial intelligence	0.14	**0.15***
mind/knowledge mapping software	-0.10	-0.08
computer based training / e-learning	-0.03	0.12
Design software (CAD, CAM, PDM...)	0.01	0.06
simulation software	0.08	**0.19****
phone	**0.15***	0.09
email or chatting software	0.07	0.10
groupware (e.g. bulletin board)	0.03	0.07
project management software	0.07	0.12
extranet	-0.03	0.01
integrated software (MRP, ERP)	0.12	0.10
content/doc management software	0.03	0.11
intranet or enterprise information portal	0.09	0.10
knowledge repository or digital archive	-0.11	0.01
workflow / process management software	0.13	**0.17****

Significance level: *** p<0.01 ** p<0.05 * p<0.10

Information Systems Profile – Organisational Characteristics

This section aims to analyse the relationships between different information and communication technologies and firm characteristics, following the same procedure for the correlation analysis.

Based on the results, it can be affirmed that older firms are more reluctant to use email as a way of communication (negative correlation). The Internet revolution happened recently, thus traditional firms may have found it difficult to seize the opportunities offered by new technologies. Within this line of thinking, results show that there is a negative correlation between age and the amount of ICT employed.

Caldeira and Ward (2002) find that SMEs have recently started using ICT, so traditional firms should realise the need to break the old habits and use ICT as a strategic tool to compete.

Firms with greater turnover in 2003 relate to more sophisticated communication technologies which allow collaboration and diffusion of information such as extranet, groupware, intranet or project management software. Similar results have been found for firms with high levels of turbulence and control and also for bigger firms in terms of number of employees. However, these characteristics are also associated to automation technologies (e.g. data mining, decision support software...) and training and design technologies. Turbulence might oblige firms to act quickly; hence ICT might become essential tool for coordination in order to survive. In case of exerting high level of control over their processes, firms can benefit of the possibilities offered by ICT. For example, project management software can contribute to effectively controlling the tasks required to complete a project. On the other hand, size seems to be another important factor linked to the use of ICT. It seems natural that bigger firms employ ICT to a greater extent in order to support their functioning, since it is likely to be more complex.

Similarly, the use of ICT such as automation, training, design and collaborative technologies are linked to a greater empowerment. ICT can provide more freedom of decision since tasks are controlled in the systems. As said before, control is linked to the use of multiple technologies. However, it is surprising that MRP/ERP technologies which integrate all the facets of the business (e.g. materials planning, manufacturing, sales, and marketing) are not correlated to higher levels of empowerment. This might be justified by the small size of SMEs.

Regarding the production process routineness, some negative correlations have been found. Negative correlation with design and expert software appears to be logical, since they imply that the more routine the process is, the less design technologies are needed. For example, if a firm produces machines, the production processes tend to be unique or in small batches, for which design technologies are usually essential. On the contrary, workflow technology is positively related to process, which justifies the use of process management software in more routine processes.

With respect to nominal variables, some relationships have been identified, although their direction cannot be assessed. Product only relates to design software, which seems reasonable since, as said before, usually complex and customized products might benefit from design software to a greater extent than more standardized products. In fact, cross-tabulation analysis demonstrates that for most of the firms manufacturing machinery design software is critical. On the other hand, there are also some interesting patterns across differing geographic areas based on cross-tabulation results (see Table 36).

Table 36: Significant differences in ICT use across Locations

ICT	Areas with highest use		Areas with least use	
data mining / text retrieval software	Reading / S.Central	75%	Brighton / S.East	0%
expert or decision support software	Belfast / N.Ireland	66%	Norwich / East	0%
automatic email alerts	Cardiff / Wales Reading / S.Central	100%	Norwich / East	58.33%
project management software	London and area	50%	Manchester / N.West	4%
expert or decision support software	Brighton / S.East	66%	Cardiff / Wales	6.7%
workflow / process management software	Belfast / N.Ireland	100%	Edinburgh / Scotland	12%

The main conclusion of these results is that some areas are significantly different in regard to the type of ICT. Some areas (Reading / South Central, Belfast/Northern Ireland) seem to be more advanced in the use of some ICT. For example, Belfast/Northern Ireland appears to be among the areas where automatic email alerts and data mining / test retrieval are more widely used. Similarly, in Reading / South Central expert or decision support software and workflow / process management software are more spread. It must be pointed out that data mining / test retrieval software and workflow / process management software were some of the few technologies most related to effectiveness and flexibility, respectively. On the contrary, Norwich / East appears to be poorer in using ICT since it is the only area that appears with the least use of some ICT twice (expert / decisions support software and automatic email alerts). The cases of Cardiff / Wales and Brighton / South East are more confusing, since they appear as the areas with the least and most widely use

of specific tools simultaneously. These differences among areas might result from the effect of local policies or governmental support. Further research should be carried out in order to analyse the reasons of such geographical differences.

The dependence of the firm is statistically related to data mining, automatic email alerts, search engine, extranet, MRP/ERP and workflow technologies. After examining the cross-tabulation results, the conclusion is that subsidiary firms use such technologies to greater extent. This could imply that dependent firms are more likely to use ICT in order to be intercommunicated with their other sites for automated activities. On the other hand, this fact might show that the support given by mother firms result in greater use of ICT.

Also in relation to the organisation of the firm, organisational structure relates to simulation software, groupware and intranet. Followed by flexible structures, matrix organisations seem to be keener of using these technologies. These matrix organisations are complex since staff is allocated to projects and departments simultaneously, hence technologies such as groupware and intranet can support their intercommunications.

Finally, it must be commented that the total number of ICT employed by firms is positively associated to size, turbulence, control, turnover in 2003 and empowerment, in order of strength. This indicates that larger firms in terms of number of employees and of turnover or firms with higher levels of turbulence, control or empowerment make more use of ICT. Although causal relationships cannot be implied, results give information about the patterns of behaviour among firms according to different organisational characteristics.

Information Systems Profile – Dispersion

Defenders of ICT claim that ICT can overcome barriers of space and time. Thus, in this section the interaction between the use of different information and communication technologies and dispersion of both, the firm and the stakeholders, will be examined based on correlation analysis.

The results show that there are few technologies related to the different levels of dispersion of the firms. Except from data mining and text retrieval software, the rest of the associated ICT are communication technologies (phone, email or chatting software, groupware and extranet), that is, those technologies which enable communication. It is interesting to see that email and phone are negatively associated to having other sites in the country and within Europe, respectively. This might be due to the use of other more comprehensive communication technologies such as groupware and extranet (also significantly related to dispersion at the country level but in a positive way). Furthermore, there has been found a relationship between the number of ICTs and the amount of sites spread within the country. Thus, data support the fact that ICTs permits firms to be disaggregated in geographically distant sites. Similarly, the use of ICT in relation to the dispersion of customers, suppliers and competitors has been investigated. Those technologies which enable communication and the acquisition of external data are analysed. The results of the correlation analysis are commented next.

First, search engines are linked to competitors located within the country and within the EU. However, the relationship of search engine with competitors within the country is negative. This might indicate that firms which have closer competitors prefer to obtain information based on other means (e.g. publications, fairs…), while firms with foreign competitors opt for using search engines to a greater extent.

Likewise, extranet, which are popular means for business partners to exchange information, is significantly related to suppliers located within the EU. However, other communication technologies (phone, email, groupware and workflow) are not associated to any of the levels of dispersion of the stakeholders.

In general, data show that there is not much interrelationship between the use of the available technology and the dispersion of the stakeholders. Only, search engines and extranet seem to have more relevance in specific cases.

7.6 Interrelationships KM Practices – ICT Tools

The last section of this chapter aims to analyse whether specific ICT are associated with specific knowledge management practices. Like in the previous sections, this analysis is carried out using Pearson correlations.

When debating the appropriateness of ICT to enable communication, detractors claim the need of personal contact since ICT cannot replace human interactions. However, data show that there is no negative relationship between personal communication practices and ICT, except from the case of groupware technologies, which negatively relates to informal communications. Nevertheless, it has to be reminded that groupware was significantly associated to dispersion within the country, hence, the possibility of having informal encounters seem to be difficult in any way. Results reveal that most of the ICT relate to more formal communications, apart from email which might be the informal version of virtual communications.

Design software, automation technologies and email are the technologies more often related to personal communication, while other technologies such extranet, intranet, content management software, digital archive and workflow are more associated to document based communications. These results seem reasonable since the design process, in which design software is used, often requires the discussion with customers, team members, suppliers, etc, and, on the contrary, the other technologies mainly rely on written communication.

Looking at the ways CEOs acquire information concerning their firms, data show that the CEO's reliance on ICT does not interfere in his/her communications with the departments through personal contact. On the contrary, personal approach of CEOs is positively interrelated to several technologies. Nevertheless, it must recalled that the use of IS by CEO was not correlated to any performance indicator, while personal contact did.

Regarding the contribution of ICT to cultural issues, data show the interrelationship between teamwork and collaborative technologies (groupware, design software, project management software). This type of technologies supports the internal interactions among individuals, hence it seems logical their positive association with teamwork. Similarly, data storage technologies (integrated software (ERP/MRP), document management software, intranet and digital archive) are also related with teamwork. One might be afraid that the use of ICT contributes to individual work. The availability of integrated data across the functions of the firm might enhance group work, since employees have a broader image of what is going on or has happened within the firm and they can easily access this information. Therefore, they enhance the use of explicit organisational knowledge.

Some significant correlations have been found between training practices (continuous plans and paper based documentation) and computer-based learning. On the other hand, on-the-site training, continuous plans and rotation appear associated to information storage technologies. This might imply that easily accessible information is required in order to facilitate the mentioned training practices. If recalled, these types of training were the only ones relating to performance indicators. Surprisingly, e-learning as a training practice only relates to knowledge mapping software and not to computer-based training. This might indicate that not all the firms which posess computer-based training make use of it for e-learning purposes. The simple acquisition of ICT does not imply that firms utilise them. However, it seems that those firms which have a more innovative ICT, the knowledge mapping software, have more probabilities to be e-learners.

The provision of sufficient resources to experiment is interrelated to several technologies (expert support software, simulation software, artificial intelligence, computer-based training, design software, project management, digital archive and workflow). These technologies allow quick and virtual experimentation based on previous experiences and/or criteria. However, time is required to carry out the experiments. In fact, time also relates to design and simulation software, data mining, content management software and workflow. As a final comment with respect to resources, there is relationship between the provision of meeting rooms and

collaborative and integrative technologies. Thus, it seems that firms which aim to facilitate collaboration would invest in both, physical and virtual collaboration.

Passing to comment the acquisition of external knowledge, market knowledge acquisition relates to various automation technologies, such as search engine or automatic email alerts. In fact, search engine is the only automation technology linked to the three levels of external knowledge acquisition: market knowledge, strategic collaboration and external events. Automation technologies facilitate quick searches for market knowledge. Furthermore, content management software, which also relates to acquisition of market knowledge, allows managing the documentation in easy ways. Another way of acquiring external knowledge is through the implementation of strategic collaborations in terms of alliances, mergers, joint ventures, etc. It is significant that these kinds of collaborations are highly related to technologies which aim to interconnect the different knowledge bases of the company, as for example, intranet, extranet or MRP/ERP. Therefore, strategic collaborations might require more complex ICT than phone or email (which appear negatively correlated). Also expert support software and document management software appear associated to strategic collaborations. Management of such collaboration may be more complex than "simple" firms, hence technologies might support it. On the other hand, although not directly related to acquisition of external knowledge, the significant correlation of design software and project management software with strategic collaborations might indicate that firms highly engage in designing and manufacturing products are more likely to search for external knowledge.

With respect to accessing organisational knowledge, storage of data both in formal and informal information in paper and computer form, reliance on memory and documentation of conclusions are the practices most often related to ICT. Personal approaches to reach organisational knowledge are hardly associated to ICT, but always in a positive way. It must be recalled that documentation of the skills existing within firms has been found associated to higher performance. However, firms seem not to take advantage of the information storage capabilities of ICT. On the other hand, no negative interactions between personal contacts and ICT have been found. This demonstrates that the use of ICT do not necessarily imply that personal contacts will be diminished. On the contrary, the use of ICT seems to be detrimental for

reliance on memory. As a result, ICT mainly enhance the explicit accumulation of knowledge, although they do not interfere in personal contacts, but only in the reliance on memory. However, firms do not take advantage of the potential of ICT for the explicit documentation of the employees' skills.

The access to knowledge might be restricted in several ways. Most of the automation technologies (data mining, expert support software, automatic email alerts and search engine) together with content management software and email software relate to restriction of access. Moreover, protection through intellectual property appear related to data storage technologies, such as document management software and digital archive, apart from being associated to automation technologies. The development of new products usually generates large amount of documentation which could be more efficiently managed and accessed electronically. Thus, the relationship seems justified.

Although many relationships have been found, to sum up, ICT seem to relate to a greater extent with practices regarding team working, strategic collaborations, storage of knowledge in documented form, use of IS by the CEOs and acquisition of external knowledge.

7.7 Summary of the Chapter

This chapter has presented the results of the univariate and bivariate analysis carried out in order to have an overview of the characteristics of the firms and their practices, and the relationships among them based on correlation analysis. The conclusions of the chapter can be summarized as follows:

1. Description of the firms

The average profile of a sample firm is a medium and mature firm which produces machines, in small batches, with R&D activities and some involvement in information systems. Generally, the education level within the companies is quite low. The typical organisational design is hierarchical, without any dependency or possession of other sites, hence they are hardly dispersed. Firms usually experiment high levels of turbulence and exert high levels of control over their processes. On the other hand, decisions are made rather centrally, thus the level of empowerment is low. Regarding the location of their stakeholders, firms tend to act within the country.

2. Firm characteristics and performance

Firms with higher levels of turbulence and control appear associated to superior flexibility. Furthermore, high production process routineness relates to better performance results of most kinds. Thus, it is probable to find support for Hypothesis 4c.

3. Knowledge management practices

Analysis of the KM practices according to their frequency in use and their importance shows the importance for firms of their relationships with customers, the provision of training on the site of job and the involvement of the CEO or manager director in the firm. On the other hand, firms poorly score practices on developing relationships with competitors, on creating a friendly atmosphere and on the adoption consultancy and e-learning.

4. KM practices and performance

Many KM practices are frequent in firms with superior results, especially with those regarding flexibility. All in all, communication and the availability of resources appear to be the most correlated factors to flexibility.

5. KM practices and firms' characteristics

The main conclusion is that firms with higher control, turbulence, and size, are related to knowledge management practices to a larger extent. Therefore, support for Hypothesis 4a could be expected.

6. ICT characteristics

In 2003 most firms have invested in ICT to greater or less extent (average of 3.39% of the turnover). Generally, the person responsible for IS belongs to the directorial team. Regarding the information and communication technologies themselves, the tools considered of greater importance enable better internal coordination but are not frequently used, except from phone, email and design software. On the contrary, those tools designed to enable more complex electronic communication or contact such extranet and groupware are rated as less important compared to other tools.

7. ICT tools and performance

Few information and communication technologies are related to performance and they do it in a positive but weak way. In fact, the number of technologies employed is not statistically linked to better performance. In fact, few tools such as data mining, artificial intelligence, simulation software, phone and workflow software are significantly associated to different performance indicators.

8. ICT tools and firms' characteristics

In spite of having identified many interrelationships, the main pattern discovered is the use of greater amount of ICT in those firms with higher levels of turbulence and control, together with bigger firms. Also, more customized products and processes relate to design software more significantly. Therefore, support for Hypothesis 4b seems likely to be found.

9. ICT tools and KM practices

To summarize the multiple relationships spotted, ICT seem to positively relate to a greater extent with practices regarding team working, strategic collaborations, storage of knowledge in documented form, use of IS by the CEOs and acquisition of external knowledge.

Although the results of this chapter might be insightful, the control of only two variables is not enough to draw conclusions. Thus, next chapter will deal with multivariate analysis in which the interactions among diverse variables are taken into account.

Chapter 8: Hypotheses Testing and Discussion

The purpose of this chapter is to:

(1) Test the hypotheses defined in Chapter 5

(2) Answer the major research questions outlined in Chapter 5:

- What are the benefits obtained by firms engaged in knowledge management practices? What is the nature of such benefits?
- What are the benefits obtained by firms with greater ICT capabilities?
- What are the key factors in KM and ICT capabilities that influence in these benefits?
- What are the vital ICT capabilities that enable a strategic use of knowledge? Do particular ICT capabilities enable specific knowledge-based capabilities?
- Do knowledge-based capabilities influence on ICT capabilities
- What similarities and differences are there between SMEs and large enterprises in relation to the previous questions?

(3) Present and explain the results obtained from using different statistical techniques

(4) Compare the results and decide the most appropriate to meet the research objectives

(5) Discuss the results in relation to the thesis and the literature commented in Chapters 2, 3, 4, and 5

(6) Assess the validity and reliability of the results

8.1 Introduction

The previous chapter has investigated characteristics related to the main variables and, also, the relationships between pairs of variables. On the other hand, this chapter will deepen the analysis to investigate the simultaneous inter-relationship between several variables regarding knowledge management capabilities and ICT capabilities and organisational performance.

To start with, the **statistical analysis** of the data using different techniques is presented. The reader should notice that detailed explanation of the analytical process is attached in Appendices (III, V, VI), given that the main concern of this chapter is not methodological but to interpret and discuss the meaning of the results.

Therefore, first of all, *factor analysis* is performed with the aim of summarising great amounts of data in a number of common factors. Concretely, this technique transforms 76 variables into 22 factors which result more manageable. Second, after having defined the latent factors, a preliminary study of the relationships between knowledge management capabilities, ICT capabilities and performance is done based on *partial correlations*, which are a especially powerful way to begin to separate causal influences and intuit possible results. However, this method does not take into account the interaction between the different independent variables. In order to deal with this weakness, the next section presents ordinary least squares (OLS) regression analysis. Thus, *regression analysis* is carried out in order to test the hypothesis and examine the significance of each variable on the organisational performance. Regression analysis is a statistical technique which aims at modelling how a set of independent variables explains a proportion of the variance in a dependent variable. Here, the independent variables will be those regarding organisational performance, and the independent variables will include the variables concerning knowledge management and ICT capabilities. Nevertheless, two different factors were extracted from applying the factor analysis to the organisational performance. Regression analysis can only deal with one dependent variable at each time; hence, either regression analysis is performed for each performance factor independently, or

canonical correlation analysis, which is a more general technique that allows the consideration of several dependent variables, is applied. Since the two techniques have their advantages and disadvantages, both techniques are used and their results are compared and discussed.

Having presented and compared the results f the different techniques explained above, they are related to the **research hypotheses and questions** of the present study proposed in Chapter 5. The findings are discussed grounded in the existing literature and empirical research.

First, the relationship between knowledge management and performance is discussed. The result of testing Hypothesis 1, that is, whether there is a positive association between knowledge management capabilities and organisational performance, is commented. Following, an examination of the critical factors of knowledge management capabilities in such relationship takes place, in comparison to previous studies within the literature. Second, the relationship between ICT capabilities and performance is addressed. After discussing the results for testing Hypothesis 2, the significant factors of ICT capabilities influencing in organisational performance are commented. Third, the discussion is directed towards the interaction and synergistic relationship between knowledge management capabilities and ICT capabilities, giving empirical evidence for the dynamic capabilities theory. Finally, adopting the contingency approach, the effect of contextual factors on the effect of knowledge management and ICT capabilities on performance is analysed.

To conclude, a summary of the main findings is presented. Based on these, next chapter presents the conclusion and recommendations for policy makers, managers and academics.

8.2 Factor Analysis

Factor analysis is a statistical technique used to group the variables, not cases, in a smaller number of dimensions or factors. The constructs used in this research include a significant amount of items defined in Chapter 5 since they aim at capturing the processes and practices involved in knowledge management. In order to handle them in an easier way, factor analysis is applied, since one of the aims of this technique is to summarize the data in fewer latent factors based on common patterns in the data.

The application of this statistical technique has followed a systematic and rigorous procedure involving making several decisions, which are explained in detailed in Appendix III, to which the reader is invited to consult any doubt on the process of data analysis. Here the most essential information is shown.

The software SPSS has been used to run all the statistical analyses. Factor analysis has identified the underlying dimensions or factors which account for most of the variance in the larger amount of variables. *Principal components analysis* has been used to extract the first solution or sets of factors. Once the factors have been determined, they have been rotated using an orthogonal rotation called *varimax* in order to get a more interpretable solution.

The selection and purification of the factors has been done according to several rules: (a) minimum Eigenvalue of 1, (b) factor loadings of at least 0.50 and with no loadings on other factors greater than 0.40, (c) minimum Cronbach's alpha of 0.60, (d) inter-item correlations greater than 0.30, (d) item-to-total correlation below 0.40.

To clarify the main points, factor analysis provides a factor matrix of loadings, in which each column represents a factor and each row a variable. The numbers within the matrix represent the loadings of each variable on each factor. It must be noticed that all variables load to more or less extent on all factors. However, those variables with higher loadings onto the same factor might constitute a scale if they meet the requirements of high reliability (measured using Cronbach alpha) and unidimensionality (using item-to-item and item-to-total correlations). Given that these

conditions are met by the results presented here, the factor analysis concludes providing a set of scales regarding knowledge management and ICT capabilities, and performance.

Initially, the idea was to include all the variables referring to knowledge management in the same factor analysis. However, due to the condition of a minimum of 5 cases per variable, three different factor analyses have been performed taking into account: knowledge management system, knowledge exploration and knowledge exploitation. The impossibility of running factor analysis including the complete set of independent variables could be considered a limitation.

Table 37 presents the results of the composition of the purified scales extracted from the factor analysis, that is, the factor loadings for all retained variables and other significant information about the scales such as their Eigenvalue, the percentage of variance they account for, their internal reliability based on Cronbach's alpha or Pearson correlation and descriptive statistics. Furthermore, the appropriateness of the factor analysis is demonstrated according to the KMO indicator, the amount of total variance explained, the result of Barlett's sphericity test.

Table 37: Factor Analysis

Model 1: **Organisational Performance**	19	20
more successful	**0.82**	0.31
greater market share	**0.89**	0.22
grown faster	**0.73**	0.41
more profitable	**0.83**	0.22
more innovative	0.26	**0.82**
respond quicker to changes in the market	0.29	**0.89**
more adaptable and flexible	0.29	**0.86**
Eigenvalue	4.38	1.10
% of Variance	41.65	36.62
Cronbach Alpha / Pearson Correlations (*)	**0.89**	**0.89**
Average value	4.48	4.82
SD	1.27	1.37

KMO = **0.86**
% of Total Variance = **65.67%**
Bartlett's Test of Sphericity = 710.28 (sign=.000)
Sample size = 156

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

The seven indicators of **organisational performance** have been summarised into two scales, which have been labelled as *Effectiveness* and *Innovative and Quick Flexibility*. *Effectiveness* measure includes indicators about relative success, growth, market share and profitability, whilst *Innovative and Quick Flexibility* comprises innovation, quick response to the market changes and flexibility and adaptability. Therefore, the impact of effectiveness is more tangible and shorter-term oriented, on the contrary to flexibility and adaptability, which can be perceived as a longer-term competitive advantage

With regard to **knowledge management system**, two scales have come up. The first one has been labelled as *Strategic Alignment* since the variables that load on it make reference to alignment and commitment of individuals through common objectives. The second one is named as *Culture for Knowledge* as it describes the required environment to enhance knowledge within organisations. Section 3.5 of this thesis demonstrates that the literature has identified these two scales essential to enable effective knowledge management.

Table 37: Factor Analysis (continued)

Model 1: **KM System**	1	2
mission, vision, objectives	**0.84**	0.19
induction about their jobs	**0.76**	0.10
induction about values and philosophy of the firm	**0.87**	0.14
commitment is promoted	**0.72**	0.40
working towards the same vision	**0.61**	0.37
alignment of functional strategies	**0.66**	0.38
communication is open	0.21	**0.81**
communication is regular	0.26	**0.79**
trust is promoted	0.18	**0.82**
transparency is promoted	0.21	**0.79**
Eigenvalue	5.19	1.48
% of Variance	35.35	31.27
Cronbach Alpha	**0.88**	**0.85**
Average value	3.76	4.21
SD	0.78	0.67

KMO = **0.87**
% of Total Variance = **66.62%**
Bartlett's Test of Sphericity = 851.55 (sign=.000)
Sample size = 156

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Variables in reference to **knowledge exploration** have been reduced to four factors named as: *Knowledge Acquisition at Organisational Level*, *Identification Of Individuals' Knowledge*, *Research Promotion* and *External Sources of Knowledge*. The first factor has been named as *Knowledge Acquisition at Organisational Level* because it refers to knowledge acquisition at all the levels except from the individual level, which is captured in the second scale (*Identification Of Individuals' Knowledge)*, and from the external knowledge, described in the fourth scale (*External Sources of Knowledge).* The third scale highlights the importance of promoting research by searching for new knowledge and/or existing knowledge by looking at past or current experiences. All these issues have been discussed in Section 3.4.

Table 37: Factor Analysis (continued)

Model 2: **Knowledge Exploration**	3	4	5	6
knowledge identification, location (group)	**0.64**	0.40	-0.11	0.14
managers' knowledge of firm activities	**0.63**	0.35	-0.04	0.21
knowledge acquisition from customers	**0.75**	0.17	0.17	0.00
knowledge acquisition from suppliers	**0.72**	-0.09	0.36	0.03
knowledge identification, location (individuals)	-0.06	**0.80**	0.17	0.00
staff valued by their knowledge	0.11	**0.70**	0.21	0.19
past/current experiences	0.17	0.22	**0.70**	-0.12
valued research activities	0.11	0.11	**0.76**	0.32
knowledge from other external sources	0.19	0.12	0.12	**0.85**
Eigenvalue	8.45	2.01	1.68	1.64
% of Variance	10.32	8.62	8.53	7.65
Cronbach Alpha / Pearson Correlations (**)	**0.74**	**0.52(**)**	**0.36(**)**	--
Average value	3.76	3.93	4.38	3.68
SD	0.78	0.64	0.60	0.86
KMO = **0.80**				
% of Total Variance = **61.81%**				
Bartlett's Test of Sphericity = 423.21 (sign=.000)				
Sample size = 156				

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

In the case of **knowledge exploitation**, seven scales have resulted due to the breakdown of Scale 11 into the three original variables (*Incentive System for Knowledge Sharing*, *Internal Distribution of Knowledge* and *Knowledge Exchange with Partners*). The researcher has decided to break down this scale, since it does not meet the reliability and unidimensionality minimums and, if dropped, the total variance explained by the factor analysis would drop below the desired level.

The remaining four scales have been labelled as *Encouragement to Participate*, *Collective Knowledge Integration*, *Resource Availability* and *Collaboration Promotion*. *Encouragement to Participate* regards knowledge exploitation processes from the individuals' perspective. It includes indicators of knowledge sharing through interaction and discussion, and knowledge integration through experimentation and practice at the individual level. Knowledge integration at the collective level is represented in *Collective Knowledge Integration*, which includes discussion to arrive to common conclusions and reflection after finalising projects, regardless their success. An important factor for enabling knowledge exploitation is the availability of resources to do so. *Resource Availability* is essential, especially in SMEs, to allow individual and collective practices regarding knowledge management. Finally, *Collaboration Promotion* has resulted as a sum of two variables, the search of inter-organisational collaborations and the possession of appropriate structures to support such collaborations. As in the previous cases, the literature related to the above scales is discussed in Section 3.4.

Table 37: Factor Analysis (continued)

Model 3: **Knowledge Exploitation**	7	8	9	10	11
encouragement to interact	**0.82**	-0.01	0.05	0.14	0.14
encouragement to discuss	**0.81**	0.08	0.08	0.14	0.23
encouragement to practice	**0.51**	0.14	0.40	-0.04	0.25
encouragement to experiment	**0.55**	0.29	0.39	0.16	-0.01
open discussions to arrive at a common view	0.34	**0.56**	0.35	-0.14	-0.10
reflection after successful projects	0.06	**0.83**	0.12	0.26	0.20
reflection after unsuccessful projects	0.11	**0.74**	0.07	0.24	0.30
adequate resources to work individually	0.08	0.13	**0.77**	0.20	0.14
adequate resources to work in groups	0.29	0.22	**0.71**	0.20	0.07
firm seeks inter-organisational collaborations	-0.01	0.11	0.04	**0.88**	0.12
structure supports collaboration	0.26	0.04	0.27	**0.79**	0.02
incentive system promotes group work	0.34	0.11	0.07	0.02	**0.68**
knowledge distribution throughout the firm	0.35	0.35	0.21	-0.05	**0.51**
knowledge exchange with partners	0.03	0.22	0.17	0.29	**0.61**
Eigenvalue	5.69	1.58	1.41	1.38	1.11
% of Variance	15.55	14.01	13.45	10.04	9.03
Cronbach Alpha / Pearson Correlations (**)	**0.77**	**0.77**	**0.69(**)**	**0.63(**)**	**0.62**
Average value	4.11	3.50	4.03	3.31	3.38
SD	0.67	0.88	0.71	1.05	0.81

KMO = **0.81**
% of Total Variance = **62.08%**
Bartlett's Test of Sphericity = 943.16 (sign=.000)
Sample size = 156

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Similarly, the resulting scales with regard to ICT capabilities are commented. Seven scales have resulted from using factor analysis. Four of them refer to human aspects or skills, while the remaining three are of technical nature. Starting with the human ICT capabilities, variables regarding the skills and attitudes towards ICT by non-technical staff have come together into the scale *Commitment to IT by non-technical staff*. The other three human scales make reference to their support to the business strategy and processes (*Business Support by IT Staff*), their IT expertise in relation to new advancements in ICT (*IT Expertise*) and their managerial skills to work with other departments and manage the involved administrative tasks (*Managerial Skills of IT Staff*). Passing to comment the three technical scales, *Secure and Sufficient IT Intercommunication* summarises the capability of developing an ICT infrastructure to promote inter-communication in a secure way without capital restrictions. *Customized and Unique IT Infrastructure* refers to the level of IT infrastructure customisation to the business needs and its protection from imitation. Finally, *Technical Compatibility* measures the level of compatibility of the IT infrastructure, which makes it flexible for future upgrades of the system. The results are in line with the classifications of ICT capabilities employed in the literature (see Powell and Dent-Micallef (1997), Byrd and Turner (2000) and Dehning and Stratopoulos (2003) in Table 4).

Table 37: Factor Analysis (continued)

Model 3: **ICT capabilities**	12	13	14	15	16	17	18
staff are trained in the use of new IT	**0.64**	0.06	0.42	0.28	0.21	0.06	-0.08
staff make full use of the current IT infrastructure	**0.77**	0.09	0.27	0.27	-0.01	0.07	-0.01
staff accept new IT with few problems	**0.74**	0.24	0.23	0.09	0.16	0.05	0.15
staff are involved in the IT adoption process	**0.68**	0.26	0.03	0.31	0.13	-0.06	0.10
managers commitment to IT	**0.57**	0.24	0.18	-0.03	0.25	-0.01	0.36
part in the formulation of organisational strategy	0.13	**0.72**	0.22	0.21	0.12	0.07	0.00
knowledge of all the firm's processes	0.37	**0.64**	0.05	0.15	0.06	0.07	-0.04
engaged in BPR	-0.03	**0.82**	0.24	0.27	-0.08	0.04	0.12
support communication across the firm	0.35	**0.65**	0.15	0.10	0.20	0.12	0.08
high level of technical expertise	0.28	0.19	**0.76**	0.02	0.13	0.16	-0.08
encouragement to learn about new technologies	0.34	0.15	**0.68**	0.00	0.25	0.12	0.06
follows emerging trends in IT	0.21	0.21	**0.80**	0.14	0.00	0.15	0.17
research the best IT practices	-0.01	0.12	**0.63**	0.46	0.19	-0.01	0.08
clear and useful doc regarding IT	0.08	0.18	0.11	**0.65**	-0.10	0.20	0.35
work together with other departments in teams	0.31	0.41	0.01	**0.54**	0.04	0.23	0.05
self-directed and proactive	0.36	0.27	0.15	**0.62**	0.02	0.11	-0.08
manage contracts effectively	0.23	0.16	0.14	**0.77**	0.28	0.05	-0.06
data security	0.23	-0.15	0.27	0.03	**0.61**	0.18	0.27
promote inter-communication	0.01	0.15	0.22	0.07	**0.80**	-0.12	-0.01
enough capital for IT investments	0.19	0.09	0.00	0.14	**0.62**	0.29	0.00
customisation when necessary	0.05	0.18	0.05	0.11	0.08	**0.78**	-0.01
prevention from imitation	-0.03	0.00	0.25	0.16	0.10	**0.80**	0.02
compatibility, connectivity	0.11	0.05	0.06	0.08	0.11	-0.01	**0.88**
Eigenvalue	8.52	1.94	1.62	1.46	1.22	1.12	1.01
% of Variance	13.33	11.91	11.16	10.13	8.60	7.04	5.34
Cronbach Alpha / Pearson Correlations (**)	**0.86**	**0.81**	**0.83**	**0.79**	**0.62**	**0.42(**)**	--
Average value	3.39	3.31	3.47	3.26	3.57	2.70	2.81
SD	0.83	0.87	0.80	0.79	0.80	1.15	1.17

KMO = **0.87**
% of Total Variance = **67.50%**
Bartlett's Test of Sphericity = 1633.91 (sign=.000)
Sample size = 156

Extraction Method. Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

To sum up, the different scales extracted have been labelled as indicated in Table 38.

Table 38: Summary of Scales with their Labels

Constructs	Name		Labels
KM system	S1cult	1	Culture for knowledge
	S2align	2	Organisational alignment
Knowledge Exploration	Expr1	3	Knowledge acquisition at organisational level
	Expr2	4	Identification of individuals' knowledge
	Expr3	5	Research promotion
	Expr4	6	External sources of knowledge
Knowledge Exploitation	Expt1	7	Encouragement to participate
	Expt2	8	Collective knowledge integration
	Expt3	9	Resource availability
	Expt4	10	Collaboration promotion
	Expt5	11.1	Incentive system for knowledge sharing
	Expt6	11.2	Internal distribution of knowledge
	Expt7	11.3	Knowledge exchange with partners
ICT capabilities	Ithum1	12	Commitment to IT by non-technical staff
	Ithum2	13	Business support by IT staff
	Ithum3	14	IT expertise
	Ithum4	15	Managerial skills of IT staff
	Ittech1	16	Secure and sufficient IT intercommunication
	Ittech2	17	Customized and unique IT infrastructure
	Ittech3	18	Technical compatibility
Organisational Performance	P1Effec	19	Effectiveness
	P2Flex	20	Innovative and Quick Flexibility

In order to facilitate the use of the above scales, some of the names will be shortened in later use. For example Innovative and Quick Flexibility will often be addressed as Flexibility.

Having in mind the objective of the factor analysis, that is, summarising, summated scales are calculated based on the original variables and the extracted factorial structure, since the resulted scales will conform the set of dependent and independent variables used in further multivariate analysis.

In order to create new variables based on the results from factor analysis, three alternatives are available: summated scales, selecting a surrogate variable and employing factor scores. The present research has opted for summated scales because of three reasons: first, it reduces "*the measurement error inherent in all measured variables*" (Hair et al, 1998: 116); second, it allows "*to represent the multiple aspects of a concept in a single measure*" (Hair et al, 1998: 117); and third, "*it includes only the variables that load highly on the factor and excludes those having little impact*"

(Hair et al, 1998: 120). Summated scales are an intermediate compromise between the other two options.

Descriptive statistics of the summated scales are gathered in Appendix IV. The correlation among scales is surprising and one could argue that given the orthogonal rotation this should not happen. However, although uncorrelated scales are theoretically desirable, few scales are uncorrelated in practice. Several authors support this fact:

"... the rationale that underpins an oblique rotation is that most, if not all, the variables being measured are correlated to some extent and, therefore, underlying major factors must also be correlated ... the assumption of correlation between factors should not worry us, therefore, and some would argue the assumption is more "realistic" that the assumption of "orthogonality" inherent in principal components and orthogonal rotations" (Alt, 1990: 72)

"*However, if the ultimate goal of the factor analysis is to obtain several theoretically meaningful factors or constructs, an oblique solution is appropriate. This conclusion is reached because, realistically, very few factors are uncorrelated, as in a orthogonal rotation*" (Hair et al, 1998: 111)

Furthermore, in the present study this issue is not of vital importance, since exploratory factor analysis has been applied. On the other hand, confirmatory factor analysis (e.g. Structural Equation Modelling) requires testing for orthogonality to check whether scales correlations are set to 0 (StatNotes, accessed 15/07/06). Thus, the issue of obtaining uncorrelated scales is of greater importance when applying confirmatory factor analysis, which only takes into account the common variance, while exploratory factor analysis considers the total variance.

8.3 Preliminary Analysis: Correlation and Partial Correlation

Impact of Knowledge Management and ICT Capabilities on Performance and the Effect of Contextual Variables on These Capabilities

In order to investigate the relationships between the main dimensions within the knowledge management capabilities, ICT capabilities and organisational performance, this section will present a preliminary analysis based on correlations and partial correlations.

Appendix IV shows the correlation analysis between the different scales, based on Pearson. Table 39 gathers the results of the *simple correlation* analysis (column r) between knowledge management capabilities and ICT capabilities, and performance. The results show that, while the majority of knowledge management related scales correlate with flexibility, they do not seem to be associated with effectiveness, except from culture for knowledge. The remaining scales and variables, information and communication technologies related scales are equally associated with effectiveness and flexibility.

However, simple correlations between independent and dependent variables do not take into account the effect of control variables. This is the reason why, in order to analyse the correlation between two variables while controlling for a third or more variables, *partial correlations* (column pr in Table 39) are used. Such technique is used for small causal models, including from 3 to 5 variables.

The initial idea was to include all available contextual variables. However, due to limitations to such as in partial correlation of a maximum of 3 control variables and later in regression analysis, of a minimum ratio of 1 variable per 5 responses, the control variables to be inserted in the model have been selected carefully. The inclusion of ordinal or nominal variables implies the creation of almost the same number of dummy variables as categories the initial variables has. In the case of location, for example, it would require 11 new variables. Therefore, the selection has been done based on the correlation analysis between contextual variables and

performance indicators presented on Chapter 7. According to the results, number of employees, turbulence, control, process and total sales in 2003 are the most related variables to performance indicators. However, process is not included since partial correlations only permit interval variables and due to the constraint of number of variables to be included (maximum of three control variables). As said in Chapter 7 firm size is controlled using the logarithm of number of employees in order to correct its skewness and given that the most commonly used within the literature (e.g. Gatignon and Anderson (1988)).

Thus, partial correlations between KM and ICT related scales and organisational performance scales have been performed, removing the effect of the three contextual variables (turbulence, control and size). Table 39 compares the results of both, simple and partial correlations.

Table 39: Correlations and Partial correlations controlling for contextual variables

	Effectiveness		Flexibility	
	r	pr	r	pr
Culture for knowledge	**0.20****	**0.28****	**0.37****	**0.45****
Organisational alignment	0.01	0.12	**0.32****	**0.32****
Knowledge acquisition at organisational level	-0.02	0.07	**0.18***	**0.25****
Identification of individuals' knowledge	0.04	0.10	**0.24****	**0.23***
Research promotion	0.00	0.08	**0.21****	**0.21***
External sources of knowledge	0.06	0.03	**0.27****	**0.25****
Encouragement to participate	-0.05	0.06	**0.25****	**0.36****
Collective knowledge integration	0.01	0.13	**0.36****	**0.38****
Resource availability	0.11	0.14	**0.28****	**0.26****
Collaboration promotion	0.06	0.12	**0.16***	0.13
Incentive system for knowledge sharing	0.00	0.07	0.14	0.16
Internal distribution of knowledge	-0.06	0.00	0.15	0.17
Knowledge exchange with partners	-0.03	0.00	**0.17***	0.15
Secure and sufficient IT intercommunication	**0.27****	**0.23***	**0.35****	**0.25***
Customized and unique IT infrastructure	**0.21****	0.16	**0.34****	**0.24****
Technical compatibility	0.03	0.01	0.03	0.03
Commitment to IT by non-technical staff	**0.22****	**0.27****	**0.33****	**0.32****
Business support by IT staff	**0.20***	0.18	**0.31****	0.18
IT expertise	**0.24****	**0.28****	**0.30****	**0.24****
Managerial skills of IT staff	0.08	0.55	**0.29****	**0.45****

Significance level: ** p<0.01 * p<0.05
r: simple correlations
pr: partial correlations

As seen in Table 39, the results of simple correlations and partial correlations are relatively similar in regard to identifying the scales significantly associated to organisational performance. However, the small differences detected will be interpreted next.

The fact that some independent variables are **not any more significantly correlated** when holding constant the control variables indicates that these independent variables are related to performance but not in a direct way, but control variables antecede or intervene in the path from the independent variables to performance. This is the case of the following pairs: *Collaboration Promotion* – Flexibility, *Knowledge Exchange With Partners* – Flexibility and Effectiveness, *IT expertise* - Flexibility, *Customized and Unique IT Infrastructure* – Effectiveness, *Knowledge Exchange with Partners* – Flexibility, *Business Support by IT Staff* – Effectiveness and Flexibility. This means that the effect of the indicated independent variables on performance scales is explained by specific contextual conditions regarding turbulence, control and firm size. For example, the level of turbulence and/or control and/or the firm size of the firm might be the determinant factor of the effect of *Collaboration Promotion* on achieving greater Flexibility.

In two cases (*Organisational Alignment* – Flexibility, *Research Promotion* – Flexibility), there is **no effect observed**, since both types of correlations are equal. This means that control variables do not affect the relationship between these independent and dependent variables. For example, the intervention of contextual factors such as firm size, turbulence and control is not modifying the effect of *Organisational Alignment* on Flexibility.

The rest of the cases show an **increase or decrease in the partial correlation**. This indicates that there is a direct path from the independent to the dependent variables, but this direct path is influenced by control variables, either partially explaining or suppressing the relationship, respectively. For example, *Customized and Unique IT Infrastructure* has smaller partial correlation than simple correlation in relation to Flexibility. This means that the influence of size has a suppressing the larger correlation the larger correlation that would appear between *Customized and Unique IT Infrastructure* and Flexibility if turbulence, control and size were held constant.

On the whole, the conclusion from this section is that most of the KM related scales influence on Flexibility while not on Effectiveness, except from *Culture for Knowledge*. On the contrary, most of the ICT scales correlate with Effectiveness and Flexibility and they do it in a similar manner. Given the different results, *Hypothesis 1 should be split into two different hypotheses*: H1a: there is a positive association between KM capabilities and Effectiveness, and H1b: there is a positive association between KM capabilities and Flexibility. Thus, in general results do *not support H1a*, while *supporting H1b*. The impact of knowledge management seems to appear on issues such as quick response and adaptability to the market changes and greater innovation capability.

The examination of partial correlations inform about the influence of contextual variables on the relationships between KM and ICT capabilities and results indicate that all variables except of two are partially or totally affected by control variables. *This supports Hypothesis 4, which states that contextual variables influence on the effect of KM and ICT capabilities on performance*.

This analysis has given a useful insight of what the results of further multivariate statistical analysis could produce. However, interactions between different independent variables are not taken into account since partial correlations study small causal models. In consequence, regression and canonical correlation analysis will be performed next.

8.4 Regression Analysis

After the preliminary analysis, regression analysis is run in order to test the research questions defined in Chapter 5. As in the section of factor analysis, further detailed information of issues dealt at the different stages that a typical regression analysis passes through is explained in Appendix V. It must be remarked that OLS regressions is applied in this analysis.

Impact of Knowledge Management and ICT Capabilities on Performance

Regressions are used to account for the variance in a dependent variable based on linear combinations of independent variables. In this study, the main objective is to analyse the extent to which knowledge management and information systems capabilities influence on the organisational performance. Therefore, the dependent variables are those regarding organisational performance and the independent variables, those with regard to knowledge management practices and information and communication technologies capabilities. The models resulted from the regression analyses will determine the set of independent variables which explain the maximum amount of variance in organisational performance.

It must be noticed that regression analysis can only deal with a unique dependent variable. Given that two scales have been extracted in relation to performance, two different regressions are analysed. Furthermore, new models are performed with the aim of controlling the effect of different contextual variables such as turbulence, control, size and process.

After applying the stepwise estimation technique to determine the statistical models resulting from regressing the variables regarding knowledge management and ICT capabilities on *Effectiveness* and *Innovative and Quick Flexibility* individually, the fulfilment of the assumptions of linearity, normality, non-outliers, non-multicollinearity and homoscedasticity has been checked.

Afterwards, control variables like turbulence, control, size, and process are included in the models in order to assess their impact on results. Several models have been tried and those offering greater explanation have been chosen. The results of the four models are shown in Table 40.

Table 40: Summary of Regression Models

Variables in the model	*Model EFF 1*	*Model EFF 2 (with control variables)*	*Model FLEX 1*	*Model FLEX 2 (with control variables)*
	B (Sign)	B (Sign)	B (Sign)	B (Sign)
(Constant)	0.84	1.01	-.31	-1.21
Culture for knowledge	0.40**	0.45**	.75**	0.59**
Business support by IT staff	0.32**	0.51**		
Customized IT infrastructure			.32**	0.24*
Commitment to IT by non-technical staff			.34**	
Collective knowledge integration				0.30*
IT intercommunication	0.28*			0.33**
Turbulence				0.25*
Adjusted R^2	15.4%	17.3%	31.6%	41.2%
F-test	15.44**	11.81**	20.59**	8.608**

Significance level: ** p<0.01 * p<0.05

The explanatory power of the models has increased after introducing the control variables. The adjusted coefficient of determination (R^2), which indicates the proportion of the variance in the dependent variable explained by their respective models, has increased in both cases. The model for *Effectiveness* has slightly increased from 15.4% to 17.3%, while the *Flexibility* model has gone from 31.6% to 41.2%. Therefore, the models considering the contextual variables explain better the variance in the dependent variables, than the models without control variables. This lends support to Hypotheses 4a/4b in regard to the mediating effect of contextual factors.

The models themselves have slightly changed when control variables are introduced. In the first case, *Secure and Sufficient IT Intercommunication* has been removed, giving more importance to *Culture for Knowledge* and *Business Support by IT Staff.* The model for *Flexibility* has removed C*ommitment to IT by Non-Technical Staff*, but

also has included more variables such as *Collective Knowledge Integration*, *Secure and Sufficient IT Intercommunication* and *Turbulence*.

In order to compare the importance of the variables within the selected models (those including the control variables), the standardized coefficients (beta in the regression outputs) should be looked at. The standard coefficients of the final models are gathered in Table 41.

Table 41: Standard coefficients of the models with control variables

	Model EFF 2 (with control variables)	**Model FLEX 2 (with control variables)**
Culture for knowledge	0.25**	0.29**
Business support by IT staff	0.33**	
Customized IT infrastructure		0.21*
Secure intercommunication		0.20**
Collective knowledge integration		0.19*
Turbulence		0.18*

Significance level: ** p<0.01 * p<0.05

The most important factor to increase *Effectiveness* is *Business Support by IT Staff*, followed by *Culture for Knowledge*. In the case of Flexibility, *Culture For Knowledge* is the most influential factor. At similar levels, *Customized and Unique IT Infrastructure*, *Secure and Sufficient IT Intercommunication*, *Collective Knowledge Integration* and *Turbulence* intervene in Flexibility.

In the case of *Effectiveness*, the reliance on information systems with the aim of supporting the business processes and the existence the appropriate climate for enhancing knowledge seem key in performing efficiently. At the same time, *Culture for Knowledge* appears to be a critical factor for *Flexibility*. As commonly stated, culture is the glue that holds together all the parts of an organisation, hence, it seems reasonable to be a key issue when determining the firms' flexibility to adapt to new changes and effectiveness in performing their tasks. Internal *intercommunication* enabled by ICT can enhance quick and coordinated ways of working, avoiding any waste of time and effort. But only if ICT are used to support the business strategy and processes, the impact on organisations will be positive. When necessary,

customisation of such information systems to the needs of the firm appears to be an important variable. Another important factor in explaining *flexibility* is the *collective integration of knowledge*. Reflection and common interpretations of experiences is essential for firms to act as a unit quickly faced with unexpected situations. Finally, it must be said that those firms suffering from high *turbulence* manage to be more flexible.

Nonetheless, the interpretation of the models should be cautious. The independent variables are highly correlated among each other (see Appendix 3); hence some variables could have been excluded from the model due to their interrelationship with the existing independent variables within the model, in spite of being related to the dependent variable. In fact, according to Hair et al. (1998), in case of having high intercorrelations among independent variables, stepwise regression should only be used for prediction, not for interpretation. In order to check whether this phenomenon has happened, further analysis would be carried out in the next section using canonical correlation analysis. Yet first, Hypothesis 4 will be tested applying further regression analysis.

Interactions Between Knowledge Management and ICT Capabilities

Another research question that this research aims to address makes reference to the interaction between knowledge management capabilities and ICT capabilities (Hypotheses 3a and 3b). The correlations between the two types of capabilities (see Appendix 3) indicate that all significant associations are positive to more or less extent. *Commitment to IT by Non-Technical Staff* is the ICT scale that correlates with the highest number of KM capabilities. Among KM scales, the most frequently correlated ones are *Organisational Alignment* and *Identification of Individuals' knowledge*. These relationships will be discussed later in this chapter.

However, in spite of providing useful insights, simple correlations do not take into account the multiple interactions among scales. Therefore, in order to analyse these interrelationships, further regressions are carried out. The relationship between the

two capabilities can have two directions: first, ICT can influence on KM capabilities, and second, KM capabilities can influence on ICT capabilities. Next, the results of the significant regressions will be presented. Having into account the recommendation given by Hair et al. (1998) and depending on the number of variables and cases available, in this case a cut-off point of the amount of variance accounted by the 9% is considered appropriate.

ICT Capabilities ➔ Knowledge Management Capabilities

From the thirteen variables regarding knowledge management, three variables have resulted to be significantly influenced by ICT related scales (see Table 42). First, *Culture for Knowledge* seems to be explained by the *Commitment to IT by Non-Technical Staff* and the *Intercommunication* enabled by the information systems. It seems reasonable that an appropriate culture for enabling knowledge will be enhanced in those firms where everybody is committed towards ICT use and where ICT infrastructure allows intercommunication within the organisation in a secure way. Second, *Strategic Alignment* is influenced by the *Commitment to IT by Non-Technical Staff* and the *Managerial Skills of Technical Staff*. ICT can provide appropriate means to align all organisational activities. However, in order to get these advantages, everybody should be able to make full use of ICT, hence the *Managerial Skills of Technical Staff* might be key in achieving this. Finally, *Managerial Skills of IT Staff* and the *Customised and Sufficient Infrastructure* influence *Research Promotion*, which will be commented in the next section.

Table 42: Regression on dependent KM capabilities variables

Variables in the model	**Culture for knowledge**	**Strategic Alignment**	**Research promotion**
	B (Sign)	B (Sign)	B (Sign)
(Constant)	3.08**	2.30**	2.25**
Commitment to IT by non-tech staff	0.16*	0.22**	
IT intercommunication	0.15*		
Managerial skills of IT staff		0.20*	0.26**
IT infrastructure			0.19**
Adjusted R^2			
F-test	9.4 %	14.2 %	16.2 %

Significance level: ** p<0.01 * p<0.05

Knowledge Management Capabilities ➔ ICT Capabilities

Four out of seven ICT variables are explained by some KM related variables (see Table 43). Variance in *Secure and Sufficient IT Intercommunication* is determined by *Incentive for Knowledge Sharing* and *External Sources of Knowledge*.

Table 43: Regression on dependent ICT capabilities variables

Variables in the model	**Secure and sufficient IT intercommunication**	**Customized and unique IT infrastructure**	**Commitment to IT by non-technical staff**	**Managerial skills of IT staff**
	B (Sign)	B (Sign)	B (Sign)	B (Sign)
(Constant)	2.49**	0.87*	1.83**	1.53**
Incentive for knowledge sharing	0.15**			
External sources	0.18**			
Research promotion		0.50**		0.22**
Strategic Alignment			0.42**	0.25**
Adjusted R^2	9.7 %	12.9 %	13.7 %	14.7 %
F-test				

Significance level: ** p<0.01 * p<0.05

The acquisition of new knowledge from external sources might provide the knowledge or information required to build a secure ICT infrastructure or might be the driver for implementing new ICT. This information or knowledge might not only refer to technical issues, but to ways of funding IT investments. Results indicate that ICT intercommunication is more common in those organisations which promote internal knowledge sharing. *Customized and Unique IT Infrastructure* is explained by *Research Promotion* while *Commitment to IT Skills by Non-Technical Staff* depends on the *Strategic Alignment*. Finally, *Research Promotion* and *Strategic Alignment* account for 14.7% of the variance of *Managerial Skills of IT Staff*. Therefore, *Research Promotion* affects *Customized and Unique IT Infrastructure* and *Managerial Skills of IT Staff*. It must be noticed that the previous section has suggested the opposite relationship, the influence of ICT capabilities on KM capabilities. This means that there is a reciprocal interactive relationship between these two sets of variables. Hence, the more research a firm promotes the more ICT capabilities will be developed in terms of *Customized and unique IT infrastructure* and *Managerial skills of IT staff*, and the contrary, the more customized the infrastructure is and more managerial skills the technical staff has, the more research will be facilitated. The same situation occurs in regard to strategic alignment. The

more committed to non-technical staff are, the more alignment will be enhanced within organisations, and the more aligned firm's activities are, the more commitment towards IT will be encouraged. The final circular relationship implies that the more managerial skills technical staff has, the more internal alignment will be achieved, while the more alignment exists within firms, the more managerial skills of technical staff will be developed.

To conclude, results show that *Hypothesis 3 is partially supported* since some interactions between knowledge management capabilities and ICT capabilities have been suggested by the data. Some capabilities seem to interact simultaneously, but generally, a greater proportion of ICT capabilities appear to be boosted by knowledge management capabilities, than the opposite.

8.5 Canonical Correlation Analysis

This section will deal with Canonical Correlation Analysis (CCA) aiming at two objectives: first, to analyse the interrelationship between independent and the two dependent variables simultaneously, and second, to validate the results obtained from regression analysis.

CCA is a little known statistical technique belonging to multiple general linear hypothesis (MLGH) family. CCA facilitates the investigation of many-to-many relationships, that is, the relationship between a set of many independent variables with another set of many dependent variables. The two sets of linear combinations obtained from CCA aim to get the maximum correlation between each other. As with previous techniques, detailed information about the steps in applying CCA is attached in Appendix V.

In spite of being a powerful multivariate technique, CCA has been "dormant" for more than a century (Krus, Reynolds and Krus (1976) cited by Nadler et al. (2003)). Some devalue CCA by arguing is only used as a last resource when the other more techniques do not work, since it has less restrictions. However, according to others such as Baggaley (1981), it is surprising the little use of CCA, since it is the most general case General Linear Models. The reasons of this relegation are mainly two: first, the mathematical complexity that involves, and second, the difficult interpretation of the multiple coefficients. In fact, interpretation of the coefficients is still difficult, but the results can help to identify what dimensions of the dependent and independent variables maximise their relationship. The development of computerized programmes has allowed taking CCA out of the darkness. Nevertheless, the take-up process is being slow, and yet CCA does not included in the standard options of statistical packages such as SPSS, but it can be performed by running the appropriate syntax.

Impact of KM and ICT Capabilities on both Performance Scales Simultaneously

Multiple regressions is a particular case of CCA. Although both techniques measure the strength of relationships, they present two obvious differences. First, regression analyses the relationship between several independent variables and a unique dependent variable, while in CCA allows more than one dependent variable. Second, in OLS regression the criterion for selecting the significant variables is based on the least squared distances, while in CCA is based on the largest correlation between the two sets of variables.

The main objective sought in this thesis is to analyse the relationships among knowledge management, ICT capabilities and performance, controlled for contextual variables. Therefore, the set of dependent variables will be constituted by Effectiveness and Flexibility and the set of independent variables will include the knowledge management related scales, ICT related scales and the selected contextual factors.

The output presents different canonical functions or variates, that is, different sets of linear combinations of dependent and independent variable. However, only the pairs of sets that are significant will be interpreted. According to Wilks' lambda test, the first variates are the only significant ones at a 0.01 significance level.

The selection of the appropriate variate in based on three indicators: (1) the canonical correlation coefficient (Rc) which measures how strong the relationship between the two variates is; (2) the redundancy coefficient for the dependent variables (Rd) which indicates the proportion of variance in the dependent variable explained by the variate; and (3) a common rule of thumb of canonical cross-loadings, or by default, canonical loadings greater than 0.3. Following these criteria, the final result of the CCA is shown in Table 44. In this case Rc is of 51.41% while Rd is of 33.47%. Both the correlation level and the proportion of variance explained are appropriate, since, given that there are more than one dependent variable, one cannot attempt to explain 100% of the variance in the dependent variable set by the independent variable set, hence the Rd obtained is acceptable.

Table 44: Cross-loadings resulted from CCA for two dependent variables

Cross Loadings for Set-2	
S1CULT	-.437
S2ALIGN	-.383
EXPR4	-.342
EXPT1	-.340
EXPT2	-.415
ITTECH1	-.308
ITTECH2	-.347
ITHUM1	-.335
ITHUM3	-.303
TURBULEN	-.327

→

Cross Loadings for Set-1	
P1EFFEC	-.400
P2FLEX	-.714

By squaring the cross-loadings, the results show that 16% of the variance in Effectiveness and 51% of the variance in Flexibility are explained by the linear combination of the following variables: *Culture for Knowledge*, *Strategic Alignment*, *External Sources of Knowledge*, *Encouragement to Participate*, *Collective Knowledge Integration*, *Secure and Sufficient IT Intercommunication*, *Customized and Unique IT Infrastructure*, *Commitment to IT by Non-Technical Staff*, *Business Support by IT Staff* and *Turbulence*. Therefore, the explanatory power of the variates is greater than the levels detected by the regression analysis.

Examining the sign of the cross-loadings, all the relationship are in the same direction, which imply that the have a positive impact organisational performance.

The independent variables identified as significant slightly differ from those detected by regression analysis. There are new variables included in the linear relationship: *Strategic Alignment*, *External Sources of Knowledge*, *Encouragement to Participate*, *Secure and Sufficient IT Intercommunication*. However, although according to the regression results they are not directly associated to organisational performance, some of these variables have been identified significant in explaining other variables directly linked to performance. For example, 42.5% of the variance in *Culture for Knowledge* is explained by *Strategic Alignment*, *Encouragement to Participate*, *External Sources of Knowledge* and *Knowledge Acquisition at the Organisational Level*.

Checking the Results from Regression

When the set of dependent variables contains a unique variable, CCA is equivalent to regression analysis in the sense that both techniques aim to explain the maximum proportion of variance in the dependent variable. However, as said before, the criteria for selecting significant variables differ. While OLS regression aims to minimise squared distance, CCA attempts to maximise correlation between the two variates. Therefore, CCA is performed and compared to the results obtained from Regression analysis, both for *Effectiveness* and *Flexibility* individually. Applying the same criteria of selection as in the previous section, results extracted from applying CCA are summarized in Table 45.

Table 45: Cross-loadings resulted from CCA for one dependent variables

Variables	*Effectiveness*	*Flexibility*
S1CULT	.282	.457
S2ALIGN		.403
EXPR4		.348
EXPT1		.351
EXPT2		.425
ITTECH1	.284	.354
ITTECH2		.373
ITHUM1	.306	.379
ITHUM3	.355	.342
ITHUM4		.306
TURBULEN		.346
Rd = Rc	*35.88%*	*53.29%*

These results are compared to the ones got from the regression analysis. Since CCA accounts for greater proportions of variances in the dependent variables, its solution is considered more convenient to identify the key variables. The interpretation of the loadings and coefficients will not be addressed due to its difficulty (Hair et al., 1998).

8.6 Summary of the Statistical Analyses

So far, different multivariate statistical analyses have been applied. First, *factor analysis* has been performed in order to summarize the data and make them more manageable. As a result 22 unidimensional and reliable scales have been extracted and have been investigated applying further statistical analysis.

A preliminary analysis based on *partial correlations* has been carried out in order to grasp what the results could look like. The conclusion from this section is that most of the KM related scales influences on *Flexibility* while not on *Effectiveness*, except from *Culture for knowledge*. On the contrary, ICT scales correlate with *Effectiveness* and *Flexibility* in a similar manner. In general, most of the variables are partially affected by control variables, although some others are either not affected in any way or totally controlled.

Since the causal models are very small and they do not take into account the interaction among the independent variables. *OLS regression* and *canonical correlation analysis (CCA)* have been employed in order to analyse the interaction and relationship between knowledge management capabilities, ICT capabilities and organisational performance.

The results of the *regression analysis* shows that the most important scale to increase *Effectiveness* is *Business Support by IT Staff*, followed by *Culture for Knowledge*. In the case of *Flexibility*, *Culture For Knowledge* is the most influential scale. At similar levels, *Customized and Unique IT Infrastructure*, *Secure and Sufficient IT Intercommunication*, *Collective Knowledge Integration* and *Turbulence* intervene in flexibility. The interaction between knowledge management capabilities and ICT capabilities has also been analysed with regressions. Results indicate that some KM capabilities affect four out of seven ICT capabilities, while ICT capabilities have an impact on three out of thirteen KM capabilities. On the other had, simple correlation analysis shows that the majority of knowledge management and ICT capabilities are intercorrelated somehow. In consequence, results suggest that capabilities are interrelated. Altogether, results gives evidence to the theory of dynamic capabilities since they show the interaction between KM and ICT capabilities.

CCA is applied to model effectiveness and flexibility at the same time and individually. The results are slightly different from the ones obtained with regressions. Table 46 summarizes the results obtained when applying each technique.

Table 46: Comparison of Results From All the Used Techniques

	Effectiveness			***Flexibility***			***Effectiveness & Flexibility***
	Partial correlation	Regression	CCA	Partial correlation	Regression	CCA	CCA
S1CULT	●	●	●	●	●	●	●
S2ALIGN				●		●	●
EXPR1				●			
EXPR2				●			
EXPR3				●			
EXPR4				●		●	●
EXPT1				●		●	●
EXPT2				●	●	●	●
EXPT3				●			
ITTECH1	●		●	●	●	●	●
ITTECH2				●	●	●	●
ITHUM1	●		●	●		●	●
ITHUM3	●	●	●	●		●	●
ITHUM4				●		●	
TURBUL				●	●	●	●
Adj R^2 / Rd	--	*17.3%*	*35.88%*	--	*41.2%*	*53.29%*	*33.47%.*

NOTE: based on results from Table 39, Table 40, Table 44 and Table 45

Given the greater explanatory power of CCA when looking at *Effectiveness* and *Flexibility* individually and the similar results obtained when considering both performance scales simultaneously, the solution extracted by this technique is considered as the most appropriate in order to test the proposed hypotheses H 1a/1b/2 proposed by this research.

8.7 Summary of Hypothesis Tests

Recalling the research questions and hypotheses proposed in Chapter 5, Table 47 summarizes the translation of the statistical results into testing the hypotheses. It must be highlighted that the initial hypotheses were simpler given that results of the statistical techniques, especially factor analysis, could not be predicted.

Table 47: Summary of Research Hypotheses

Hypotheses	Result	Explanation
Hypothesis 1a: there is a positive relationship between knowledge management capabilities and effectiveness	Not supported	No KM capability except from *Culture for Knowledge* seems to influence on Effectiveness
Hypothesis 1b: there is a positive relationship between knowledge management capabilities and flexibility	Supported	A mix of scales regarding KM system, knowledge exploration and knowledge exploitation result significantly. Concretely, *Culture for Knowledge, Strategic Alignment, External Sources of Knowledge, Encouragement to Participate, Collective Knowledge Integration* positively affect Flexibility
Hypothesis 2: there is a positive relationship between ICT capabilities and organisational performance.	Supported	A mix of technical and human ICT capabilities appears to be positively related to performance. These capabilities are *Customized and Unique IT Infrastructure, Secure and Sufficient IT Intercommunication, Commitment to IT by Non-Technical Staff, Business Support by IT Staff* and *Managerial Skills of IT Staff*
Hypothesis 3a: knowledge management capabilities are mediated by ICT capabilities	Partially Supported	Regression and correlation analyses show that there are positive relationships between KM and ICT capabilities. Specially, *Culture for knowledge, Strategic Alignment* and *Research Promotion* are affected by specific ICT capabilities.
Hypothesis 3b: ICT capabilities are mediated by knowledge management capabilities	Partially Supported	Regression and correlation analyses show that there are positive relationships between KM and ICT capabilities. *Customized and Unique IT Infrastructure, Secure and Sufficient IT Intercommunication, Commitment to IT by Non-Technical Staff*, and *Managerial Skills of IT Staff* are positively influenced by KM capabilities
Hypothesis 4a: the impact of knowledge management capabilities on performance is mediated by the organisational context	Supported	Partial correlations show that all except from two KM capabilities are affected by contextual factors
Hypothesis 4b: the impact of ICT capabilities on performance is mediated by the organisational context	Supported	Partial correlations show that all ICT capabilities are affected by contextual factors
Hypothesis 4c: the impact of knowledge management capabilities and ICT capabilities are mediated by the organisational context	Partially Supported	Regression analysis and CCA show that the level of turbulence through which firms undergo have a positive impact on flexibility.

8.8 Discussion in Relation to the Hypotheses and Research Questions

Hypotheses 1a/1b: there is a positive relationship between knowledge management capabilities and organisational performance

The statistical results partially support the positive impact of knowledge management capabilities on organisational performance since the importance of knowledge management capabilities on explaining organisational performance depends on the type of performance measurement looked at. While effectiveness is hardly predicted by knowledge management capabilities (no support for Hypothesis H1a), quick and innovative flexibility benefits from them to a greater extent (support for Hypothesis H1b). The analysis of the non-causal relationships based on corrrelations (Appendix IV) corroborates the greater impact of knowledge management on flexibility, since most of the knowledge management scales are significantly related to flexibility. By contrast, Pearson's correlation coefficients between knowledge management scales and effectiveness show non-significant and very weak correlations, sometimes even negative. In conclusion, the results suggest that the contribution of knowledge management lies in issues such as innovativeness, responsiveness and adaptability.

This finding agrees with Gold et al. (2001), who found a positive association between knowledge management and organisational performance operationalised using similar concepts to flexibility as defined here. On the other hand, the results contradict the empirical evidence offered by studies such as Lee and Choi (2003), Tippins and Sohi, (2003) and Tanriverdi (2005), which support the positive relationship between knowledge management or organisational learning and organisational performance in terms of what here has been named as effectiveness. The different results could be due to the fact that the present study deals with SMEs while previous researches mainly focus on large firms.

Nevertheless, this reason seems to be dubious since, the only study within the context of SMEs (Ruiz-Mercader et al., 2006) finds that individual and organisational learning have a positive and significant effect on organisational performance measured as indicated in Table 4. They concentrate on firms with less than 10 employees within the IT sector,

characterized as knowledge-intensive sector and where they basically provide a service. Therefore, the real impact of knowledge management might depend on the type of sector and its characteristics. However, it must be pointed out that the set of performance indicators they used include different aspects than the ones adopted in this research. In consequence, the results cannot be compared.

Droge et al. (2003) find that the impact of knowledge management is inconclusive, since new knowledge creation do not predict financial performance, but applied knowledge do it. In response to the lack of support of the relationship knowledge creation and financial performance, Droge et al. (2003) argue that "*knowledge creation is more important in generating flexibility and innovativeness*" (p.564), however, they do not empirically support it, since, as most of the previous studies, it focuses on financial indicators. Thus, this study contributes to lend empirical evidence to the conclusions drawn by Droge et al. (2003).

The results commented above contribute to the debate commented in Chapter 3 regarding the effect of knowledge management on organisational performance (Lyles and Easterby-Smith, 2003), between two extremes: those who claim positive relationships (Cangelosi and Dill, 1965; Fiol and Lyles, 1985; Appleyard, 1996; Bontis et al., 2002; DeCarolis and Deeds, 1999; Hitt et al., 2001; Lee and Choi, 2003), and those who oppose this view (Argyris and Schon, 1996; March and Olsen, 1975). As Droge et al. (2003) claim, how performance is measured is a key point in this debate.

In the present study, two performance measures have come up: effectiveness and innovative and quick flexibility. The use of these two types of organisational performance measures comprises all the manufacturing competitive priorities: "*cost, quality, timeliness, and flexibility (Hayes & Wheelwright, 1984; Hill, 1994; Ward, McCreery, Ritzman, & Sharme, 1998); some authors also discuss innovativeness (Leong, Snyder, & Ward, 1990)*" (Droge et al., 2003:564), and has allowed assessing the impact of knowledge management in a comprehensive way. As said in Chapter 6, SMEs are known for their financial constraints and for their over-emphasis on their daily tasks. Therefore, the analysis of the two types of performance measures is very useful, since it will permit to make recommendations for fostering effectiveness and, above all, for enhancing innovative and quick flexibility.

As explained in the factor analysis, given their composition, the impact of effectiveness is more tangible and short-term oriented, on the contrary to flexibility, which can be perceived as a long-term competitive advantage. In fact, effectiveness and flexibility are highly related, since regression analysis suggests that flexibility mediates in effectiveness after controlling for contextual variables such as turbulence, control, size and process. Although there are extensive studies that provide empirical evidence of the positive relationship between innovative output and financial performance (Soo et al., 2003; Banbury and Mitchel, 1995; Chakravarti, 1990 among others), the relationship between financial performance and a comprehensive measure including innovation, responsiveness and adaptability, has never been tested before. The result supports that innovative and quick flexibility predicts effectiveness. Therefore, there is a trade-off between short-term and long-term benefits: firms might not immediately see the competitive advantage of knowledge management, but they will benefit on the long term since it determines flexibility. In fact, this can be the explanation to the phenomenon presented by Droge et al. (2003). Knowledge creation might have an effect on organisational performance, by mediating in knowledge application. Knowledge application would be the equivalent to the flexibility scale, since innovation, quick response and adaptability result from the application of knowledge management.

Given the characteristics of the new business environment, where "*the only certainty is the uncertainty*" (Nonaka, 1991:96), the strategic value of flexibility is indubitable. Even though firms are profitable and successful, their competitive advantage might be unsustainable if they are not innovative and do not adjust quickly to the increasing changes in the environment. Therefore, knowledge management is part of the renewal process which might provide sustainable competitive advantage in the current environment, where firms must engage themselves in constant transformation and retransformation (Teece, 1998a). As Penrose (1958) predicts and Nelson and Winter, (1982) support, firms' competition lies in the idea of disequilibrium, flexibility and organisational learning. On the other hand, given that the strength of SMEs over larger firms is their flexibility to cope with high levels of environmental uncertainty (Pfeffer and Sutton, 2000; Storey, 1994; Whittington, 1993), developing knowledge management capabilities will nourish this strength.

To sum up, knowledge management might not directly provide financial benefits, but its effect on the organisational capabilities such as innovation, flexibility and adaptability might be the source of competitive advantage in the long term. Having in mind the volatility of the new economy, long-term advantages might be more reliable. Thus, "*knowledge makes performance more reliable*" (March, 1991:83), although in the short-term learning may negatively impact performance (Crossan et al., 1995).

What aspects of knowledge management capabilities are more influential on organisational performance?

(1) Culture for Knowledge

Culture for Knowledge is the only scale which appears to be significant in improving both performance measures: effectiveness and flexibility. The effect of culture on effectiveness might seem initially unconnected to effectiveness, however, as Williamson (1991) claim, currently trust is the coordination mechanisms, so it is basic for efficient coordination and functioning. In fact, within the field of human resources, some articles have give evidence of the relationship between firm culture and financial performance, conceiving firm culture as the sharing of basic organisational values and norms. Researchers have found relationships between culture and performance in the short-term (Denison and Mishra, 1995; Calori and Sarnin, 1991 and Gordon and DiTomaso, 1992) and in the long-term (Kotter and Heskett, 1992). Even, from the ICT perspective, culture has a mediating role on the strategic use of ICT (Walsham, 1993). The interaction between actors, practices, technologies and social elements such as culture can be explained from the Activity Systems theory outlined in Chapter 2.

On the other hand, given that knowledge management seems to enhance flexibility to a greater extent, it is expected that culture be intrinsically linked to flexibility. Theory supports that a climate of trust, where open and transparent communications regularly take place, is a key factor for enabling knowledge management (Davenport and Prusak, 1998; Von Krogh et al., 1998; Nonaka et al., 2000). A trustworthy and caring work

atmosphere is essential for employees to feel safe and comfortable to interact, discuss and collaborate since it provides the grounds for common understanding. As Nahapiet and Ghoshal (1998) and Tsai and Ghoshal (1998) claim, cultures based on goodwill trustworthiness increase the influence of social capital. Indeed, an appropriate culture for knowledge supports the integration of the individual and group learning, and, as a result, the renewal of the organisational knowledge bases and the formation of a common language and the organisational values. In other words, it enables the development of organisational knowledge. Culture acts as the invisible glue that unites individuals into social structures (Smircich, 1983)). Given that organisational culture is developed over time, it becomes an important strategic capability difficult to be replicated, hence it provides sustainable competitive advantage (Barney, 1986).

On the other hand, no control variables (Appendix IV) seem to be associated to culture for knowledge. One could expect that, for example, more hierarchical and centralized structures would hinder culture for knowledge. However, in the context of SMEs it does not appear significant.

Previous research (Lee and Choi, 2003) empirically supports the essential role of trust for enhancing knowledge management, and, indirectly, improving organisational performance. Gold et al. (2001) also conclude that organisational culture is key in knowledge management, however, the operationalisation of their construct refer to alignment issues and encouragement to participating, among others. Although Ruiz-Mercader et al. (2006) incorporate this concept as part of individual learning, further information about its specific impact on individuals and on performance is not provided. However, since the relationship individual learning and performance is supported, indirectly a positive relationship between culture for knowledge and performance could be implied. The rest of the empirical studies fail to account this aspect in their analysis.

Regarding the specific practices that promote an appropriate culture for knowledge, Table 31 in Chapter 7 shows that providing incentives for team results and for helping others, organizing social activities outside the firm and clearly stating the values are the practices most correlated to better organisational performance. These results can give firms some insights on how to develop a culture or atmosphere that enhances knowledge acquisition, creation, sharing and integration.

The next scales regard to knowledge management and, as said before, they only contribute to quick and innovative flexibility.

(2) Strategic Alignment

This study gives evidence of the importance of strategic alignment within organisations in order to maximise flexibility. As Levitt (1989) state, "*learning does not always lead to intelligent behaviour*" (p.335). Therefore, the establishment and effective communication of organisational objectives might be the key to guide all the learning efforts taking place in different parts of the organisation to work towards a common objective in coordinated way. According to Bierly and Chakrabarti (1996), regardless the extent to which knowledge management practices are carried out, their impact on the organisational performance depends on the suitability to support the organisational strategy. Other researchers (Leonard-Barton, 1992; Nonaka et al., 2000) also emphasise the importance of providing mental goals and meaning to the everyday actions. Even the need to develop a vision of manufacturing in the next 20 years has been addressed by governmental initiatives (DTI, 1999). Therefore, given the results presented here, managers should ensure the organisational mission and objectives are widely known across the firm and that all the activities are aligned in advancing towards them.

Although strategic alignment is also important for effectiveness matters, other scales seem to be more significant in predicting effectiveness. In fact, the impact of strategic alignment is indirect, through flexibility.

Correlation analysis shows that control and strategic alignment appear statistically related. This seems reasonable, since, in order to ensure the strategic alignment of all the activities of the firm, control over its processes is critical. Thus, the results demonstrate that the strategic alignment is a differential factor in flexibility and in terms of knowledge management, specific objectives should be pursued in order to support the business strategy. However, as commented in Chapter 6 SMEs usually lack of a knowledge vision.

The only study which takes into account this concept is the research of Gold et al (2001), but under the name of organisational culture. They also found a positive relationship between this and organisational effectiveness or, using the terms of this research, quick and innovative flexibility. As in the previous case, Ruiz-Mercader et al., (2006) include it under the concept of individual learning, thus, indirectly, the positive relationship between strategic alignment and performance is suggested. Tanriverdi (2005), on the other hand, considers the strategic alignment from the IT strategy point of view, as part of the IT human resource management processes. Thus, its significance is also indirectly found through this scale. The remaining studies fail to include this aspect.

In respect to specific practices which enable strategic alignment, several comments can be done bearing in mind the results of Table 31 in Chapter 7. As said before, the statement of the values of the firm is significantly correlated to both performance scales. This implies that common codes of behaviour are ensured in order to avoid internal conflicts. Another important factor in strategic alignment is the role of the CEO as a coordinator of firm activities. Table 31 shows that regular communications of the CEO with departmental managers is positively associated to effectiveness and flexibility. The knowledge acquired by the CEO by wandering around the firm is also significantly correlated with flexibility. This type of knowledge is important since it may concern important but intangible issues that are overlooked. For example, the observation of certain attitudes of employees or the work processes might inspire new ideas or potential actions for improvement. Finally, communication within the organisation and with stakeholders is an essential factor for assuring the internal alignment of organisational activities with the aim of responding to the market needs. The relationship between communication practices and performance will be commented later due to its greater implication in encouragement to participate.

(3) External Sources of Knowledge

From all the scales extracted from knowledge exploration, the acquisition of knowledge from external sources is the only one that has resulted significant in explaining flexibility. This finding is in line with the argument of Hartley and Hutton (1998), who state that SMEs flexibility might be constrained by their lack of external scanning capabilities.

Those firms in contact with external sources of knowledge are more likely to have superior flexibility, given that they are more exposed to new opportunities and they develop the ability to recognize opportunities. In other words, it helps to develop entrepreneurial learning. In the case of the mechanical engineering sector, this factor might be crucial because of its exports-orientation commented in Chapter 4.

Soo et al. (2003) conclude that not only external networking but also internal networking is important sources of information and know-how. However, it is interesting to see that the identification of internal knowledge or knowledge from their stakeholders do not appear significant. While larger firms find problematic to identify and use all their internal knowledge bases, SMEs achieve it naturally in the course of their activities due to their reduced size. On the other hand, larger firms are more able and aware of interacting with the external environment, while SMEs are usually over-focused on daily "fire-fighting" operational problems and on tangible results (Vos et al., 1998). Therefore, it seems that larger firms find it more difficult to take advantage of internal networking whilst SMEs are more challenged by the external networking. Indeed, they should engage in more knowledge management strategic activities such as benchmarking (Nelder and Skandalakis, 1999), attendance to fairs or events, etc. in order to keep up-dated on the dynamics of the environment and, in this way, ensure the sustainability of their effectiveness. This dynamic process will contribute to open a broad range of knowledge bases and the development of absorptive capacity since firms will learn to recognize the value of new and external information.

This study is consistent with the research of Liao et al. (2003), who empirically demonstrate that external knowledge acquisition, as fundamental part of absorptive capacity, is a strong predictor of SMEs responsiveness.

As the report of DTI (1999) claims "*the increasing pace of change in science and technology is forcing manufacturers not only to invest faster than ever before in their next generation of products but also to keep abreast of the latest manufacturing techniques and processes in order to manufacture them competitively*" (p.4). In fact, external sources of knowledge is statistically related to turbulence and control, demonstrating that in turbulent environments, control over external and internal issues might be crucial since they enable continuous alignment between internal activities and

the needs of the market. Chakravarthy (1986) argues that the quality in this process of aligning with the environment is the key in performance differences. Similarly, and Cyert March (1963) claim that the access to external knowledge is essential, since organisational learning should continuously adjust and respond to the feedback from the environment. The globalisation of the markets has made this capability essential to survive and SMEs should prevent the globalisation by interacting with their external environment. Once again, firms should make a trade-off between short and long-term benefits.

Acknowledging the lack of financial resources, policy makers should take notice of the importance of external exposure and implement initiatives to implement it. At the same time, SMEs should rely on governmental support (e.g. governmental initiatives such as "Environmental-Best Practice Programme") and regional clusters in order to access external sources of knowledge. They can create opportunities for knowledge acquisition and also, exploitation (Yli-Renko et al., 2001; Dyer and Singh, 1998) and develop the contacts which enable knowledge transfer and collaborations within regional social networks (Rogers and Larsen, 1984). It could be named as "external social capital" development. In fact, the continuous contact with external sources of knowledge could be the solution for SMEs' financial constraints (CBI, 2001).

Results from Table 31 help to understand which practices regarding sources of external knowledge are preferred by firm with better performance. As explained in Chapter 7, attendance at external centres and fairs is highly correlated with both performance scales, while consultancy services does not seem to have a great impact on organisational results. Results of Table 29 show that firms do not highly value the acquisition of external knowledge through consultancy services or the attendance to external events. Thus, firms should realise and be encouraged to participate in external activities where the can relate with possible clients, collaborators and also observe the dynamics of competitors. Regarding market knowledge, benchmarking, market research and monitoring the market continuously appear significantly related to performance. Specially, market research has the highest correlation with effectiveness while continuous monitoring of the market has it with flexibility. These results seem reasonable, since in order to respond to the market on time and successfully, firms should be alert of its movements. On the other hand, firms can acquire external knowledge by establishing strategic collaboration with other

firms in the form of mergers, acquisitions, joint-ventures and R&D contracted-in. Results in Table 31, however, show that only mergers have a slight significant effect on effectiveness, while only R&D contracted-in relates to flexibility. Indeed, R&D contracted-in or Licensed-in can allow firms to be innovative and adaptable quickly, without requiring the development of internal capabilities. Having in mind the above comment, firms can start devising what activities they should start engaging in.

Having dealt with knowledge exploration, knowledge exploitation significant scales will be discussed. Two scales from knowledge exploitation have resulted strong predictors of quick and innovative flexibility: encouragement to participate and collective integration.

(4) Encouragement to Participate

Encouragement to participate refers to encouraging employees to interact and discuss with others, but also, at an individual level, to experiment and practice their ideas. Therefore, it involves how individuals share and integrate knowledge.

Sabherwal and Becerra-Fernandez (2003) find that both processes socialisation and internalisation influence on knowledge management effectiveness, while Lee and Choi (2003) give evidences of the impact of such processes on organisational performance.

Valuable knwoelde held by people can be acquired through social interactions. The importance of interaction between individuals in generating knowledge and innovation has been highlighted by many scholars (Argyris and Schon, 1996; Arrow, 1963; Brown and Duguid, 1991). Even empirical studies have found a positive relationship between social interaction and knowledge acquisition (Liebeskind, 1996; Yli-Renko et al., 2001; Van Wijk et al., 2003; Soo et al., 2003). Within the same line of thinking, the results of the present study support the causal relationship between social interactions and flexibility.

In respect to individual integration, individuals must experiment and practice in order to apply the knowledge acquired. What Nonaka et al. (2000) name internalisation allows the accumulation of tacit knowledge through experience, and it should be an inevitable step

after acquiring external knowledge or exchanging internal knowledge. The level of empowerment could influence on individuals' knowledge integration, however, correlation analysis does not indicate to be relevant. In the context of SMEs, empowerment might not be as important as in large firms, since all the operations are quite centralized around the manager due to the small size of the firm and interactions are less bureaucratic and more spontaneous.

Together with external knowledge acquisition, intraknowledge dissemination forms the conceptualisation of absorptive capacity in the study of Liao et al. (2003). They define intraknowledge dissemination as the process of disseminating and assimilating knowledge, which makes it equivalent to the scale commented here. As said earlier, Liao et al. (2003) find a positive relationship between absorptive capacity and SMEs responsiveness.

Next, specific practices and variables related to encouragement to participate will be commented. Regarding the format of the interactions, SMEs are more prone to have informal contacts and, given their size, have more human interaction than larger firms. As commented in Chapter 7, Table 26 shows the greater reliance on informal meetings than on formal ones. However, Table 27 shows that the respondents highlight the importance of holding formal meetings with team members, in spite of the fact that informal meetings are very frequent. This might reflect the importance of more formal discussion in order to arrive to a common understanding and direction of working. On the other hand, correlation analysis shows that firms with superior results, specially those related to flexibility, are engaged in team working and try to promote it by adopting incentive systems based on team results. This corroborates the positive association between social interaction within organisations and flexibility.

Regarding the way in which SMEs communicates, Table 31 shows that all types of communications, formal and informal, direct or indirect, are related to performance indicators to some extent. Informal meetings with the CEO has the highest correlation with flexibility, while formal face to face meetings with other departments is the most correlated with effectiveness. On the other hand, the exchange of visits with suppliers and customers are significantly correlated to flexibility and those visits to the premises of suppliers and customers to effectiveness. Observation of activities in firms', suppliers'

and customers' premises can provide tacit knowledge of great importance, for example, to develop innovations, to enhance collaborations and to build up a relationship of trust. In respect to indirect communication in the form of memos, suggestion schemes which allow upwards communication, and periodic internal publications significantly relate to both performance indicators. To a lesser significance and extent, the use of metaphors and visual communications seem to be associated to flexibility. These results should help managers to shape their communication activities based on empirical evidence.

On the other hand, individual participation requires spare time and resources, since it does not directly contribute to product manufacture. Although resource availability does not come up as significant in the multivariate analysis, Table 31 shows that the provision of appropriate resources is related to organisational performance, specially, to flexibility. Furthermore, Table 31 also indicates that flexibility is highly associated with the availability of resources to experiment, of pilot areas and software to simulate, of meeting rooms, comfortable work places and spare time to solve problems, research and discuss. To a lesser extent, all except from the provision of resources to experiment appear significantly linked to effectiveness, especially, to the provision of ergonomic work place. Indirectly, the latter can imply the sense of care towards staff, thus contributing to the atmosphere at work.

Given the lack of resources of SMEs, resources play a role in achieving differential competitive advantage in terms of adaptability, innovativeness and quick response. As Penrose (1958) predicted, the existence of "*resources in excess*" might be a key determinant of competitive differentiation. The fact that control is not related to encouragement to participate cannot be enhanced under strict control systems.

Given the dispersed distribution of the knowledge systems (Tsoukas, 1996), the organisational structure might be determinant in enabling internal and external interactions. When running cross-tabulations between the types of organisations and encouragement to participate, differences are found between two groups: on the one hand, hierarchical and flat structures, and on the other hand, matrix and flexible structures, being the latter superior in terms of encouragement to participate. The similar results for hierarchical and flat structures were intuited, since due to the small size of

SMEs, hierarchies cannot have many levels, hence they are quite flat in comparison with larger firms.

As seen before, an appropriate culture for knowledge gives the right basis to enable true social interactions within organisations. At the same time, intensive social interaction nurtures this culture. According to March (1991), there is a mutual learning between socialization processes and organisations (culture, values, routines) over time.

Another aspect that can facilitate social interactions is the implementation of interactive technologies. Information systems can also be key in supporting individuals interaction and integration across time a space. Chapter 3 describes the existing ICT which aim at supporting collaboration, social interaction and communication processes. However, only computer-based learning relates to encouragement to participate, which indicates that it can be a useful tool to enhance individual knowledge integration. Those ICT designed to support new channels of communication and collaboration (e.g. e-mail, intranet-extranet, groupware, forums, etc.) are not correlated to any performance scale, with the exception of the slightly significant correlation of phone with effectiveness. Furthermore, these ICT are not associated to encouragement to participate. This result shows the less significant role of these technologies in SMEs compared to larger firms. There can be two possible explanations: first, the small size and little dispersion of manufacturing SMEs makes these technologies less necessary; or second, SMEs have not discovered yet or they do not make full use of the advantages offered by ICT. Indeed, Levy et al. (1999) argue that SMEs still conceive ICT as a waste of money, rather than as strategic opportunities. Furthermore, Caldeira and Ward (2002) indicate that the use of ICT in SMEs is a recent phenomenon. These issues will be expanded later in relation to the ICT results.

(5) Collective Knowledge Integration

The final significant scale in predicting flexibility is collective integration, which makes reference to integrating knowledge into the organisation through open discussions, and reflection after projects, regardless their success. Making sense of new knowledge and experiences at the collective level is essential to enrich the organisational knowledge bases and incorporate them in terms of new routines or practices. Reflection should be

accompanied by open discussions in order to arrive to common interpretations and conclusions, hence, collective integration is influenced by organisational alignment, and vice versa. Therefore, collective integration ensures that the firm learns from their experiences and will apply them in the future. Past experiences, especially failures, are one of the richest sources of knowledge, thus firms should engage in extracting the maximum from them, but to do so, firms should exert certain control over their processes. This justifies the correlation between control level and collective integration. In fact, integration is another process that allows firms to amplify their absorptive capacity, since it increases the ability to recognise and evaluate new knowledge. In the dialoguing "ba" (Nonaka et al., 2000), organisations build up a common understanding, a shared sense of identity over the time (Von Krogh, 2003; Boland and Tenkasi, 1995), which allows the community to seize knowledge opportunities timely by deeply improving knowledge sharing (Von Krogh, 2003). However, as commented in previous scales, their lack of resources and their lack of attention to non-operational issues make SMEs more difficult to engage in collective integration.

Since the classification of knowledge management capabilities differs across the different empirical studies, the comparison of this scale with previous research result becomes difficult. The only reference to empirical evidence of collective integration is made by Gold et al. (2001), who include it as part of the knowledge management application processes, finding a positive relationship between KM application and flexibility indicators.

Apart from the commented communication practices, the way in which work is organized can influence collective knowledge integration. Indeed, individual work does not relate to any of the performance scales. However, all types of team working (functional, cross-functional and multidisciplinary) indicate significant correlations to effectiveness and flexibility. Therefore, firms should be aware of the importance of teamwork and promote it in their organisations, as it promotes the integration of individual knowledge into collective knowledge.

Regarding the contextual variables, it seems that firms with greater levels of control score higher in collective integration. This seems logical since it reflects the typical process of improvement: control, sense making of the data and action to readjust. On the other hand,

structure also appears significantly related to collective integration. As in the previous case, matrix and flexible structures are keener on getting involved in collective integration than hierarchical and flat structures.

The organisational learning produced as a result of the collective integration can be stored in explicit ways such as meeting reports, or simply in individuals' minds. Table 31 shows that there are significant associations between generation of meeting reports and all performance indicators, especially with flexibility. Although reliance on individuals' memory is not significantly related to any indicator, access to past experiences by contacting staff involved appears significantly related to the performance indicators forming flexibility. This result highlights the importance of sharing personal experience as a way of building the organisational memory.

General comments about critical factors

To conclude, the impact of knowledge management capabilities on performance depends on the type of performance measure adopted. This study has differentiated two main performance scales: effectiveness and quick and innovative flexibility. While a culture based on trust and open communication is the only basic scale related to knowledge management which determines effectiveness, four other scales appear to be critical for SMEs flexibility. An appropriate knowledge management system in terms of culture and strategic alignment seems to be essential to achieve better results in respect to flexibility. Once the base is set up, knowledge exploration and exploitation can take place effectively. One scale regarding knowledge exploration results significant, while two scales come up from knowledge exploitation as critical in predicting flexibility. The three scales correspond with the capabilities defined by Almeida et al. (2003): scanning, sourcing and combinative capabilities.

Among knowledge exploration scales, external sources of knowledge stands out. SMEs who acquire external knowledge excel in terms of innovation, timely response and adaptability. Furthermore, external sources of knowledge enable the development

external social capital, essential for supporting SMEs fragile conditions and in continuously adjusting to the new conditions of the market.

Regarding knowledge exploitation, issues regarding knowledge integration and sharing at both levels, individual and organisational have resulted significant in predicting flexibility. Encouraging individuals to take an active role within firms by interacting with other individuals and by experimenting appears to be a distinctive factor for flexibility. Furthermore, results show that sense making at the collective level is also significant.

Therefore, processes within and between different levels of the organisation, individual and collective, seem to affect organisational flexibility in terms of innovativeness, quick response and adaptability. This finding supports the basic posit of the KBV which conceives firms as social communities whose essence is their organisational capability to integrate the different knowledge bases (Grant, 1996). Furthermore, the results corroborate the idea of dynamic interactions between the different components in an activity system and a mutual learning over time (March, 1991).

The results also support the idea that knowledge management intrinsically involves developing the absorptive capacity of the firm and, as a result, improving firm's responsiveness. This study is consistent with the research of Liao et al. (2003) which also deals with SMEs since internal and external interactions have been found significant in explaining flexibility.

Another important conclusion from the results is the need to keep an eye on the external environment. The RBV has often been criticised for overlooking the external environment, however, the results demonstrate that from the KBV the capability of scanning external sources of knowledge and taking the most from them is of particular importance within the context of SMEs. It can represent the feedback loop required to respond to the environment timely and effectively.

Other issues, such as collaboration or identification of internal skills have not resulted significant. The reason for this might be the characteristics of SMEs, such as size, "survival" pressure and informality among others.

These results differ from studies using a similar approach to this research, such as Choi and Lee (2003), Gold et al. (2001) and Tippins and Sohi (2003) in the sense that they find that all constructs regarding knowledge management capabilities are important. Apart from the fact of using different constructs and different analytic techniques, this might be due to the context of SMEs in the mechanical engineering sector, since, as theory suggests, context shapes the way in which knowledge is managed.

In spite of the potential to agile interaction and integration of knowledge, generally SMEs are not engaged in knowledge management activities (Pelham, 2000; Duhan et al., 2001; Loebbecke et al., 1999). However, sooner or later SMEs should become more involved in these activities. The increasing importance of knowledge management for UK manufacturing firms is highlighted by the report of DTI (1999): "*all manufacturers, large or small and whether from a "traditional" or high-technology sector, are and must see themselves as part of the knowledge-driven economy. Many UK manufacturers are already integrating this challenge into their thinking and action but many need to move faster*" (p.4).

Thus, this section has highlighted and discussed the key factors in knowledge management. Moreover, specific advices on knowledge management practices have been commented on a best-practice basis. As a result, guidance on what aspects SMEs should aim at in order to successfully implement knowledge management-oriented initiative and catch up with the current dynamics of the marketplace. Next, the discussion on ICT capabilities will take place.

Hypothesis 2: there is a positive relationship between ICT capabilities and organisational performance

The results of this study show that ICT capabilities, both technical and human capabilities, positively influence organisational performance, both in terms of effectiveness and flexibility.

Within the literature most of the studies show a positive relationship between ICT and organisational performance (Bharadwaj, 2000; Lehr and Lichtenberg, 1999; Lichtenberg, 1995; Siegel, 1997), while fewer studies find this association inconclusive (Cron and Sobol, 1983; Stiroh, 2001). This study agrees that it is erroneous to assume that ICT themselves can enhance performance (Dewett and Jones, 2001) since any competitor can acquire them. However, the adoption of the RBV or capabilities perspective has allowed to research from a more comprehensive view the real impact of ICT on organisational results. In this way, this research contributes to the gap in the literature spotted by Dewett and Jones (2001): "*the role of IT in promoting innovation is very underrepresented in the literature because of the focus on its effectiveness-enhancing properties*" (p.326).

The results of the present research agree with existing studies based on the RBV, which generally find positive relationship between ICT capabilities and performance. However, most of them analyse the effect on organisational performance by using financial metrics. Only the research of Powell and Dent-Micallef (1997) uses qualitative indicators to capture the firm's self-assessment on the indicators that are summarized here by the scale effectiveness. No study, to the best of my knowledge, has studied the effect of ICT capabilities on quick and innovative flexibility. Therefore, an important contribution of this study is that it adopts a broader concept of organisational performance. All previous studies focus on effectiveness, but here the impact of ICT capabilities on issues such as innovativeness, responsiveness and flexibility is assessed additionally. The results demonstrate that not only ICT capabilities improve short-term performance, but also play a role in long-term results. In fact, ICT capabilities are developed over time (Ravichandran and Lertwongsatien, 2005), so the history of choices regarding ICT and the accumulated experience on ICT capabilities make them difficult to be replicated, and thus, have an impact on the long term. In consequence, ICT capabilities seem to provide

sustainable competitive advantage, since they have an impact on a holistic range of performance indicators

Furthermore, previous researches focus on large firms; hence this analysis contributes to research the scarcely studied SMEs. When comparing the results, it can be concluded that indistinctively, large and SMEs, find positive relationships between ICT capabilities and effectiveness. However, while previous studies (Powell and Dent-Micallef, 1997; Bharadwaj, 2000; Ravichandran and Lertwongsatien, 2005) conclude that advantages provided by ICT capabilities do not especially lay on technical issues but on human aspects, this research finds that both types of factors contribute to make a difference in the organisational results. Sectoral differences should be studied further in order to ensure that this finding is generalisable to all SMEs.

To sum up, technical and human aspects influence both effectiveness and flexibility, although more ICT scales affect the latter. However, the analysis of the non-causal relationships based on correlations (Table 39) show that similar ICT capabilities relate to both performance scales. Next the critical ICT capabilities identified in this study will be discussed.

Which aspects of information and communication technologies capabilities exert most influence on organisational performance?

(a) Secure and Sufficient IT Intercommunication

The possession of the sufficient technical infrastructure to promote secure inter-communication determines benefits in terms of effectiveness and flexibility. This finding support the idea that ICT lower transaction costs, enabling inter-communicate the different parts of the organisation, regardless of the physical distance. Therefore, since costs and time are reduced by secure and sufficient IT intercommunication, it improves organisational effectiveness. At the same time, an inter-communicative infrastructure supports the interaction within the firm and with external parties. In consequence, it

enables the development of internal and external social capital. According to report of the EU (European_Commission, 1995), the degree to which different agents are interconnected has dramatically increased. Thus, the significance of ICT in supporting this intercommunication seems logical.

While Tanriverdi (2005) gives evidence of the relationship between IT infrastructure and performance, Dehning and Stratopoulos (2003), however, find that there is no support for IT infrastructure as source of sustainable competitive advantage. As in the case of knowledge management capabilities, different constructs and measurements have been used within the literature, thus results should be compared with caution. For example, Dehning and Stratopoulos (2003) measure sustainable competitive advantage based on peer rating. Another aspect to take into account is that no study before has empirically tested the relationship between ICT capabilities and organisational performance in SMEs; hence the critical factors to enhance performance might differ from larger firms. Given that SMEs lack of financial resources, the possession of specific technical infrastructure can be a distinctive factor, since firms might find difficulties in raising the necessary investments for ICT. Although IT investments themselves do not provide sustained competitive advantages, some firms may gain competitiveness by investing in ICTs (McFarlan, 1984; Mata and Fuerst, 1995).

(b) Customised and Unique IT Infrastructure

ICT have been criticised for been easily replicable, since they are pervasive and relatively and easy to adopt. However, the adaptation and protection of ICT to the specific problems of organisations is an important determinant of flexibility or long-term benefits. The implementation of ICT takes time, so firms should not expect immediate results but acknowledge that the benefits will be realized in the long-term. Powell and Dent-Micallef (1997) speak about the 'productivity paradox'. On the other hand, it has not to be forgotten that the ICT can be the driver to reorganize organisational structures, promoting innovation and creativity inside firms as a result (Dewett and Jones, 2001).

However, generally SMEs find it hard to justify the high-cost of customizing ICT (Levy and Powell, 2000; Sparrow, 2005), since they do not see them as strategic opportunities

(Levy et al., 1999). Nevertheless, this study gives evidence that the customisation and protection of the IT infrastructure is a determinant of organisational results and given its tailoring to the business needs, is difficult to be copied or transferred, thus it might provide sustainable strategic advantage.

(c) Commitment to ICT by Non-Technical Staff

The skills and commitment of non-technical staff, from workers to CEOs, towards the use of ICT predicts better effectiveness and flexibility, given that the real value of ICT resides on their application. However, often final users of ICT do not possess the required skills to make a full use of the opportunities offered by ICT (Caldeira and Ward, 2002). With the aim of preventing this weakness and ensure that all levels of workforce are equipped with the appropriate ICT skills, governmental action is taking place (DTI, 1999; European_Commission, 1995)

Bearing in mind that SMEs are starting to use ICT and that ICT capabilities are developed over time, first movers can get competitive advantage over their competitors. Prior experience in using ICT will foster the absorptive capacity in respect to ICT implementation. In fact, the diffusion of ICT is sequential, from generic to specific applications (Haugh and Robson, 2005). Therefore, in order to be able to implement more complex applications, firms should develop the right set of skills over time by continuous learning at all levels of the organisation (Yates et al., 1999). The more committed to ICT final users are, the easier and more successfully they will accept new technologies. Thus, their knowledge regarding ICT is integrated both in technologies and humans (Zack, 1999).

(d) Business Support by IS Staff

Business support provided by IS staff results significant in improving flexibility. The intelligent use of ICT aiming at supporting and improving the business processes enables firms to innovate their products and processes, to coordinate their processes more efficiently and to react flexibly to new challenges. Within this vein, Ravichandran and

Lertwongsatien (2005) empirically find that firms should be more concern on developing cooperations between ICT and business strategy, rather than investing in technologies.

Similarly and in relation to strategic alignment, Blili and Raymond (1993) highlight the need for integrating IS as part of the strategic planning in order to improve firm's competitiveness. In contrast, the drive for adopting new ICT in SMEs usually comes from their clients (Sparrow, 2005). Kearns and Lederer (2003) and Tanriverdi (2005) empirically support the significant relationship between alignment of IT and Business plans and the use of IT for competitive advantage. Furthermore, as said before, the implementation of ICT can yield product and or process innovation (Dewett and Jones, 2001).

(e) Managerial Skills of IS Staff

Finally and in connection to the previous point, the results indicate that managerial skills of IS staff are an important factor for flexibility. Technical staff should have the managerial skills to coordinate the effective and efficient implementation of ICT, although SMEs are poor at managerial skills (Caldeira and Ward, 2002). Traditionally, IS staff were a supportive function which was addressed when asked. However, nowadays firms require proactive IS staff who adopt a more central role in the firm, who actively works with other departments and manage the IS projects appropriately. Nevertheless, as commented in Chapter 7, the IS department or person responsible does not interact with other departments so often as others.

Mata and Fuerst (1995) defend that managerial skills of IS staff is a source of competitive advantage, since they are developed in a socially complex process.

To sum up, the results of the present study agree with Powell and Dent-Micallef (1997) who conclude that ICT alone do not produce sustainable performance advantages but advantages can be gained by using IT to leverage related intangible, complementary human and business resources. In a similar line, Ravichandran and Lertwongsatien (2005) and Tanriverdi (2005) empirically support the needed complementarity between

human and technical resources. Effective ICT capabilities draw on the 'fusion' perspective, that is, on the mix of people, business, and technology resources (Keen's (1993) cited by Powell and Dent-Micallef (1997). The importance of the three human scales regarding ICT is reflected in the following statement of Powell and Dent-Micallef (1997): "*Most IT users either don't know or don't trust those who designed the systems they work on, people only want to use ITs to the extent that they participated in defining them, or trust those who did*" (p.396). Human capabilities, however, are usually neglected and its master is probably the most difficult in developing ICT capabilities (Tanriverdi, 2005).

The fact that technical expertise has not resulted significant support the conclusion of Mata and Fuerst (1995) stating the unlikeliness of technical IT skills to sustain competitive advantages, since technical skills are easily transferred or copied, although, given the lack of in-house expertise in SMEs, it could have been expected.

Another important issue to be commented is the wide agreement in the little attention to the strategic value of ICT (Ravichandran and Lertwongsatien, 2005; Sparrow, 2005; Levy et al., 1999). Empirical results, however, show that ICT capabilities can improve the firm's competitiveness by embracing a comprehensive view of all the tangible and intangible factors related.

On the other hand, these results contradict the conclusion of Tippins and Sohi (2003) who state that ICT capabilities only have effect on the organisational performance through influencing in knowledge capabilities. Tanriverdi (2005) only studies the indirect effect of IT on financial performance through knowledge management, so no comparison can be done in relation to the direct effect. Previous studies might have failed to include intermediating capabilities (e.g. Ruiz-Mercader et al. (2006)), however, this research supports the direct significance of ICT on performance by adopting a holistic approach.

Finally, the existing empirical studies highlight the importance of intangible IS resources (Ravichandran and Lertwongsatien, 2005; Bharadwaj, 2000; Powell and Dent-Micallef, 1997; Dehning and Stratopoulos, 2003; Caldeira and Ward, 2002). However, this research also find significant the contribution of technical IS resources to organisational effectiveness and flexibility. This different result must be due to the particular conditions

of SMEs or to the focus of previous research effectiveness issues. In contrast, Byrd and Turner (2000) find that both technical and human ICT factors mediate in the infrastructure flexibility, which contribute to the overall flexibility of the firm.

Comments on the relationship between specific information and communication technologies capabilities and organisational performance

As commented in Chapter 8, few correlations are found between the types of ICT and performance indicators. Few integrative and interactive technologies relate to better organisational results. Similarly, the number of technologies employed is not statistically linked to better performance. This fact indicates that ICT themselves might not be as important as the development of the right human and technical ICT capabilities.

On the other hand, the percentage of turnover invested in IS is related to flexibility. This result agrees with the study of Agarwal (1998) who finds that IS investments are vital for SMEs.

According to the report of the European Commission (2004), "*UK manufacturing sector makes good use of ICT compared with other UK industrial sectors. However it performs less well in comparison with overseas competitors*" (p.6). The reasons for this might lie in the learning curve associated with IT (Orlikowski et al., 1995; Dewett and Jones, 2001). Barney (1995) also highlight the role of history as a source of sustained competitive advantage. Lucchetti and Sterlacchini (2004) justify the better performance of US economy compared to European countries arguing that US business units and households have adopted ICT earlier, faster and more widespread. In other words, the development of absorptive capacity to acquire new technologies fast and effectively is of critical importance (Teece, 1998a). Given the turbulent conditions of the current environment, SMEs should understand the need of developing such ability in order to catch up and compete in more equal conditions with countries such as the US.

Hypothesis 3a: the impact KM capabilities is mediated by ICT capabilities

Results partially support Hypothesis 3a, which tests the effect of ICT capabilities on knowledge management capabilities. Three knowledge management scales are found to be explained by ICT scales. These knowledge management scales are organisational for culture, strategic alignment and promotion of research. It is striking that knowledge exploration and exploitation are not specially influenced by ICT capabilities, contrary to knowledge management enablers. However, correlation analysis shows that most of them are interrelated to a certain extent.

The existence of the required intercommunicative infrastructure support the internal communication processes within firms. As a result of lowering the physical communication barriers, social interactions are supported, and as a result, organisational cultures may be enhanced. However, this is not achieved unless employees are committed towards ICTs and have the skills to make full use of them. Although a strong focus on ICT is at the expense of the development of a suitable organisational culture (Liebowitz and Chen, 2001), an intelligent and balanced use of ICT can also promote organisational culture by facilitating communication within groups and among groups (Ciborra and Lanzara, 1994).

Similarly, the commitment to IT by non-technical staff together with the managerial skills of ICT staff are linked to strategic alignment. Managerial skills of ICT staff such as proactiveness and effective team working with other departments is critical in enabling strategic alignment within firms. It is surprising that intercommunicative infrastructure and business support by ICT do not seem to be determinants of strategic alignment, even though they can help ensure that activities within the firm are in line with the firm strategy and thus, its environment (Tippins and Sohi, 2003). However, when looking at the correlation analysis, strategic alignment appears to be related to all the ICT scales except from technical compatibility, which indicates that ICT capabilities are highly associated to strategic alignment. This result highlights the role of ICT as a supportive function, which may have an underlying key role in organisational competitiveness. As Ciborra and Lanzara (1994) claim, ICT can support the dissemination of the business mission.

Managerial skills of IT staff and the customised and unique infrastructure influence on research promotion. An intercommunicative infrastructure specially adapted to the characteristics and processes of the firms can enable better internal communications and sharing of organisational knowledge on past and current experiences. Research can be fostered as a result of the interaction of IT staff with other departments and the proactiveness of IT staff. On the other hand, correlation analysis demonstrates that all the human ICT capabilities correlate with research promotion, which demonstrates the strong relationship between ICT capabilities and KM capabilities.

Although widely defended within the literature (Alavi and Leidner, 2001; Scarbrough et al., 1999; Ruggles, 1998; Davenport and Prusak, 1998), the intermediating role of ICT in enabling knowledge management has scarcely been addressed by empirical research. Tippins and Sohi (2003) and Tanriverdi (2005) spot this gap in the literature and empirically tested. The focus of Tippins and Sohi (2003) is on market knowledge, while Tanriverdi (2005) concentrates on large multibusiness firms. Both researches utilise statistical techniques different to the ones employed here. These techniques do not allow analysing the specific relationships between KM scales and ICT scales, but in general, the interrelationship between KM capabilities and ICT capabilities is supported. Their studies give evidence of the indirect effect of ICT capabilities on firm performance by leveraging KM capabilities.

The present study adopts another perspective and analyse the scales individually in order to get a deeper understanding of the interaction and synergies between knowledge management and ICT capabilities.

To sum up, the result of this study partially supports the hypothesis that capabilities complement and leverage each other in a synergistic way. Agreeing with Powell and Dent-Micallef (1997) and Mata and Fuerst (1995), firms can gain sustained competitive advantage by using information technology to leverage fundamental capabilities of the firm, mainly intangible, complementary human and business resources.

Hypothesis 3b: the impact of ICT capabilities is mediated by KM capabilities

While the influence of ICT capabilities on knowledge management is widely recognized within the literature, the reverse relationship has been overlooked. Therefore, this study undertakes a comprehensive examination of the complementarities between ICT capabilities and knowledge management.

Four ICT scales are explained by some KM related variables according to the regression analysis. However, the non-causal relationship based on correlation analysis shows further interrelationships between ICT and knowledge management capabilities.

The implementation of an intercommunicative infrastructure is explained by incentive systems based on knowledge sharing and the acquisition of knowledge from external knowledge. Thus, the need to support internal collaborations may be the motive for implementing an intercommunicative IS. Furthermore, the relationship between intercommunicative infrastructure and external sources of knowledge can be explained by arguing that external contacts can provoke the implementation of intercommunicative infrastructure, either because their advantages have been observed or because external sources of funding and support have been found. As Powell and Dent-Micallef (1997) states "*best-practices benchmarking is essential to the development of competitive IT systems (Boar, 1994; Hammer and Champy, 1993)*" (p.383).

Research promotion seems to be a determinant of implementing a customised and unique IT infrastructure. The encouragement to research may result in exposing firms to new technologies or practices which, once adopted and adapted to the firms' needs, will benefit their functioning. Furthermore, by assessing current and past experiences, firms can determine what customisation of the ICT infrastructure will improve their processes. Given that the infrastructure will be customized according to the idiosyncratic situation of the firm, it becomes unique and useless to be copy. It has to be noticed that both scales, research promotion and customized and unique IT infrastructure feed on each other creating a favourable cycle. Similarly, such reciprocal interaction also occurs between research promotion and managerial skills of IT staff. Therefore, the promotion of research and managerial skills of IT interact synergistically.

The same synergistic phenomenon happens when considering strategic alignment. Strategic alignment influences on commitment to IT from non-technical staff and on the managerial skills of ICT staff, but at the same time, these scales enhance the strategic alignment within the firm. The development of human skills with respect to ICT should be guided by the business strategy of the firm. ICT staff equipped with the right managerial skills will contribute to supporting the strategic alignment, since they would interact with other departments and manage the implementation of ICT to support the business processes properly. Managerial ICT skills are relevant in linking different functions within firms (Mata and Fuerst, 1995). Within the same vein, the ability of effective use of ICT will allow better internal collaboration through ICT and alignment to the business strategy.

Thus, results show that capabilities interact synergistically and empirically test the concept of dynamic capabilities (Teece et al., 1997).

Hypotheses 4a/4b/4c: the impact of KM and ICT capabilities and on organisational performance is mediated by the organisational context

When analysing the mediating effect of contextual variables on the relationship between KM and ICT capabilities and organisational performance, two contextual variables (turbulence and process) appear to be influential in flexibility and effectiveness, respectively.

Technological turbulence refers to the level of change to which firms undergo. Results show that those firms which frequently undergo changes are more likely to obtain superior performance in terms of innovative and quick flexibility. This finding supports the argument of Antonacopoulou et al. (2005) which state that the ability to reconfigure the firm's asset structure continuously enhances the organisational renewal. Firms which perform in technologically turbulent environments are forced to adapt themselves continuously in order to respond to the environmental changes (Lin and Germain, 2003), developing better knowledge management capabilities than those who operate in less turbulent environments (Teece et al., 1997; Teece, 2000). Thus, technological turbulence makes firms more proactive and less complacent. Firms develop capabilities to change over time that will enable them to face sudden changes in the marketplace better. Somehow, this phenomenon illustrates the concept of absorptive capacity augments the capability to identify opportunities and the speed at which knowledge is assimilated by firms. As commented before, absorptive capacity has a positive effect on the effective acquisition of ICT. In fact, the number of ICT adopted correlates to the level of turbulence (see Chapter 7). Non-causal analysis based on correlations shows also associations between technological turbulence and effectiveness, although to a less extent. Thus, results agree with Droge et al. (2003), who find that technological turbulence is positively related to created knowledge and applied knowledge

Looking at the knowledge management practices more related to turbulence, as commented in Chapter 7, those regarding the provision of resources and the acquisition of external knowledge stand out. This indicates that those firms firms going through higher levels of change provide more resources to work individually and in teams. Change requires time and effort, not directly related to production, and firms should realize of the importance of investing in such aspects. Furthermore, the fact that

turbulence and external sources of knowledge are statistically related, being both significant determinants of flexibility, suggests that continuous renewal might result from adjusting to the market dynamics. Furthermore, turbulence was found negatively related to data stored in paper-form. Nowadays, responsiveness requires the availability of the right and last minute updated information at the right moment, a characteristic that computer databases enormously enhance.

With respect to specific ICT, turbulence is highly correlated to all sorts of tools, including sophisticated communication technologies (groupware, extranet, intranet, integrated software (ERP/MRP) among others), automation technologies (data mining, expert decision software, workflow, etc.) and training based on computers.

To sum up, firms with high levels of turbulence usually excel in the use of ICT, they have greater exposure to external sources of knowledge and they provide sufficient resources to work individually and in teams. As a result, they achieve superior innovativeness, responsiveness and adaptability. Using the words of Augier and Teece (2006), these firms are entrepreneurial. Based on the work of Winter (1986), they argue that "*entrepreneurs carry out "new combinations", mere managers do not*" (p. 396).

Partial correlations show that, in general, KM and ICT capabilities are affected by contextual variables. Furthermore, correlation analysis between contextual variables and KM and ICT capabilities (Appendix IV) also gives some useful insights about their interactions. Some of these correlations have been explained in previous sections, but others are worthwhile to be addressed. For example, control is linked to external sources of knowledge, collective knowledge integration and collaboration promotion. Control over the organisation processes seems to imply also control over external source of knowledge. This can lead to work together and discuss about the information gathered in order to reach common views and action plans. On the other hand, size and age are significantly but negatively related to some KM capabilities. In contrast, Droge et al (2004) did not find any relationship between size and knowledge application and creation. However, the present study is only dealing with SMEs, hence result can differ. Therefore, within the context of SMEs, older and bigger firms are less keen in carrying out specific knowledge management practices such as collective knowledge acquisition and knowledge exchange with business partners. These scales refer to the firm's

relationships with their partners. Older firms might still work in traditional ways, focusing on productivity and without realizing of the importance of external networking in the current environment. On the other hand, larger firms appear to develop greater ICT capabilities, in terms of infrastructure and technical expertise. This is justified by the financial difficulties faced by small firms. In fact, the availability of resources appears negatively related to size.

In general, ICT capabilities appear more related by contextual variables than knowledge management capabilities. Specifically, size, technological turbulence, control and empowerment are positively associated to several human and ICT capabilities.

Although external factors can also influence on the effect of knowledge management and ICT capabilities, they are already controlled to some extent, since this research has concentrated on a specific group of firms: manufacturers, within the mechanical engineering and machine sector, located in the UK. Furthermore, the turbulence of the external environment can be reflected in the technological turbulence within firms.

To conclude, context matters, and, in consequence, *the contingency theory is valid when studying information systems and knowledge management capabilities.*

8.9 Validity of the Results

Statistical analysis carried out by the present study has aimed to ensure validity and reliability. *Validity* means that the measures are measuring what they attempt and that the conclusions drawn from the analysis are rigorous and reliable. *Reliability* refers to the consistency of the results, that is, the degree to which repeated measurements in the same conditions would yield the same results.

There are different types of validity but not consensus on how to label or differentiate them. Here the four more common types will be discussed:

(1) Statistical conclusion validity

Statistical validity implies that the conclusions are drawn following a proper use of statistics. Extensive reading on statistics and consultation to specialists have allowed analysing the data with confidence. In order to achieve this type of validity, different techniques have been applied by following systematic procedures. Although conclusions should validated by replicating them with a new sample, in the case of CCA, such validation has been achieved by doing a sensitivity analysis of the correlations.

(2) Internal (causal) validity

The interrelationships between the main variables (KM, ICT and Performance) are based on the existing literature and have been controlled by several variables, carefully selected. In this way, the analysis has avoided some kind of bias in the cause-effect relationship.

(3) External (generalising) validity

This type of validity refers to generalising the conclusions to the population. The best way of ensuring generalisability is by replicating the study as many times as possible. However, due to the lack of resources, this step will be left for future research. On the other hand, the researcher extracted a random sample from the population, so, to some extent, this supports the generalisability of the results. Furthermore, the ratios of observation per variables have been sufficient in most of the cases.

(4) Construct (measurement) validity

As seen in section Factor Analysis, all the constructs have been rigorously selected. After, they have been examined in order to ensure that the items within a construct correlated among themselves. This is the so-called convergent validity and is measured by Cronbach's alpha. All the constructs used in the present research have appropriate Cronbach's alphas and also, they meet the requirement of unidimensionality.

Another way of ensuring construct validity is by doing cross-validation for example on a new sample. However, the lack of sufficient data makes the cross-validation impossible. This is one of the limitations of the study, which should be addressed in future research.

8.10 Summary of the Chapter

This chapter has aimed to analyse and discuss research questions and hypotheses defined in Chapter 5. The findings are summarised in Table 47 and their discussion is resumed below.

Hypotheses 1a/1b: there is a positive relationship between knowledge management capabilities and performance

The importance of knowledge management capabilities on explaining organisational performance depends on the type of performance measurement looked at. The effect o knowledge management capabilities is hardly noticed on effectiveness, while they predict quick and innovative flexibility to a greater extent. Having in mind the volatility of the new economy, long-term advantages such as greater innovation, quicker response and adaptability might be critical in surviving. Thus, "*knowledge makes performance more reliable*" (March, 1991:83) .

Knowledge enablers such as culture and strategic alignment are significant determinants of flexibility. When considering the KM processes, three scales appear to be significant: external sources of knowledge, encouragement to participate and collective knowledge integration. They correspond to scanning, sourcing and combinative capabilities (Almeida et al., 2003). Processes within and between different levels of the organisation, individual and collective, affect flexibility, which corroborates the idea of dynamic interactions between the different components in an activity system and a mutual learning over time (March, 1991).

Hypothesis 2: there is a positive relationship between ICT capabilities and organisational performance

Technical and human ICT aspects influence both effectiveness and flexibility, although more ICT scales influence on the latter. However, the analysis of the non-causal relationships based on correlations (Appendix IV) show that similar ICT capabilities relate to both performance scales. Past studies have usually studied the relationship between ICT capabilities and performance by paying attention to financial performance.

Therefore, this study introduces a new perspective to analyse the effect of ICT capabilities and also finds that in the context of SMEs, not only human capabilities but also technical capabilities are important for organisational outcomes.

Hypotheses 3a/3b: knowledge management capabilities and ICT capabilities intermediate between each other

The result of this study partially supports the hypothesis that capabilities complement and leverage each other in a synergistic way. Several relationships between ICT capabilities and knowledge management capabilities are found, in one or both directions according to regression analysis. Especially, ICT capabilities influence on knowledge management enablers (culture for knowledge and strategic alignment). However, the correlation analysis shows further interrelationships between ICT and knowledge management capabilities. All in all, results show that capabilities interact synergistically and empirically test the concept of dynamic capabilities (Teece et al., 1997).

Hypotheses 4a/4b/4c: the effect of knowledge management and ICT capabilities are mediated by contextual variables but also their effect on organisational performance is mediated by the organisational context

When analysing the mediating effect of contextual variables on the relationship between KM and ICT capabilities and organisational performance, a contextual variable, turbulence, seems to be of critical importance in predicting effectiveness and flexibility since it represents the ability of firms to transform and retransform themselves continuously. It can be an indicator of the absorptive capacity developed by the firm and it usually goes accompanied by extensive use of ICT, frequent exposure to external sources of knowledge, provision of resources to work individually and in teams and the non-reliance on paper-based information.

Simple and partial correlation analysis between contextual variables and KM and ICT capabilities (Table 39) suggest that contextual variables have an effect on ICT, knowledge management and performance, which supports that importance of considering the contingency approach in knowledge management and ICT research.

Chapter 9: Conclusions

The purpose of this chapter is to:

(1) Summarise the main findings of the research in relation to the research questions and objectives defined in Chapter 5

(2) Assess the contributions of this thesis and thus, discuss the following research question (also outlined in Chapter 5):

- What advice should be given to practitioners and policy makers in order to promote the effective implementation of KM capabilities and enhancement of ICT capabilities?

(3) Identify the limitations of this study

(4) Define possible directions for future research

9.1 Introduction

This research has met the main objective defined in Section 1.3 by examining the relationships between knowledge management capabilities, information and communication technologies capabilities and their impact on organisational performance. It has addressed the research objectives proposed in Section 5.2 and tested the hypotheses also defined in Section 5.2, with a sample of 159 SMEs manufacturers within the UK mechanical sector. After checking the validity of the data, different statistical techniques have been applied.

The results suggest that knowledge management have a positive effect on issues such as innovativeness, responsiveness and adaptability (here named under the label of "quick and innovative flexibility" or simply "flexibility"), while not effect was found on success, profitability, market-share and growth (here named under the label "effectiveness" given their more tangible nature). The most important factors in contributing to SMEs' flexibility are: (a) the existence of an appropriate culture for knowledge, where open and transparent communications can take place, (b) the alignment of all the organisational activities towards common objectives, (c) the acquisition of knowledge from external sources, (d) the exploitation of this knowledge by individuals, assimilating it by personal experience and sharing it with others, (e) the integration of knowledge at the organisational level by discussing and reflecting on past or current experiences with the aim of arriving to common interpretations. Table 31 shows an examination of specific practices and their relationship with performance indicators, which gives an idea of what practices are more frequent in those firms with superior performance.

On the other hand, results indicate that there is a positive relationship between ICT capabilities and both types of performance indicators. The most critical factors in enabling better organisational results include technical and human capabilities. Among the technical capabilities, the possession of a (a) safe and adequate infrastructure which supports intercommunication and (b) which is adapted to the specific needs of the business are the most significant factors. There are three main human ICT capabilities which result significant in explaining better performance: (a) the commitment towards

ICT by all staff not specialist in ICT, (b) the support provided by the IT staff in supporting the business activities and strategy and (c) the managerial skills of the IT staff to implement ICT and work with other parties.

The interaction among some ICT and KM capabilities has been supported, hence the complementarity of capabilities is suggested. Furthermore, the investigation of the effect of contextual factors concludes that they mediate in the impact of ICT and KM capabilities on organisational performance and on performance itself. Especially technological turbulence, which represents the level of change firms undergo, has a significant impact on the flexibility.

Thus, results suggest that a set of firm's physical, human and organisational capital influences on improving efficiency and flexibility (Wernerfelt, 1984). Due to the nature of the topic, most of the factors are intangible and they are developed over time, hence they are difficult to be imitated but also to be achieved. As commented in Chapter 2, this type of resources or capabilities provide with sustainable competitive advantage.

After having resumed the conclusions of this research, this final chapter will discuss the theoretical and practical contributions and the future research directions that emerge.

9.2 Contributions of the Present Research

As predicted in Section 1.3 and Section 5.3, this research has provided theoretical and practical contributions which will be discussed next.

- ***Contributions to the theory***

This research contributes to the KM and IS literatures by merging the research on knowledge management capabilities and ICT capabilities done separately, into a unique conceptual model. While research on ICT has incorporated a more comprehensive view of the value and impact of ICT based on the RBV, prior studies on knowledge management have studied the role of ICTs in knowledge management by simply analysing the use of specific technologies. In spite of the similar paths followed by researches on knowledge management and ICT, an integrative research has been scarcely explored. Only Tippins and Sohi (2003) and Tanriverdi (2005) have adopted a more holistic approach. The study of Tippins and Sohi (2003) focuses on market knowledge while Tanriverdi (2005) concentrates on customer, product and managerial knowledge. This research, however, focuses on the creation of organisational knowledge regardless the content of knowledge, involving all the parties of the firm. Thus, the conceptualisations differ and allow providing different perspectives of the phenomenon. The integration of research done independently into a single model has allowed the assessment of the real impact of knowledge management and ICT on organisational performance and, simultaneously, their interrelationships with greater and more holistic theoretical coherence. As Teece (1998a) argues, knowledge management can integrate important work in different fields such as strategy and information systems which might provide important insights into specific aspects of knowledge management, difficult or even impossible to be achieved when studied individually. Similarly, the role of knowledge management enhancing ICT capabilities has been overlooked in the literature. Although the literature recognizes the influence of cultural issues (Walsham, 1993) and on learning activities on ICTs (Eisenhardt and Martin, 2000), previous research has failed to empirically examine it under a holistic view.

As a result, this research has contributed to the debate regarding to the role of ICTs in knowledge management by adopting a more balanced and comprehensive perspective of ICTs based on a socio-technical approach. The results show their synergistic and in no case negative interactions. Therefore, this research also contributes to the debate between knowledge management and organisational learning presented in Chapter 3. Their opposite views can be brought together when adopting a comprehensive view of ICT capabilities. Knowledge management should not be equivalent of developing new technologies, but of enhancing individuals and their social relationships, both internally and with the external environment, with the aim of pursuing the organisational goals. However, the strategic role of ICT in supporting such processes should not be overlooked.

This research contributes to the IS and KM literature by empirically testing the concepts of ICT and KM capabilities within the context of SMEs. Despite their large number and their importance in the European economy, previous researches on knowledge management (Chaston et al., 2001; Ruiz-Mercader et al., 2006) and on information systems (Caldeira and Ward, 2002) have neglected it. As seen in Tables 3 and 4, no previous study adopting a socio-technical view of ICT, either alone or conjunction with knowledge management, has ever focused on this segment of firms that have especial characteristics. Only one study (Ruiz-Mercader et al., 2006) has studied organisational learning on IT small firms. However, they fail to incorporate a comprehensive view of ICT capabilities. Given the turbulent environment and SMEs' volatile situation, it is critical to understand the dynamics of SMEs regarding knowledge management and ICT capabilities, in order to increase and sustain their competitive advantage. Therefore, this study has contributed to study and theorise about the specific problems of SMEs, specifically, of manufacturer SMEs located in the UK within the mechanical engineering sector, and manufacturers.

Within the line of dynamic capabilities, this study finds support for the complementarity of ICT technical and human resources in SMEs. Thus, this research contributes to emphasise the importance of considering socio-technical principles and practices, which has not received the expected practical impact (Doherty and King, 2005; Clegg, 2000). Both human and technical capabilities are necessary to support SMEs' performance as a whole. The conclusions with respect to the relationship between ICT capabilities and performance in large firms are inconclusive (Melville et al., 2004), most of the studies agree on the

greatest importance of human factors. Moreover, the adoption of a holistic view of ICT can explain why, regardless acquiring the same technologies, results differ from firm to firm. The over-emphasis on developing and implementing ICT has misled the impact of ICT on organisations and, in consequence, on knowledge management. The disappointment of implementing ICT and not getting the expected results, but even opposite outcomes, should not conclude in diminishing the value of ICT. If appropriately directed, ICT have enormous power. Therefore, the conclusion of failed implementations of ICT should lie in the misuse or mismanagement of ICT. The understanding of the successful development of ICT is of critical importance in the current environment. ICT are increasing, both in complexity and in strategic role. The development of the internal capabilities to take the maximum advantage of the potential of ICT would become essential to survive. For example, the OECD (2005) claims that e-commerce might be the gateway for SMEs. However, firms should notice that such development happens over time, following a learning curve which develops the absorptive capacity of the firm to implement new technologies. Although ICT per se usually do not provide competitive advantage, they can become strategic by their complementarity with human and business resources and by supporting other capabilities, by supporting the business strategy and by driving innovations in terms of products, processes and organisations. Mata and Fuerst (1995) claim that empirical tests of the resource-based arguments about ICT attributes should be carried out. More recently, Doherty and King, 2005 claim that "*there is an urgent need for well focused and rigorous research that seeks to shed fresh insights into the nature of the organisational impacts of information technology and the ways in which they can best be proactively managed to promote the development of effective, value-adding information systems*" (p.2).

Regarding knowledge management, this study concludes that an appropriate culture to enable knowledge and strategic alignment of internal activities are essential in SMEs, as other studies conclude when studying larger firms. Furthermore, the significance of both sharing and integrating knowledge at the individual and organisational level is common to larger firms. However, it also observes that, while for larger firms the main challenge is usually to identify internal skills and capabilities, for SMEs the interaction with the external environment seems of critical importance. This has been the first study that has researched the phenomenon in SMEs from an integrative perspective and has arrived to some important findings which should be a strong ground for further research.

This research contributes to the KM literature by offering an alternative operationalisation of KM capabilities. This research provides at least a partial to the criticism that the RBV has not been sufficiently operationalised (Hoskisson et al., 1999). The lack of operationalisation within the knowledge management area has also been spotted by Staples et al. (2001). They claim that more empirical research on knowledge management focused on the knowledge-based capabilities is needed, since this view may help to develop a new and more managerial approach.

Although this research basically lies in the KBV which derives from the RBV, ideas from different theories have been brought up together in their operationalisation: mainly the *dynamic capabilities* approach (Teece et al., 1997) by assuming the complementarity among capabilities and among human and technical aspects; the *evolutionary approach* by assuming that knowledge is embedded in the organisational routines, culture, etc.; and *activity systems theory* (Blacker, 1993), as knowledge is created through interactions among all the organisational elements (Tsoukas and Vladimirou, 2001). Results give evidence of the significance of managing knowledge bases at all levels of the organisation: individually, organisationally and externally. Thus, firms should be studied as dynamic systems which integrate internal and external knowledge. The consideration of these theories has also enabled to adopt a comprehensive approach of study, which previous researches usually lack. For example, although commonly agreed in the theory, the inclusion of contextual factors fails in many empirical studies on knowledge management, but even more, within the ICT capabilities literature. Contextual factors can have much to explain in the state of ICT capabilities within the firm. For example, Levy and Powell (2000) state that usually the reason for ICT adoption failure is the lack of reorganisation of the organisation structures. On the other hand, the external context has been controlled by some extent by narrowing the focus to manufacturer SMEs within the mechanical engineering sector. Prior research has overlooked the influence of the external environment on KM and, especially, on ICT capabilities.

Therefore, this study contributes to the operationalisation of the RBV/KBV by addressing it from a relatively comprehensive perspective, by taking into account the different theoretical arguments established in the literature.

As a result, this research contributes to the KM literature by providing empirical grounding. A methodological contribution of this study is the empirical application of the KBV or RBV by empirically analysing the influence of knowledge and ICT on performance, individually and in a combinative way, in a sample of 159 manufacturer SMEs within the UK mechanical engineering sector. Literature on knowledge management mainly focuses on conceptual work or anecdotal evidence (Un and Cuervo-Cazurra, 2004; Chaston et al., 2001), which has led to a lack of empirical studies based on large-scale surveys, especially on SMEs, which provides more generalisable findings. Similarly, empirical theory testing about ICT from the RBV is more acute within SMEs. Doing so, this research contributes to advancing in the "research wheel" commented in Chapter 6 and represented in Figure 28.

Given that the KBV has recently emerged as a new stream of the RBV, therefore, it needs empirical foundations to contribute in its establishment. Therefore, this research contributes to reduce the lack of empirical grounding of the RBV (Priem and Butler, 2001) or the KBV (Eisenhardt and Martin, 2000).

Last but not least, this research contributes to the strategy literature by adopting a comprehensive view of organisational performance. As seen in Chapter 10, a key point in the discussion of the role of knowledge management and ICT on organisational outcomes is how organisational performance is measured. This research has contributed to the field by adopting a comprehensive set of organisational performance indicators, which has resulted in two main scales: effectiveness and innovative and quick flexibility. These two scales represent short- and long-term advantages for firms, which has enabled a comprehensive understanding of the impact of ICT and KM capabilities. Knowledge management capabilities have been found to have a greater impact on long-term advantages, such as innovativeness, quick response and adaptability. As Corso et al. (2003) predict: "*knowledge now plays and will continue an important role in the future in determining a firm's capability to innovate and hence, its long-run effectiveness and survival*" (p.397). This could explain the failed expectations of practitioners with regard of the impact of knowledge management initiatives on their outcomes. Generally, previous researches have limited to include financial metrics or indicators. Regarding ICT capabilities, the need of assessing the effect of ICT in a more comprehensive way is spotted

by Dewett and Jones (2001): "*theoretical or empirical treatment of the way IT moderates the effects of strategy on organisational outcomes such as effectiveness and innovation or performance in general has not been a recent focus in top management journals*" (p.335). Similarly, Corso et al. (2003) propose the study of the effect of knowledge management according to different types of performance. Therefore, this research contributes to fill in this gap and, also, to clarify the real effect of knowledge management and ICT capabilities in organisations.

- ***Practical contributions***

From the practical standpoint, this study makes several contributions.

Contributions to practitioners

First of all, *this research contributes to practitioners by eliciting the actual impact of knowledge management in SMEs.* This study has demonstrated the lack of quantitative studies on knowledge management and the urgency to address this topic in order to generate a greater understanding on the issues involved, since fifty percent of the knowledge management initiatives fail (Call, 2005).

Knowledge management has a significant effect on innovation, quick response and adaptability, which is essential in the current economy. Thus, managers must not expect immediate effects of activities enhancing knowledge management, but they should acknowledge that they contribute to the development of capabilities which might be essential to overcome the uncertainties of the markets and whose effect will be visible in the long-term. Therefore, SMEs must make a trade-off of immediate and long run benefits. As stated in Chapter 4, SMEs should be aware of the need for competing, not only on a low-cost basis, but on a knowledge and innovation basis due to the fact that the globalisation of the markets have made industrialized countries such the UK high-cost environment (Vos et al., 1998).

Second, *this empirical study contributes to identifying the critical factors on knowledge management for SMEs and give advice to managers based on a best-practice basis*. This research has aimed to help practitioners in identifying the key areas where their firms should start working on given that they seem not be discouraged for not having experiencing its benefits. The adoption of a practice-based approach facilitates the understanding of the "problem" of knowledge management in more graspable and simple ways based on empirical evidence by giving empirical evidence of what specific practices regarding knowledge management are positively related to organisational performance. Specific recommendations for managers are summarised in Table 31 and commented in Chapter 7 and 8 with the aim of promoting the defined critical factors in knowledge management which are recalled next:

(a) **Managers** should make efforts in enabling a trustworthy working atmosphere since results show that a *transparent and caring culture* where communications are open and frequent is basic for enhancing the well functioning of the firm and thus, achieving better organisational results.

(b) Furthermore, **managers** should make sure that all individuals and functions in the firm pursue the same objectives and mission, that all the functions of the firm should be *strategically aligned*. In this way, every member of the staff will be guided and will enable the coordinated action of the firm.

(c) At the same time, **managers** should realise of the critical importance of interacting with the external environment. They must realise of the changing environment where traditional ways of working are not longer valid and acquire *new ways of thinking* to play according to the new competition rules. SMEs, known for their concern on daily problems, should be aware of the dynamics of the marketplace and believe that the key for their survival might be the development of internal and external capabilities. The survival in the global economy depends on the development of competencies to exploit external opportunities (Lei et al., 1996; Hitt et al., 2000).

(d) Similarly, **managers** must promote *experimentation, interaction among people and discussions to arrive to common understandings* since they are highly determinants of the organisational flexibility, regardless the lack of productivity or tangible outcomes. Thus, they should provide enough resources such as spare time to enable these activities (Brown and Duguid, 1991).

To know what practices regarding the above scales are more related to organisational performance, that is, more used in those firms with better results, see Table 31.

(e) Although, in general, specific ICT do not seem to be related to better organisational results (see Table 35), **managers** should know that the use of simulation software (which enables experimentation) and workflow or process management software (which enhances internal coordination) appears to be significantly related to greater flexibility. On the other hand, data mining (which enables sophisticated and efficient data management) is highly associated to greater effectiveness.

Third, *this research lends evidence of the importance of the organisational renewal*. **Managers** must realise that the level of *technological turbulence* which firms undergo enhances flexibility. Thus, the more changes firms go through, the more innovative, the quicker and the more adaptable firms become. Therefore, practitioners must not be afraid of changes and understand its benefits. Indeed, history is an important factor in knowledge management, since the organisational learning that occurs over time remains embedded in the firm's culture, routines and structures. As DTI (1999) claims, UK manufacturers need to move faster in the integration of knowledge management into their strategic thinking.

Similarly, from the ICT perspective, the learning curve associated with IT (Orlikowski et al., 1995; Dewett and Jones, 2001) can explain the lag of UK industrial sectors regarding the use of ICT in comparison with overseas competitors (European_Commission, 1995). Lucchetti and Sterlacchini (2004) also justify the better performance of US economy compared to European countries arguing that US business units and households have adopted ICT earlier, faster and more widespread. Given the turbulent conditions of the current environment, managers should understand that more efforts should be made in order to catch up competitors and compete in more equal terms.

Fourth, *the present research contributes to defining which ICT capabilities are vital for business success* (Sambamurthy and Zmud, 2000b). Sambamurthy and Subramani (2005) highlight the lack of insight into knowledge management for practitioners commented before and state that "*it is equally problematic for IT researchers because the diversity of organisational processes through which information systems affect the management of intangible assets in firms are not fully appreciated*" (p.2). They also remark the need for understanding the contextual differences. A set of recommendations are drawn on observed "best practices" and will help managers and policy makers to have a better understanding and make the right decisions about ICT, without overemphasizing neither underestimating them. Results show that, regardless the technology, those firms with superior ICT capabilities achieve better results in terms of effectiveness and flexibility. These ICT capabilities refer to human and technical skills, which proves that, despite their promising potential, the use of ICT is not straight forward, but requires certain skills or accumulated capabilities. Plenty of failed applications of ICT for knowledge management purposes endorse this fact.

Therefore, **managers** should not concentrate on investing in ICT but have in mind several issues: the need for implementing secure intercommunicative infrastructures customized to their needs. Also, **managers** should concern on developing managerial skills among technical staff while technical skills should be promoted among non-technical staff. For example, training could be provided. Technical staff should adopt a more proactive role and participate in the business strategy since they, and as a result ICTs, can support of the business activities and strategy. They should work in close cooperation with other functions, since in the 21st century technology has become essential part of our lives and, thus, businesses. The increasing development of these technologies, both in number and in complexity, their use might be a decisive factor in surviving under the new "rules" of competition. Due to the new conditions of competition and the rapid development of innovative information and communication technologies, firms are able to operate in ways that were unthinkable before. Thus, no longer technology should be used for simply automation, but for more strategic uses in a coordinated way in line with the business strategy. Practices such as benchmarking may play an important role in using ICT to upgrade organisational capabilities. For example, by enhancing other capabilities such as knowledge management. The understanding of the real effect of ICT is critical given the costly investments which some firms are allocating to implementing new ICTs (Lucas, 1999).

All in all, **managers** should consider a *balanced mix of human, organisational and technical aspects* when implementing knowledge management initiatives, as well as new information and communication technologies. The violation of this balance such the overemphasis of technological issues might be the cause of failures in knowledge management programmes. As Tsui (2005) recalls, many of these programmes are primarily driven by the implementation of new technologies. In fact, as Figure 32 shows, in spite of acknowledging their importance, people and culture are usually overlooked. This study gives evidence of the critical role of such aspects.

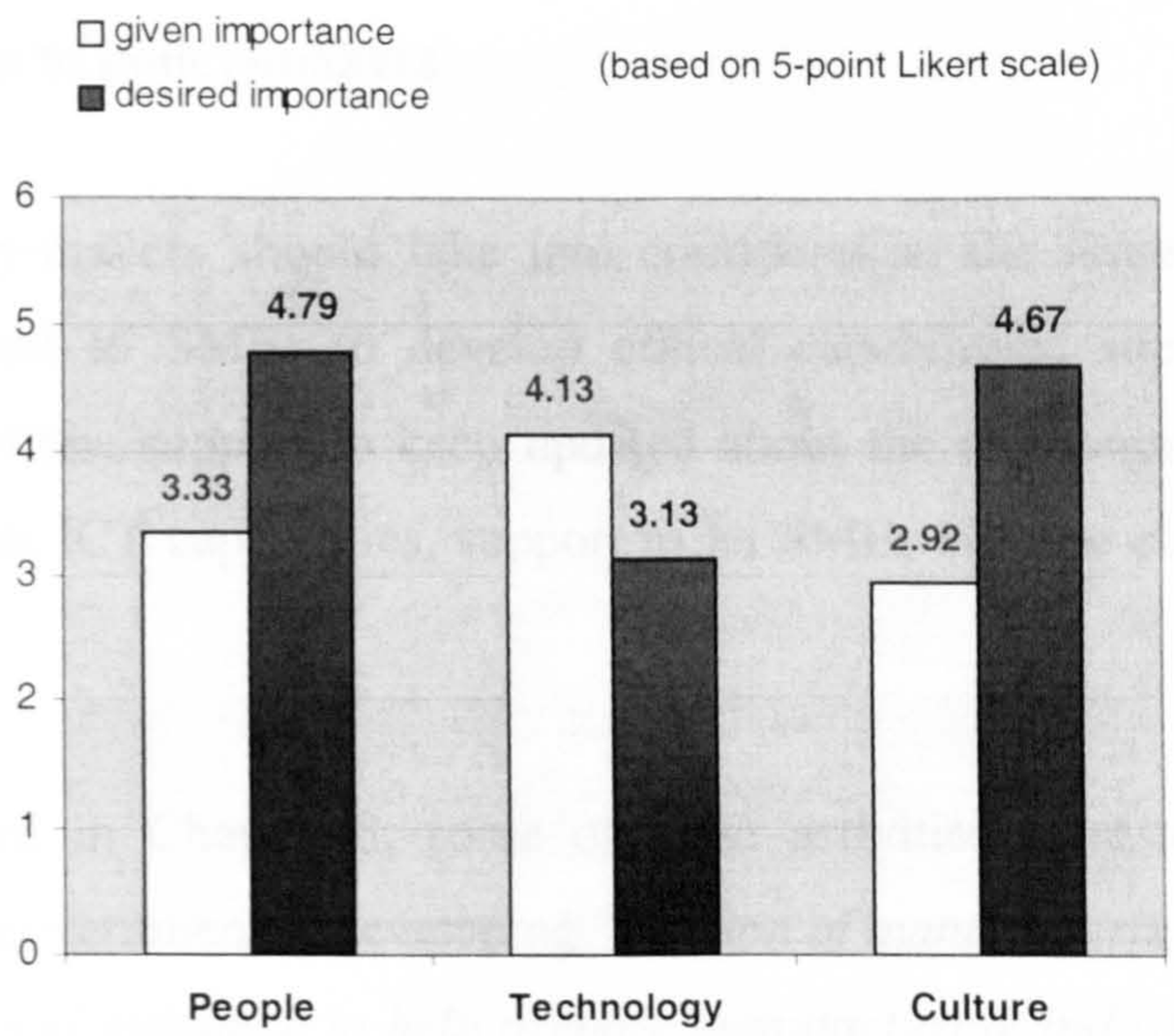


Figure 32: Comparison of the issues that are and that should be considered when implementing KM initiatives

(Source: (Edwards et al., 2003))

Contributions to policy-makers

Finally, policy-makers should take into consideration the issues highlighted above and provide support to SMEs to develop critical capabilities: support to engage in more strategic activities, support to keep updated about the environment dynamics, support to develop human ICT capabilities, support to let SMEs become closer to each other and to institutions.

As commented in Chapter 8, some of these activities have already been set up. For example, the government is developing "*a vision of manufacturing in the next 20 years and provide practical guidance to help prepare manufacturing industry for the future, through the Manufacturing 2020 Foresight Panel*" (DTI, 1999:5). Also, other institutions (Regional Development Agencies (RDAs), Business Links, Small Business Council (SBC) or Business Gateway in Scotland) or initiatives (UK's Skills Strategy, Sector Skills Councils, Small Firms Initiative, Lifelong Learning Department, etc.) are providing information, advice and access to experts and are facilitating the development of the required skills on issues related to businesses.

Therefore, results support the governmental policy directions, but the inclusion of the critical factors highlighted here should be taken into consideration. For example, means to facilitate:

- technological and markets surveillance
- organisational change (e.g. training on change management)
- interaction with external parties (e.g. organising or promoting the attendance to external events)
- technical advice on what ICTs to implement and how to do it
- the required resources to work individually and in collaboration with other companies (e.g. laboratories, meeting rooms, etc.)
- constantly update on programmes or activities of interest through ICTs in order to do it fast and dynamic
- and many others

could be of strategic importance for the strategic development of SMEs.

9.3 Limitations of the Present Research

First, the limited sample size has restricted the statistical analysis and validation of the results. Larger samples would have allowed to used techniques such as structural equation modelling and also, validate the results by splitting the sample. However, I believe that the statistical analysis carried out has alleviated these initial difficulties in the best way, by having in mind the limitation of the sample size in all the techniques and by using diverse statistical methods in order to corroborate the results.

Second, the reliance on a unique informant to gather organisational data is widely used given their advantages of response rate, time and cost. However, it presents the weakness of a single opinion or perception. Given the small size of SMEs, the information provided by managers is considered valid, since they usually take part in most of the firm's activities. Another assumption that could be under question is the sample homogeneity. As discussed in Chapter 6, the impact of this limitation is relatively small, since the sample has already narrowed down according to key characteristics such as sector, manufacturing and size.

Third, the results provided by this research are limited to a specific sector and to a unique country. However, the reason to do so was the acknowledgement of heterogeneity within SMEs. Therefore, the conclusions can be applied to firms within this segment of firms, hence the generabilisability of the results should be cautious. However, similar results would expected in other European countries within the same sector, since location within the UK has not shown big differences and the European Union is provoking the homogenisation of the countries to a certain extent. That is, greater differences could be expected with nations such as USA, Japan or China.

Fourth, one of the weaknesses of this research is that the data have been gathered in a snapshot. In order to validate the results, the study should be replicated in the future. As Tippins and Sohi (2003) argue in their study, "*this (cross-sectional research design) is currently the standard methodology in strategy research but is known to suffer from certain drawbacks. Although we tried to correct these drawbacks through careful selection of the respondents and a cross-check of their knowledgeability and involvement, the drawbacks*

cannot be completely ruled-out" (p.757). The best way to deal with this limitation is through longitudinal studies. However, given the limited span of time to do further longitudinal examination was considered unfeasible. Therefore, a follow-up survey should be undertaken in some years' time in order to give us greater confidence in the causal relationships identified in the present study. However, the low responses in surveys and the high volatility of firms might not allow to carry out a proper longitudinal study. In this respect, the most appropriate manner to address the evolution of capabilities would be by employing qualitative methods, however, it would be at the expense of low generabilisability.

The results of this research, therefore, should be interpreted with caution, although they provide a useful base to initiate qualitative investigations on those factors identified as significant in order to study how dynamic capabilities are shaped over time, a different research question from the one addressed here.

Indeed, any survey methodology should be preceded and followed by qualitative investigations, as part of the "research wheel" mentioned in Chapter 6, page 124. However, due to the limited period to do a PhD, a trade-off had to be made. As explained in page 136, the researcher decided to go for a survey without a previous qualitative investigation, since she considered that the extensive literature on knowledge management was plenty of qualitative studies and provided sufficient basis to inform the construction of the model. In this way, further qualitative investigation could be carried out to strengthen the results and conclusions drawn. However, given the difficulties in getting enough responses, the research covered the quantitative stage, leaving the qualitative follow-up part for future research. Therefore, the solely reliance on quantitative methods is a limitation of the present research which should be solved in future research, by gaining more profound insights of the results by using "fine-grained" methodologies (Harrigan, 1983).

On the other hand, the cross-checking of the data would allow further refinement of the model and more insight on the long-term sustainability of competitive advantages. In order to minimise this weakness, different statistical techniques have been used in order to corroborate the results obtained.

Fifth, the adoption of the KBV and, in consequence, the firm as unit of analysis does not allow taking into account the agency theory. Therefore, the specific interactive influence of actors on organisations cannot be assessed.

Sixth, although all researches are based on the same theoretical grounds, there is not agreement in definitions, classifications and operationalisations differ among them. Therefore, this makes difficult the comparison of results. On the other hand, the employment of different approaches allows addressing the problem from different perspectives, which provides useful and complementary insights.

Seventh, as said in Chapter 5, this study has assumed Likert-scales as continuous variables, hence measurement error have been introduced. However, given that this assumption is a common practice in management research, this limitation is common in quantitative researches, although not always stated. There are two other limitations regarding the statistical analysis. First, as mentioned in page 195, the factor analysis regarding knowledge management capabilities was limited due to the impossibility of including all the variables related to knowledge management given the lack of sufficient responses. Alternatively, different factor analyses have been performed according to the conceptualisation of knowledge management capabilities. Second, it must be highlighted that there are correlations among the scales obtained by orthogonal rotation, and, though ideally they should be uncorrelated, these correlations represent a frequent limitation when applying this rotation method.

Finally, given the great amount of data gathered, further analysis could have been carried out. However, acknowledging the limitation of resources, the researcher has stuck to the initial research questions and objectives.

9.4 Future Research

The results of this study points to a number of interesting directions for future research. Based on the limitations presented above, the following avenues for additional research are suggested.

Overall, this thesis represents the first attempt to study knowledge management capabilities and ICT capabilities within SMEs using a quantitative approach. Acknowledging the difficulties in defining knowledge management capabilities and the little previous research regarding SMEs, this research should be considered as the first attempt in addressing the problem in an academic way. Therefore, more empirical validation of the results is needed. For example, comparison of results between large firms and SMEs within the same sector could give very useful insights.

The lack of enough sample size has not allowed some validation techniques. In order to validate this study, further research could replicate it and check whether the results remain. Nevertheless, the application of different statistical techniques has corroborated the general results. Thus, further research could concentrate on refining conceptual definitions and the measurement scales for the constructs, especially those who have come up more significant. "*Such incremental refinement is in the tradition of cumulative research that could build on and extend the findings reported here*" (Ravichandran and Lertwongsatien, 2005:260).

Similarly, In order to be able to have common measures and definitions, academics involved in this area could discuss the appropriateness of typologies and constructs. Another way of discussing about this would be by employing different constructs for the same concept within the same survey and compare the results, using the same statistical techniques. Under equal conditions, the scales could be compared and assessed. Nevertheless, it must be reminded that the results might depend on the type of firms addressed. Service firms might not require the same capabilities as manufacturing firms.

Once the key factors have been identified, future research should concentrate on investigating the results, studying the significant factors in depth, for example, carrying out longitudinal and/or qualitative studies, in order to study how dynamic capabilities are shaped over time, a different research question from the one addressed here. For example, future research should analyse the organisational culture in SMEs more profoundly and investigate whether and how the existence of different sub-cultures influences knowledge management and ICT capabilities. Also, future reseach could investigate how and why SMEs access external knowledge could be of extreme importance for policy makers to design their programmes, given the dependence of SMEs on governmental support. As seen in section 6.5, quantitative and qualitative methodologies (in Harrigan's words, "coarse-grained" and "fine-grained" methodologies) have complementary advantages and disadvantages. Therefore, a robust research should rely on both methodologies. Given the practical constraints, future research should continue the investigation initiated here by employing qualitative techniques.

Moreover, it would be interesting to analyse and compare the differences of this research in other contexts, either sector or countries. Cross-cultural comparison against the main competitors of EU manufacturers such as USA, Japan or, recently, China.

Although managers in SMEs can give a relatively reliable view of the firm's functioning, future research can benefit from multiple respondents within organisations, since the present research has taken firms as unit of analysis, not persons, even though in the analysis the effect of people as agents is taken into consideration. Furthermore, undertaking a multilevel study can improve the understanding of how the different parts of an activity system, how they shape each other and, for examining the role of CEO in promoting knowledge management within SMEs given their central role. Also, given that culture for knowledge has resulted a critical factor in predicting all kinds of organisational results, the analysis proposed in this research could benefit from studying different styles of organisational culture. Furthermore, if this analysis was multilevel, the discussion of the effect of the general organisational culture and different co-existing sub-cultures in knowledge management could generate insightful results. On the other hand, IS function is

becoming more and more spread within organisations, hence multiple respondents will provide richer measurement. Another way of dealing with unique respondents, it is by applying methodological triangulation, that is, using different sources of information such as secondary data or interviews.

As said before, this research is based on a snapshot, in spite of having considered performance over the past three years in order to counterbalance good or bad years attributable to unusual circumstances (Miller, 1991). However, the development of capabilities occurs over time, hence longitudinal research would be extremely useful in studying how dynamic capabilities evolve and interact.

On the other hand, it should point out that other relationships in different directions could be included. The focus of this research is the interaction and effect of knowledge management and ICTs as complementary capabilities on organisational performance. Future research could add more constructs and relationships to the model in order to analyse other interesting interrelationships with knowledge management and ICT, such as leadership or entrepreneurial orientation. Apart from other constructs, additional theories such as agency theory could be included in the research in order to analyse in detail the interaction between actors, organisations and practices within organisations.

Finally, the application of this research model on SMEs which have taken up e-commerce as part of their activities, might inform us of what capabilities are important to develop in order to be able to undertake this powerful way of acting globally. A comparison of firms which have and have not taken up e-commerce among their activities might provide very interesting conclusions.

It is hoped that the theoretical and empirical results presented here provide a useful starting point for embarking on future research directions, such the ones described above. Therefore, the present research is a valuable foundation of debate for both academics and practitioners.

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Appendix I: Research Questionnaire

Analysing Knowledge Management and Information Technologies capabilities and their effect on Performance

UNIVERSITY
of
GLASGOW

Thank you very much *for filling out this questionnaire.*
All information will be kept ***strictly confidential***

In case of requiring ***further explanations****, please contact Miss Amaia Ibáñez de Opacua at: 0216831i@student.gla.ac.uk or at: +44 (0)141-330 2000 (ext: 0061)*

In case of ***not filling up*** *the questionnaire, please send it back in enclosed self-addressed freepost envelope, stating the reason/s why you are not participating.*

SECTION A: INTRODUCTORY QUESTIONS

1.1 **How would you characterize the MAIN PRODUCTS (in terms of sales) of your firm?** (please tick one)

- ☐ Machinery/equipment
- ☐ Materials and components
- ☐ Consumer products
- ☐ Others (please specify) .....

.....

1.2 **Please indicate which SECTOR your firm belongs to:** .....

1.3 **How would you characterize the PRODUCTION PROCESS for your main product (in terms of sales)?** (please tick one)

- ☐ Single unit
- ☐ Small series
- ☐ Large series
- ☐ Mass production
- ☐ Don't know

1.4 **Please, indicate whether your firm is:** (please tick one)

- ☐ Autonomous
- ☐ Subsidiary of a larger firm

1.5 **Please indicate the YEAR OF FOUNDATION of your firm:** _____

1.6 **Please estimate the proportions of your staff that reach each of the following as the highest levels of FORMAL EDUCATION:**

_____ % School leavers
_____ % College graduates
_____ % University graduates
_____ % Postgraduates
100 % **TOTAL**

1.7 **Please estimate the following:**

Number of employees in your firm: _____
_____ % employees involved in Research and Development activities (R&D) or tick ☐ if being outsourced
_____ % employees involved in Information Systems activities or tick ☐ if being outsourced

1.8 **Please estimate the following amounts 5 years ago:**

Number of employees in your firm: _____
_____ % employees involved in Research and Development activities (R&D) or tick ☐ if being outsourced
_____ % employees involved in Information Systems activities or tick ☐ if being outsourced

Tick ☐ if this does not apply

1.9 **HOW MANY other sites does your firm have in the following areas apart from your main location?**

_____ Locally (within 50 miles from the main location)
_____ Within the country but not locally
_____ Within the EU but not within the country
_____ Beyond the EU

1.10 **What does the STRUCTURE of your firm look like?** (Please tick one)

- ☐ Hierarchical structure
- ☐ Flat structure
- ☐ Structure by projects (matrix organization)
- ☐ Flexible and temporary organisation
- ☐ Others (please specify) .....

.....

1.11 **Please describe the position of the person RESPONSIBLE FOR INFORMATION SYSTEMS WITHIN the organization structure** (Please tick one)

- ☐ Part of the Finance Department
- ☐ Part of Directorial Team
- ☐ Others (please specify) .....

.....

1.12 **Please indicate the LEVEL OF CHANGE that your firm undergoes in the following aspects:**
(Please circle one number to indicate the speed of change)

	No change within the last 5 years		Small changes in the last 3 years		Significant change within the last year
- Logistics processes change	(1)	(2)	(3)	(4)	(5)
- Product life cycle i.e. products becoming obsolete	(1)	(2)	(3)	(4)	(5)
- Core production processes change	(1)	(2)	(3)	(4)	(5)
- New product introduction	(1)	(2)	(3)	(4)	(5)
- Others (please stipulate)	(1)	(2)	(3)	(4)	(5)

1.13 **How often have you used the following CONTROL METHODS in the last year?**
(Please circle one number to indicate the degree of usage)

	Never	Once	Every 6 months	Monthly	Weekly
- Comprehensive management and information system control	(1)	(2)	(3)	(4)	(5)
- Use of cost centres for cost control	(1)	(2)	(3)	(4)	(5)
- Quality control of operations (e.g. using sampling and other methods)	(1)	(2)	(3)	(4)	(5)
- Formal appraisal of personnel	(1)	(2)	(3)	(4)	(5)

1.14 **At what level are the following DECISIONS made?** (Please circle one number to indicate the level of decision)

	Gral. Manager				At the shop level
- Factory/warehouse location planning	(1)	(2)	(3)	(4)	(5)
- New process design/research budgeting	(1)	(2)	(3)	(4)	(5)
- Information system decisions (e.g. adopting new technology)	(1)	(2)	(3)	(4)	(5)
- Inventory planning	(1)	(2)	(3)	(4)	(5)

1.15 **Please estimate the proportion of your STAKEHOLDERS (customers, suppliers, competitors) in each of the following classes:**

	Customers	Suppliers	Competitors
Large firms (with more than 250 employees)	_____ %	_____ %	_____ %
Medium firms (between 50 and 250 employees)	_____ %	_____ %	_____ %
Small firms (between 10 and 50 employees)	_____ %	_____ %	_____ %
Micro firms (with less than 10 employees)	_____ %	_____ %	_____ %
Individual consumers	_____ %	N/A	N/A
Others	_____ %	_____ %	_____ %
TOTAL	**100** %	**100** %	**100** %

1.16 **Please estimate the proportion of your STAKEHOLDERS (customers, suppliers, competitors) located:**

	Customers	Suppliers	Competitors
Locally (within 50 miles from the main location)	_____ %	_____ %	_____ %
Within the country	_____ %	_____ %	_____ %
Within the EU	_____ %	_____ %	_____ %
Beyond the EU	_____ %	_____ %	_____ %
Others	_____ %	_____ %	_____ %
TOTAL	**100** %	**100** %	**100** %

SECTION B: KNOWLEDGE MANAGEMENT CAPABILITIES

Please circle one number for each of these statements, indicating the extent to which you agree or disagree with them

B.1 *KNOWLEDGE ACQUISITION*

This section is concerned with the way your firm acquires knowledge from individuals, from groups or from external sources.

		Strongly disagree				Strongly agree
1	**The firm knows the skills and capabilities of each of their staff**	(1)	(2)	(3)	(4)	(5)
2	Staff are valued for their individual expertise	(1)	(2)	(3)	(4)	(5)
3	**The firm provides all their staff with training**	(1)	(2)	(3)	(4)	(5)
4	The mission, vision and objectives of the firm are clearly explained to new staff	(1)	(2)	(3)	(4)	(5)
5	**New staff are briefed on the technical specifications and their job/role**	(1)	(2)	(3)	(4)	(5)
6	The values and philosophy of the firm are clearly explained to new staff	(1)	(2)	(3)	(4)	(5)
7	**Staff know who to ask when they need knowledge which already exists in the firm**	(1)	(2)	(3)	(4)	(5)
8	Staff are encouraged to ask for assistance when is needed	(1)	(2)	(3)	(4)	(5)
9	**Groups get knowledge from existing data about past and/or current experiences**	(1)	(2)	(3)	(4)	(5)
10	The firm values research activities	(1)	(2)	(3)	(4)	(5)
11	**Managers keeps themselves updated about what happens within the firm**	(1)	(2)	(3)	(4)	(5)
12	The firm learns a lot from its customers	(1)	(2)	(3)	(4)	(5)
13	**The firm learns a lot from its suppliers**	(1)	(2)	(3)	(4)	(5)
14	The firm learns a lot from its competitors	(1)	(2)	(3)	(4)	(5)
15	**The firm acquires knowledge from other external sources**	(1)	(2)	(3)	(4)	(5)

16 Indicate on scale below the description of the nature of communication of each firm function with the rest of the functions:

	Sporadic and informative contacts	Passing information when required	Frequent Communications	Regular communications and sporadic collaboration	Frequent and strong collaborations
	(1)	(2)	(3)	(4)	(5)
Production	(1)	(2)	(3)	(4)	(5)
Purchasing	(1)	(2)	(3)	(4)	(5)
Finance	(1)	(2)	(3)	(4)	(5)
Sales	(1)	(2)	(3)	(4)	(5)
R&D	(1)	(2)	(3)	(4)	(5)
Information Systems	(1)	(2)	(3)	(4)	(5)
Human Resources Management	(1)	(2)	(3)	(4)	(5)

B.2 KNOWLEDGE SHARING

This section is concerned with the knowledge your firm possesses or has acquired and how it is disseminated and shared across the firm.

		Strongly disagree				Strongly agree
17	Staff are encouraged to interact with other groups	(1)	(2)	(3)	(4)	(5)
18	Staff are encouraged to discuss their work with people in their own workgroup	(1)	(2)	(3)	(4)	(5)
19	The incentive system promotes group work and activities	(1)	(2)	(3)	(4)	(5)
20	Knowledge and/or information are distributed throughout the firm	(1)	(2)	(3)	(4)	(5)
21	Knowledge and/or information is exchanged with business partners	(1)	(2)	(3)	(4)	(5)
22	The firm looks for possible collaboration opportunities with other firms	(1)	(2)	(3)	(4)	(5)
23	The firm's organizational structure supports collaboration	(1)	(2)	(3)	(4)	(5)
24	Staff have adequate resources to work individually	(1)	(2)	(3)	(4)	(5)
25	Staff have adequate resources to work in groups	(1)	(2)	(3)	(4)	(5)
26	Communication within the firm is open	(1)	(2)	(3)	(4)	(5)
27	Communication within the firm happens regularly	(1)	(2)	(3)	(4)	(5)
28	Trust is promoted by the firm	(1)	(2)	(3)	(4)	(5)
29	Transparency is promoted by the firm in communication	(1)	(2)	(3)	(4)	(5)
30	Commitment to the firm's mission is promoted by the firm	(1)	(2)	(3)	(4)	(5)
31	The firm attempts to protect its strategic knowledge	(1)	(2)	(3)	(4)	(5)

B.3 KNOWLEDGE INTEGRATION

This section relates to the knowledge your firm possesses or has acquired and how it is integrated and assimilated across the firm.

		Strongly disagree				Strongly agree
32	Staff are encouraged to practice what they have learnt	(1)	(2)	(3)	(4)	(5)
33	Staff are encouraged to try out new ideas at work	(1)	(2)	(3)	(4)	(5)
34	Disagreements between staff are allowed	(1)	(2)	(3)	(4)	(5)
35	Outdated knowledge and/or information is replaced systematically	(1)	(2)	(3)	(4)	(5)
36	Open discussions happen in order to arrive at a common view	(1)	(2)	(3)	(4)	(5)
37	After every successful project, the group reflects on the "lessons learned"	(1)	(2)	(3)	(4)	(5)
38	After every unsuccessful project, the group reflects on the "lessons learned"	(1)	(2)	(3)	(4)	(5)
39	All the staff are working towards the same vision	(1)	(2)	(3)	(4)	(5)
40	Functional strategies are aligned with the general strategy of the firm	(1)	(2)	(3)	(4)	(5)

This section describes different practices related to knowledge.
Please tick whether your firm carries out the practices below or not and, if yes, rate their importance by circling the appropriate number (1: very little importance, 5: very important)

In terms of *learning experiences*, our firm provides:			Importance				
		do	**don't**	**-**			**+**
1	**Training on the site of job**	☐	☐	(1)	(2)	(3)	(4)	(5)
2	**Continuous plans of training for each employee**	☐	☐	(1)	(2)	(3)	(4)	(5)
3	**Apprenticeship / shadowing with experienced staff**	☐	☐	(1)	(2)	(3)	(4)	(5)
4	**Employee rotation to learn new tasks**	☐	☐	(1)	(2)	(3)	(4)	(5)
5	**Opportunity to attend at external centres, fairs, conference or other events**	☐	☐	(1)	(2)	(3)	(4)	(5)
6	**The use of consultancy services when required**	☐	☐	(1)	(2)	(3)	(4)	(5)
7	**Courses provided through the Internet**	☐	☐	(1)	(2)	(3)	(4)	(5)
8	**Documentation showing the skills of every person in the firm**	☐	☐	(1)	(2)	(3)	(4)	(5)
9	**Knowledge of people's skills based through direct contact or informal means**	☐	☐	(1)	(2)	(3)	(4)	(5)
10	**Paper-based documentation (books, articles, brochures, handbooks, etc.)**	☐	☐	(1)	(2)	(3)	(4)	(5)
11	**Records stored in paper form**	☐	☐	(1)	(2)	(3)	(4)	(5)
12	**Records stored in computer-form**	☐	☐	(1)	(2)	(3)	(4)	(5)
13	**Opportunities to speak to staff involved in previous projects**	☐	☐	(1)	(2)	(3)	(4)	(5)

In order to *know the changes in the environment*, our firm:			Importance				
		do	**don't**	**-**			**+**
14	**Benchmarks** (analysing competitors' products, processes, technologies, strategies...)	☐	☐	(1)	(2)	(3)	(4)	(5)
15	**Does market research**	☐	☐	(1)	(2)	(3)	(4)	(5)
16	**Monitors the environment continuously**	☐	☐	(1)	(2)	(3)	(4)	(5)

In order to enable *experimentation and innovation*, our firm facilitates:			Importance				
		do	**don't**	**-**			**+**
17	**The provision of resources to experiment**	☐	☐	(1)	(2)	(3)	(4)	(5)
18	**Simulations / experiments in pilot areas**	☐	☐	(1)	(2)	(3)	(4)	(5)
19	**Simulation by computer software**	☐	☐	(1)	(2)	(3)	(4)	(5)

***CEO* gathers information about what is happening in the firm via:**			Importance				
		do	**don't**	**-**			**+**
20	**Regular communication with functional / departmental managers**	☐	☐	(1)	(2)	(3)	(4)	(5)
21	**Use of data provided by the information system**	☐	☐	(1)	(2)	(3)	(4)	(5)
22	**Walking around the firm**	☐	☐	(1)	(2)	(3)	(4)	(5)

Our firm *communicates* with different parties through:		do	don't	Importance -				+
23	Formal face to face meetings with team members	☐	☐	(1)	(2)	(3)	(4)	(5)
24	Formal face to face meetings with other functions or departments	☐	☐	(1)	(2)	(3)	(4)	(5)
25	Formal face to face meetings with CEO	☐	☐	(1)	(2)	(3)	(4)	(5)
26	Formal face to face meetings with suppliers	☐	☐	(1)	(2)	(3)	(4)	(5)
27	Formal face to face meetings with customers	☐	☐	(1)	(2)	(3)	(4)	(5)
28	Personal and informal contact with team members	☐	☐	(1)	(2)	(3)	(4)	(5)
29	Personal and informal contact with other functions or departments	☐	☐	(1)	(2)	(3)	(4)	(5)
30	Personal and informal contact with CEO	☐	☐	(1)	(2)	(3)	(4)	(5)
31	Personal and informal contact with suppliers	☐	☐	(1)	(2)	(3)	(4)	(5)
32	Personal and informal contact with customers	☐	☐	(1)	(2)	(3)	(4)	(5)
33	The use of memos, suggestion schemes, etc	☐	☐	(1)	(2)	(3)	(4)	(5)
34	Periodic internal publications (e.g. newsletters)	☐	☐	(1)	(2)	(3)	(4)	(5)
35	The use of metaphors, examples or visual communication	☐	☐	(1)	(2)	(3)	(4)	(5)
36	Visits by customers to our firm	☐	☐	(1)	(2)	(3)	(4)	(5)
37	Visits to customers	☐	☐	(1)	(2)	(3)	(4)	(5)
38	Visits by suppliers to our firm	☐	☐	(1)	(2)	(3)	(4)	(5)
39	Visits to suppliers	☐	☐	(1)	(2)	(3)	(4)	(5)

The normal way(s) of *working* in our firm is:		do	don't	Importance -				+
40	Individual work	☐	☐	(1)	(2)	(3)	(4)	(5)
41	In functional teams	☐	☐	(1)	(2)	(3)	(4)	(5)
42	In cross-functional teams	☐	☐	(1)	(2)	(3)	(4)	(5)
43	In multidisciplinary groups (including external people such as customers and/or suppliers)	☐	☐	(1)	(2)	(3)	(4)	(5)

In order to facilitate *work activities*, our firm:		do	don't	Importance -				+
44	Provides meeting rooms	☐	☐	(1)	(2)	(3)	(4)	(5)
45	Acknowledges the need for spare time for problem solving, research, etc.	☐	☐	(1)	(2)	(3)	(4)	(5)
46	Provides ergonomic and comfortable work places	☐	☐	(1)	(2)	(3)	(4)	(5)
47	Gives incentives for team results	☐	☐	(1)	(2)	(3)	(4)	(5)
48	Gives incentives for helping others	☐	☐	(1)	(2)	(3)	(4)	(5)
49	Gives incentives for participation in social activities	☐	☐	(1)	(2)	(3)	(4)	(5)
50	Has a statement of the values of the firm	☐	☐	(1)	(2)	(3)	(4)	(5)
51	Organises social activities outside the firm	☐	☐	(1)	(2)	(3)	(4)	(5)
52	Uses the examples given by senior staff	☐	☐	(1)	(2)	(3)	(4)	(5)

In general our firm's written data are *stored*:		do	don't	Importance -				+
53	In paper form	☐	☐	(1)	(2)	(3)	(4)	(5)
54	In computer databases	☐	☐	(1)	(2)	(3)	(4)	(5)

Our firm *remembers* meeting outcomes and other internal communications through:		do	don't	Importance -				+
55	Reliance on our memory	☐	☐	(1)	(2)	(3)	(4)	(5)
56	Generation of some kind of meeting report after meetings	☐	☐	(1)	(2)	(3)	(4)	(5)
57	Collection of records such as written notes, e-mail, sketches, etc.	☐	☐	(1)	(2)	(3)	(4)	(5)

Knowledge produced or acquired in our firm is *protected* by:		do	don't	Importance -				+
58	Intellectual property rights (such as patents, trademarks, copyrights, etc.)	☐	☐	(1)	(2)	(3)	(4)	(5)
59	Controlling access to confidential information stored in paper form	☐	☐	(1)	(2)	(3)	(4)	(5)
60	Controlling access to confidential information stored in databases	☐	☐	(1)	(2)	(3)	(4)	(5)

In terms of *external relationships*, our firm:		do	don't	Importance -				+
61	Regularly exchanges basic data with customers	☐	☐	(1)	(2)	(3)	(4)	(5)
62	Regularly exchanges basic data with suppliers	☐	☐	(1)	(2)	(3)	(4)	(5)
63	Regularly exchanges basic data with competitors	☐	☐	(1)	(2)	(3)	(4)	(5)
64	Collaborates with customers on specific projects or initiatives	☐	☐	(1)	(2)	(3)	(4)	(5)
65	Collaborates with suppliers on specific projects or initiatives	☐	☐	(1)	(2)	(3)	(4)	(5)
66	Collaborates with competitors on specific projects or initiatives	☐	☐	(1)	(2)	(3)	(4)	(5)

Our firm applies *collaboration strategies* such as:		do	don't	Importance -				+
67	Mergers	☐	☐	(1)	(2)	(3)	(4)	(5)
68	Acquisitions of firms	☐	☐	(1)	(2)	(3)	(4)	(5)
69	Joint-ventures / Strategic alliances	☐	☐	(1)	(2)	(3)	(4)	(5)
70	R&D contracted-in or Licensed-in	☐	☐	(1)	(2)	(3)	(4)	(5)

Our firm carries out other practices to manage knowledge		do	don't	Importance -				+
71	.....	☐	☐	(1)	(2)	(3)	(4)	(5)
72	.....	☐	☐	(1)	(2)	(3)	(4)	(5)

Please add any comment about the practices indicated in this section

SECTION C: INFORMATION TECHNOLOGIES CAPABILITIES

C.1 *IT INFRASTRUCTURE*

This section relates to the Information Technologies which exist in your firm, their importance and their intensity of their use.

Please tick whether your firm has the technologies below or not and, if yes, rate their importance by circling the appropriate number (1: very little importance, 5: very important)

		do	don't	Importance -				+
a	Data mining / text retrieval software	☐	☐	(1)	(2)	(3)	(4)	(5)
b	Expert or decision support software	☐	☐	(1)	(2)	(3)	(4)	(5)
c	Automatic e-mail alerts	☐	☐	(1)	(2)	(3)	(4)	(5)
d	Search engine or Web crawler	☐	☐	(1)	(2)	(3)	(4)	(5)
e	Intelligent agent or artificial intelligence	☐	☐	(1)	(2)	(3)	(4)	(5)
f	Mind / knowledge mapping software	☐	☐	(1)	(2)	(3)	(4)	(5)
g	Computer based training / e-learning.	☐	☐	(1)	(2)	(3)	(4)	(5)
h	Design SW (CAD, CAM, PDM)	☐	☐	(1)	(2)	(3)	(4)	(5)
i	Simulation software	☐	☐	(1)	(2)	(3)	(4)	(5)
j	Phone	☐	☐	(1)	(2)	(3)	(4)	(5)
k	E-mail or chatting software	☐	☐	(1)	(2)	(3)	(4)	(5)
l	Groupware (e.g. bulletin board)	☐	☐	(1)	(2)	(3)	(4)	(5)
m	Project management software	☐	☐	(1)	(2)	(3)	(4)	(5)
n	Extranet	☐	☐	(1)	(2)	(3)	(4)	(5)
o	Integrated software (MRP, ERP)	☐	☐	(1)	(2)	(3)	(4)	(5)
p	Content / document management software	☐	☐	(1)	(2)	(3)	(4)	(5)
q	Intranet or enterprise information portal	☐	☐	(1)	(2)	(3)	(4)	(5)
r	Knowledge repository or digital archive	☐	☐	(1)	(2)	(3)	(4)	(5)
s	Workflow / process management software	☐	☐	(1)	(2)	(3)	(4)	(5)
	Others							
t	.....	☐	☐	(1)	(2)	(3)	(4)	(5)
u	.....	☐	☐	(1)	(2)	(3)	(4)	(5)
v	.....	☐	☐	(1)	(2)	(3)	(4)	(5)
w	.....	☐	☐	(1)	(2)	(3)	(4)	(5)
y	.....	☐	☐	(1)	(2)	(3)	(4)	(5)

This section considers issues related to Information Technologies (IT) infrastructure, in terms of both software and hardware.
Please circle one number on each statement to indicate the degree of agreement or disagreement with the following statements.

		Strongly disagree				Strongly agree
1	Few problems of compatibility arise when adding new IT to the existing one	(1)	(2)	(3)	(4)	(5)
2	The firm has addressed the issue of data security	(1)	(2)	(3)	(4)	(5)
3	New IT aims to enable better communication	(1)	(2)	(3)	(4)	(5)
4	The firm is consistently able to provide the necessary capital for IT investments	(1)	(2)	(3)	(4)	(5)
5	The firm creates customized software applications when necessary	(1)	(2)	(3)	(4)	(5)
6	The firm prevents its IT infrastructure from being imitated	(1)	(2)	(3)	(4)	(5)
7	The firm possesses an appropriate IT infrastructure to support the business	(1)	(2)	(3)	(4)	(5)

C.2 *HUMAN IT SKILLS*

This questions consider the human issues related to Information Technologies (IT), including those people in charge of IT implementation, those that use the technology and the managers.
Please circle one number on each statement to indicate the degree of agreement or disagreement with the following statements.

	Staff responsible for the implementation of IT...	Strongly disagree				Strongly agree
8	... possess a high level of technical expertise	(1)	(2)	(3)	(4)	(5)
9	... are encouraged to learn about new technologies	(1)	(2)	(3)	(4)	(5)
10	... closely follows emerging trends in IT	(1)	(2)	(3)	(4)	(5)
11	... take part in the formulation of organisational strategy	(1)	(2)	(3)	(4)	(5)
12	... know well all of the firm's processes	(1)	(2)	(3)	(4)	(5)
13	... are actively engaged in the redesign of the business processes	(1)	(2)	(3)	(4)	(5)
14	... aim to support communication across the firm	(1)	(2)	(3)	(4)	(5)
15	... collaborate with customers & suppliers to ease communications	(1)	(2)	(3)	(4)	(5)
16	... write clear and useful documentation regarding IT	(1)	(2)	(3)	(4)	(5)
17	... work together with other departments in teams	(1)	(2)	(3)	(4)	(5)
18	... are self-directed and proactive	(1)	(2)	(3)	(4)	(5)
19	... manage contracts effectively with IT suppliers	(1)	(2)	(3)	(4)	(5)
20	... actively research the best IT practices of other companies	(1)	(2)	(3)	(4)	(5)

	Staff, in general,...	Strongly disagree				Strongly agree
21	... are well trained in the use of new IT	(1)	(2)	(3)	(4)	(5)
22	... make full use of the current IT infrastructure	(1)	(2)	(3)	(4)	(5)
23	... accept new IT with few problems	(1)	(2)	(3)	(4)	(5)
24	... are involved early in the process of IT adoption	(1)	(2)	(3)	(4)	(5)

	Managers...	Strongly disagree				Strongly agree
25	... are clearly committed to IT	(1)	(2)	(3)	(4)	(5)

SECTION D: ORGANIZATIONAL PERFORMANCE

Please circle one number on each statement to indicate the degree of agreement or disagreement with the following statements.

Compared with your main competitors, over the last 3 years your firm...:		Strongly disagree						Strongly Agree
1	... has been more successful	(1)	(2)	(3)	(4)	(5)	(6)	(7)
2	... has had a greater market share	(1)	(2)	(3)	(4)	(5)	(6)	(7)
3	... has grown faster	(1)	(2)	(3)	(4)	(5)	(6)	(7)
4	... has been more profitable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
5	... has been more innovative	(1)	(2)	(3)	(4)	(5)	(6)	(7)
6	... has responded quicker to changes in the market	(1)	(2)	(3)	(4)	(5)	(6)	(7)
7	... has been more adaptable and flexible, adjusting your objectives to changes in the market	(1)	(2)	(3)	(4)	(5)	(6)	(7)

Please indicate the percentage change over the last 3 years on each of the following indicators:

		% change from previous year (please indicate + or -)		
		2001	2002	2003
8	Sales growth	_____%	_____%	_____%
9	Market share growth	_____%	_____%	_____%
10	Profit growth	_____%	_____%	_____%
11	ROA (return on assets)	_____%	_____%	_____%

Where is your main geographic location located? _____

In relation to this main geographic location, please estimate:

12 **Percentage of turnover in 2003 invested in Information Systems:** _____%

13 **Estimated total sales in 2003:** _____

14 **The following sources of competitive advantage** *(Please circle one number on each source to indicate the degree of strengt*

Firm-specific advantages	Very poor		Neutral		Very strong
Product development efforts	(1)	(2)	(3)	(4)	(5)
Service level	(1)	(2)	(3)	(4)	(5)
Product quality level	(1)	(2)	(3)	(4)	(5)
Price level	(1)	(2)	(3)	(4)	(5)
Technological flexibility	(1)	(2)	(3)	(4)	(5)
Brand positioning	(1)	(2)	(3)	(4)	(5)
Process development efforts	(1)	(2)	(3)	(4)	(5)
Level of process technology	(1)	(2)	(3)	(4)	(5)
New product introduction	(1)	(2)	(3)	(4)	(5)
Labour costs	(1)	(2)	(3)	(4)	(5)
Localization-specific advantages					
Raw material costs	(1)	(2)	(3)	(4)	(5)
Number of competitors	(1)	(2)	(3)	(4)	(5)
Degree of industry concentration	(1)	(2)	(3)	(4)	(5)
Relationship with retailers	(1)	(2)	(3)	(4)	(5)
Relationship-specific Advantages					
Low costs of distribution	(1)	(2)	(3)	(4)	(5)
Relationships with suppliers	(1)	(2)	(3)	(4)	(5)
Access to cheap raw materials	(1)	(2)	(3)	(4)	(5)

*Please add **any comment** (if more space is needed, continue in another sheet)*

RESPONDENT

Your time and effort in completing this questionnaire is very much appreciated. In case we need to find interesting to contact you for additional information in our further research, could we contact you? Please, indicate:

☐ Yes ☐ No

Please tick if you would like a copy of the research results: ☐

We would appreciate if you could provide us with your contact details, but if you would prefer to remain anonymous, please return the questionnaire with the following section blank.

Your name .....

Position / Job title .....

Company .....

Address .....

.....

.....

Email address .....

Thank you very much for filling out this questionnaire.
All information will be kept strictly confidential

UNIVERSITY of GLASGOW

Appendix II: Covering Letter

Miss Amaia Ibáñez de Opacua
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Fax +44(0)141 330 5669
Email: 0216831i@student.gla.ac.uk

20th September 2004

Dear Sir/Madam

I am writing you to ask for your collaboration in a research project studying autonomous and subsidiary Small and Medium Enterprises (SMEs) within UK, Ireland and Spain. This project is part of my PhD, therefore your participation is critical to the completion of my studies.

The purpose of my research is to explore the way(s) in which SMEs manage knowledge, utilize Information and Communication Technologies and the impacts of these activities on organizational performance.

Your help in this study is invaluable. As a mark of my gratitude for the time spent filling in the attached questionnaire, I will develop a specific report assessing your company in comparison with the final results of the survey and return it to you at the end of the project.

All the information returned in this questionnaire will be used purely for the purposes of this research and will be treated as strictly confidential.

Finally, I would like to highlight the fact that there are no right answers for the questionnaire since the study is concerned about aggregated results in order to identify trends. Please do not feel that either you or your firm is being subjected to undue scrutiny when completing the questionnaire.

If you require further information, please do not hesitate to contact me at the address specified above. Thank you in advance for your collaboration. If you do not wish to participate in the study, please return the questionnaire using the enclosed envelope, noting your name and address in order that you can be deleted from our mailing list. I would also be grateful if you could state the reason(s) why you do not wish to participate.

I look forward to receiving your filled-up questionnaire using the enclosed freepost envelope within the next three weeks.

Yours sincerely

Amaia Ibáñez de Opacua
Doctoral Student
University of Glasgow

Appendix III: Factor Analysis

The application of the statistical technique called factor analysis will follow a systematic procedure, which requires making decisions regarding different aspects involved in the use of factor analysis for the given data. Such decisions are illustrated in the decision diagram shown in Figure III-1. Thus, the following section will describe the stages of the factor analysis procedure followed by the present study.

Stage 1: Objectives of Factor Analysis

The constructs used in this research include a significant amount of items since they aim at capturing the maximum amount of aspects involved. In order to handle them in an easier way, factor analysis is applied, since one of the aims of this technique is to summarize the data in a smaller number of dimensions or factors. Due to the exploratory nature of the research, the type of factor analysis applied is exploratory.

Stage 2: Designing a Factor Analysis

Factor analysis has been used to group the variables, not cases, in a smaller number of dimensions or factors. Otherwise, the statistical technique to be employed would have been cluster analysis.

Hair et al (1995) recommend a set of pre-conditions to perform factor analysis. First, factor analysis should be applied to samples of not fewer than 50 observations and, preferably, more 100 or larger. In this case, the sample of 159 valid answers meets the requirements. Second, the general rule of having at least five times as many observations as there are variables has been covered, since the maximum number of variables included in factor analysis is 25, thus it requires a minimum of 125 cases.

Anyway, the adequacy of sampling will has also been checked later looking at other measures, such as Kaiser-Meyer-Olkin Measure.

Stage 1: Objectives of FA

Stage 2: Designing a FA

Stage 3: Assumptions of FA

Stage 4: Deriving Factors and Assessing Overall Fit

Stage 5: Interpreting the Factors

Stage 6: Validation of FA

Stage 7: Additional uses of FA results

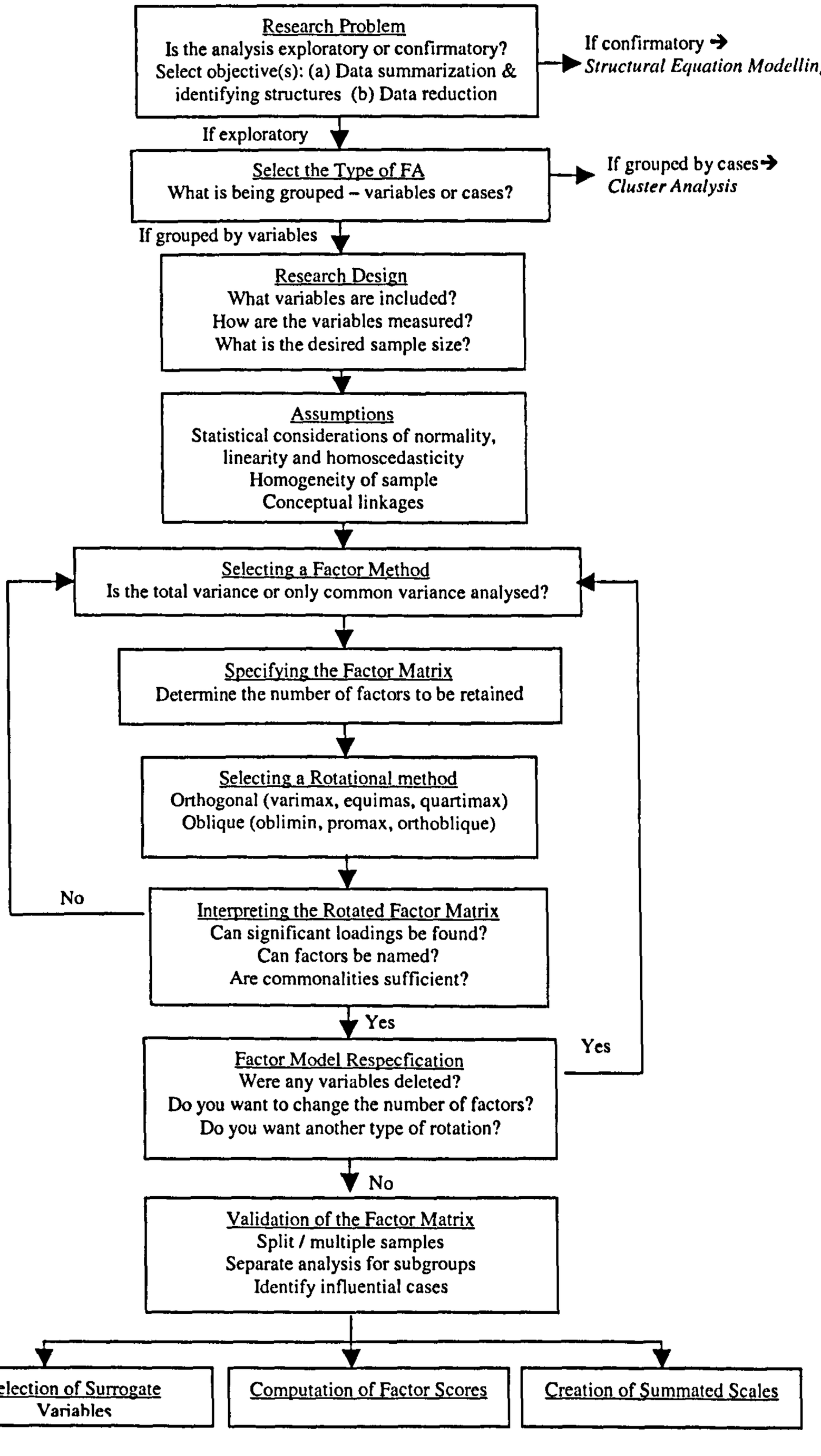


Figure III-1: Decision diagram in Factor Analysis (Source: Hair et al, 1995)

Stage 3: Assumptions of Factor Analysis

As for the rest of multivariate techniques, factor analysis is based on the assumption of normality, linearity, homoscedasticity and multicollinearity. However, these assumptions are more conceptual than statistical (Hair et al, 1995). While, the violation of the first three assumptions slightly affects the results, multicollinearity is even desired. Hair et al (1995) suggest that the inter-items correlations should be greater than 0.30, condition that is also met by the sample data. The Barlett test of sphericity has also given information about the correlation among the variables, showing positive results.

Stage 4: Deriving Factors and Assessing Overall Fit

The present study uses the software SPSS to run factor analysis with the aim of identifying the underlying dimensions or factors which account for most of the variance in the larger amount of variables. Principal components has been used to extract the first solution has been, since this method is adequate when the objective is to summarize the original information into a smaller number of factors (Hair et al, 1995). The difference between this and other methods, such as factor component, is that it considers the total amount of variance.

In order to extract the factors, having Eigenvalues greater than 1 has been applied as a decision rule. Having set the number of factors, the loadings of each variable on them have been examined in order to assess to which factor variables load more significantly. The factor loadings in the solutions indicate the degree of correlation between the variables and the factors. Following the guidelines of BMDP statistical software (Hair et al, 1995), in a sample of 150 observations factor loadings greater than 0.45 may be considered significant. However, here a more conservative criteria has been selected: items with a factor loading of at least 0.50 and with no loadings on other factors greater than 0.40 have been perceived as component of one scale. Those variables not loading to any factor have been removed.

Once the scales have been determined, they are rotated by using an orthogonal rotation called *varimax* in order to get a more interpretable solution. Orthogonal

rotation has been chosen given that the objective of the factor analysis is to reduce the number of original variables, while oblique rotation is more used in confirmatory studies, where the number of factors is known. Among the orthogonal rotations, the varimax approach has been adopted, since it maximises the variance of the scale and it is the most widely used for exploratory purposes. Table 39 in Chapter 8 summarises the scales extracted from the factor analysis.

Stage 5: Interpreting the Scales

The number of responses to perform factor analysis is meritorious (between 0.80 and 0.89) according to Kaiser-Meyer-Olkin (KMO) measure, is characterized as meritorious (see Table 39). KMO measure indicates the proportion of common variance among the variables accounted for by the extracted factors. *Bartlett's test of sphericity* is also satisfactory, thus it demonstrates the equal variance among the group of variables. On the other hand, the *total variance* explained by the solution is good, since in the social sciences a percentage greater than 60 is considered satisfactory (see Table 39).

The scales have been purified based on their *internal reliabilities;* that is, on Pearson correlation when the scales are formed by two items, while for those factors with more than two items internal reliability is assessed by using *Cronbach's alpha.* This coefficient measures how well a set of items measures a unidimensional latent construct. In exploratory researches a lower limit for Cronbach's alpha of 0.60 is agreed. However, all factors except for one (Factor 11, with alpha=0.62) have a Cronbach's alpha greater than 0.70, which is considered satisfactory. Also, the scales have been purified in order to get internal consistency. According to Robinson et al (1991), the thumb rules should be to have *item-to-total correlations* greater than 0.50 and *inter-item correlations* greater than 0.30. However, different opinions about the threshold values for item-to-total correlations propose values ranging from 0.30 and 0.60 (Green et al, 1988; Steenkamp and Van Trijp, 1991). This research adopts the middle view and follows the advice of Nunnally (1967) who recommends that items with item-to total correlation below 0.4 be excluded.

Taking into account the above criteria, some constructs have been purified (see appendix). *Factor 3* does not meet the requirements for unidimensionality due to factor KACQ14, hence it is removed from the scale. For the same reason, in *Factor 5* and *Factor 8* items KACQ3 and KINT35, respectively, are removed. Regarding, *Factor 9, item* KSH31 is excluded from the scale since, although it still exceeds the threshold of item-to-total correlation greater than 0.40, the purification results in increased internal reliability. On the contrary, *Factor 11* shows that KSH21 has a low item-to-total correlation and does not correlate very well with KSH19. However, the reliability of the scale would be reduced to 0.56, which is unacceptable here. In consequence, two alternatives are possible: one is to drop this scale from the final result, while the other option is to include the three items that compound the scale separately. The researcher has opted for the latter as, otherwise, the total variance explained by the factor analysis would drop below the desired level. The different scales extracted have been labelled as indicated in Table 40 (Chapter 8).

Stage 6: Validation of Factor Analysis

Once the results have been obtained, the researcher should assess the level to which they represent the population. There are different ways of doing so: by replicating the study with a random sample of the data or even with a new separate data. Also, confirmatory factor analysis through structural equation modelling could be applied.

The alternative of replicating the procedure with a sample of the available data is not possible due to the insufficient sample size according to the requirement of a minimum of 5 cases per variable. On the other hand, Further confirmatory factor analysis could be performed in the future, since such technique will not be addressed in this thesis.

Stage 7: Creation of Summated Scales

Having in mind the objective of the factor analysis, that is, summarising, summated scales are calculated based on the original variables and the extracted factorial structure. Such scales are conformed the set of dependent and independent variables used in the follosing statistical analysis.

NOTE: Purification of the Scales

Factor 1: Culture for knowledge

	Cronbach Alpha	Pearson Correlations KSH27	KSH28	KSH29	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.85					
KSH26		0.66	0.60	0.57	0.72	0.81
KSH27			0.61	0.54	0.70	0.82
KSH28				0.63	0.72	0.81
KSH29					0.67	0.83

Factor 2: Organizational alignment

	Cronbach Alpha	Pearson Correlations KACQ5	KACQ6	KSH30	KINT39	KINT40	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.88							
KACQ4		0.60	0.72	0.68	0.45	0.52	0.76	0.85
KACQ5			0.63	0.49	0.36	0.37	0.60	0.88
KACQ6				0.63	0.50	0.51	0.76	0.85
KSH30					0.51	0.66	0.75	0.85
KINT39						0.67	0.62	0.87
KINT40							0.68	0.87

Factor 3: Collective learning

	Cronbach Alpha	Pearson Correlations KACQ11	KACQ12	KACQ13	~~KACQ14~~	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.74						
KACQ7		0.49	0.44	0.32	0.19	0.48	0.71
KACQ11			0.48	0.35	0.17	0.49	0.70
KACQ12				0.51	0.31	0.61	0.66
KACQ13					0.47	0.59	0.66
~~KACQ14~~						0.39	0.74

Factor 5: Individuals knowledge identification

	Cronbach Alpha	Pearson Correlations KACQ2	~~KACQ3~~	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.61				
KACQ1		0.52	0.33	0.51	0.40
KACQ2			0.27	0.46	0.48
~~KACQ3~~				0.35	**0.68**

Factor 7: Encouragement to participating

	Cronbach Alpha	Pearson Correlations KSH18	KINT32	KINT33	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.77					
KSH17		0.62	0.36	0.36	0.57	0.72
KSH18			0.48	0.45	0.67	0.66
KINT32				0.51	0.55	0.73
KINT33	-				0.53	0.74

Factor 8: Collective integration

	Cronbach Alpha	Pearson Correlations KINT36	KINT37	KINT38	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.75					
~~KINT35~~		0.33	0.37	0.28	0.39	0.77
KINT36			0.44	0.35	0.46	0.74
KINT37				0.76	0.73	0.57
KINT38	-				0.63	0.64

Factor 9: Resource availability

	Cronbach Alpha	Pearson Correlations KSH25	KSH31	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.73				
KSH24		0.69	0.39	0.64	0.54
KSH25			0.38	0.62	0.56
~~KSH31~~	-			~~0.42~~	**0.81**

Factor 11: Internal knowledge sharing

	Standardized Cronbach Alpha	Pearson Correlations KSH20	KSH21	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.62				
KSH19		0.41	0.29	0.41	0.51
KSH20			0.36	0.48	0.45
KSH21				0.38	0.56

Factor 12: Commitment to IT by non-specialists

	Cronbach Alpha	Pearson Correlations ITHUMG22	THUMG23	ITHUMG24	THUMM25	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.87						
ITHUMG21		0.73	0.59	0.53	0.47	0.70	0.84
ITHUMG22			0.64	0.58	0.44	0.73	0.83
ITHUMG23				0.58	0.68	0.76	0.82
ITHUMG24					0.49	0.66	0.85
ITHUMM25						0.63	0.85

Factor 13: Business support by IT staff

	Cronbach Alpha	Pearson Correlations ITHUMX12	ITHUMX13	ITHUMX14	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.81					
ITHUMX11		0.51	0.63	0.52	0.68	0.74
ITHUMX12			0.46	0.45	0.55	0.77
ITHUMX13				0.56	0.68	0.74
ITHUMX14					0.61	0.77

Factor 14: Proactive IT management

	Cronbach Alpha	Pearson Correlations ITHUMX17	ITHUMX18	ITHUMX19	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.80					
ITHUMX16		0.55	0.38	0.45	0.55	0.77
ITHUMX17			0.52	0.5	0.65	0.73
ITHUMX18				0.58	0.61	0.74
ITHUMX19					0.62	0.74

Factor 15: IT expertise

	Cronbach Alpha	Pearson Correlations ITINFR5	ITINFR6	ITINFR7	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.83					
ITHUMX8		0.63	0.64	0.41	0.67	0.78
ITHUMX9			0.64	0.45	0.69	0.77
ITHUMX10				0.55	0.75	0.74
ITHUMX20					0.54	**0.84**

Factor 16: Secure and sufficient IT intercommunication

	Cronbach Alpha	Pearson Correlations ITINFR3	ITINFR4	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.69				
ITINFR2		0.38	0.33	0.43	0.51
ITINFR3			0.34	0.44	0.50
ITINFR4				0.40	0.55

Factor 19: Efficiency

	Cronbach Alpha	Pearson Correlations PERSHARE	PERGROWT	PERPROFI	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.89					
PERSUCC		0.78	0.60	0.64	0.76	0.86
PERSHARE			0.68	0.68	0.82	0.83
PERGROWT				0.65	0.72	0.87
PERPROFI					0.74	0.87

Factor 20: Flexibility

	Cronbach Alpha	Pearson Correlations PERRESPO	PERFLEXI	Corrected Item-Total Correlation	Alpha if Item Deleted
	0.89				
PERINNOV		0.73	0.64	0.71	**0.91**
PERRESPO			0.83	0.86	0.78
PERFLEXI				0.79	0.84

	Item 1	Item 2	Pearson Correlation
Factor 4: External sources	KACQ15	--	--
Factor 6: Research promotion	KSH9	KSH10	**0.36****
Factor 10: Collaboration support	KSH22	KSH23	**0.64****
Factor 17: Customized and unique IT infrastructure	ITINFR5	ITINFR6	**0.42****
Factor 18: Technical compatibility	ITINFR1		

Appendix IV: Descriptive Statistics

		N	Mean	S.D.	Pearson Correlations																				
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	27	28
1	Culture for knowledge	156	4.21	0.67	1	0.56**	0.48**	0.28**	0.25**	0.35**	0.51**	0.51**	0.44**	0.31**	0.26**	0.40**	0.34**	0.24**	0 1	0.16*	0.27**	0.13	0.09	0.13	0.20**	0.37**
2	Strategic Alignment	157	3.76	0.78		1	0 53**	0.38**	0.42**	0.28**	0.47**	0.63**	0.52**	0.26**	0.37**	0.50**	0.39**	0.17*	0.16*	0.08	0.36**	0.24**	0.18*	0.34**	0.01	0.32**
3	Collective knowledge acquisition	159	4.07	0.66			1	0.30**	0.35**	0.27**	0.50**	0.42**	0.47**	0.14	0.22**	0.48**	0.35**	0.12	0.01	0.16*	0.22**	0.18*	0.06	0.18*	-0.02	0.18*
4	Identification of individuals' knowledge	159	4.38	0.60				1	0.26**	0.18*	0.41**	0.23**	0.40**	0.20**	0.18*	0.28**	0.25**	0.08	0.04	0.07	0.01	0.02	0.02	0.11	0.04	0.24**
5	Research promotion	156	3.68	0.86					1	0.23**	0.34**	0.43**	0.28**	0.19*	0.18*	0.28**	0 07	0.15	0.34**	-0.08	0.25**	0 25**	0.17*	0.33**	0.00	0.21**
6	External sources of knowledge	158	3.50	1.12						1	0.30**	0.34**	0.22**	0.40**	0 11	0.21**	0.26**	0.23**	0.03	0.03	0.18*	0.08	0.11	0.12	0.06	0.27**
7	Encouragement to participate	158	4.11	0 67							1	0.42**	0.40**	0.30**	0.35**	0.42**	0.29**	0.20**	0.12	0.15	0.14	0.18*	0.08	0.15	-0.05	0.25**
8	Collective knowledge integration	159	3.50	0.88								1	0.36**	0.27**	0.27**	0.41**	0.29**	0.06	0.16*	0.08	0.19*	0.15	0.1	0.17*	0.01	0.36**
9	Resource availability	159	4.03	0.71									1	0.30**	0.25**	0.42**	0.34**	0.04	0.09	0.02	0.18*	0.08	0.06	0.12	0.11	0.28**
10	Collaboration promotion	157	3.31	1.05										1	0.19*	0.15	0.31**	0.08	0.12	-0.01	0.20**	0.15	0.09	0.1	0.06	0.16*
11	Incentive for knowledge sharing	154	3.10	1.22											1	0.39**	0.29**	0.22**	0.19*	0.17*	0.15	0.12	-0.06	0.02	0.00	0.14
12	Internal distribution of knowledge	159	3.70	0.87												1	0.37**	0.08	0.12	0.08	0.25**	0.12	0.14	0.14	-0.06	0.15
13	Knowledge exchange with partners	156	3.29	1.15													1	0.05	0.07	0.14	0.05	0.11	-0.07	0.00	-0.03	0.17*
14	Secure and sufficient IT intercommunication	154	3.57	0.80														1	0.29**	0.23**	0.40**	0.45**	0.27**	0.31**	0.27**	0.35**
15	Customized and unique IT infrastructure	153	2.70	1.15															1	0.04	0.21**	0.33**	0.29**	0.34**	0.21**	0.34**
16	Technical compatibility	156	2.81	1.17																1	0.24**	0.13	0.13	0.15	0.03	0.03
17	Commitment to IT by non-technical staff	150	3.39	0.83																	1	0.56**	0.49**	0.53**	0..22**	0.33**
18	IT expertise	156	3.31	0.87																		1	0.45**	0.44**	0.20*	0.31**
19	Business support by IT staff	154	3.47	0.80																			1	0.61**	0.24**	0.30**
20	Managerial skills of IT staff	154	3.26	0.79																				1	0.08	0.29**
27	Efficiency	153	4.48	1.27																					1	0.60**
28	Flexibility	156	4.82	1.37																						1

Appendix V: Regression Analysis

8.4.1 Impact of Knowledge Management and ICT Capabilities on Performance

After the preliminary analysis, regression analysis is run in order to test the research questions defined in Chapter 8. As in the section of factor analysis, the different stages which a typical regression analysis passes through (see Figure V-1) will be explained. It must be remarked that OLS regressions will be applied in this analysis.

Stage 1: Objectives of Multiple Regression

Regressions are used to account for the variance in a dependent variable based on linear combinations of independent variables. In this study, the objective is to analyse the extent to which knowledge management and information systems capabilities influence on the organizational performance. Therefore, the dependent variables are those regarding organizational performance and the independent variables, those with regard to knowledge management practices and information and communication technologies capabilities. The models resulted from the regression analyses determine the set of independent variables which explain the maximum amount of variance of the organizational performance.

It must be noticed that regression analysis can only deal with a unique dependent variable. Given that two factors have been extracted in relation to performance, two different regressions are analysed. Furthermore, the models resulted will be controlled by different contextual variables in order to check for differences depending on organizational characteristics.

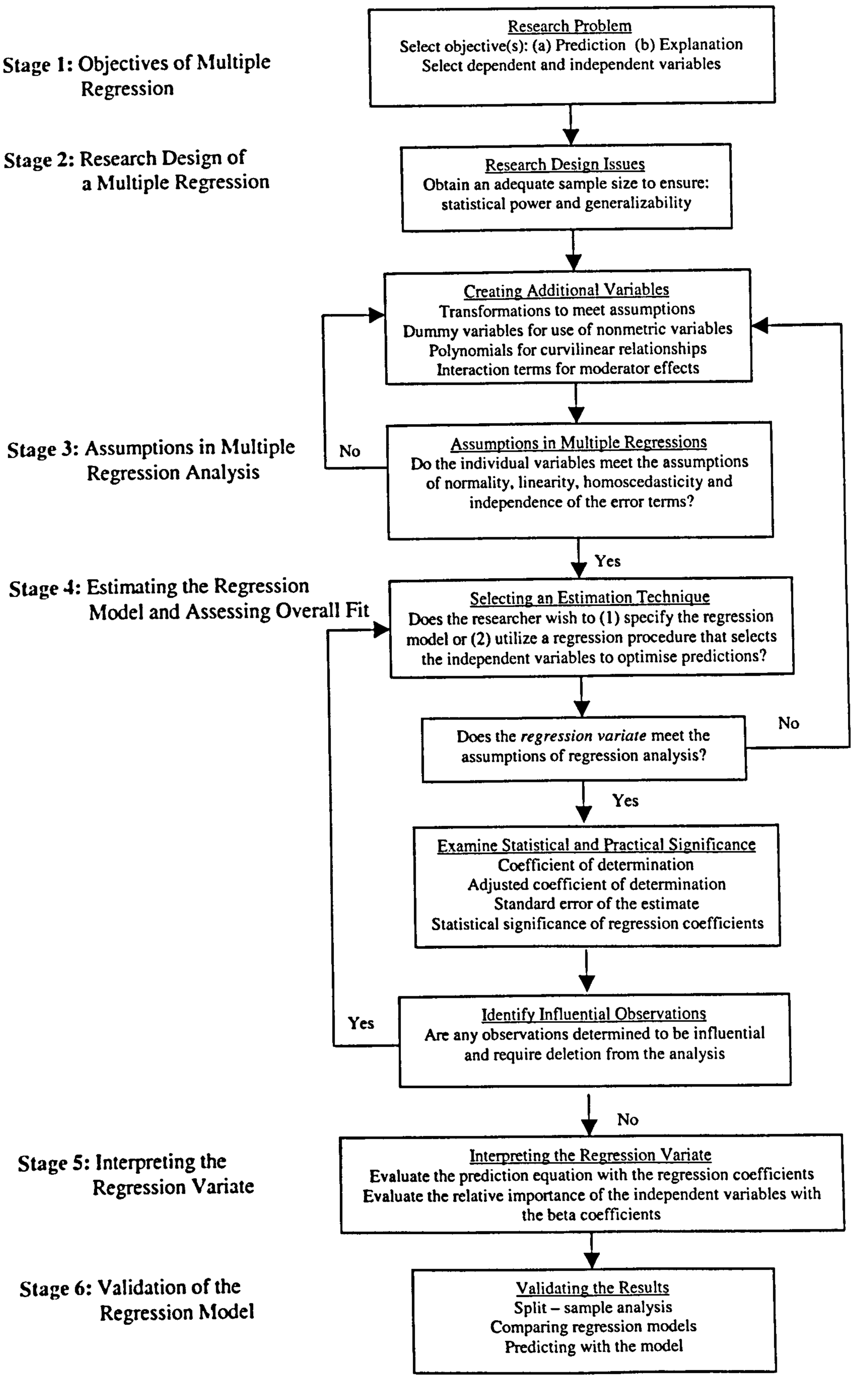


Figure V-1: Decision diagram in Regression Analysis
(Source: Hair et al, 1995)

Stage 2: Research Design of A Multiple Regression

When designing a multiple regression, the sample size is of critical importance since it influences the statistical power and the generabilizability of the results. In consequence, according to Hair et al (1995), the minimum regression coefficient (R^2) that can be found statistically significant at a significance level of 0.05 with a power of 0.80 for the given conditions of size (156 cases) and number of independent variables (18) is above 15%. With reference to the generabilizability of the results, the ratio of observations to independent variables is 1 to 8.66, which is not very high but fairly above the minimum (1 to 5, Hair et al, 1995).

Furthermore, in a second stage, regressions have been controlled by different contextual characteristics such as size, control, turbulence and production process. In the last case, dummy variables have been created taken as a reference category "single process", given its categorical nature.

Stage 3: Assumptions in Multiple Regression Analysis

Normality of the variables is met according to the P-P graphs. The rest of assumptions (multivariate normality, linearity, homoscedasticity and non-multicollinearity) are checked after estimating the model, since most of the tests involve analysing the residuals.

Stage 4: Estimating the Regression Model and Assessing Overall Fit

- *Estimation technique*

At this stage, the estimation of the regression model finally starts. There are several methods to select the independent variables to be included in the model. Confirmatory selection is based on the entire control of the researcher to select the variables. However, the large amount of variates makes the process complicated. Hence, the most widely used approach, the sequential method stepwise, has been adopted, since it automates the selection process. In order to corroborate the results, backward

deletion (another sequential method) has been applied and the results have come up very similar.

The results of regressing the variables regarding knowledge management and information and communication technologies capabilities on the factor called Effectiveness are as follows:

Table V-1. Regression on dependent Variable: Effectiveness

Variables in the Model	B (Sign)
(Constant)	.84
IT intercommunication	.28*
Business support by IT staff	.32**
Culture for knowledge	.40**

The results for the regression on the other performance factor, labelled as Innovative and Quick Flexibility, are shown in Table V-2.

Table V-2. Regression on dependent Variable: Flexibility

Variables in the Model	B (Sign)
(Constant)	-0.31
Culture for knowledge	0.75**
Customized IT infrastructure	0.32**
Commitment to IT by non-technical staff	0.34**
Culture for knowledge	.40*

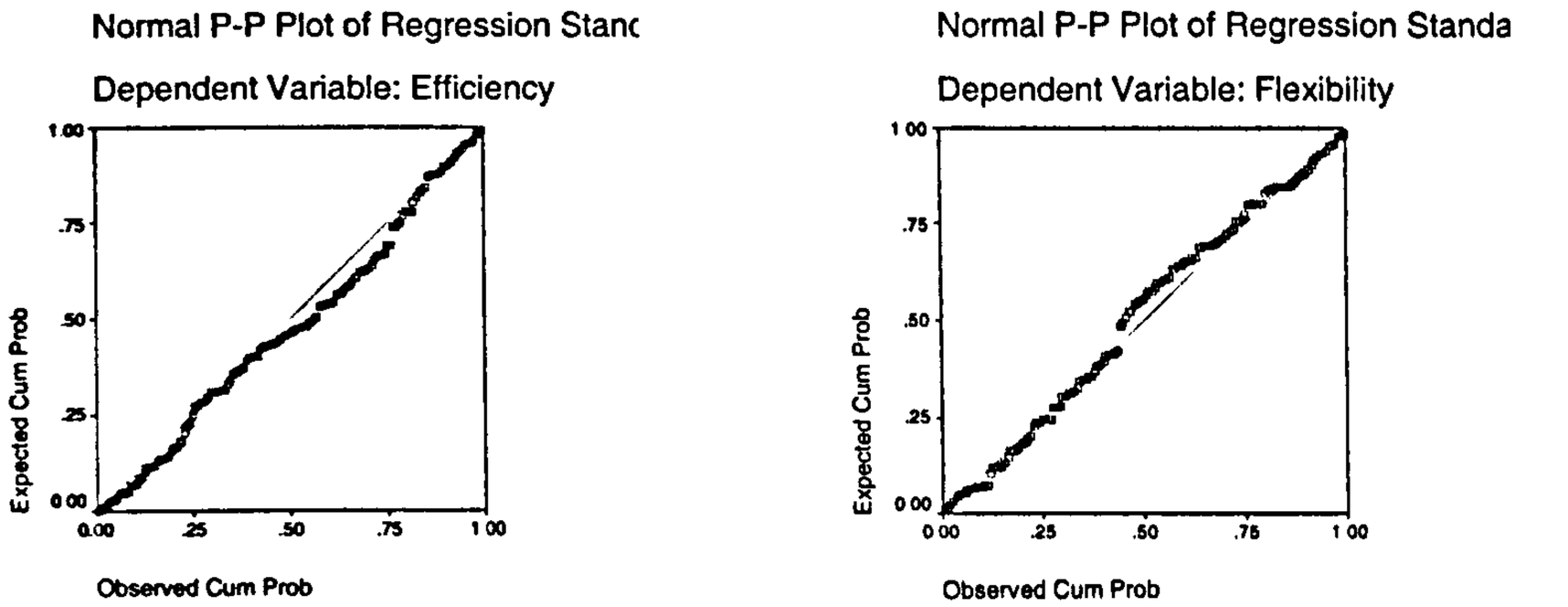
The above models can be translated into the following mathematical relationship:

Effectiveness = 0.84 +0.28 * IT intercom. + 0.32 * B. support by IT staff + 0.40 * Org. culture

Flexibility = -0.31 + 0.75 * Org. Culture + 0.32 * Cust. IT infrastructure + 0.34 * IT skills non specialists

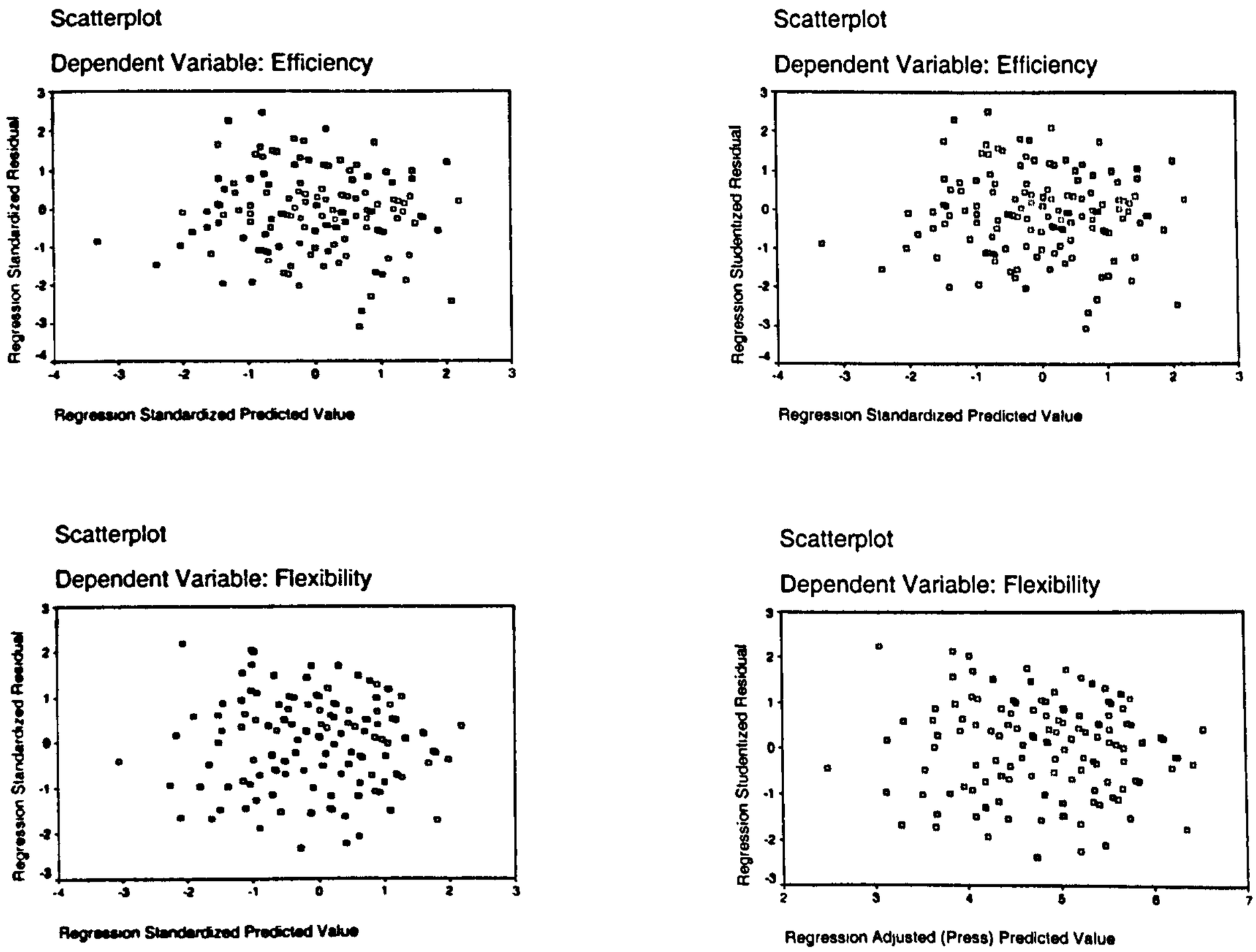
- *Meeting assumptions*

Regarding multivariate normality, P-P plots (Figure V-2) show that the regressions meet the assumption. Furthermore, they do not present problems of multicollinearity, that is, of highly intercorrelated explanatory variables. Tolerances are close to 1 and their inverse, the Variance Inflation Factors (VIF), are close to 1, which means that there is little multicollinearity.



Figures V-2: P-P plots for Effectiveness and Flexibility models

In order to check whether the variate meets the remaining assumptions of linearity, homoscedasticity and independency and normality of the error terms, the residuals are plotted against the predicted values of the dependent variables (Field, 2001). The plots (Figures V-3) show a random fall and equally dispersion around zero of the residuals, which indicate that the models meet the assumptions.



Figures V-3: Plots of residuals against the predicted values

- *Significance of the models*

The adjusted coefficient of determination (R^2) indicates that 15.4% of the variance in effectiveness and 31.6% of the variance in flexibility are explained by their respective models. According to the F-tests, the models show great significance. This proves that the amount of variation explained by the regression model is more than the variation explained by the average, that is, that R^2 is greater than 0. In other words, there is a linear relationship between dependent and independent variables.

- *Significance of the regression coefficients*

The t-tests of the coefficients test that all the coefficients of the resulting models have an impact on the model and that can be generalized to the population. The significant level of the coefficients is 0.05 at the most, but in the majority of cases is less than 0.01.

- *Identifying influential observations*

All Cook distances are less than 0.11, which indicates that no influential observations or outliers have misled the regression, as some suggest that Cook distances greater than 1 are indicators of outliers.

Impact of KM and ICT Capabilities on Performance with Control Variables

The models have been controlled for several variables such as turbulence, control, size, and process in order to assess their impact on the previous models. The resulting models can be seen in Tables V-3 and V-4. The model for *Effectiveness* has slightly increased from 15.4% to 17.3%, while the *Flexibility* model has gone from 31.6% to 41.2%. Therefore, the obtained models explain better the variance in the dependent variables, than the models without control variables.

Table V-3. Regression on dependent Variable: Effectiveness (with control variables)

Variables in the Model	B (Sign)
(Constant)	1.01
Business support by IT staff	0.51**
Culture for knowledge	0.45**

Table V-4. Regression on dependent Variable: Flexibility (with control variables)

Variables in the Model	B (Sign)
(Constant)	-1.21
Culture for knowledge	0.59**
Customized IT infrastructure	0.24*
IT intercommunication	0.33**
Collective knowledge integration	0.30*
Turbulence	0.25*

After satisfactorily testing the assumptions following the procedures explained before, it can be concluded that the final models meet all the requirements for OLS regressions. Therefore, the latest models are adopted to explain the dependent variables.

In consequence, the new models can be represented as follows:

Effectiveness = 1.01 +0.45 * Org. Culture + 0.51 * Business support by IT staff

Flexibility = -1.21+ 0.59 * Org. Culture + 0.24 * Customized and unique IT infrastructure + 0.30 * Collective knowledge integration + 0.33 * Secure and sufficient IT intercomm. + 0.25 * Turbulence

Stage 5: Interpreting the Regression Variates

See Chapter 8, Section 8.4.

Stage 6: Validation of the Regression Model

Once the regression models have been defined, they should be validated. According to Hair et al (1995), there are different ways of validating regression models. The most appropriate way is to apply the model to a new sample from the same population.

Given the limitations of time and resources, the collection of new data is practically impossible, hence this option has been discarded. Due to the same reason, prediction based on new data applied to the resulted models cannot be carried out. Another common practice is to split the sample in two equal parts and test the model in the subsets. However, this option has also been rejected, since the amount of responses is not sufficient to perform the regression using half of the cases. The minimum ratio of 1 variable to 5 cases would not be met. Therefore, the only possible way of validating the results is by comparing different regression models based on the adjusted R^2. As said before, different models have been tried before presenting the final results. The comparison of two models, without and with control variables, has been presented. Nevertheless, in order to validate the models, canonical correlation analysis will be performed in the next chapter, although further validation could be performed in the future, with a new sample of the population.

Appendix VI: Canonical Correlation Analysis

As in the previous parts, a systematic procedure will be followed. Such procedure is summarized in Figure VI-1.

Stage 1: Objectives of Canonical Correlation Analysis

The objective sought in this thesis is to analyse the relationships among knowledge management, ICT capabilities and performance, controlled for contextual factors. Therefore, the set of dependent variables will be constituted by Effectiveness and Flexibility, factors extracted from FA. The set of independent variables includes the factors related to knowledge management and to ICT and the selected contextual factors.

Stage 2: Designing Canonical Correlation Analysis

When designing the analysis, issues such as the sample size must be considered. Hair et al (1995) recommend having 10 observations per variable. Such recommendation is not met in this research. However, the results will be confronted in order to check their validated by doing a sensitivity analysis.

Stage 3: Assumptions in Canonical Correlation Analysis

Assumptions in CCA are less restrictive than in OLS regression analysis. For example, normality is desired but CCA can also include non-normal variables.

Stage 4: Deriving the Canonical Functions and Assessing Overall Fit

CCA is performed in SPSS by running the appropriate syntax. The output presents different canonical functions or variates, that is, different sets of linear combinations of dependent and independent variable. However, only the pairs of sets that are significant will be interpreted. According to Wilks' lambda test, the first variates are the only significant ones at a 0.01 significance level.

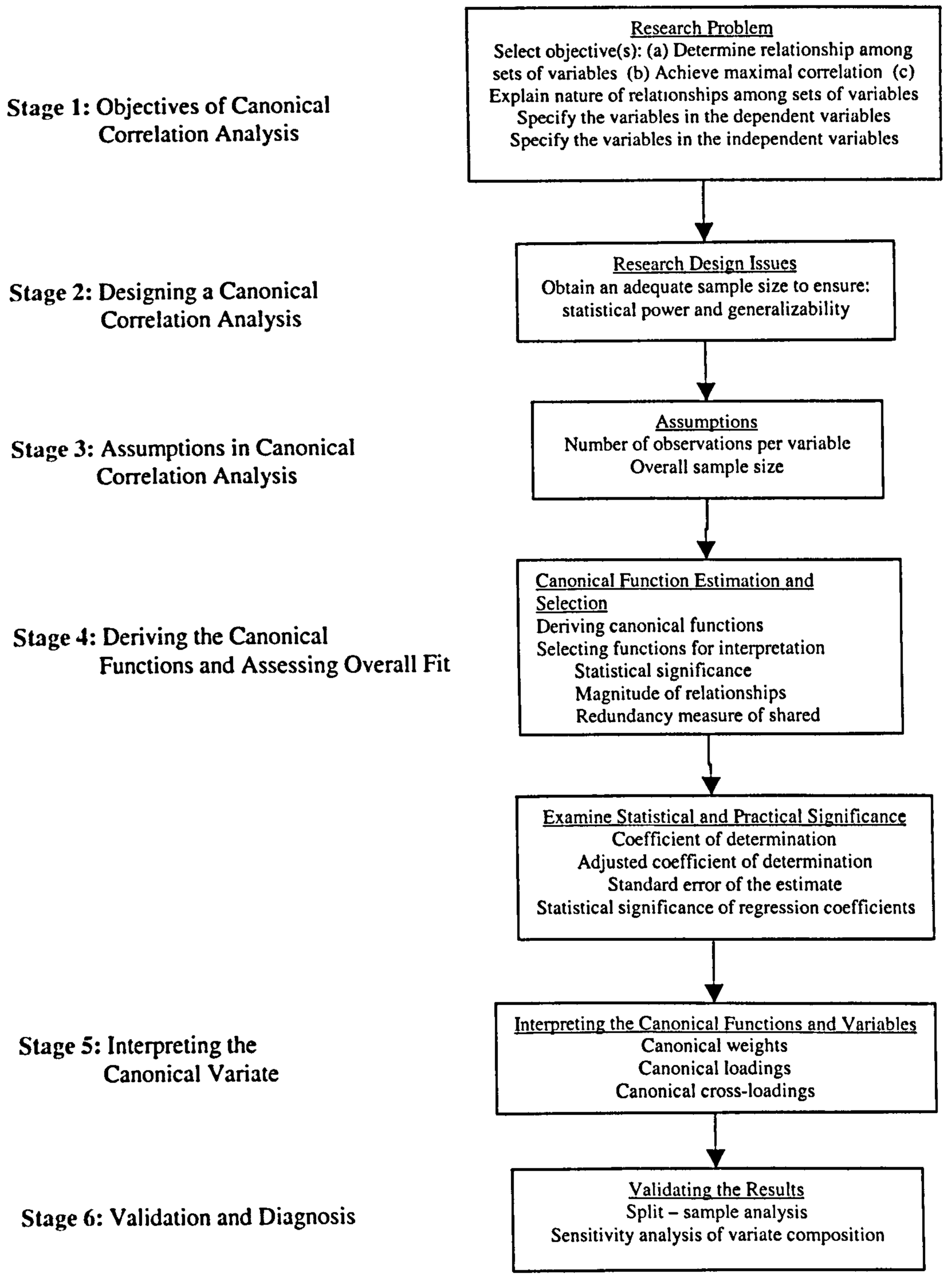


Figure VI-1. Decision diagram in Canonical Correlation Analysis
(Source: Hair et al, 1995)

The canonical correlation coefficient (Rc) measures how strong the relationship between the two variates is and is calculated by squaring the canonical correlation. In this case the canonical correlation coefficient is of 51.41%.

However, although correlations between the two variates are relatively high, the variates might not explain significant proportions of the variance of the dependent variables (Hair et al, 1995). In order to solve this weakness, another coefficient should be looked at: the redundancy coefficient for the dependent variables (Rd), which is an equivalent of the Adjusted R^2 in regression analysis. Thus, Rd shows the proportion of the original dependent variables explained by the set of independent variables. Rd is calculated by multiplying the shared variance of the dependent variate and Rc. The Rd for the present case is 33.47%. It must be highlighted that, since there are more than one dependent variable, one cannot attempt to explain 100% of the variance in the dependent variable set by the independent variable set, hence the Rd obtained is acceptable.

To sum up, the canonical relationship has proved to be significant and the redundancy test acceptable.

Stage 5: Interpreting the Canonical Variate

In order to determine the importance of the variables within the canonical variates, there are three possible methods: looking at the canonical weights or coefficients, at the canonical loadings or at the canonical cross-loadings. Canonical weights are the equivalents to the B coefficients in regression. Since they represent the contribution of each variable to the variate or linear combination. However, they are unstable, so the canonical loadings are preferred. Canonical loadings represent the correlation between the variable and its own variate. It is similar to factor loadings in factor analysis. It must be remarked that the squared loadings measure the amount of variation in each of the dependent variables explained by the dependent canonical variate, and the same, for independent variables (Hair et al, 1995). Cross-loadings, however, gives the correlation between the variable and the opposite canonical variate.

Although canonical loadings are also suitable, canonical cross-loadings are preferred since they provide a more direct measure of the interrelationship (Hair et al, 1995). With the aim of determining the significant variables that conform each variate, a common rule of thumb of correlations greater than 0.3 has been followed. The results are shown in Table 46 and explained in Chapter 8, Section 8.5.

Stage 6: Validation and Diagnosis

As in the regression analysis, validation by splitting the data is not possible due to sample size. However, a sensitivity analysis has been carried out. The stability of the correlations has been checked after deleting some variables. It has been decided to delete the variables which have resulted significant in the CCA. The outcome (Table VI-1) is very positive, since the correlations remain stable.

Table VI-1: Sensitivity Analysis

Variables	Initial Solution	Variables removed									
		S1CULT	S2ALIGN	EXPR4	EXPT1	EXPT2	ITTECH1	ITTECH2	ITHUM1	ITHUM3	TURB
	Cross-loadings	Cross-loadings	Cross-loadings	Cross-loadings	Cross-loadings	Cross-loadings	Cross-loadings	Cross-loadings	Cross-loadings	Cross-loadings	Cross-loadings
S1CULT	-.437		-.437	-.436	-.439	-.438	-.437	-.440	-.405	-.425	-.434
S2ALIGN	-.383	-.357		-.376	-.368	-.378	-.382	-.377	-.374	-.390	-.322
EXPR1	-.202	-.192	-.200	-.195	-.188	-.197	-.197	-.200	-.176	-.212	-.164
EXPR2	-.157	-.144	-.157	-.156	-.160	-.159	-.161	-.154	-.166	-.150	-.147
EXPR3	-.239	-.222	-.239	-.237	-.231	-.237	-.242	-.239	-.225	-.243	-.246
EXPR4	-.342	-.338	-.339		-.311	-.332	-.339	-.331	-.348	-.367	-.308
EXPT1	-.340	-.340	-.338	-.328		-.330	-.334	-.337	-.328	-.361	-.277
EXPT2	-.415	-.401	-.413	-.399	-.391		-.415	-.410	-.397	-.431	-.342
EXPT3	-.230	-.209	-.230	-.228	-.224	-.229	-.227	-.229	-.225	-.232	-.238
EXPT4	-.210	-.187	-.210	-.204	-.209	-.210	-.206	-.208	-.227	-.206	-.239
EXPT5	-.180	-.150	-.180	-.176	-.177	-.179	-.180	-.179	-.149	-.179	-.205
EXPT6	-.147	-.127	-.145	-.138	-.131	-.141	-.142	-.144	-.121	-.160	-.147
EXPT7	-.120	-.104	-.118	-.112	-.104	-.114	-.113	-.118	-.124	-.133	-.084
ITTECH1	-.308	-.290	-.310	-.312	-.324	-.314		-.313	-.307	-.284	-.343
ITTECH2	-.347	-.331	-.348	-.340	-.348	-.348	-.341		-.351	-.339	-.356
ITTECH3	-.053	-.056	-.054	-.050	-.055	-.054	-.055	-.060	-.036	-.051	-.074
ITHUM1	-.335	-.327	-.337	-.344	-.352	-.343	-.325	-.338		-.310	-.410
ITHUM2	-.220	-.203	-.222	-.226	-.236	-.226	-.217	-.212	-.210	-.198	-.261
ITHUM3	-.303	-.290	-.307	-.314	-.333	-.315	-.305	-.315	-.300		-.364
ITHUM4	-.291	-.298	-.291	-.291	-.286	-.290	-.294	-.294	-.290	-.290	-.303
SIZE_LN	-.151	-.153	-.152	-.154	-.161	-.155	-.148	-.149	-.152	-.138	-.181
CONTROL	-.248	-.249	-.247	-.240	-.232	-.243	-.250	-.242	-.262	-.259	-.205
TURBULEN	-.327	-.309	-.326	-.324	-.321	-.325	-.329	-.326	-.346	-.325	
PSS2	.217	.214	.217	.220	.219	.218	.212	.222	.179	.209	.238
PSS3	-.136	-.133	-.136	-.141	-.139	-.137	-.134	-.147	-.143	-.130	-.141
PSS4	-.179	-.171	-.180	-.183	-.190	-.183	-.177	-.180	-.162	-.164	-.200