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Unpacking Dynamic Capabilities in the Small to Medium Software Enterprise: Process, Assets and History

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Abstract

Previous studies of commercial software enterprises have employed industry-level analyses, or have focused on major players in the industry. There is, therefore, a dearth of in-depth research on small-to-medium software enterprises (SMSE). The need to understand the institutional contexts and firm-specific capabilities of such firms is important, as they account for over 90% of software enterprises operating in Europe and the US. This paper adopts a dynamic capabilities perspective to help understand the social and institutional web of conditions and factors that shaped and influenced capability development in one European SMSE. The findings illustrate that a commitment to learn and to evolve this firm's intangible knowledge assets underpinned the development of dynamic business and IT capabilities. Another contribution is this paper's identification of—and distinction between—'soft' and 'hard' IT capabilities, which were embedded in the firm's organizational and managerial processes. The lessons learned here are applicable to other European SMSEs, as they share similar institutional contexts with the organization studied—for example, European SMSEs can access direct and indirect R&D funding from EU and individual member states. This study is, therefore, well timed as the EU has, in 2003, set aside a significant proportion of its 16 billion euro 6th Framework R&D budget for small-to-medium enterprises. Finally, this paper presents a dynamic capabilities model that captures the firm-specific capabilities and assets of innovative SMSEs.

Keywords

Dynamic Capabilities, Resource-Based View (RBV), Intangible Knowledge Assets, IT Capabilities

1. Introduction

The Irish software industry is one of the world's most dynamic and competitive. In 2000, this sector comprised more than 900 companies, 130 of them foreign-owned, competing to deliver software products and services to national and international markets. Over 30,000 people were employed in the industry, which exported over €10.15bn worth of products and services to Europe, Asia and the Americas. Significantly, indigenous companies account for €1.4bn of all exports. All the more interesting then is that approximately 95% of Irish

software firms employ less than 49 staff (National Software Directorate 2000). This compares well with US and European averages, as approximately 92% of US software firms have an average of 35 staff, while the vast majority of Europe's 16,000 software companies employ less than 20 staff (O'Gorman, O'Malley & Mooney 1997).

While industry-level analyses reveal generalities and trends, and software innovation in large organizations such as Microsoft (Zachary 1994) and IBM (Phan, Vogel & Nunamaker 1995) have been the subject of study, very little is known about the IT capabilities of small-to-medium sized software enterprises (SMSEs), which are argued to be wellsprings of innovation (Baskerville & Pries-Heje 1998). There is an imperative, therefore, to explore and understand capability development in such firms, and the influence of social, institutional, and organizational factors on their development[1]. This point is echoed by Nonaka and Takeuchi (1995, pp. 48-49), who note the absence of empirical research on successful, innovative firms across all sectors. They point out that extant studies *"do not shed much light on how companies actually went about building core competence or capabilities."* Similarly in the IS field, Agarwal, Ross & Samamurthy (1998, p. 530) argue that *"[w]hile the importance of a strong IT competence is rarely argued, the means by which firms develop such a competence are not clearly understood."*

This paper adopts theory from the resource-based view (RBV) of the firm to explore the development of IT capabilities and related resources—IT products and services—in a small-to-medium sized Irish software firm, Interactive Multimedia Systems. Several IS researchers have employed resource-based theory to explore the development of IT capabilities in commercial firms where IT is a strategic resource (see, for example, Bharadwaj 2000). However, the development and application of IT capabilities in software firms has not received the attention it deserves—this paucity in extant research is one that begs to be addressed.

The RBV conceptualises firms as a bundle of tangible and intangible resources or assets, from which valuable services or products are leveraged through the application of capabilities or competencies (Penrose 1959, Wernerfelt 1984, Itami 1987, Grant 1991). A central tenet of the RBV is the argument that to be of strategic import, resources and capabilities must be valuable, rare, imperfectly imitable, and without a strategic equivalent (Barney 1991). Researchers have also noted the role of time in the development of resources and capabilities (Dierickx & Cool 1989); especially the learning involved in building intangible or invisible people-based information or knowledge assets (Itami 1987, Nordhaug 1994). This last point is important, as researchers from Penrose (1959) to Teece (2001) argue that a sustainable competitive advantage results in firms who create, own, protect and apply knowledge assets which are firm-specific and difficult to imitate. Research in the IS field has concluded that the IT Human Asset is the key to resource and competency development (Ross, Beath & Goodhue 1996), with core IS or IT capabilities being heavily dependent on the application of the managerial and technical knowledge and skills of IS managers and professionals (Mata, Fuerst & Barney 1995, Feeney & Willcocks 1998, Bharadwaj 2000). This observation is particularly relevant to the present study as small-to-medium software firms seldom have significant tangible resources, and depend almost entirely on the innovative capabilities of their human asset (Baskerville & Pries-Heje 1998).

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[1] A distinction has to be made here between research perspectives on software process improvement, which focus on capability maturity through the narrow lens of project management theory, and those which take a holistic view of the firm, its activities and the social, economic and instructional matrix in which it is embedded—the present study adopts the latter perspective.

2. A Framework for Unpacking the *Dynamic Capabilities* of the Firm

Research on the resource-based view gives rise to a wealth of theoretical perspectives and competing frameworks. However, it is clear from comments made by Richard Nelson (1994), co-author of one of the seminal works on the RBV, that the *dynamic capabilities* perspective first articulated by Teece, Pisano and Shuen (1990), and refined by Teece and Pisano (1998), is the most complete-to-date in that it incorporates previous perspectives and correctly focuses on the *dynamic capabilities* of firms. In the IS field, Carlsson (2001) echoes the points made by Nelson (1994), and highlights the strengths of this perspective above others in the RBV.

The term *dynamic capabilities* incorporates two valuable observations: first, the shifting character of the economic environment renders it *dynamic*; second, organizational *capabilities* lie at the source of competitive success (Teece et al. 1990). Recent research by Teece and Pisano (1998) develops their earlier work into a conceptual framework that helps capture and describe the nature of a firm's *distinctive competence*. In presenting their analytic framework, Teece and Pisano focus on the inter-temporal development and renewal of firm-specific capabilities and assets. They build on previous research on the RBV in order to identify the foundations upon which distinctive, inimitable competitive advantages can be created. In keeping with extant thought on the RBV, Teece and Pisano (1998, p. 195) state that in order to be considered strategic, capabilities and the resources on which they operate must be *"honed to a user need",* must be *"unique",* and *"difficult to replicate"* (Itami 1987, Dierickx and Cool 1989, Barney, 1991). Teece and Pisano advance the position that a firm's *distinctive competence* originates in: (a) organizational and managerial processes—which reflect current core and non-core capabilities as evidenced in institutionalised practices, norms, and routines; (b) asset positions—both generic and firm-specific; and (c) the historical paths navigated by the firm and current opportunities for future progression—these shape capability development and influence the accumulation of asset positions. Table 1 provides a detailed overview of Teece and Pisano's framework and incorporates additional insights from the literature.

3. Research Objective and Method

The objective of this exploratory study is to help deepen the IS field's understanding of how small-to-medium software companies create, develop and apply IT competencies to build firm-specific IT resources and unique services. In order to help achieve this objective, the following research questions are drawn from the *dynamic capabilities* research framework and applied in this paper's case study of Interactive Multimedia Systems.

RQ1. What are the major historical R&D milestones that mark the *paths* to capability and resource development at IMS?

RQ2. What are IMS' firm-specific tangible and intangible *assets*?

RQ3. What firm-specific *organizational and managerial processes* characterise success in the small-to-medium software enterprise, such as IMS?

These questions are tightly bound to the *dynamic capabilities* framework presented previously. The following section briefly outlines the research approach adopted to help attain the research objective and to answer the questions posed.

Dimension	Description
Paths The strategic alternatives available to the firm (which are a function of past activities and positions), and its future strategic possibilities.	**Path Dependencies:** A firm's present position in the market is a function of its past performance and future possibilities. A firm's past investments and present repertoire of productive routines constrain future behaviour. Not all routines are beneficial. Some may be dysfunctional and limit learning and innovation. These so-called 'core rigidities' have been noted in the literature (Leonard-Barton 1995). **Technical Opportunities**: The recognition of technological opportunities is often due to internal and external organizational and institutional structures, collaborations and knowledge links. High-cost R&D may deter some firms; in others, the experiential knowledge or lack thereof is also a constraint. Quite often it is a firm's idiosyncratic experiential knowledge that guides it in choosing the most appropriate and feasible of opportunities, and the competencies in its skills-base that allow it to realize such opportunities.
Positions The firm's current endowment of technology and intellectual property (as indicated by its difficult –to-trade knowledge assets) as well as its relational assets with partners, customers and suppliers.	**Technological Assets:** R&D**,** production, and information technologies that are highly firm- and task-specific may be considered unique and difficult to imitate (Nordhaug 1994). **Complementary Assets:** The development of new products and services, or the mechanism by which they are to be delivered, depends on the use of certain related assets. Such assets are considered complementary and typically have uses beyond their immediate function. Under this heading is included intangible information- or knowledge-based (tacit and explicit) assets viz. customer-related (customer loyalty, brand recognition, service network, service quality etc.), channel assets (distribution networks and dealer loyalty), and culture-based (values and norms) (Penrose 1959, Nelson & Winter 1982, Itami 1987, Nordhaug 1994, Leonard-Barton 1995, Ross et al. 1996) **Financial Assets:** What a firm can do in terms of reconfiguration and transformation is often a function of the state of the balance sheet. **Locational Assets:** A firm's location may influence its ability to produce and distribute products and services at low cost.
Organizational and Managerial Processes Describes the patterns of current practice and learning in a firm: tangible evidence of which is to be found in its routines.	**Integration:** Concerns itself with capabilities that govern the efficient and effective internal coordination of organizational activities, particularly with how production and service delivery is routinized with due regard to the congruencies and complementarities among processes (Nelson and Winter, 1982). Teece and Pisano (1998) argue that routines in themselves are insufficient, the commitment, *'effort and enthusiasm'* of organizational actors has to be built up and maintained. Hence, the authors argue that incentive systems and other more intangible, symbolic, social mechanisms play an important role. Core capabilities are highly firm-specific, supplemental capabilities are non-proprietary and imitable, while enabling capabilities are

	those deemed necessary for firms to enter the game (Leonard-Barton 1995, Andreu & Ciborra 1996). **Learning:** Learning is a social process whereby repetition and experimentation enable tasks to be performed better and more rapidly, it also helps new production routines to be identified (Levitt & March 1988). Capabilities or competencies are a function of individual and organizational learning aimed at evolving individual and collective knowledge and skills (Nordhaug 1994). They are developed through communication, involvement, and a commitment to working and learning across disciplinary, functional, divisional and organizational boundaries (Leonard-Barton 1995, Broadbent & Weill 1997, Feeney & Willcocks 1998, Bharadwaj 2000). **Reconfiguration and Transformation:** The capacity to reconfigure the firm's asset structure is itself a learned, organizational skill. The ability to reconfigure and transform ahead of the competition, and at low cost, is, for Teece and Pisano, a key aspect of a firm's *distinctive competence*.

Table 1 The Dynamic Capabilities Framework (adapted from Teece and Pisano 1998)

A qualitative, interpretive, case-based research strategy was implemented (see Lincoln & Guba 1985, Walsham, 1995). This strategy involved a case study on software products and services developed at Interactive Multimedia Systems (IMS), a highly successful small-to-medium software firm based in Dublin, Ireland. Given the paucity of theoretically grounded empirical research on small-to-medium software enterprises in Europe, IMS presented itself as an interesting case with which to explore the development of software products and delivery of IT services. Purposeful sampling was employed throughout. Research was conducted in the summer of 1998 at three sites, two in Ireland and one in the US, at Analog Devices Inc. The US site-visit to Analog Devices Inc. afforded the researcher an opportunity to evaluate systems development practice at IMS by capturing user/client perspective on one of IMS' successful software products, which was developed for by Analog Devices' customers. Eleven social actors participated in the study. A wealth of documentary evidence was also gathered, and a significant amount of data accrued from informal conversations and observations while on-site at the research locations. The *dynamic capabilities* framework provided the main themes so that the findings could be more readily interpreted and understood using the qualitative data analysis techniques of content and constant comparative analysis. Triangulation techniques were also extensively employed to provide insights into events, relationships etc. between primary data sets (Patton 1990). The grounded theory approach suggested by Lincoln and Guba (1985) was employed to extend Teece and Pisano's (1998) framework and to present a model of factors that underpin the *dynamic capabilities* of typical European SMSEs.

4. Dynamic Capabilities at Interactive Multimedia Systems: A Case Study

Interactive Multimedia Systems (IMS) was established in 1991 as a non-trading, wholly owned subsidiary of Irish Medical Systems Ltd, a major supplier of IS to the health care sector in Great Britain and Ireland. IMS emerged as a response to the technological opportunities presented to Irish Medical Systems in the late 1980s and early 1990s. In 1996, IMS began to trade as a member of the Irish Medical Systems Group. At the time of the study, IMS employed 30 IT professionals in applied research and development, new product/service development, and product/service delivery and support.

4.1 Navigating Path Dependencies and Realising Technical Opportunities at IMS (RQ1)

Although operating in a different sector of the IT industry than Irish Medical Systems, IMS' progress mirrored that of its parent company, in that it grew from R&D activities to creating fully-fledged commercial products and services for a range of customers. As with Irish Medical Systems' early initiatives, much of the funding for its R&D program came from the European Commission under the ESPRIT and TIDE programmes. In the early-to-mid 1990s IMS received over £1 million Irish pounds in funding; this was in addition to the £7 million Irish pounds paid to the European consortium involved in the creation of the ITUSE application, IMS' first major R&D project. This product was a commercial failure, however. It is significant that IMS recognised that it could not fulfil its aspirations to develop and market innovative products without entering into collaborative partnerships with European software developers and universities. During the 1990s, the European Union provided the institutional framework and much of the funding for these collaborations (see Figure 1).

Figure 1 presents a historical path analysis that focuses on IMS' R&D activities and the products and services it subsequently developed. Also delineated are the institutional sources of funding and support, IMS' various collaborators and development partners in its R&D activities and product/service development, and finally, several members of its client and user base.

In describing the institutional obstacles that had to be surmounted in order to secure funding from the European Union Sean Breen, IMS' CEO, stated that: *"[The European Commission] did not part with the funding just like that. We had to illustrate the commercial applicability of CBR and our other projects, and realise our goals, while managing the bureaucrats in the Commission at the same time."* Thus, the ability to develop and maintain formal and informal working relationships across Europe with fellow practitioners and academics in Germany and France, and with civil servants in Brussels and Strasburg, was the source of IMS' success in obtaining the financial and technical resources for R&D activities. More important, however, was the learning-enabled knowledge transfers that occurred between the participants in the various initiatives. Coupled with the dynamic process of internal learning and knowledge integration, the external knowledge linkages helped IMS develop its most valuable, rare, and imperfectly imitable resource—the experiential (tacit) and technical (explicit) knowledge of its human asset, the IT professional.

4.2 Cataloguing IMS' Firm-specific Tangible and Intangible Assets (RQ2)

In its formative years, Interactive Multimedia Systems did not possess financial assets of any great note. Rather, its R&D activities were funded by its parent company and the European Commission. From 1991 to 1999, IMS generated over £1,000,000 Irish pounds in European Union funding. From the mid-1990s on, its products began to earn positive cash flows, which

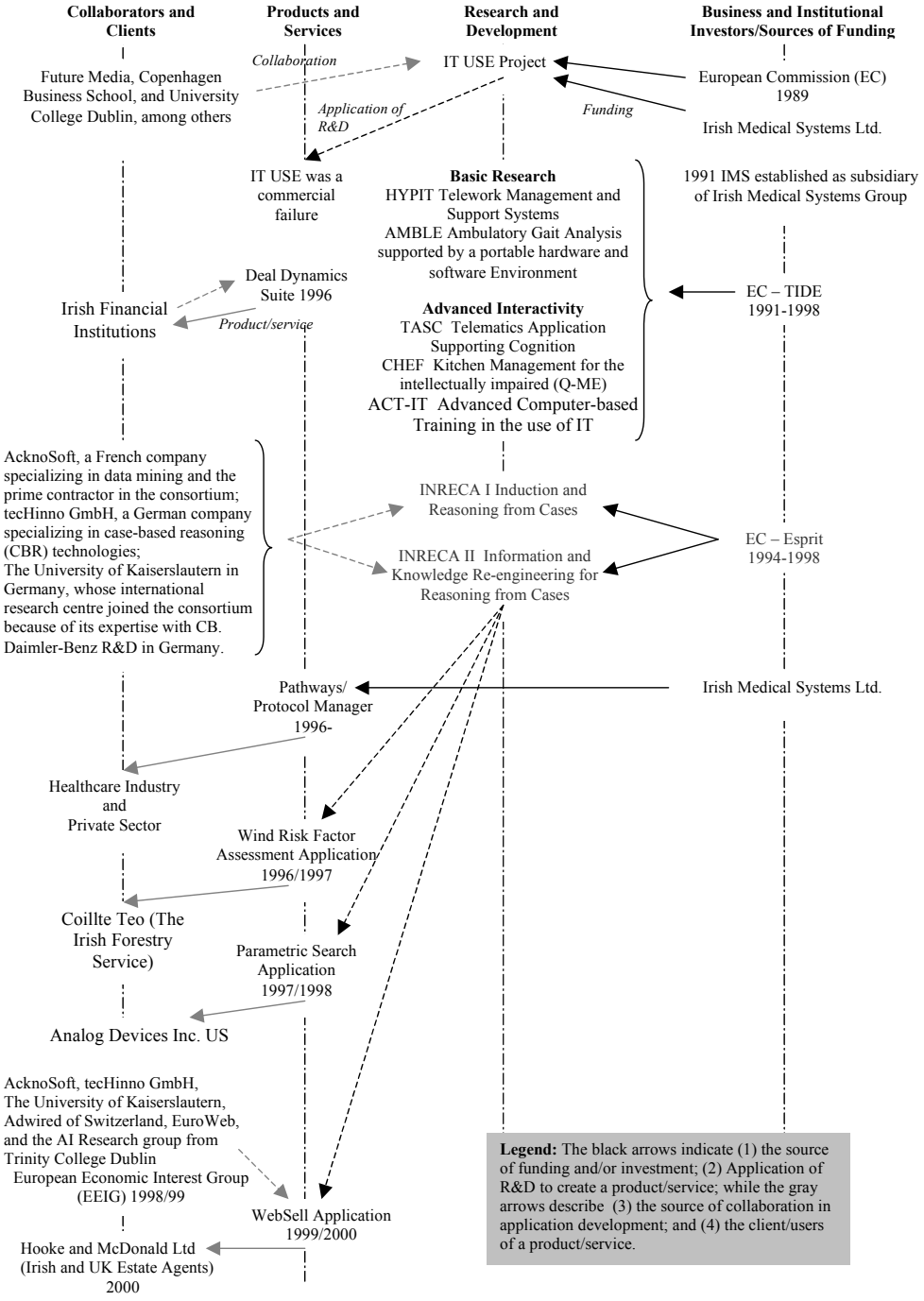

Figure 1 Path Dependencies and Technical Opportunities at IMS (1990-1999)

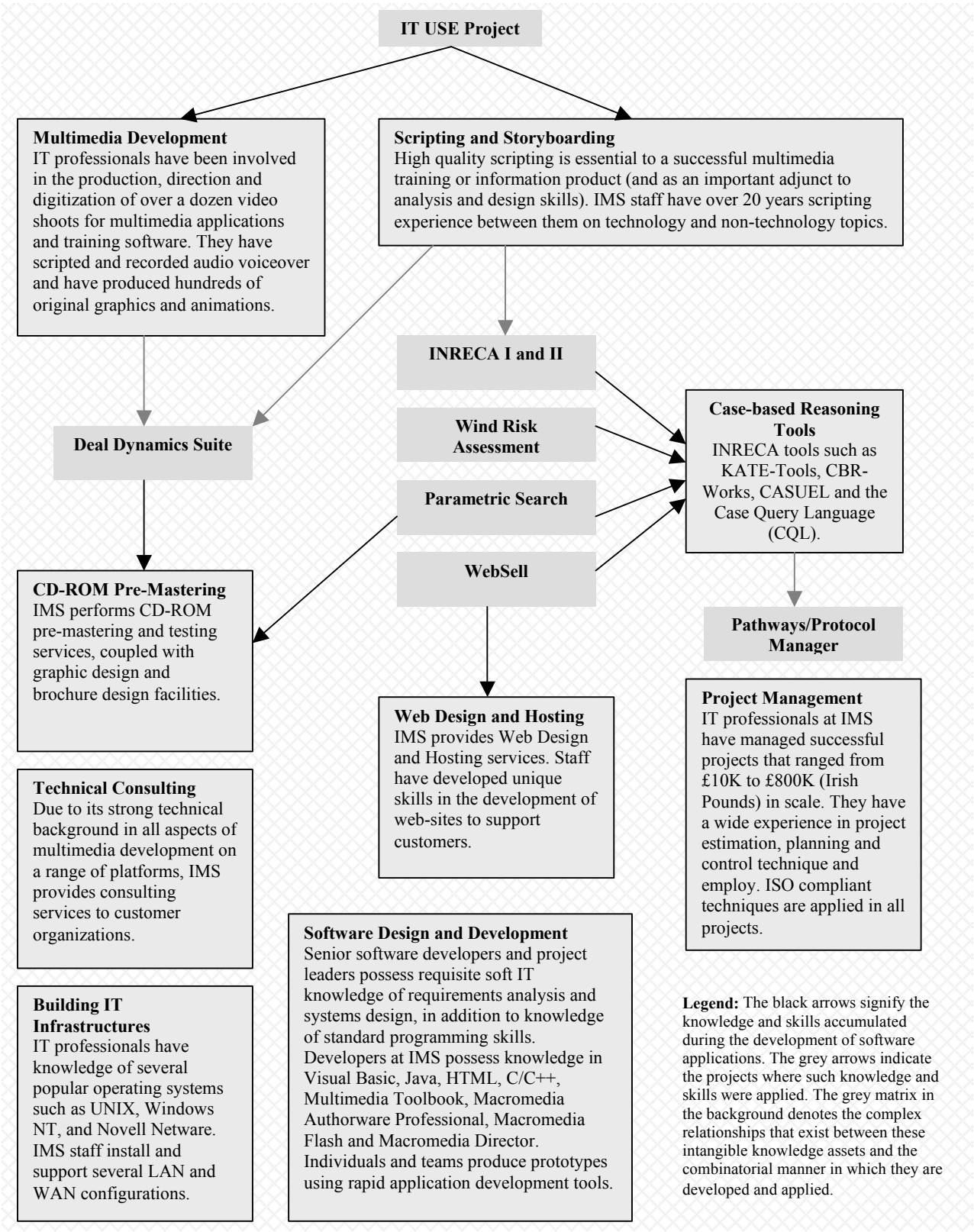

Figure 2 Building Intangible Asset at IMS: A Knowledge and Skills Inventory

were reinvested into R&D or transferred to the group accounts of its parent company. By the end of the decade, IMS had achieved significant commercial success and was a major player in web-based and knowledge management systems in Ireland.

IMS' technological assets were generic and non firm-specific, consisting of industry standard CASE and multimedia development tools. It did, however, have exclusive access to the CBR-Works, the web-based case-based reasoning technology that grew out of INRECA I and II research and development programs, as IMS was responsible marketing case-based decision support applications based on this technology in the UK and US. The Pathways/Protocol Manager application jointly developed with its parent company was also a significant technological asset in that it had multiple applications in the knowledge management and decision support market. The Deal Dynamics Suite of training applications for the financial services sector was also a key revenue generator.

Being the centre of the Irish software industry, the company's presence in Dublin was an obvious locational asset; so too was the location of IMS' development centre, which was situated across the street from that of its parent company. This afforded opportunities for developers from both operations to build close professional relationships, transfer their expertise, and help build development-related knowledge and skills. This was particularly important for IMS in the growth years of the early 1990s. Dublin also proved a useful location from which to service the UK and US requirements for CBR technology.

Chief among IMS' firm-specific assets were its complementary assets, the major component of which was the intangible knowledge resource of its IT human asset. Evidence of the significance of IMS' intangible knowledge asset is found in the group balance sheet for the financial year ending 2000 which had an entry of £14,312,000 Sterling against intangible assets, while tangible assets accounted for a mere £209,000 Sterling[2]. Figure 2 describes IMS' chief firm-specific resources—the knowledge and skills of the company's IT human assets. The knowledge and skill sets described in the figure are drawn from the descriptions offered by social actors in IMS, and from the content analysis of the research database. The figure places the evolution of individual and collective knowledge and skills in context, and with reference to the various R&D projects undertaken by IMS. It was in applying generic non firm-specific and non task-specific knowledge and skills that social actors developed the firm-specific knowledge and skills which underpinned the firm's *dynamic capabilities* (Nordhaug 1994, Leonard-Barton 1995).

4.3 Organizational and Managerial Process as Dynamic Capability in the Small-to-Medium Software Enterprise (RQ3)

Previous studies of IT capabilities in organizations report on the importance of managerial and technical competencies (Mata et al. 1995, Bharadwaj 2000). The following statement by a senior IT professional at IMS indicates that such capabilities were a vital ingredient in building *dynamic capabilities* at IMS:

The key people that really know this, the ins and outs of [our case-based reasoning technologies] are Roy and Sean [—the technical director and CEO]: Roy knows it at a technical level very, very well; Sean is more alert to its commercial potential in a lot of

[2] *This figure for intangible assets was based on estimates of the human capital and associated capabilities possessed by the firm. The figure for tangible assets reflects the industry practice of leasing office space and computer equipment.*

different areas, so there is a marriage of different skills here—Roy is good at technical things, Sean is good here too, but he's got a better overall view.

It was evident that these two actors pooled their experiential and technical knowledge to develop strategies aimed at securing both the funding and collaborative partnerships required to develop software applications for existing and future market needs. Some of their major achievements in this regard have been described earlier. The CEO of IMS, Sean Breen, imprinted his personality and management style on the 'character' of the organization. As CEO, he became the main spokesperson and marketing strategist for the company, its various activities, its relationships with development partners, and its products. His early experiences with the pedagogical potential for IT shaped his vision for IMS in that it focussed on the development of tools that helped individuals and organizations learn and manage their knowledge. In order to realize his vision, he built a team of highly committed, creative IT professionals, while he forged links with external institutions and software vendors—these provided IMS with the fundamental software building blocks for its applications. In describing the outcomes of his endeavours to build a highly competent 'community-of-practice' at IMS, the CEO put it thus:

The things we are good at and we have accomplished are part of our routine: Training, Pathways, and CBR—this is becoming one of those. The collaborative workspace product is emerging…. The focal point between these teams is Roy and myself; Roy is responsible for keeping the big picture, keeping track of papers and conferences, and so on, ensuring that what we are producing is what are required in the marketplace. The outside world does not see this vision; it's part of our task to convey our product capabilities to them.

Thus the organization's two senior managers acted to control and coordinate, manage and mentor, individual and team activities across all development projects. In many ways they acted not only as 'knowledge nodes', in that they interpreted the inner workings of new technologies like those that emanated from the INRECA initiative, with which they had become intimate, they also facilitated individual learning by fostering a culture of experimentation. This approach found concrete expression in the practice of delegating challenging tasks to young IT professionals at IMS and instilling commitment in them, a strategy that ensured the growth and expansion of IT competencies in the 'community-of-practice' at IMS. Take, for example, comments from two IT professionals, one a senior analyst the other a junior analyst/programmer:

I am paid a fixed salary, and paid well…But when you think of the experience we have as well, I don't think I would have got it in any other company.

Because this is such a small company they ask a lot more out of you, but you learn a whole lot of different skills

The dynamic nature of the development environment at IMS was manifested in the organizational routine of moving developers on to new areas of practice, to enhance their existing competence base, or to develop new competencies. IT professionals were challenged not only by the development problems they had to solve, but also by the very tools that they used to develop solutions to those problems. Social cohesion, informal communication, and close personal and professional ties among members of the development 'community' at IMS were strengthened by this approach, as developers came to rely on the experiential knowledge of others to help them negotiate the learning curves involved in coming to grips with new software concepts and tools.

Soft and Hard Firm-Specific IT *Dynamic Capabilities* Observed in the Case
'Soft' competencies: • The ability to build business partnerships and collaborate with business and academic partners over long time horizons. • The ability to secure adequate funding to develop innovative software, while at the same time strengthening and growing the firm's supplementary, enabling, and core capabilities. • The ability to effectively manage the IT development process and the IT human asset by acting as overall facilitators, integrators, mentors, knowledge nodes, and so on. • The ability to engender high levels of commitment and creativity among IT professionals. • The ability of IT professionals to acquire and apply experiential knowledge of interpersonal communication techniques, to understand business needs of customers, to be creative and imaginative, and to be able to script and represent graphically the salient aspects of clients' problem domains. • The ability of IT professionals to integrate themselves with their 'community-of-practice' and share their experiential and technical knowledge. **'Hard' IT Competencies:** • The ability to build applications for heterogeneous IT platforms. • The ability to rapidly master and apply IT skills in new programming languages, technology platforms, and CASE tools, and subsequently move on to other areas and learn new skills.

Table 2 Dynamic Capabilities as Soft and Hard Firm-Specific IT Capabilities

As indicated in the previous sections, 'soft' and 'hard' IT capabilities that were built during the development of the unsuccessful ITUSE application were instrumental in creating the company's first commercial success—the Deal Dynamics suite of foreign exchange training applications. This early period in the company's history saw IT professionals learn and transfer knowledge within IMS and with the company's development partners across Europe. The organizational routines or, to be more precise, informal patterns of institutionalized behaviour that developed helped integrate the activities of IT professionals and facilitated further learning. The capabilities that emerged because of IT professionals' experiential and technical learning are listed in Table 2. This list of competencies results from an interpretive analysis of the empirical evidence presented in the case. It is clear from the findings that 'soft' IT competencies are the more important of the two types of competencies observed.

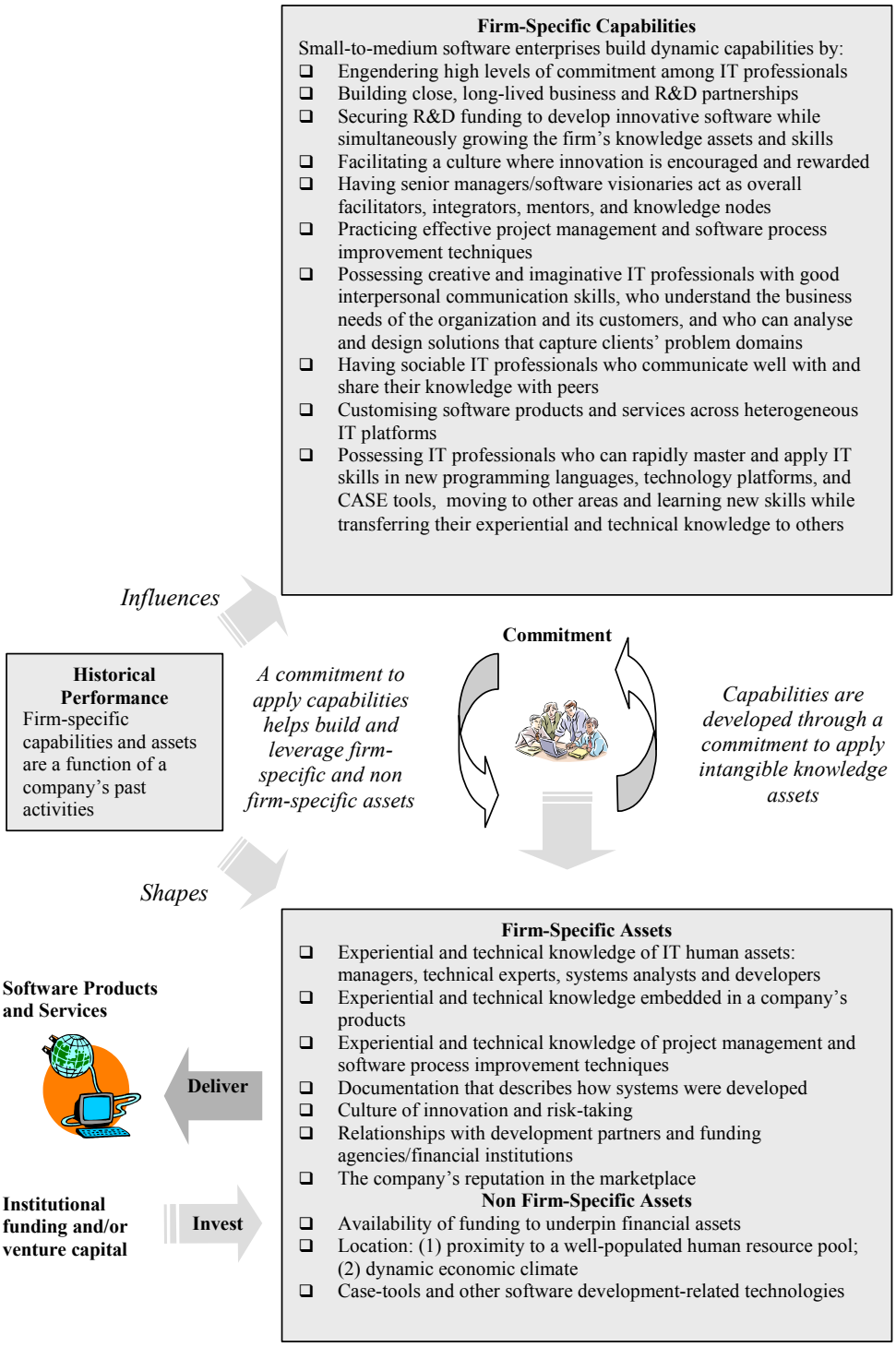

Figure 3 A Dynamic Capabilities Model for the Small-to-Medium Software Enterprise

5. Conclusions

This paper argues that the development of *dynamic capabilities* in European SMSEs is a function of learning through trial and error, success and failure, and of entering into collaborations with others in the software industry and with academic institutions. Furthermore, it is clear from this study's findings that a commitment to apply IT knowledge and skills in pursuit of organizational objectives creates the firm-specific capabilities required to leverage tangible and intangible assets in order to produce products and services that are of value to customers. Hence, commitment underpins the acquisition of knowledge, the application of this knowledge in developing capabilities, and the application of capabilities in leveraging knowledge to direct development activities. Figure 3 illustrates this graphically and presents a *dynamic capabilities* model that builds on extant research by highlighting the key characteristics of innovative SMSEs, such as that studied. These firms operate in institutional contexts, like those that prevail in the EU and its member states, which provide important start-up and R&D funding. They also facilitate the establishment of collaborative partnerships. The model was arrived at through a grounded theory approach suggested by Lincoln and Guba (1985); as such, it will help inform future research in this important area by highlighting the firm-specific capabilities and resources required by successful SMSEs. However, while a single interpretive case study lacks *generalisability*, it does, as Lincoln and Guba (1985) argue, possess *transferability*, which conveys a certain *trustworthiness* on its findings. This study is also timely, as the EU is launching its 6th Framework Programme in 2003, and is targeting a significant amount of its 16 billion euro R&D funds at the IT sector, and in particular at SMSEs. Hence, while this paper's findings provide important insights into the little-understood phenomenon of SMSEs operating in a European institutional context, it also presents a useful point of departure for future research.

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