Introduction

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The focus of this special issue of the *International Journal of Technology Management* is on firm-level learning and technological capability building in industrialising economies. The main motivation for editing this special issue was to mark three decades of the appearance of the first studies on these topics within firms in industrialising economies. This special issue brings together a number of articles in order to reflect on what has so far been achieved, to expand the analysis and to stimulate future research to respond to the challenges that lie ahead. The ultimate purpose is to contribute to deepening our understanding of the intricacies of technological learning within firms in industrialising economies or latecomer firms.

A deeper understanding of technological learning and innovative capability building in latecomer firms is a key condition for providing managers and policy makers with practical recommendations for accelerating industrial innovation and growth in the developing world. To generate such an understanding, we need to carry out research in the light of analytical frameworks that take into account the specifics of the latecomer firm.

There is a well-established body of literature on the issues of learning and technological capabilities in the context of firms in industrialised economies. Since the 1970s, however, development researchers have sought to build a literature that provides insights on how the latecomer firm can catch up with international levels of performance. On the one hand, the literature on industrialised firms is not enough to cover many of the issues involved in latecomers; on the other, the latecomer literature *per se* does not offer sufficient conceptual and empirical frameworks for examining many of the issues related to firm-level technological learning.

To put it differently, neither body of literature on its own provides a complete framework for studying learning and capability building within the latecomer firm. Nevertheless, as Cooper pointed out, some bodies of literature on firms in industrialised economies have much to offer to studies of technological capability in latecomer firms (see Cooper, 1991). Thus, one of the critical tasks for development researchers is to identify potentialities and limitations of existing approaches to learning and capability building and seek to adapt them to meet the research needs of the latecomer firm.

1 Why approaches to industrialised firms' learning and capability building are not enough

Since the early 1990s, there has been a profusion of conceptual and empirical articles, books and conferences on 'knowledge', 'firm-specific capabilities' and 'learning' as the key sources of competitive advantage of firms in industrialised economies. However, such prevalent studies and frameworks, although important, are not enough on their own to examine the issues of learning and capability building in the latecomer firm.

Well-known empirical studies have addressed these issues from different perspectives in diverse industrial sectors (*e.g.*, Cohen and Levinthal, 1990; Kogut and Zander, 1992; Leonard-Barton, 1992; 1995; Iansiti and Clark, 1994; Boisot, 1998; Iansiti, 1998; Brady *et al.*, 2002; D'Adderio, 2004). Such studies have drawn on conceptual literatures as, for instance, the 'resource-based view' (*e.g.*, Penrose, 1959; Rumelt, 1974; Dietrickx and Cool, 1989), the 'dynamic capabilities framework' (Teece *et al.*, 1990; Prahalad and Hamel, 1990) and the 'evolutionary perspective' (*e.g.*, Rothwell, 1977; Nelson and Winter, 1982; Dosi, 1988a–b; Pavitt, 1991; 1998; Dosi and Marengo, 1993). Others include the 'organisational learning' and 'corporate knowledge creation' literatures (*e.g.*, Polanyi, 1966; Simon, 1961; Argyris and Schön, 1978; Hedberg, 1981; Senge, 1990; Nonaka and Takeuchi, 1995; Edmondson and Moingeon, 1996), the literatures on other types of 'learning' (*e.g.*, Rosenberg, 1982; von Hippel, 1988) and those on issues of 'intellectual property rights' (Teece, 1987) and 'intellectual capital' (Stewart, 1997).

These literatures have made an enormous contribution to our understanding of the role of firm-level knowledge, capability building and learning as the primary sources of wealth creation and sustainable competitive advantage. They have also helped unveiling the organisational basis of firms' capabilities and learning processes and the influence of certain organisational factors such as power struggles, corporate values, norms, beliefs and sagas on firms' learning and capability building. However, these literatures are not sufficient to provide an understanding of these issues in the context of latecomer firms. There are at least two inherent problems with the conventional approaches to firms' capabilities and learning that have implications for the technological perspective on the latecomer firm.

Latecomer firms: at odds with conventional approaches to technological capabilities

The first problem is that most of the existing firm-level studies of 'knowledge', 'capability building' and 'learning' tend to focus on the most innovative firms at or near the technological frontier. These are firms that are for the most part concerned with sustaining, deepening and renewing their existing innovative capabilities. For them,

learning processes and knowledge management practices are examined on the basis of the use, exploitation, deployment and codification of knowledge that already exists in the firm – either in the minds of people or in the organisational routines. Studies, thus, tend to examine what firms know today in terms of technological activities and how they will help push the technological frontier further forward. They rarely tell us how these firms have accumulated their current knowledge in the first place.

Latecomer firms, however, normally move into a business on the basis of the technology they have acquired from firms in industrialised countries. Very often, most latecomer firms lack even the basic technological capability or knowledge base during their start-up time. Additionally, latecomer firms are usually dislocated from the key international sources of technology (*e.g.*, R&D centres and universities) and also from the mainstream international markets they wish to supply (Hobday, 1995). To become competitive and catch up with the technological frontier, they have to engage in technological learning processes in order to build up their own capability to be able to carry out innovate activities independently.

While radical and breakthrough innovations are of a major concern of firms like Microsoft or IBM and leading Japanese firms, latecomers, on the other hand, are mostly preoccupied with the need to 'keep up' and 'catch up' through small, incremental improvements to existing products, production processes and equipment on the basis of non-R&D activities. Such basic to intermediate innovative activities are normally carried out within departments of quality, engineering or maintenance (Bell and Pavitt, 1993; 1995; Hobday, 2003).

When it comes to technological development in most latecomer firms, it is necessary to understand the *process*, specifically, the nature, direction, and rate at which firms move over time from the building of *production-based capabilities* into *innovation-related capabilities* (Bell and Pavitt, 1993; 1995). That the process of moving up the 'technological ladder' is neither automatic nor linear is a well-known fact. We do, however, need more understanding of the *dynamics* and organisational basis related to such an accumulation path, as pointed out in Bell (2006, in this journal issue). These are topics that are not covered by those well-known studies of technological frontier firms, not even by the more traditional models of innovation such as those in Abernathy and Clark (1985), Tushman and Anderson (1986), Henderson and Clark (1990), and Clark and Fujimoto (1991).

The second problem has to do with the measurement of technological capabilities. In most firm- and industry-level studies, technological capabilities are measured on the basis of R&D expenditure (Mansfield *et al.*, 1979), the gross domestic expenditure of R&D (GERD) (Hayter, 1996), individuals' qualifications (Pack, 1987; Jacobsson and Oskarsson, 1995), investments in R&D personnel (Wortmann, 1990), and US patent statistics (Patel and Pavitt, 1997). A combination of R&D, patenting, education, science and engineering personnel statistics is used at times to measure technological capabilities (*e.g.*, Daniels, 1997).

However, there are situations in which some of these measures have their own limitations and are less relevant (Lall, 1992; Bell and Pavitt, 1993; 1995; Ariffin and Bell, 1999; Ariffin, 2000; Hobday, 2003; Ariffin and Figueiredo, 2004). First, R&D and international patenting capabilities are only prevalent in advanced industrialised countries (*e.g.*, the USA, Japan and selected European countries like the UK and Germany). In

these countries, firms have sufficiently advanced levels of innovative capabilities to conduct R&D and produce international patents.

Second, the application of such proxy indicators (usually on the basis of conventional surveys) does not capture the non-R&D innovative activities that take place in different organisational units in the firm. To put it differently, the application of such measures, as well as the aggregated analysis they generate) fails to take into account the organisational fabric in which technological capability is developed and embodied. Neither are they useful for examining latecomer firms' technological paths.

Specifically, conventional surveys and aggregated studies fail to gather evidence of innovative capabilities at intermediate or high-intermediate levels for different technological functions. These functions include project management, process and production organisation, products and equipment-related capabilities. These, however, are the most prevalent levels and types of technological capabilities in latecomer firms and industries. In particular, such intermediate capability levels are a *precondition* for attaining research-based and patenting capabilities. As a result, applying conventional proxy indicators to latecomer firms produces not only a limited and/or misleading picture of the industrial reality. It also excludes several latecomer firms and industries from the international debate and evidence of technological development and industrial innovation.

2 The latecomer literature: the need for comprehensive and tailored frameworks

From the 1970s, we can identify three major sets of studies in the latecomer literature, as briefly commented on below:

2.1 The pioneer studies of the 1970s

During the mid-1970s, a pioneer and inspiring set of empirical studies adopted a dynamic perspective on technology in Latin American and Asian firms by setting aside the static question of choice out of a given set of techniques (Stewart and James, 1982). These studies looked at the various mechanisms by which firms acquired technical knowledge to build up (or failed to build up) their innovative technological capabilities *over time* (see for instance, Katz, 1976; 1987; Katz *et al.*, 1978; Dahlman and Fonseca, 1978; Bell *et al.*, 1982; Bell, 1984; Lall, 1987 among others).[1] They made an enormous contribution to our understanding of the nature and dynamics of technological learning inside the latecomer firm. However, their focus of analysis was largely centred on the technical aspects of technological capabilities. Such narrow focus of analysis did not examine the organisational dimensions of learning and capability building.

2.2 The production organisation studies of the 1980s

The emergence of these studies was influenced by two main factors:

1 The economic and industrial restructuring that took place in several developing countries during the 1980s.

2 The appearance of a new set of studies in industrialised countries by the mid-1980s (based on the spread of Japanese production management techniques).

From the late 1980s, manufacturing companies in developing countries, particularly in Latin America, began to face the pressures from foreign competition. This pressure resulted from the opening up of the previously protected market and the end of the Import Substitution (IS) policy, leading to an intense industrial restructuring.

Within these studies, changes in production organisation were then studied as part of that restructuring process (Humphrey, 1995). This set of studies drew heavily on the principles of Just-In-Time (JIT), Total Quality Control or Management (TQC/M) and Continuous Improvement (CI) (Humphrey, 1993; 1995; Kaplinsky, 1994; Bessant and Kaplinsky, 1995).[2] Other studies emphasised the importance of changes in the organisational dimensions of production if the company were to achieve substantial gains (Hoffman, 1989; Meyer-Stamer *et al.*, 1991). They also suggested that the focus on organisational practices (*e.g.*, benchmarking) might be even more important than micro-electronics technologies (Mody *et al.*, 1992) for latecomer companies. These studies contributed to opening up the box of key organisational dimensions of technological capability.

However, this time the focus of analysis tipped substantially towards production organisation techniques. Indeed, most of these studies treated organisational practices in terms of given 'techniques', rarely mentioning concepts like 'knowledge' or 'learning mechanisms' unlike the studies of the 1970s. They did not develop a long-term examination of firms' production organisation capabilities, again unlike the studies of the 1970s.

2.3 The comprehensive studies of the 1990s

By the mid-1990s, a new set of empirical studies began to appear in the literature on latecomer firms' learning and technological capability building. These were, in turn, influenced by the profusion of studies on knowledge, firm-specific capabilities and learning as key sources of firms' competitive performance in technological frontier firms.

Building on Cooper's proposal (as mentioned earlier), Kim pioneered the strategy of drawing on conceptual and empirical literatures on technologically advanced firms to build frameworks for investigating learning and capability building in the latecomer firm. Such a research strategy proved quite successful as demonstrated by the studies he carried out during the 1990s in South Korean firms (see Kim, 1997a–b; 1998). It should be noted that Hobday made another pioneer contribution in the 1990s through his studies of capability building in several electronics firms in East Asia (see Hobday, 1995).

Such initiatives paved the way for the emergence of more studies that sought to examine the organisational basis of learning mechanisms and capability building on the basis of a long-term research design (*e.g.*, Dutrénit, 1998; Hwang, 1998; Figueiredo, 1999; Ariffin, 2000). In a sense, these 1990 studies sought to revive many of the research features of those pioneer studies of the 1970s.

Another contribution of the 1990 studies was to adapt and apply a systematic, comprehensive and time-friendly alternative framework to examine firm- and industry-level technological capability building. This is a framework developed by Lall during the late 1980s (see Lall, 1992). Bell and Pavitt later refined this framework (see Bell and Pavitt, 1995). As in Gerschenkron (1962), it identifies stages or 'levels' of capabilities for different technological functions. However, it does not presume that all firms will necessarily build up capabilities in a linear sequenced process, neither does it imply that firms will start and end at the same stages (Ariffin, 2000). One of the advantages of such

a framework is that it can be used to capture the evolution or development (*i.e.*, the *dynamics* of technological capability building of firms and industries over time). The empirical application of such a framework can be found in Ariffin (2000), Figueiredo (1999; 2001) and Tacla and Figueiredo (2006, in this journal issue).[3]

To sum up, the latecomer firm offers a challenging, yet rich and fruitful empirical setting for researchers. During the past ten years, there has been a very positive response by several researchers around the world in terms of producing creative studies on firm-level learning and capability building in industrialising economies. Indeed, more effort is needed to expand the focus of analysis, not only within the boundaries of the latecomer firm, but also for the purpose of understanding better the links between capability building within the firm and other external factors such as innovation systems and macro-economic policies. Bell and Frischtak address this concern in this special issue. Certainly, researchers will have to draw on industrialised firms literatures; but they also have to challenge existing frameworks and explanations by carrying out extensive and systematic fieldwork observations in the context of latecomer firms and industries. In terms of research design, we also need more quantification of results and more long-term approaches. It is by responding to these challenges that development researchers will be able to contribute to making a difference to the industrialisation process in the developing world. This special issue seeks to contribute to meeting this challenge.

3 Overview of this special issue

Part 1 of the special issue presents the reflective pieces from our four invited contributors, whereas Part 2 brings together 12 empirical studies from different regions of the industrialising world.

3.1 Part 1. Reflective pieces

We have in this part the works of four eminent researchers in this field. I am deeply grateful to them for kindly accepting my invitation to write these papers for this particular edition of the *International Journal of Technology Management*. I deem it a special privilege to have all four of them together in one issue.

We begin with the article by the late Sanjaya Lall. In the course of writing this introduction, we were all struck by the sudden and untimely death of Sanjaya. Prior to this sudden turn of events, he and I had exchanged ideas about his paper as I edited the issue. He was quite enthusiastic about this special issue and once noted that he was 'looking forward to seeing it in print'. Without a doubt, we will all miss his impressive and relentless research and publication efforts to find new explanations for the industrialisation process in the developing world. At the same time, his prolific work, enthusiasm and engagement will serve as a constant source of inspiration for the development research community, governments and development agencies in responding to the challenges lying ahead. In view of his remarkable contribution to the field of industrialisation in the developing world, we would like to dedicate this special issue to his memory. I would like to thank Larry Westphal for kindly providing us with a biographical note in honour of Sanjaya Lall in this special issue.

The pieces by Lall and Katz briefly reflect on some of the implications of changes in policy regimes – from inward- to outward-looking industrialisation, trade liberalisation

and globalisation – for industrial technological capability in developing countries. Bell and Frischtak offer a very insightful and critical perspective on the achievements of the literature on firm-level technological capability building.

3.2 Part 2. Empirical studies

Nine of the articles in Part 2 of this issue focus on learning and technological capabilities strictly within the firm. The other three papers examine some of the implications of industrial policy and innovation systems for firms' learning and technological capabilities.

3.2.1 Firm-level learning and technological capability: a focus on intra-firm strategies

We begin with the article by Dutrénit. This article moves a step further in relation to Kim (1997b; 1998) and explores the implications of learning processes for a truncated technological capability accumulation path. These issues are examined within the context of a large Mexican glass-making firm during a long time period.

Applying a Lall-type taxonomy and a specific framework for learning processes, Tacla and Figueiredo examine the implications of the key features of the underlying learning processes for the manner and rate (speed) of technological capability accumulation in a large Transnational Corporation (TNC) subsidiary that produces capital goods (plant for the pulp and paper industry) in Brazil from 1980 to 2004.

Consoni and Quadros examine the building of capabilities for Product Development (PD) under a liberalised industrial regime in Brazil. They draw on an in-depth case study of the Meriva Project (General Motors Brazil). This is one of the most complex cases of PD carried out in an automotive unit in Brazil. Their study points to a change on the quality, complexity and responsibility of the activities that Brazilian engineering has conducted, thus playing a major role on global automotive PD activities.

Arvanitis *et al*. examine firms' technological learning strategies from the standpoint of external sources of learning. Drawing on descriptive evidence from a sample of six firms in Southern China, they argue that the use of external linkages with foreign clients has been a key feature of the technological learning strategy of those Chinese firms.

In addition to learning processes, technological capability accumulation is also affected by other (rather invisible and abstract) variables inside the firm (*e.g.*, norms, values, beliefs, and the culture developed within the organisation). In line with this perspective, Tsekouras argues that most firm-level capability studies in industrialising economies tend to focus on the accumulation of technical resources, ignoring the significant managerial and organisational aspects of the innovation process. Drawing on a sample of eight leading food-processing firms in Greece (a European industrialising economy), he shows how the organisational and managerial capability to integrate knowledge over time, across technology, and with suppliers and other external bodies of expertise, critically affects the innovative and competitive performance of companies.

Refining this approach, Vera-Cruz examines the extent to which the firms' culture shape the learning processes and create rigidities in the way in which firms respond to changes in the economic and policy contexts. Such issues are explored on the basis of a comparative in-depth case study of two large Mexican breweries over an extended period of time.

In an effort to enlarge the focus of analysis, Rajah Rasiah looks at the representativeness and statistically tested evidence relative to the relationship among technological intensities, ownership and firms' economic performance. Based on a sample of foreign and local auto parts, electronics, food, pharmaceutical and garment firms in South Africa, his findings suggest that South African firms have acquired considerable learning and innovation potential, although production is still very much confined to regional and domestic markets.

Two other articles offer new frameworks for examining firm-level learning and technological capability building in industrialising economies. The article by Liu *et al*. proposes a framework that consists of gap analysis of three core components (*i.e.*, technological capability, learning strategy and patterns of capability building) and four supporting components (*i.e.*, strategy, organisation, exogenous environment and firm performance). Their framework is based on an observation of five large technology-based firms in China.

Seeking to advance the understanding of the relationship among Information Technology (IT) capability, organisational capability and firm performance, Li *et al*. propose an integrated framework that consists of a road map for building up technological capabilities and improving performance. Their framework is derived from the existing literature and explores the interactions between information synergy, innovativeness and performance.

3.2.2 Firm-level learning and technological capability: taking external factors into account

The studies underlying the next three articles address the links between firms' capability and external conditions. In particular, the link between industrial policy and innovation system for firms' learning and technological capabilities is examined.

It should be remembered that Kim's argument that firms' successful technological learning requires an effective national innovation system 'to force firms to expedite that learning' (Kim, 1997a,p.219) has intrigued some development researchers. Evidence in Dutrénit (2000), Figueiredo (2001) and Ariffin and Figueiredo (2004), however, suggests that such an argument seems doubtful. At best, it deserves more empirical testing in order to generate more conclusive results and convincing explanations, particularly to provide practical recommendations for policy makers, firms' managers and development agencies.

A few of the writers in this issue have taken on the challenge of addressing issues related to the argument put forward by Kim. On the basis of an expanded focus of analysis, Xie and White examine the linkages among the industry, policy environment, firm-level capabilities and learning strategies of mobile phone handset makers in China. The article shows how local firms have linked their product innovation efforts to the local market characteristics in order to enter the mobile phone market and challenge dominant TNCs.

In a similar way, Choung *et al*. seek to explain the successful catch up of three IT-related industries in South Korea. Their paper looked at innovation system arrangements such as cooperative R&D consortium that served as a domestic knowledge pool from which firms were able to learn about basic and generic technology in a cooperative manner. They argue that it is critical to design corresponding organisational

and institutional arrangements in line with the need for technological change in the process of technological capability building.

Finally, Berger and Revilla-Diez draw on empirical data from Singapore, Penang (Malaysia) and Bangkok (Thailand). They raise the question as to whether the quality of the innovation system would influence firms' innovative capabilities. They argue that the quality of the innovation system is very important to firms' learning and innovation, even though evidence from Penang suggests that firms can do better than the quality of their National Innovation System (NIS). Also, they succeed in advancing some policy recommendations for strengthening the innovation system as a means to support firms' innovative technological capability building.

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I would like to reiterate my deep appreciation for the authors of the reflective articles for their insights and superb contribution to this special issue. A large number of authors from different countries around the world responded to the call for papers. I would like to thank all the authors who submitted their papers to this special issue. This special issue would not have been published without the invaluable cooperation of a large number of reviewers to whom I owe a debt of gratitude.

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Notes

1 An extensive and detailed review of these studies is found in Dutrénit (2000) and Figueiredo (2001).

2 For a detailed review of these studies, see Humphrey (1995) and Figueiredo (2001).

3 There are other frameworks based on stages or levels that have been developed for technological capability in latecomer firms: the 'reversed product-cycle' (Hobday, 1995) and the 'acquisition-assimilation-improvement sequence' (Kim, 1997a). However, these frameworks, despite their merits, are more focused on product capabilities. They do not cover other technological activities like process and production organisation, equipment and project engineering.