

Knowledge Generation in Developing Countries: A Theoretical Framework for Exploring Dynamic Learning in High-technology Firms

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Abstract: In the case of events such as fundamental regulatory reforms or radical technological advances, firms have to undertake discontinuous or dynamic learning. Such learning involves the generation of new capacity through the acquisition of new knowledge and the combination of it with the firm's existing accumulated knowledge. In developing countries the challenge for firms to develop new competencies through dynamic learning is more complex due to political and economic complexities. This paper discusses the limitations of existing frameworks for analysing the process aspect of transformation and proposes a theoretical framework with which to explore dynamic learning in firms from developing countries. The proposed theoretical framework is based on a constructivist approach to organisational knowledge and uses the concept of absorptive capacity. The responses of large pharmaceutical firms to biotechnological change are used to illustrate the areas under investigation. The theoretical framework is used to explore the responses of Indian pharmaceutical firms to changes in patent law required by that country's accession to the World Trade Organisation (WTO). The cases show that the theoretical framework is comprehensive and useful for exploring firm level knowledge processes within firms from developing countries. However a broader analysis of firm-level learning in developing countries should include an analysis of the institutional environment as this plays an important role in creating environment for firm based learning.

Keywords: Dynamic learning, knowledge, capabilities, developing countries, innovation

1. Introduction

The transition to a new technology, science, market or regulatory regime is difficult for any organisation, public or private, to manage. Technological change or institutional change has proven to be a major cause of failure for established firms and history is full of such examples (Tushman and Anderson, 1986; Henderson and Clark, 1990). In the case of technological advances or fundamental regulatory reforms firms have to develop new competencies through revolutionary change or dynamic learning (Tushman and O'Reilly, 1996). Discontinuous learning normally involves a crisis and a strategy to turn the situation around whereas cumulative or incremental learning is learning that can take place along a firm's current trajectory under normal circumstances (Tushman and O'Reilly, 1996; Kim, 1998). The example of the development of biotechnology capability by large pharmaceutical firms in response to advances in molecular biology represents one such example of a dynamic learning (Henderson et al., 1999). In developing countries, particularly where the state plays an orchestral role in industrialisation, changes in government

policy or new regulations can impose a crisis in particular industry. This creates a greater challenge for firms in such countries to become more adoptable and respond to change more quickly which requires rapid and greater learning. Henderson and Clark, (1990) suggest that such change and adoption involves not only learning new components of knowledge but also new linkages between these and existing components and therefore requires reconfiguration of the existing systems of linkages.

In the last decade many researchers have concentrated on the process of dynamic learning within firms. However, this research has mainly focused on firms from advanced countries (e.g., Nonaka and Takeuchi, 1995; Leonard- Barton, 1995; Kogut and Zander, 1992; Teece et al., 1997). In developing countries this reconfiguration process is more difficult as it is shrouded in economic, political and social complexities. Previous research on developing countries focused mainly on building the minimum knowledge base essential for production and innovation activity (e.g. Kim, 1998; Bell and Pavitt, 1993). During the mid -1990s some researchers such as Kim, (1998) and

Dutrénit, (2000) explored dynamic learning in firms from developing countries or newly industrialising countries. These studies are based on the Nonaka and Takeuchi (1995) concept of the conversion of individual knowledge to organisational knowledge and the SECI model. In the literature dealing with developing countries, there is a scarcity of analytical frameworks which examine the firm level processes involved in discontinuous or dynamic learning.

This paper proposes a theoretical framework to explore the processes involved in dynamic learning focusing on firms in developing countries. The framework is used to explore the responses of Indian pharmaceutical firms to strengthening of patent laws due to the TRIPS agreement (Trade Related Intellectual Property Laws), a requirement of accession to the World Trade Organisation (WTO). In some developing countries, particularly India and China, the presence of weak patent laws played a crucial role in the development of a domestic pharmaceutical industry which would now be severely affected by the TRIPS agreements. For the first time signatory countries are required by international law to provide protection to both process and product inventions in all fields of technology, subject to classical parameters of novelty, non-obviousness and usefulness. As a result of this regulatory change, Indian firms will have to acquire new knowledge and combine that with accumulated knowledge to develop competencies in innovative R&D, as opposed to their current competencies in the replication and production of existing pharmaceuticals.

Some Indian firms have made this transformation towards innovative R&D, albeit in a small way and these provide the case studies for this research. Six innovative Indian firms were studied to explore the processes involved in dynamic learning by using theoretical framework proposed in this research. The framework applied to these studies is based on absorptive capacity concept and focuses on the social processes or mechanisms involved in knowledge generation.

Section 2 reviews the literature on organisational knowledge creation and shows the role of knowledge in developing capabilities for innovation. Section 3

describes the processes involved in dynamic learning in large pharmaceutical firms as a response to the biotechnological turn. Section 4 presents the theoretical framework proposed for exploring the dynamic learning in firms from developing countries. Section 5 analyses the Indian pharmaceutical firms' responses to change in patent law using the theoretical framework. Section 6 concludes the paper.

2. Managing knowledge within the organisation

The knowledge based view argues that firms exist because they provide the ideal platform for the creation, transfer and application of knowledge (Nonaka, 1994, Spender, 1996; Tsoukas, 1996). There is an increasing understanding that knowledge allows the creation of capability and that this determines the ability to do things (Grant, 1991; Henderson and Cockburn, 1994; Leonard- Barton, 1995) and so the manner of knowing or learning is as important as what should be known (Spender and Grant, 1996). According to Tsoukas and Mylonopoulos (2004) the knowledge based perspective on organisation links two traditionally different domains: the skills that sustain organisational learning and a firm's competitive advantage through its idiosyncratic capabilities.

Central to the emergence of knowledge as a key resource is Michael Polanyi's distinction between tacit and explicit knowledge. Tacit knowledge is subjective and experimental and hard to formalise. Belief, perspective, mental models, ideas and ideals are examples of tacit knowledge. Explicit knowledge is objective, rational knowledge and can be expressed in forms such as data, scientific formulas, specific actions and manuals. This classic distinction is then used to elaborate additional knowledge dichotomies, for example canonical versus non canonical, procedural versus declarative, and know-how versus know what. This distinction between different types of knowledge is the reason often cited for distinguishing knowledge from other resources (Kogut and Zander 1992).

One of the key contributions towards the emergence of this focus on knowledge and its strategic role are the studies of organisational knowledge creation in

Japan by Nonaka and Takeuchi. Building on the distinction between tacit and explicit knowledge proposed by Polanyi (1966) and linking the resource and capability view of the firm with organisational learning literature, Nonaka and Takeuchi (1995) developed the model of the various ways in which organisations create knowledge. Organisational knowledge creation is seen as a capability of the organisation. They postulate that the organisation creates new knowledge through interactions between tacit and explicit knowledge, and through the dynamic conversion of knowledge between these two dimensions. Through this 'social conversion' process tacit and explicit knowledge expands in terms of both quality and quantity. Knowledge is transferred from individuals to the larger group in a spiralling process. This follows from the proposition that, although tacit knowledge is initially locked up in the heads of the individuals, shared experiences allows individuals to project themselves into each other's thinking processes. This 'SECI' (socialisation, externalisation, combination, internalisation) perspective suggests that organisational knowledge creation takes place between three levels: individual, team and organisation. The spiral represents the dynamic process, starting at the individual level and expanding as it moves through communities of interaction that transcend sectional, departmental, divisional and even organisational boundaries.

Cook and Brown (1999) present a different model for organisational knowledge creation albeit based on a different view of the types of knowledge. They argue that tacit and explicit knowledge are two different forms of knowledge which complement each other but cannot convert into each other. They propose that individuals and groups can each possess explicit knowledge and tacit knowledge, giving four different categories of knowledge. However all four knowledge types can be mutually enabling in the pursuit of purposeful activity or 'active process of knowing'. New knowledge is generated as different knowledge types 'dance' together in course of doing something.

Continuing with different types of knowledge and ways of knowing, Spender

(1996: 74) sketches a theory of the firm as a system processing different kinds of knowledge and generating common knowledge. He suggests that knowledge, learning and memory form t

interdependent parts of organisational systems which are influenced by particular types of knowledge. Firms comprise four distinct types of knowledge: conscious (explicit knowledge held by the individual), objectified (explicit knowledge held by the organisation), automatic (preconscious individual knowledge) and collective (highly context dependent knowledge which is manifested in the practice of an organisation). Each implies different learning and memory processes. These different types of knowledge interact dialectically to form an organic system with knowledge both at the level of system and at the level of the individuals it embraces.

These perspectives all propose that organisations have different types of knowledge and that identifying and examining these will lead to more effective means of generating, sharing and managing knowledge in organisations. However, Tsoukas (1996) characterised such perspectives as 'taxonomic' and argues that typologies of knowledge are marked by 'formistic' type of thinking as typologies are based on the assumption that observable systematic similarities and differences exist between objects of study. He further explains that as tacit and explicit knowledge are mutually constituted – they should not be viewed as separate types of knowledge. Tacit knowledge is a necessary component of all knowledge; it is not made up of discrete means which may be grounded, lost or reconstituted – tacit and explicit knowledge are inseparably related. According to Tsoukas (2001:976) organisational knowledge is the capability that members of an organisation have developed to draw distinctions in the process of carrying out their work, in particular in concrete contexts, by enacting sets of generalisations whose applications depends on historically evolved collective understandings. Based on this perspective Orlikowski (2002) suggests that organisational knowledge is observer dependent and action based; it is an outcome of the process of knowing where organisational knowing refers to ongoing

and situated actions of organisational members as they engage the world.

Continuing with this perspective, Tsoukas (2001) suggests a 'constructivist' view of organisational knowledge emphasising that the content of organisational activities or the social processes and practices surrounding these activities construct and create organisational knowledge. This supports Leonard-Barton's (1995) observation that firms nurture and create knowledge through certain activities which basically involve sharing of knowledge within the organisation and the transfer and integration of knowledge across organisational boundaries. She further argues that firms create 'the whole system of knowledge management' through different activities which are an integral element in gaining competitive advantage.

According to Tsoukas (1996) firms are distributed knowledge systems which means that they are composed of knowledge embodied in individuals and their social interactions. The creation of knowledge in such systems requires the promotion of interaction among the individuals situated in various parts. Spender (1996) refers to knowledge emerging from such interactions as collective knowledge. He suggests that a firm's most strategically important feature is its body of collective knowledge and the key to management impact on a firm is influence over the growth and shaping of this collective knowledge. This is based upon the different 'organisational practises', and activities supporting those 'different practises or ways of doing things'. This view is also shared by Nonaka et al. (1995) as they suggest that knowledge creation is a dynamic human process; knowledge is created through the dynamic interactions among individuals and/or between individuals and their environment rather than by an individual who operates alone in a vacuum.

To summarise, the insights from various perspectives on organisational knowledge creation indicate a central role for activities or processes that facilitate interactions among distributed knowledge systems within firms for creating, sustaining or renewing organisational knowledge. Many researchers: Nonaka et al. (1995), Cook and Brown (1999), Spender (1996), Tsoukas (1996), Leonard-Barton (1995)

suggest that organisational knowledge is located in a complex web of social practices and this has implications for capability transformation and the development of new competencies.

The approaches of large pharmaceutical firms to the transformation of technological capabilities in response to the challenge of biotechnology provide an intriguing window into the processes involved in dynamic learning.

3. Transforming the identity of large pharmaceutical firms: the biotechnological turn

Advances in genetic and genetic engineering popularly known as biotechnology have affected profoundly the scientific and technological basis of the pharmaceutical industry and represent a dramatic shift in the '*scientific*' knowledge base of this industry (Zucker and Darby, 1997; Henderson et al., 1999). Zucker and Darby (1997) referred to such advances as 'archetypical example of externally generated, incumbent skill obsoleting, discontinuous innovation' which can potentially replace incumbents (pharmaceutical firms) by entrants (new biotechnology firms). However, incumbent firms responded successfully to the technological challenge by transforming existing capabilities and developing new competencies.

The drug discovery pharmaceutical industry offers a case in which numerous firms have pursued a strategy of adopting a new technological trajectory by transforming existing technological identity and capabilities. According to Henderson et al., (1999) the molecular biology revolution and the response from firms reveals the detailed mechanisms of industrial transformation at firm and industry levels, with the co-evolution of scientific knowledge on one side and organisational capabilities, industry structure and institutional context on the other side.

3.1 Transformation of the identity at large pharmaceutical firms

The revolution in the life sciences changed the organisational and managerial aspects of drug research; it changed the internal structure of R&D by increasing emphasis

on collaboration, publication and willingness to exploit external sources of technology (Cockburn, 2004). Large pharmaceutical firms focused on internal R&D transformation primarily by hiring new personnel, embracing new technology and incorporating these into existing structures. They promoted collaboration and joint ventures with university scientists and new biotechnology firms to augment internal expertise (Zucker and Darby, 1997). Nicholls-Nixon (1993) presents the absorptive capacity model to explain the use of internal R&D and technology sourcing linkages to develop the capabilities required in a new technological paradigm. The process of transforming an existing knowledge base is dependent upon a firm's absorptive capacity. This capacity has two important elements: a prior knowledge base and mechanisms for knowledge transfer. Nicholls-Nixon (1993) points out that large pharmaceutical firms developed new capabilities by investing in biotechnology related R&D activities and by accessing new external technological linkages. According to Galambos et al., (1998) some pharmaceutical firms used an incremental approach of working with biotech companies to develop in-house biotechnology capability, while other firms used the acquisition route. Supporting this observation Gamberdella (1995) explained that large pharmaceutical firms used different forms of linkages with universities and research institutes as mechanisms of knowledge transfer to complement internal capabilities in biotechnology. He identified four types of linkages: research and/or joint development agreements with other firms, research agreements with universities, investments in the capital stock of biotechnology firms and acquisitions of biotech firms. Such changes led to the transformation of new drug discovery and development in large pharmaceutical firms from a totally in-house activity to a networked activity.

To sum up, advances in biological science and the advent of biotechnology made several of the core competencies of existing pharmaceutical firms' obsolete (Henderson et al., 1999). As a response to these challenges, large global pharmaceutical firms acquired biotech capability by hiring star scientists, restructuring internal mechanisms of managing research, accessing new

external sources of knowledge and investing in internal biotech R&D. These firms collaborated, and in some cases acquired biotech firms and changed the in-house nature of their R&D to a network model of the R&D. Thus the transformation of technological identity by large pharmaceutical firms as a response to the emergence of biotechnology provides a better understanding of processes used by incumbent firms for dynamic learning in the face of radical innovation and resultant technological discontinuity.

4. A theoretical framework for analysing the firm level processes involved in development of competency for innovation

The current experience of both developed and developing countries shows that differentiated and path dependent processes of learning are the basis for changing capabilities as they develop. Both historical and contemporary analysis is needed to understand fully the dynamics of learning processes (Bell and Pavitt, 1993). Therefore the theoretical framework described here focuses on both historical and contemporary analyses of the processes involved in learning and change in Indian pharmaceutical firms.

In the face of events such as fundamental regulatory reforms or radical technological advances firms have to adapt and change by developing new competencies through dynamic learning. This ability of firms to learn, change and develop new competences is termed *dynamic capability* by Teece et al., (1997). According to Teece et al., (1997) the dynamic capability of a firm refers to its capacity to renew competencies so as to achieve congruence with changing business environments. It refers to a firm's ability to make effective use of knowledge in efforts to assimilate, use, adapt and change existing technologies. Therefore it enables firms to create new technologies and develop new processes in response to a changing economic environment.

A review of strategic management literature suggests that the capability of a firm to renew or reconfigure technological capabilities is based on the ability of that firm to develop new competencies by

acquiring new knowledge and integrating or combining it with existing knowledge bases (Kogut and Zander, 1992, Teece, et al., 1997; Cohen and Levinthal, 1990; Pavitt, 2002). In a similar vein Henderson and Clark, (1990) show that in order to adapt and change in response to competency destroying challenges, firms must learn not only new components of knowledge but also new linkages between components and so reconfigure existing systems to manage and create knowledge in new ways. In the case of pharmaceutical R&D, the biotechnological turn required new competencies in both research and process development which consequently altered the relationship between the different components of knowledge involved in pharmaceutical R&D. Therefore as a response to the biotechnological turn, large pharmaceutical firms not only developed new competencies through dynamic learning but also reconfigured existing system of managing and creating knowledge in a new way.

Cohen and Levinthal (1990) present a simple model depicting sources of technological knowledge generation in a firm (fig.1); its own R&D and external knowledge generated outside of a firm. A firm's ability to develop new knowledge through these sources depends upon its learning capacity, that is, on its ability to acquire, create and disseminate new knowledge. Cohen and Levinthal (1990) refer to this organisational capacity to generate new knowledge as *absorptive capacity* and define it as the ability of a firm to identify, assimilate and apply external knowledge. However they suggest that absorptive capacity tends to be cumulative and path dependent as it builds on a prior knowledge base and on experience which is firm specific. This prior knowledge base is an essential component of a firm's learning ability or absorptive capacity as existing knowledge increases the ability to make sense of, assimilate and apply new knowledge. Firms tend to move along particular trajectories in which past learning (by doing and by other mechanisms) contributes to particular directions of technical change, and in which the experience derived from those paths of change reinforces the existing stock of knowledge and expertise (Bell and Pavitt, 1993). The stock of past capabilities and

routines provides the base on which firms develop new capabilities to cope with change in technology or external environment: change is certainly possible, but it is conditioned by the past. Patel and Pavitt (1994, 2000) point out that firms are in fact heavily constrained by their prior competencies in the extent to which they are capable of accumulating competencies in new emerging fields.

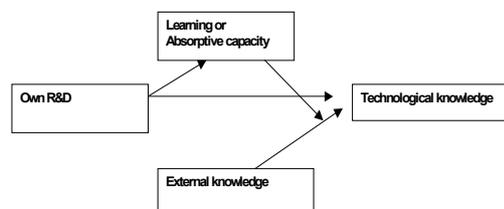


Figure.1: Model of sources of firm's technological knowledge (Source: Cohen and Levinthal, 1990)

Absorptive capacity also refers to the organisation's ability to exploit externally acquired or assimilated knowledge. Therefore an organisation's absorptive capacity does not simply depend on the organisation's direct interface with the external environment but it also depends on the transfer of knowledge across and within subunits that may be quite removed from the original point of entry. The structure of communication between the external environment and organisation as well as among sub units of the organisation is an important determinant of absorptive capacity (Cohen and Levinthal, 1990:132).

Thus an organisation's absorptive capacity or capability to learn depends on its prior knowledge base, that is, the sum of the abilities of all the individuals in the organisation to recognise what they know and the way(s) in which they know; and on mechanisms of knowledge transfer; the effectiveness with which information or knowledge is transferred between firm and external source as well as internally from one unit to another.

Absorptive capacity is thus a function of two separate but interrelated dimensions: a. the firm's ability to acquire the knowledge relevant to the new technological paradigm, and b. the firm's ability to integrate external knowledge into existing capabilities.

The theoretical framework broadly focuses on practices or mechanisms associated with these two dimensions of absorptive capacity. Its focus is on the transformation of what happens in 'practise' as a response to change in the external environment. It covers accumulation mechanisms which govern the content and location of stocks of knowledge in the firm; the transfer mechanisms which govern the balance between internal and external sources of knowledge; it includes assimilation mechanisms which governs the way in which firms internalise newly accessed knowledge and it also focuses on application or deployment mechanisms like coordination and integration practises which govern the ways in which the stocks of knowledge or specialised knowledge bases are brought to bear within decision making.

Other approaches or frameworks focusing on firm level studies in developing countries have concentrated mostly on the differences in tacit and explicit knowledge or between individual, group and organisational knowledge and the conversion of different knowledge types knowledge to create organisational knowledge (see for instance Kim, 1998; Dutrenit, 2000). However various studies of innovation have shown the limitation of such approaches. Categorisation of knowledge for innovation reflects a fair degree of overlap. The knowledge used in innovation does not come in watertight boxes but is mutable and multidimensional, precisely because of complex social processes by which it is generated and utilised (Tsoukas, 1996; Faulkner, 1994). The review of organisational knowledge creation literature also suggests that the social processes that facilitate interactions among distributed knowledge systems within as well as across firms enable the creation of knowledge and this research explores these social processes. Therefore the focus of the theoretical framework is on the practices or processes involved in managing and creating knowledge in contrast to the other approaches used for exploring firm based learning processes in developing countries.

To summarise, the theoretical framework (Fig.2) focuses on the social processes or mechanisms used for knowledge

acquisition, transfer, assimilation, and application. It also analyses the emergence and development of prior knowledge bases in terms of their usefulness in the new environment.

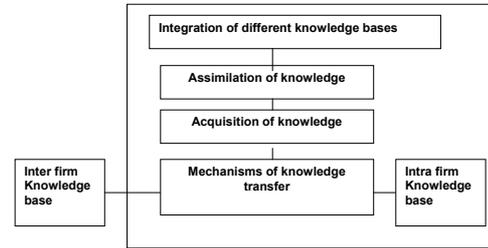


Figure. 2: Theoretical framework

5. Process involved in dynamic learning to develop competencies in innovative R&D in Indian pharmaceutical firms

5.1 Prior knowledge base:

From 1990 onwards these innovative Indian firms targeted the generic market in advanced countries. In an intellectual property regime based on process rather than product protection, this involved developing equivalent products with non-infringing processes. This exposed these Indian firms to global markets, creating an awareness of future regulatory changes and giving a creative orientation to their imitative research. It also created a 'research tradition' in these firms.

From 1995 these firms began increasing their R&D investment, momentum was gained in 2000 (table 1), with the building of the knowledge bases required for innovative R&D.

Table 1: R&D intensity of innovative Indian firms (source: annual reports)

Firms	No. of R&D labs	R&D intensity (R&D spend % of sales)			
		2000	2001	2002	2003
A	5	4.22	6.29	7.7	10
B	3	4.2	3.8	5.2	6.1
C	2	7.2	6.2	6.2	7.9
D	3	1.80	2.16	1.63	3.9
E	1		2.41	2.30	3.09
F	2	1.45	3.50	4.41	6.52

The R&D intensity of Indian firms has grown consistently from 2000 although it is still low compared with the R&D intensity of large multinational pharmaceutical

firms. However, according to some respondents, the cost of development of a drug in India can be a tenth of the international cost.

5.2 Processes involved in acquisition of new knowledge

Innovative Indian firms started building innovative capabilities by hiring scientists who were experienced in innovative R&D and were working overseas in the laboratories of multinational companies. In India only a handful of scientists had experience in innovative R&D and these scientists became the 'guides' for the transformation. These scientists carried the crucial tacit knowledge with them.

According to one R&D manager, the innovative firms focused on R&D scientists and started investing in them. Firms targeted returning post-graduates and post-doctorates from overseas universities. Currently around 20% of scientists working on innovative research projects have either trained at overseas universities, or have working experience abroad in MNC laboratories. One R&D president explains,

"Our target was returning post grads who have gone abroad to do either PhD or post docs, they were returning and were very good."

5.3 Processes involved in assimilation of new knowledge

To create an environment for creative research, firms changed their approach towards publication and have started to understand its importance for the growth of R&D. In these Indian firms' scientists' participation and publication in conferences is now valued and encouraged more. As one senior R&D scientist suggests,

"publication is certainly an incentive to the scientist, there is no doubt about that and we also need to showcase our science, it stimulates scientists to think."

These firms are encouraging scientists to take training in new scientific tools or are allowing them to pursue their academic ambitions while working in the organisations. These firms have

manufacturing and marketing centres all over the world including the US and Europe and as a result, they can make the best research facilities accessible to their scientists. This allows scientists from these firms to pursue their academic interests and develop new skills in innovative R&D.

These firms set up separate R&D centres with 'state of the art' analytical instruments, totally dedicated to innovative R&D. They changed their R&D structures, starting new divisions to manage intellectual property rights (IPR), as well as establishing new disciplinary divisions and in initiating a 'matrix' style of project management. Some firms even opened laboratories in developed countries to make use of the knowledge spillover and to attract research talent which was reluctant to shift to India. These firms concentrated on providing more experience to their scientists by providing opportunities to design research projects, as well as freedom to work on their chosen therapeutic areas.

To increase the quality of the interactions with international scientists, these firms have set up scientific advisory boards (SAB) to review their research. The SAB contains well known scientists from overseas as well as Indian academia and meet on a quarter or half yearly basis. This forum provides an opportunity to scientists from these firms to have closer interactions with external experts, and as one of the research scientist suggest,

"all of which generates valuable feedback and built the confidence of researchers".

5.4 Mechanisms of knowledge transfer

Innovative Indian firms are building research networks by collaborating with Indian as well as overseas research institutes, and research companies. Networking has emerged as one of key mechanisms for knowledge acquisition for Indian pharmaceutical firms. One R&D scientist explains the rationale behind the networking,

"Drug discovery is very complicated and you may not have everything in house, we can't and we don't have

everything in house so you have to. It's a sort of collaborative approach, a collaborative process."

These firms have set up different departments to scout for opportunities for collaboration. During collaboration, these firms send their scientists to work in the collaborators' R&D divisions. This has changed the nature of R&D in these firms; from insular in-house R&D, to a collaborative network model.

5.5 Processes involved in integration of different knowledge bases

It was not enough to just hire the scientist or build new R&D centres, the difficult part was to increase the cross disciplinary understanding of the scientists. To achieve that these firms focused on increasing the interactions and communications between different specialised knowledge groups by building cross-disciplinary teams of scientists from different disciplines like biology, pharmacology, medicinal chemistry, intellectual property rights.

These firms also use internal review meetings for increasing cross disciplinary understanding, as one senior scientist suggests,

"when chemistry is being discussed, a biologist will be present, when biology is discussed, a chemist would be present and so a chemist will learn some biology, at least will appreciate what their difficulties are and vice versa".

To sum up the firm level analysis of learning processes shows that Indian pharmaceutical firms are developing capability in innovative R&D by acquiring new components of knowledge and reconfiguring the architectural linkages between these components. New components of knowledge have been acquired by increasing R&D investment, by hiring new scientists embodying knowledge of innovative R&D and collaborating with Indian as well as overseas research institutes and universities. However, in India the necessary infrastructure required for implementation of patent regulations is severely under developed, raising the questions about the effectiveness of the

new patent law in preventing reverse engineering. This is also affecting the R&D investments of Indian firms in innovative areas of pharmaceutical research. Thus in developing countries economic, social and political complexities make firm-level knowledge generation a challenging and difficult process.

6. Conclusion

This paper proposes a theoretical framework based on the concept of absorptive capacity to explore the processes involved in dynamic learning in firms from developing countries. This framework is used to analyse dynamic learning in Indian pharmaceutical firms intended to develop competencies in innovative R&D as a response to regulatory change. The result shows that the theoretical framework is a comprehensive and useful tool for exploring the firm level learning processes involved in knowledge generation. However, the growth in membership of the WTO means that firms in other countries and in other sectors will be faced with pressures to re-organise their knowledge creating capabilities which will be similar to those being dealt with by the Indian pharmaceutical companies. A broader analysis of firm-level learning in developing countries should also include an exploration of the institutional environment as this plays an important but varied role in creating the environment for firm-based learning.

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